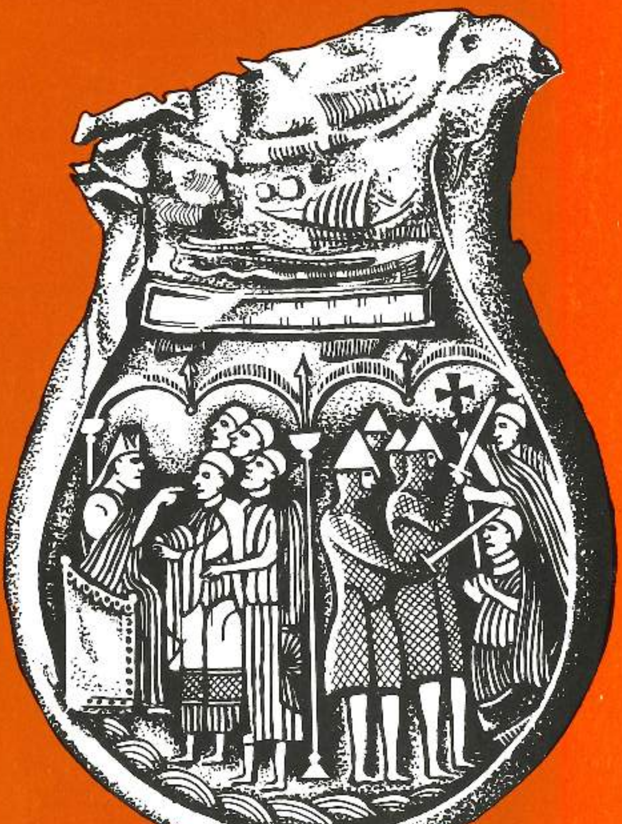
THE BRYGGEN PAPERS

Supplementary series No 1



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The Bryggen Papers

give a scholarly presentation of the archaeological finds from the excavations at Bryggen – The German Wharf – in Bergen.

The Papers consist of two series, *the main series* and *the supplementary series.*

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BERGEN · OSLO
STAVANGER · TROMSØ

ISBN 82-00-07119-7

Distribution offices:

NORWAY
Universitetsforlaget
P.O. Box 2977 Tøyen
0608 Oslo 6

UNITED KINGDOM
Global Book Resources Ltd.
109 Great Russell Street
London WC1B 3NA

UNITED STATES and CANADA
Columbia University Press
136 South Broadway
Irvington-on-Hudson
New York, NY 10533

Published with a grant from
the Norwegian Research Council
for Science and the Humanities

Printed in Norway by

A/S JOHN GRIEG, BERGEN

CONTENTS

THE BRYGGEN PAPERS

is a series of publications giving a scholarly presentation of the archaeological finds from the excavations at Bryggen, later called Tyskebryggen (The German Wharf), in Bergen, which took place between 1955 and 1968.

Bryggen was the economic centre of the old Norwegian capital. Later – in Hanseatic times – Bergen became one of the largest and most important seaports and commercial centres in Northern Europe.

The excavations at Bryggen have revealed extensive material which gives valuable information about the development of the city as well as European cultural history in general.

THE BRYGGEN PAPERS will be published in a main series and a supplementary series. The main series, the first volume of which is to be published early in 1984, contains works by Asbjørn E Herteig: Excavation Methods, Stratigraphy, Chronology, Field Documentation and by Arne Emil Christensen: The Boat Finds from Bryggen. Successive volumes in the main series will include: The Topographical and Chronological Development of the Bryggen Area; Textile Implements and their working Environment, Bryggen 1150–1700; Use of Stave or Timber-frame Construction in Buildings at Bryggen; Combs; Kitchen Utensils; Shoes from the Gullskoen Tenement, Bryggen; Sheaths for Swords and Knives; The Osteological Material, etc.

THE SUPPLEMENTARY SERIES will cover shorter studies on central subjects, preliminary results, and to some extent also studies of related themes. The present issue includes studies which are of crucial importance for the total synthesis of the Bryggen material. Through a combination of ethnobotanical and radiocarbon analyses Krzywinski & Kaland in the first article have succeeded in presenting a new and fascinating picture of the local natural and cultural environment at different pre-urban periods as well as the background for the earliest farm settlement and for the first built-up area along the shore. By using new methods for calibrating radiocarbon dates Krzywinski & Gulliksen in the second study give an absolute basis for the fire-chronology of the excavation in Rosenkrantzgt 4 within the southern part of Bryggen. Ellen Schjølberg presents the various types of material made from animal hair in the Bryggen finds and the different uses made of them. New methods have been applied in the analysis of the hair-fibres. The numismatist Kolbjørn Skaare comments on the importance of excavated coins, casting-counters and some runic inscriptions with bearing on the local monetary history. Special weight is attached to a hoard of coins from a mass grave containing 94 bracteates, the greater part of which were probably struck in Bergen during the later years of King Sverre Sigurdsson (1177–1202).

During the excavation some 1600 samples were taken for tree-ring analysis but after some years the project was brought to a halt for reasons beyond our control. A new start was initiated in 1980 and the article by Terje Thun is a summing up of the state of research at the beginning of this new phase. Jean Le Patourel's paper is the first on our vast pottery material including products from more than 50 pottery-districts in North Western Europe and the Western Mediterranean.

Subsequent issues in the supplementary series will include: Charred Grains as Evidence of Brewing in Medieval Bergen 1248–1450; Latrines as Sources of Information about Food, Health and Hygiene in Medieval Bergen; The Importance of Hazelnuts in the Diet of the Population in Medieval Bergen; Methods for Evaluating the Importance of Cereal Food in Human Faeces; Models of Dispersal and Distribution of Pollen within an Urban Archaeological Site; The Use of Mosses found in Latrines in Medieval Bergen; Ropes and Textiles; Recent Finds of Runic Inscriptions at Bryggen, etc.

The series is published by the University of Bergen and partly financed by the Norwegian Research Council for Science and the Humanities. With exception of Le Patourel's paper, the articles have been translated by Clifford Long.

Bergen October 1983

Asbjørn E Herteig
Chief Editor

Bergen - from Farm to Town

KNUT KRZYWINSKI AND PETER EMIL KALAND

INTRODUCTION

According to later saga versions Bergen became a town in King Olav Kyrre's reign (1066–1093). The town grew up on the eastern side of the bay Vågen which provided, from the outset, a naturally safe and capacious harbour.

For more than a hundred years historians and archaeologists have discussed the town's origins. Basically, two different views exist (cf Helle 1982, 94 ff). According to the oldest one, King Olav furthered the development of a pre-existing fishing and trading community to the point where it acquired the character and formal status of a town (see especially Munch 1849, Nielsen 1877, Nicolaysen 1890, Koren-Wiberg 1908, 1921, 1932). Koren-Wiberg was the most energetic proponent of this hypothesis. He assumed that Bergen as a town grew gradually from the older farm of Bjorgvin which he believed to be situated under the mountains on the gently sloping eastern bank of Vågen. Over the years, the farm was divided into several holdings with their boat houses along the bay and further developed into a pre-urban community of some 1000 inhabitants, more than any other writer would concede before the days of King Olav.

On the other hand, a group of historians have advanced the opinion that Bergen was founded as a completely new town by King Olav (Storm 1899, Lorentzen 1952, Schreiner 1953) although one of them (Lorentzen) admits the possibility that the much older royal estate of Alrekstad, approximately 2 km to the southeast, used Vågen as a harbour in the pre-urban period.

All these writers agree that the estate of Alrekstad was, in any case, an important prerequisite for the emergence of the town. Most of them would also subscribe to the opinion that the town grew up on land belonging to the presumed farm of Bjorgvin, whatever its exact location and relationship to Alrekstad. Most probably, the area on which the town later was built, was already in the hands of the king (Lorentzen 1952, Helle 1982). The extensive archaeological excavations at Bryggen in the years 1955–68 to a large extent covered reclaimed land. An important feature of the oldest recognized building structures from the first half of the 12th century was their regularity organized as they were in the same pattern as the still extant part of Bryggen. As no remains of any earlier settlement were revealed, the archaeological features were interpreted as supporting the hypothesis of a royal town foundation under Olav Kyrre (Herteig 1969, 1970). Below the oldest recognized archaeological structures from the 1st or 2nd quarter of the 12th century, marine beach deposits were found at approximately mean sea level (± 0). These were interpreted as the primary deposits on the original beach surface prior to the foundation of the town.

In 1979 excavations for the foundations of the Norske Folk/SAS Royal Hotel buildings at Bryggen exposed a transect through the shore deposits (fig 2). A series

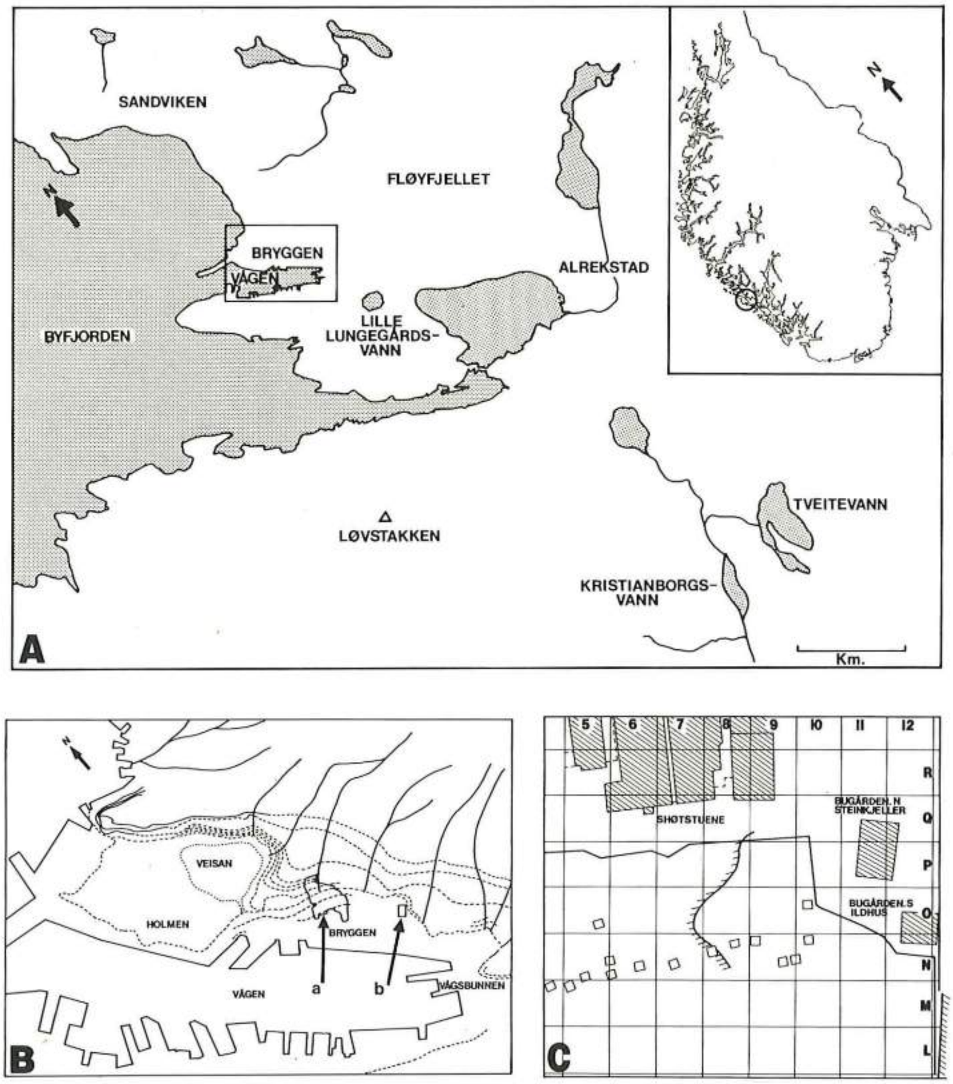


Fig 1 A. Bergen area with present day topography.
B. Main topographic features of the Bryggen area prior to the foundation of the city. a. Main excavation area at Bryggen, b. Rosenkrantzgt 4.
C. Part of the excavated Bryggen area. The caisson system of the 12th century along the underwater shelf and the location of the section is indicated

of alternating minerogenic and organic layers was found dipping towards the sea. For half a day the mechanical excavators were stopped to clarify whether these layers were of cultural-historical interest. An interdisciplinary team of archaeologists, botanists and Quaternary geologists performed the fieldwork. The stratigraphy was documented as detailed as possible and samples were collected for later analysis in the laboratory. In this way it was hoped to obtain information elucidating the origin of the sequence and the process of sedimentation. No conclusive artefacts were found during the field work, but charcoal and woodchips in the organic layers indicated a human activity prior to the deposition of the urban layers found by earlier excavations. Unfortunately the rescue work was left unfinished due to the time limit given by the developing company. The machines started too early. Final stereophoto measurements and a series of pollen samples could not be taken. A possible additional third organic layer which turned up at the base of the established profile could not be investigated.

STRATIGRAPHIC FIELDWORK AND LABORATORY METHODS

Since the field investigations were limited by an extreme shortage of time, no part of the deposit could be properly excavated. A profile in the side of the machine trench was the only source of information (cf fig 3). This profile was cleaned by hand and made vertical. Monoliths from the organic layers (3 and 5 in fig 5) at 5 m and 16 m were taken out. Each monolith was 50 x 15 x 15 cm and subsamples of the stratigraphy within each monolith were taken in the laboratory. These subsamples were taken for macrofossil analysis, pollen sampling and to some extent for ^{14}C-dating. In addition larger samples for macrofossil analysis were mainly taken directly from the section.

The configuration of the section in relation to the grid system of the earlier excavations is shown in figs 1 and 3 together with the caissons 40–43 along the edge of the former beach which were left after the earlier excavation. A profile sketch was drawn by the archaeologists in the field. The stratigraphy shown in fig 3 is based on this sketch, amended by post-excavation reconstruction. Numerous pictures were taken of the section in the field and the general stratigraphy of fig 3 was confirmed by projection of these photographs. In addition three sets of stereophotographs were taken, which were also used. The use of the stereophotos was limited, however, by lack of trigonometric measurements. The curvature of the section caused interpretation problems as parts run almost at 90 degrees to each other. Two sets of lithostratigraphic description were made. Individual verbal descriptions were made on the primary stratigraphic sketch and a proper lithostratigraphic analysis was made every 2 metres along the section.

The latter analysis was made by five different persons and followed Troels-Smith's system for classification of organic sediments (Troels-Smith 1955). Consistency in characterization was confirmed by comparison of analysis and laboratory tests of the sediments collected. Both the main component and the physical properties were noted. Time did not permit the tracing of the boundaries between the layers in detail according to Troels-Smith (Limes superior) and no attempt has been made to reconstruct this in the laboratory, as it is impossible to obtain from the photographs. In the lithostratigraphic figure (fig 3), the character of the boundaries has not been differentiated. At 10 m the line of the section curved 90 degrees and at 23–24 m the section was badly disturbed by the machine. The border

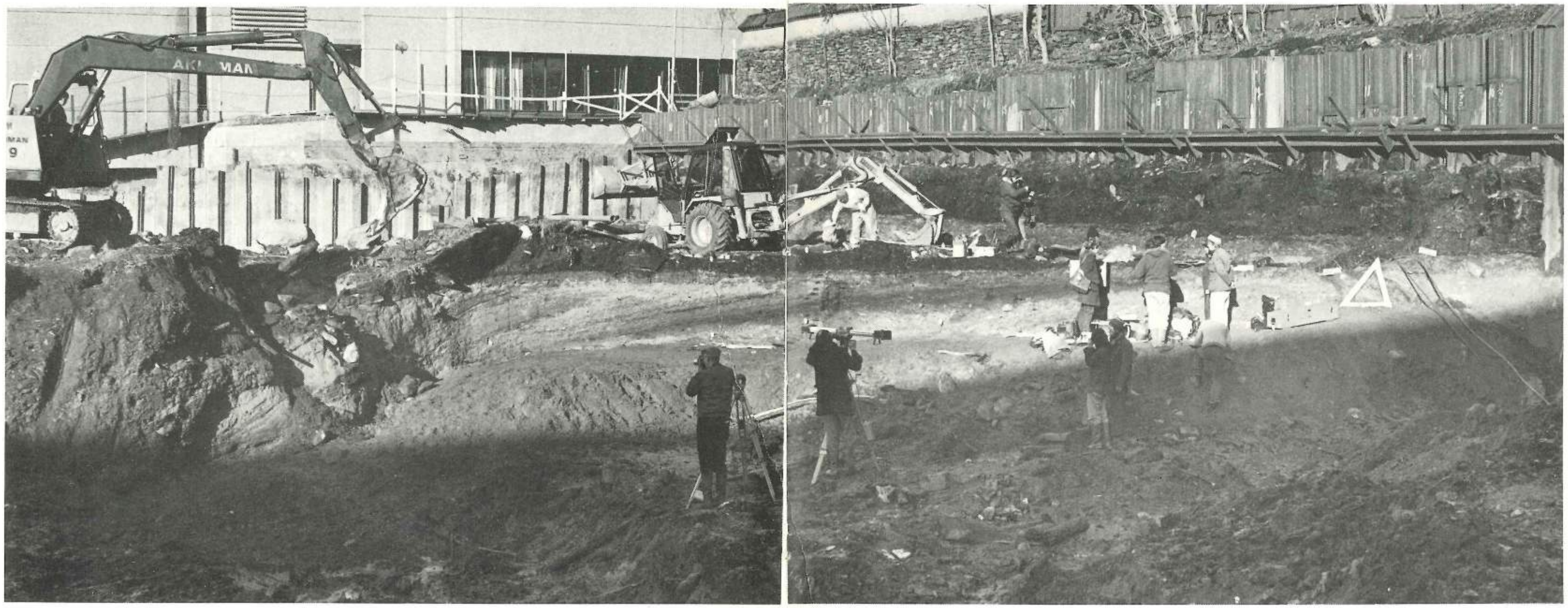


Fig 2 The investigated section at the end of the rescue work. In the middle, unit 3 is shown by a dark band. To the left the machine is removing caisson 41. Unit 5 can be seen below the stones

between the layers in these areas was difficult to trace and the limits have therefore been stippled. The topmost layers were partly disturbed by earlier excavations and these are marked as Stratum confusum.

Primary refuse layers with abundant wood-chips were found at 0–4 m. In the description these wood-chips are classified as Detritus lignosus. In that way it can be incorporated in the lithological formula. However, in accordance with Troels-Smith (1955) wood-chips should be classified as Lignum arte formatum, but the abundance in the deposits is difficult to indicate in the formula. In most of the layers, each stratum is too thin to be presented, and the stratified part is grouped in larger layers and described as the sum of the general composition.

The genetic interpretations of the minerogenic deposit is based on stratigraphy, textures and structures. Samples for grain size analysis were taken directly from the section. As clay and silt were absent from the samples, dry sieving was used. The grain size distribution curves are plotted by means of a computer program (Myhre 1974) and are shown on figs 7–10. A few samples of stones between 60 and 80 mm

were obtained for a classification of roundness. The samples consist of 100 stones and the classification is based on modifications of the systems of Reichelt (1961) and Bergersen (1964, 1970, 1973) using four classes of roundness: angled (K), rounded angled (KR), rounded (R) and well rounded (GR). The classes KR and R are somewhat modified.

K: the surface uneven, more than half the edges and corners sharp

KR: more than half the edges and the corners worn but edges are still clearly visible

R: stone convex with oval or circular projection in at least one plane, edges are only partly possible to see and the surface is smooth without irregularities. The stone may be broken

GR: smooth surface, the stone is convex with oval or circular projection in at least two planes. Small breaks are accepted

Twenty samples were taken from the section for grain size distribution analysis. Diagrams are presented in figs 7–10. The nomenclature is based on Holtedahl (1971), while genesis is discussed on the basis of the nomenclature in Selmer-Olsen (1954), cf fig 4. The parameters Medial value (Md) and Sorting (So), also based on

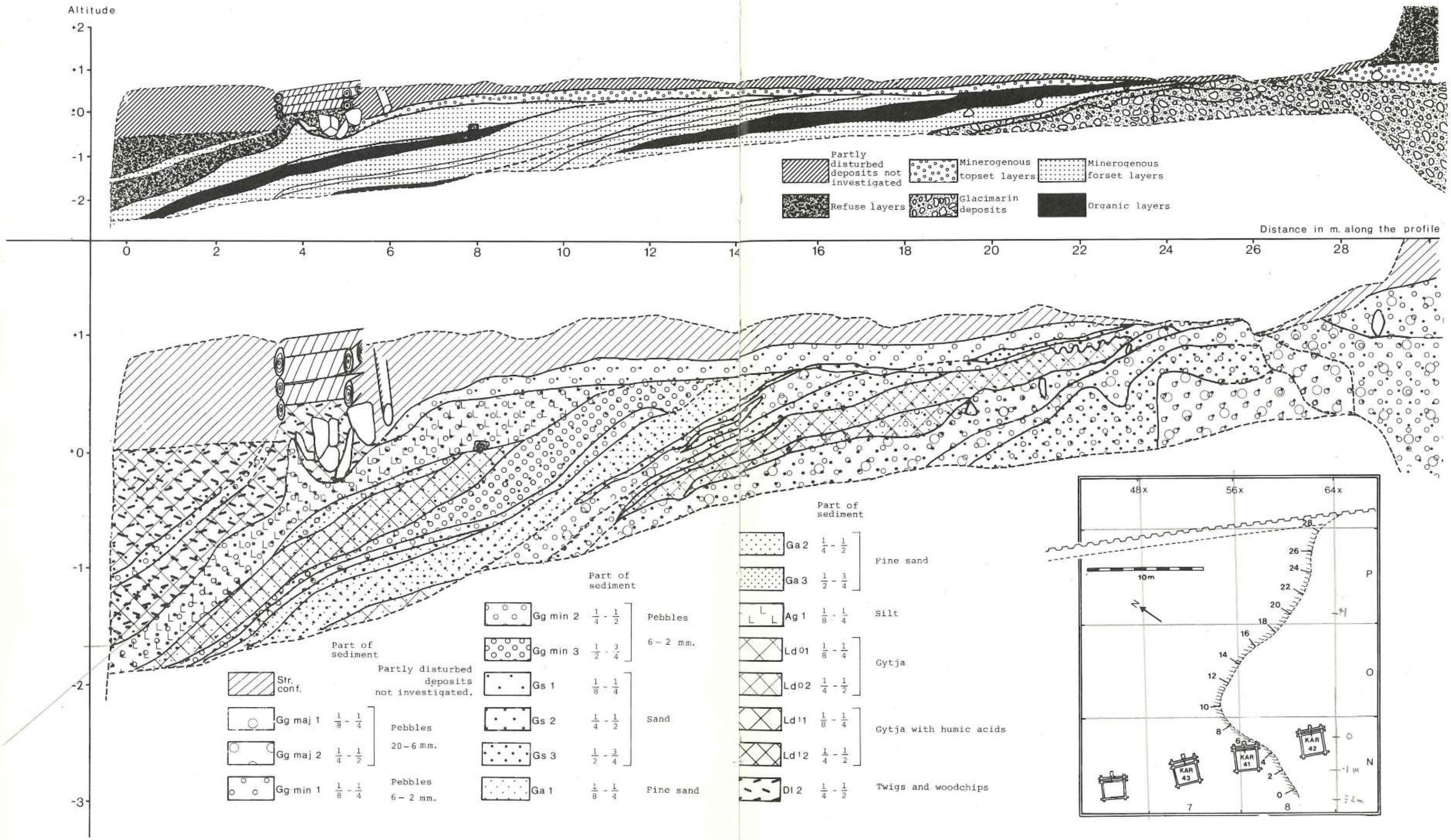
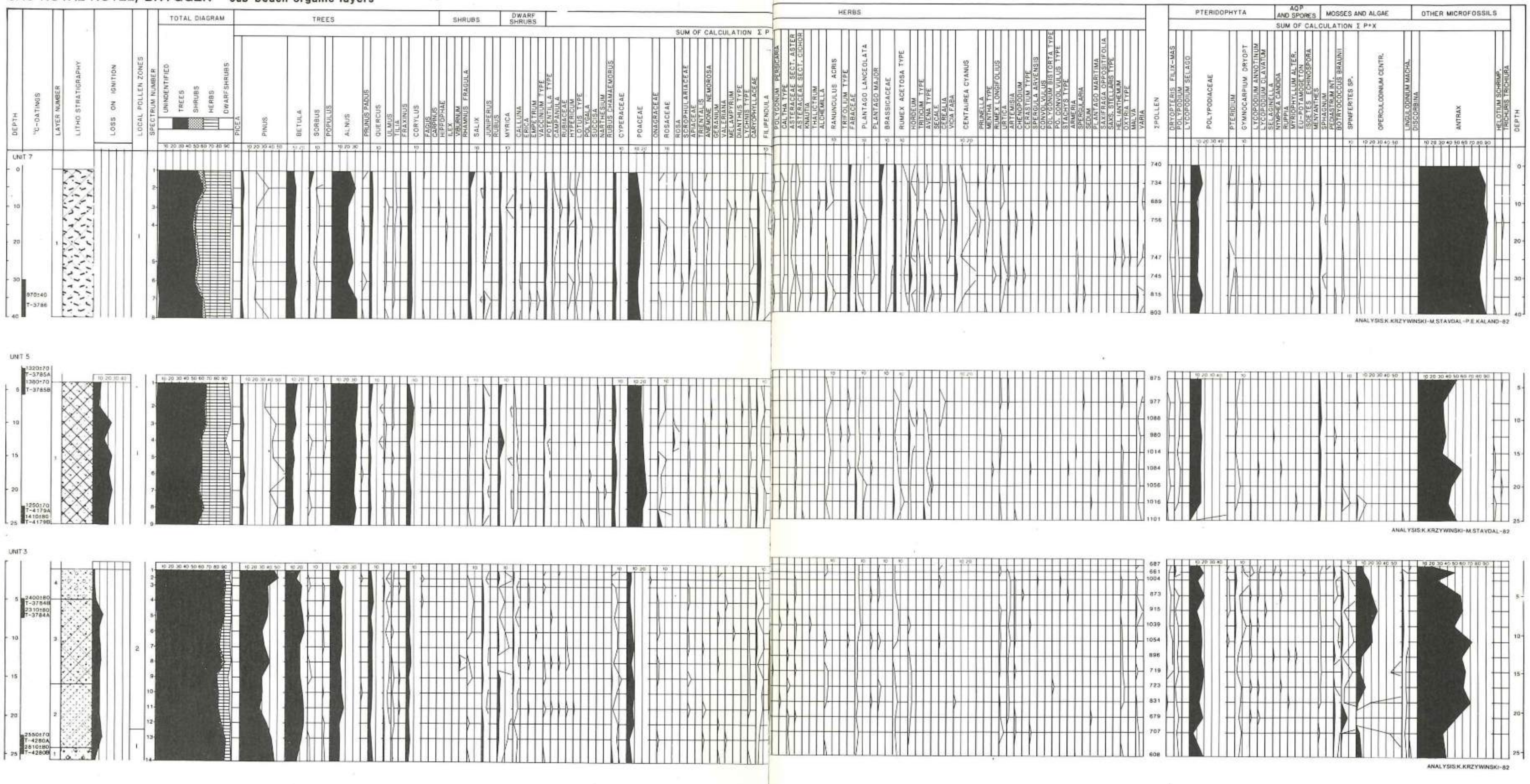


Fig 3 Stratigraphy of the investigated section. Above: vertical and horizontal scales identical. Below: the vertical scale is exaggerated. Stratigraphic description in accordance with Troels-Smith (1955) with modifications cf text. Stratum confusum refers both to disturbed deposits and to layers not investigated. Lower right: simplified map of the site showing position of section (with distances marked in m) together with previously excavated caissons

PLATE 1

SAS ROYAL HOTEL, BRYGGEN sub-beach organic layers



Selmer-Olsen (1954), are calculated from the grain size distribution diagram. Md is the calculated grain size where the curve reaches 50%.

$$Md = Q50$$

and sorting is

$$So = \log \frac{Q75}{Q25}$$

Median values and sorting are plotted in the Md/So diagram, fig 12 (Selmer-Olsen 1954). In fig 4, the classification of Holtedahl (1971) is plotted.

Samples for macrofossils were gently sieved after dispersion in distilled water. Material and particles larger than 0.25 mm were transferred to a glycerol-ethanol mixture (1:1) and sorted manually.

Pollen analysis was carried out in accordance with Fægri and Iversen (1975). All samples were acetolysed and HF treated. Pollen identification was made with oil immersion phase contrast objectives and mainly at 500 times magnification. Critical identification was carried out under 1400 times magnification. Discrimination within Cerealia was made according to Beug (1961) and Andersen & Bertelsen (1972). Within coryloid pollen grains the discrimination was easily done

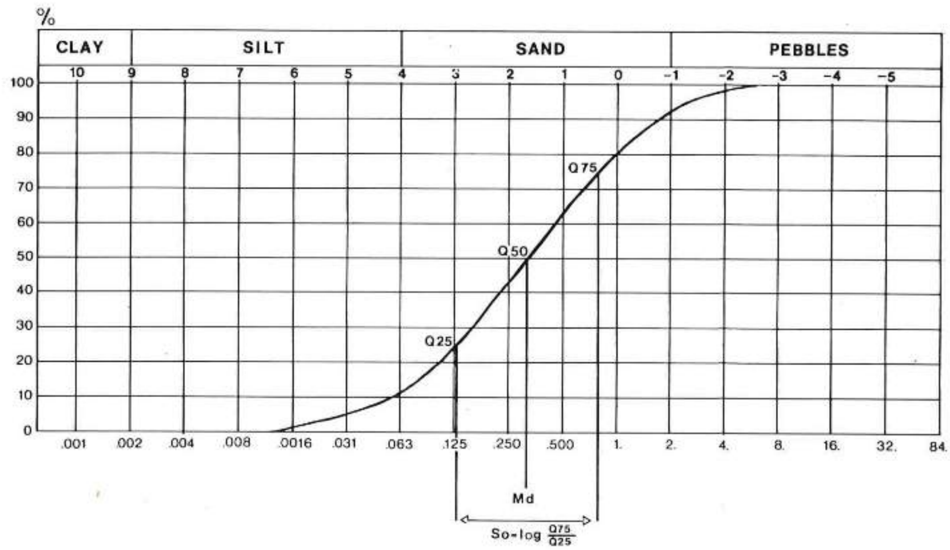


Fig 4 Principle of grain size distribution analysis based on cumulative percentage diagram. Median value, Md, is the grain size corresponding to Q 50, ie where the curve passes 50%. Sorting (So) is defined by:

$$So = \log \frac{Q25}{Q75}$$

$$So = \log Q75 - \log Q25$$

which can be read directly from the graph in phase contrast based upon both aperture morphology and sculpturing. During pollen analysis human parasite ova were determined with the aid of Pietkarski (1962) and Soulsby (1965, 1968).

The radiocarbon sample 1 (fig 13 and table 1) is based on 6.8 g hazelnut shells (Corylus avellana). The shells were washed in KOH and rinsed in water. Thereafter the sample was boiled in 1 l distilled water and the process repeated 10 times until no more humic acid could be extracted.

Eight radiocarbon dates have also been obtained from organic layers samples 2–5. Samples were treated with 10% hot diluted NaOH after HCl treatment to remove carbonates. The NaOH soluble fraction was then precipitated in HCl and dried before combustion. These fraction datings can be treated as individual dates. Material for radiocarbon dating was stored in a cool dark place until it was processed by the Radiological Dating Laboratory in Trondheim. The δ ^{14}C was measured in a gas proportional counter and the results are presented in table 1. All dates are corrected for the actual content of δ ^{13}C measured by mass spectrographic analysis. Standard MASCA correction is applied to the dates, as no local correction curve exists for North Europe.

Recently Stuiver (1982) published a high precision calibration curve of the AD radiocarbon time scale. Using this calibration curve slight differences are obtained and these are also presented in table 1. The standard deviation of the Stuiver calibration is obtained by the formula

$$\sigma_c = \sqrt{\sigma_0^2 + \sigma_1^2}$$

where σ_0 is the standard deviation in measured radiocarbon age and σ_1 is the standard deviation of the curve at that time (Krzywinski & Gulliksen 1984).

The alternative method of graphic calibration obtained by plotting the date on Stuiver's curve is presented in figs 17, 18 and 21. The curve is based on 10 years' dendrochronological samples (Stuiver op cit). The measured ^{14}C age of each dendro sample is used as a measure of remnant ^{14}C activity. In the present paper only the part of the curve from AD 500–1500 is used. Graphic calibration is obtained by plotting the actual ^{14}C dates (^{14}C years BP) of each radiocarbon sample on the ordinate together with its standard deviation. On the abscissa, the period with remnant ^{14}C activity equal to the date can be read. The probable period is not necessarily symmetric around the mean value.

RESULTS

The field work revealed that the minerogenic «sterile deposits» underlying the occupation layers of the 12th century town resembled a delta-configuration, with a horizontal minerogenic top-set layer covering a lower series of dipping fore-set layers (fig 3). The caisson 41 represented an important change in sediment-composition. To the west the sediments dipped more steeply and had a higher content of organic matter including charcoal and wood chips. The caisson 41 was part of the foundation of the pier dated by fire-chronology to AD 1178. The organic fore-set layers west of the caisson 41 therefore represent occupation material filled into the Vågen bay contemporaneous with or later than the use of the 1178 pier. The organic and minerogenic fore-set layers underlying and east of the caisson 41 represent layers that were interpreted as older than AD 1178. Most of these eastern layers were purely minerogenic but with some highly organic layers in between. These older organic layers also had a certain content of charcoal and wood-chips. If the field interpretation of the sedimentation process and the chronology were correct, the wood chips and the charcoal would indicate an earlier human activity in the Bryggen area than hitherto found by the archaeological excavations. To test this field interpretation a laboratory study of the minerogenic and organic sediments has been done. A test of the chronology has been performed by ^{14}C-dating of the organic sediments. Based on the field observations the stratigraphic section is divided into 9 main units (fig 5). Each unit consists of one or several independent layers, characterized by composition and position in the profile. In the middle and eastern part of the section there is a top layer of sand and gravel with horizontal layering and lamination (unit 9). This unit underlies the wooden construction of caisson 41.

In the western part of the section (0–4 m) the two wood-chip refuse layers (units 8 and 7) underneath the disturbed top layers are separated by a sand layer with some gravel. Underneath these lies the fore-set series of minerogenic layers dipping to the west (units 6 and 4), alternately coarse and fine grained with a layered and laminated structure. The general composition varies from gravel and sand to sand and fine sand, partly in the form of graded bedding. In the upper part of unit 6 silt is also present.

The two distinct organic and fine grained units (5 and 3) also dip westwards. Unit 5 fades out before it reaches the overlying top-set layer, while its western, lower part dips beneath the bottom of the profile.

The lower organic layer (unit 3), however, is truncated by the top-set layer and its organic part has a lower content of humic acids than unit 5. Its western limitation fades out in the middle of the profile.

The dipping fore-set layers in the units 3–7 rest on a more homogeneous sand and gravel (unit 2). In the eastern part of the section, 20–30 m, a glacigenic unit (1) is documented. This element is complex with a distal western limitation dipping westward and a glaciotectonically disturbed central part. East of this the layers dip eastwards. The minerogenic deposit (unit 1) contains no organic components.

The Minerogenic Units

The two samples from the glacial disturbed zone (unit 1), samples 20 and 13 in figs 7 and 8, were taken at +40 cm above present sea-level at 27 and 29 m in the section. Sample 20 has a median value (Md) of 2.8 and sorting (So) is 1.9. Sample 13 (Md = 4.18, So = 1.23) is coarser. Plotted in the Md/So diagram, fig 12, both fall into the range of transported glaciofluvial material. According to Holtedahl (1971) both samples are classified as gravelly sand. The stone sample R1 had most stones in classes K and KR indicating short transport and reworking (fig 11).

Related to this (fig 7) are the samples 6, 5 at 16 m (unit 2) and sample 7 at 10 m in the profile (unit 4). Their grain size ranges from pebbles to silt. Sample 6 (Md = 1.53, So = 1.66) is classified as pellitic sandy gravel. In fig 12 it falls within the range of moraine gravel. Its stratigraphical position suggests a more heterogeneous deposition mechanism, cf below. Sample 5 (Md = 0.55, So = 0.93) was taken above this at 16 m and is also ranging from silt to 8 mm

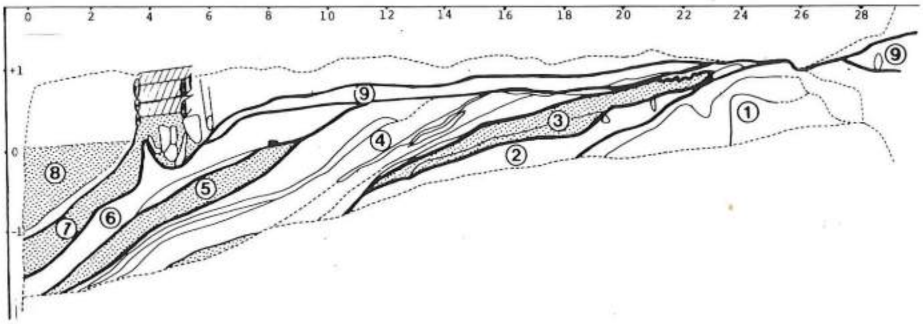


Fig 5 Main stratigraphic units defined. Each unit may consist of several layers and is defined by its composition (minerogenic or organic) and its position in the section

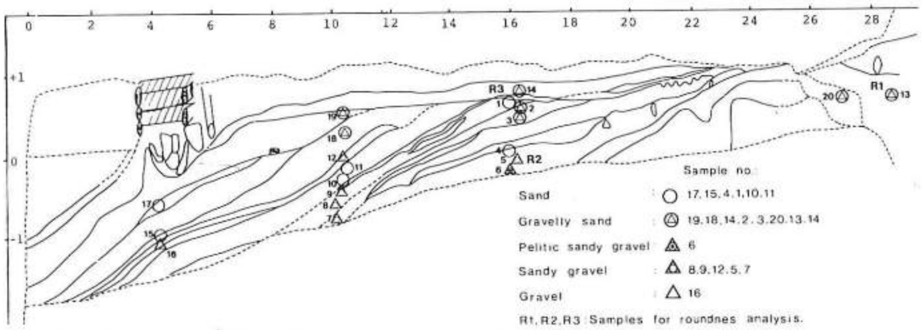


Fig 6 Sampling grid of the minerogenic units. The samples for roundness analysis are marked R1, R2 and R3. The numbers refer to samples for grain size analysis. Classification is in accordance with Holtedahl (1971)

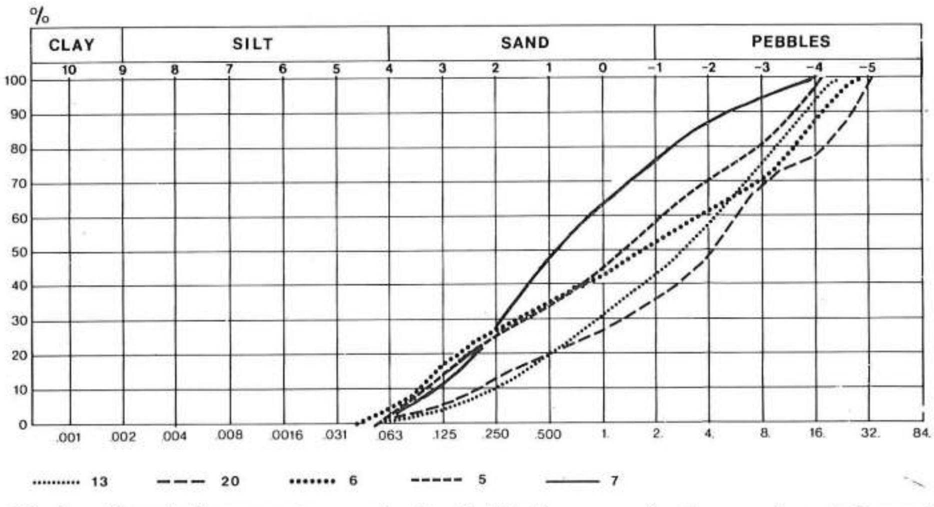


Fig 7 Cumulative percentage grain size distribution curve for the poorly sorted samples 13, 20, 6, 5 and 7

pebbles. This sample is classified as sandy gravel and its genesis is probably the same as sample 6 below.

Sample 7 (Md = 0.55, So = 0.93) at the base of 10 in the profile is somewhat finer grained, but generally related to the other samples on fig 7. It was sampled at the diffuse transition between unit 2 and 4 at 10 m in the profile. Sample 4, (Md = 0.41, So = 0.97) immediately above sample 5 at the transition to unit 3, has approximately the same grain size range, but is not so evenly distributed as the other samples 5 and 6. The sample is related to transported moraine material, classified as sand.

Unit 2 is most probably glacigene material reworked by the regressing sea or short range transport by a stream or small river. This interpretation is supported by the better rounding of stones in sample R2 (fig 11).

The grain size distribution in unit 4 (fig 8) differs slightly from unit 2. Sample 3 (Md = 0.4, So = 0.94) just above the organic layer is a bimodal mostly sand sediment composed of fine sand with some pebbles larger than 8 mm. It is classified as sand and can be interpreted as a beach deposit. Sample 2 (Md 1.9, So 1.2) is ranging from silt to 16 mm pebbles. It is classified as gravelly sand and its grain size is related to sample 5, unit 2. Sample 1 above this is well-sorted sand with Md 1.4 and So 0.6.

A series of 7 samples is taken at 10 m in the profile (figs 9, 10). All the analysed samples are from unit 4. Sample 7 is treated above. Sample 8 (Md = 1.66, So = 0.66) is unimodal sorted gravelly sand, within the beach deposit range of fig 12. Sample 9 (Md = 3.14, So = 0.79) is well-sorted gravel. It is classified within the range of river sorted material. Sample 10 is well-sorted sand (Md = 1.06 and So = 0.58) and is almost identical with sample 11 (Md = 1.27 and So = 0.55). Both samples are classified as sand and are within the beach deposit range in fig 12. Sample 12 is bimodal with Md 0.46 and, due to the bimodality, the sorting is as high as 1.3. Therefore the sample is diverging from its neighbouring samples plotted in fig 12. Sample 18 is gravelly sand well sorted within the range of typical beach deposit (Md = 1.79, So = 0.49) and almost

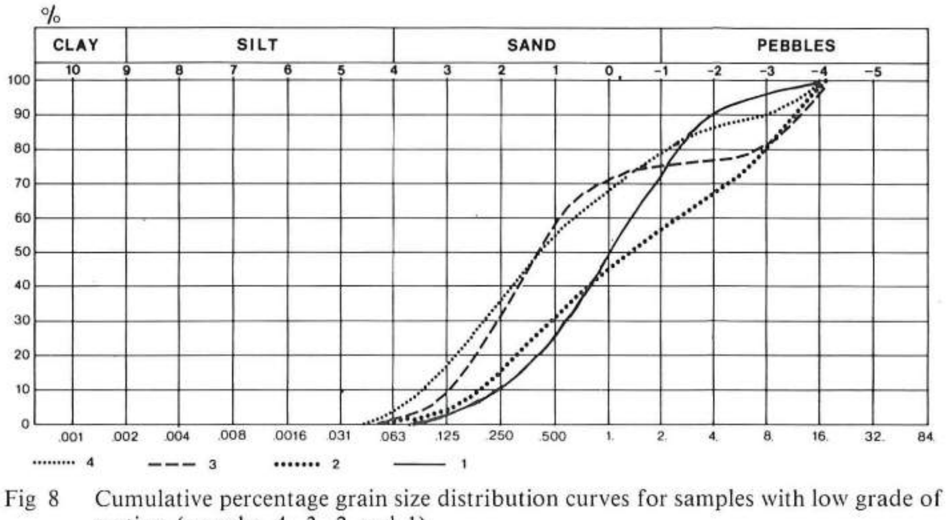


Fig 8 Cumulative percentage grain size distribution curves for samples with low grade of sorting (samples 4, 3, 2 and 1)

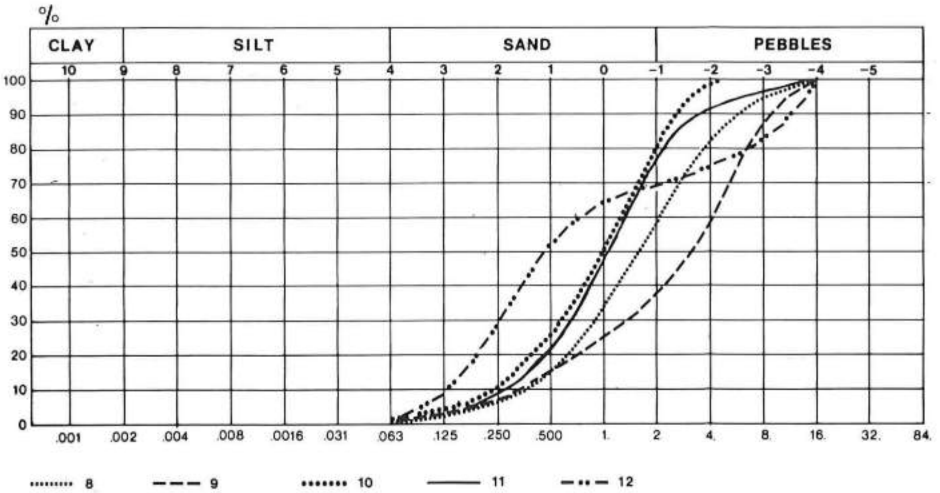


Fig 9 Cumulative percentage grain size distribution curves for the well-sorted and limited bimodal samples 8, 9, 10, 11 and 12

identical with sample 19 (Md = 1.59, So = 0.52). The samples from the unit 4 at 10 m are all indicating a beach deposit genesis for this structure apart from samples 7 and 9.

At 4 m, below the caisson, 3 samples have been analysed, 2 in unit 4 and 1 in unit 6. Sample 16 below the organic layer is a bimodal gravel (Md = 4.75, So = 0.47). It is composed of about 25 per cent sand with different grain sizes and 75 per cent well sorted gravel from 4 to 8 mm in diameter. Sample 15, a typical beach deposit, cf fig 12, is well-sorted sand (Md = 0.60, So = 0.71) and sample 17 is well-sorted gravelly sand (Md = 0.86, So = 0.60). Also this is a typical beach deposit according to fig 12. The stone sample R3 (fig 11) with fairly well-rounded stones, supports this view.

The samples from unit 4 are all typical, well-sorted and partly bimodal beach deposits with the exceptions mentioned above. The top-set layer unit 9 was sampled at 16 m (sample 14). It consists of coarse sand and gravel and is classified as gravelly sand (Md = 1.6, So = 0.4). According to fig 12 it is also a typical beach deposit. To summarize, the samples in unit 6 are similar to most of the samples in unit 4 and clearly point towards a beach genesis. The sample from unit 2 forms a transition to the glacial genesis of unit 1.

The Organic Unit 3

Unit 3 is 20 to 30 cm thick and contains an appreciable quantity of organic matter. The colour is brown to greyish-brown. In the western part it disappears in the diffuse transition between units 4 and 2. The organic content is high in the lower 10 cm and decreases slowly upwards. The deposit is finely laminated or stratified (Stratificatio 1–2) which is clearly seen when drying. The organic component is mainly fine grained (Limus detriosus). Only a small portion is soluble in NaOH (Limus humosus). Larger particles are almost absent, but some charcoal fragments

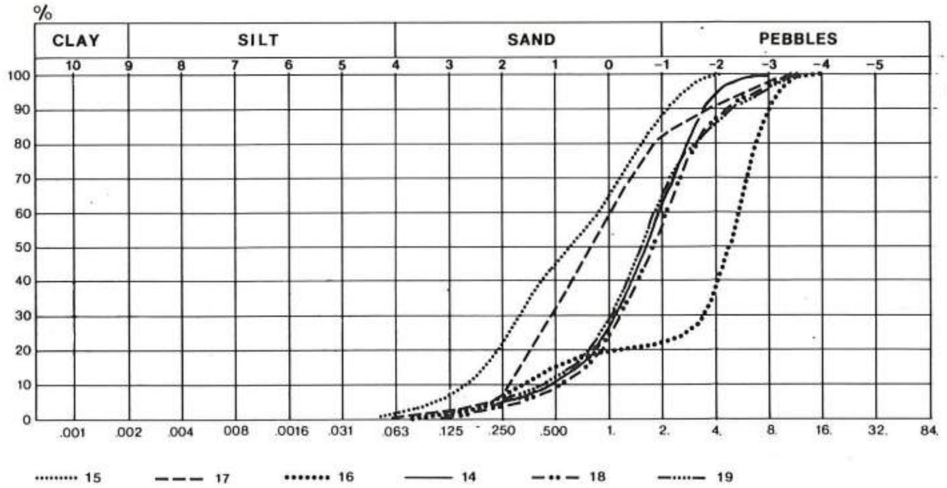


Fig 10 Cumulative percentage grain size distribution curves for the very well-sorted and partly bimodal samples 15, 17, 16, 14, 18 and 19

were detected by visual inspection. During microscopic analysis, however, charcoal dust appeared in large quantities. The minerogenic component is nearly all sand in the size range 0.25–1 mm, but silt below 0.063 mm is also present.

During the cleaning of the section in the field, a piece of pine wood was found at +75 cm in the eastern part at 22 m where the unit is truncated by the minerogenic upper layer. The wood was about 10 cm in diameter and had been cut by an axe at one end and was broken at the other. The wood was badly attacked by pile-worm (*Teredo navalis*). From its stratigraphic position it was difficult to exclude the possibility that the wood had been pressed down through later human work at the shore, but no evidence of such could be found in the layer above. It is unlikely that such a badly destroyed piece of wood should be used (if it would have resisted such treatment at all). The pile had to be driven through 30 cm of coarse minerogenic deposits. It is unlikely that the pile-worm had eaten the wood so far down below the sediment surface. It is therefore most probable that it belongs to the layer in which it was found and is contemporary with activities on the shore at a time when the sea-level was approximately 1 m higher.

Characteristic for the pollen diagram of unit 3 (fig 13, pl 1) are small changes through the period of sedimentation. On the basis of a slight but distinct change from pollen-spectrum 13 to 12, the diagram has been divided into two pollen zones.

The pollen zone 1 is characterized by high values of *Pinus* (pine). The *Betula* (birch) pollen frequencies are low, but increasing. *Plantago lanceolata* (ribwort plantain) is the only cultural indicator. The content of charcoal dust is low. At the transition to pollen zone 2 *Pinus* decreases and is replaced by other trees like *Betula* and *Alnus* (alder). Pollen from trees is still the most important constituent throughout the zone. The total tree pollen curve amounts to 80–90% of the pollen sum. *Pinus* is the main type, varying between 25% and 50%. The high pine values may partly be due to the well-known over-representation of *Pinus* in marine deposits (Fægri 1944). *Betula* has moderate values, while tree species like *Corylus* (hazel), *Fraxinus* (ash), *Ulmus* (elm) and *Tilia* (lime), which prefer rich soil, are infrequent. The pollen diagram therefore indicates dominance of a mixed pine and birch forest on acid soil. This type of forest has been common in coast districts of Hordaland county during the last 4000 years (Fægri 1944, 1954, Mamakowa 1968, Hagebø 1967, Bakka & Kaland 1971, Kaland 1974, 1979, Eide & Paus 1982). The high frequencies of alder pollen may be due to local over-representation of *Alnus glutinosa* along the shore close to the site. In the diagram there is clear evidence of agriculture and pastoralism. Pollen of cereals, *Hordeum* (barley) type, is found together with pollen of light demanding herbs characteristic for beach or field weed communities (*Urtica, Rumex longifolius* type, *Artemisia, Chenopodiaceae, Cerastium* type, *Spergula arvensis*). *Centaurea cyanus*, however, is an exclusive cereal field indicator. Pasture is also indicated by pollen of *Plantago lanceolata, Plantago major, Rumex acetosa* type and *Asteraceae sect. Aster*. High frequencies of charcoal dust throughout the zone is also a strong indication of human activity in the area. The occurrence of *Filipendula* indicates the presence of a rich moist soil close to the shore.

Dinophyceae cysts occur in all analysed samples through the organic sediment of unit 3, indicating sedimentation in a marine environment. In the middle and top part of the diagram high values of *Operculodinium centrocarpum* and increasing frequencies of *Lingulodinium machaerophorum* may indicate a change in salinity. Cysts of these species and some pollen of *Ruppia* make it probable that the salinity at the sampling spot has been somewhat lower than 30‰. On the other hand very low frequencies or absence of *Chlorophyceae* such as *Pediastrum*, *Scenedesmus* and *Botryococcus*, indicate a somewhat higher salinity than 5–10‰. In two spectra a few shells of the foraminifer *Discorbina* have been found. High frequencies of

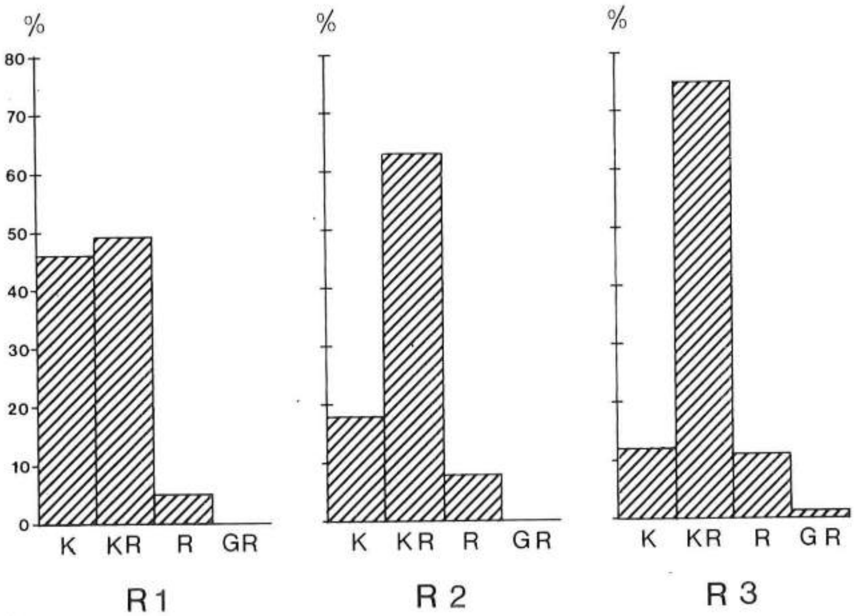


Fig 11 Degrees of roundness of visually analysed stones shown as a percentage within each sample (cf text p 5). The roundness increases from R1 to R3

this foraminifer indicate deeper water than approx. 1 m. The few shells found may have been washed in, and a shallower depth of water is therefore probable. Below this (sample 12-14), salinity conditions are less clear. A peak in *Spiniferites* is found in sample 12, and in the lowermost sample *Discorbina* is found. Unit 3 (figs 5 and 13) has been radiocarbon dated from fractioned gytja (detritus mud) samples (table 1, dates 4 and 5). Sample 4 originates from the top part and sample 5 from the bottom part. For sample 4, the humic acid fraction T-3784A produced the radiocarbon date 2400 ± 80 BP (Masca: 590 ± 160 BC) and the insoluble fraction T-3784B produced the date 2310 ± 80 (Masca: 520 ± 120 BC). Sample 5 (fig 13) dates the bottom part. The humic acid fraction T-4180A produced the radiocarbon date 2550 ± 70 BP (Masca: 775 ± 65 BC) while the insoluble fraction T-4180B gave the date 2810 ± 80 BP (Masca: 1045 ± 125 BC). δ ^{13}C values for all the dates are between -18.1 to -19.6‰ PDB. From the ^{14}C dates alone a short deposition period is suggested . Based on the soluble fraction, the deposition period can be approximately 100 years, while based on the insoluble fraction a deposition period of 500 years is possible. If redeposited soil from terrestrial deposits is incorporated, none of these dates can be regarded as absolutely correct. The dates can, however, be considered as maximum dates for the unit.

Organic Unit 5

Unit 5 is a greasy organic layer of greenish-brown colour. Its content of humic acids (Limus humosus), in relation to insoluble fraction, is 15-30%. Fine sand and silt is present all through the deposit, and wood-chips, bark, twigs, moss fragments and hazelnut shells (fig 15) are found in small amounts. The pine-chips (fig 14) were produced by working on logs with an axe. The mosses are very decomposed and mostly present in the form of leaf fragments. Some larger moss fragments of *Hylocomnium splendens, Rytidiadelphus loreus, Pleurozium schreberi* and *Spagnum papilosum* have been found. The layer fades out eastward and a piece of square-cut pine timber was found at the upper limit at 8 m in the section, 10 cm below present sea-level. The piece was recorded when the section was drawn but unfortunately not collected during rescue fieldwork. Sea urchin spines were found at 5 cm below the transition to unit 4 as a distinct thin layer at 6–8 m in the section.

The pollen spectra (plate 1, fig 13) show no change through the layer. The diagram is therefore treated as one single pollen zone. The total diagram is dominated by tree pollen (55–65%) and herbs (30–40%). *Alnus* (alder) is the dominating taxon exceeding 30% of the pollen sum, while *Betula* (birch) only has a frequency around 10%. The other tree species are less frequent. *Myrica gale* (sweet-gale) is the most important shrub with pollen percentages varying between 1 and 9%. The herb pollen is dominated by *Poaceae* (20–30%) and *Cyperaceae* (around 5%). There is a high number of weeds, cultivated plants and herbs typical for pasture. There are very high frequencies of charcoal dust particles.

Although the organic layer is deposited in a marine environment, the material is mainly of terrestrial origin. This is evident from the macrofossil content (twigs, mosses and wood-chips) and the δ ^{13}C-values of the ^{14}C-samples (-19.9, -23.5, -26.2 and -27.9‰ PDB). The phytoplankton content in the pollen samples is extremely low. Only scattered finds of *Spinifirites* type, *Operculodinium centro-*

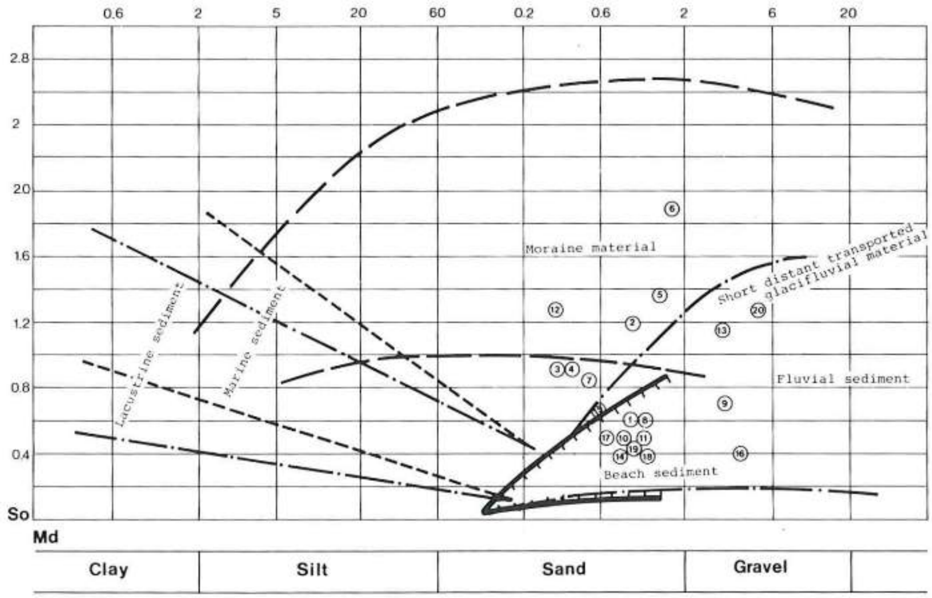


Fig 12 Md/So diagram. The samples from the minerogenic units are plotted. Lines refer to normal Md/So distribution of Norwegian minerogenic sediments according to Selmer Olsen (1954)

carpum and *Lingulodinium macarophorum* indicate the marine environment together with *Ruppia* pollen. The deposition of the organic layer is most likely neither the result of a single event (eg a slide) nor due to action over a very long period of time.

In two pollen samples parasite ova of *Trichuris trichiura* (whip worm) have been found (fig 16). The ova are about 50 micron long with two plug-like poles. The larvae inside the ova could clearly be seen. The size is characteristic for *T. trichiura* and can hardly be confused with other species of *Trichuris* (Pietkarski 1962, Saulsby 1965, 1968). The finds of these parasite ova in the sediment prove that some of the sediment of unit 5 originates from human faeces.

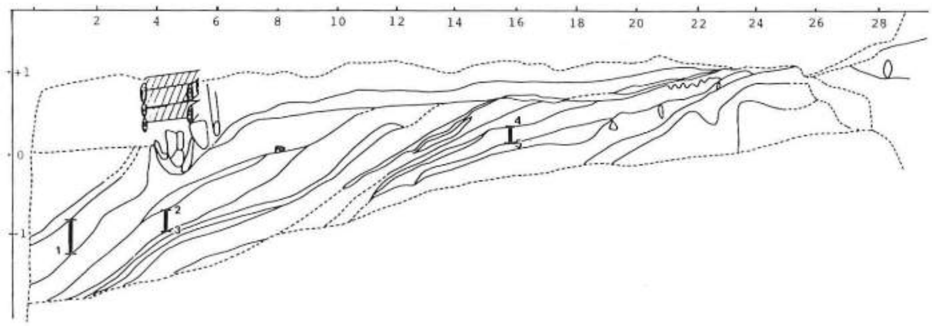


Fig 13 Sampling spots of the organic units. Pollen profiles indicated by vertical lines, numbers refer to numbers of radiocarbon samples

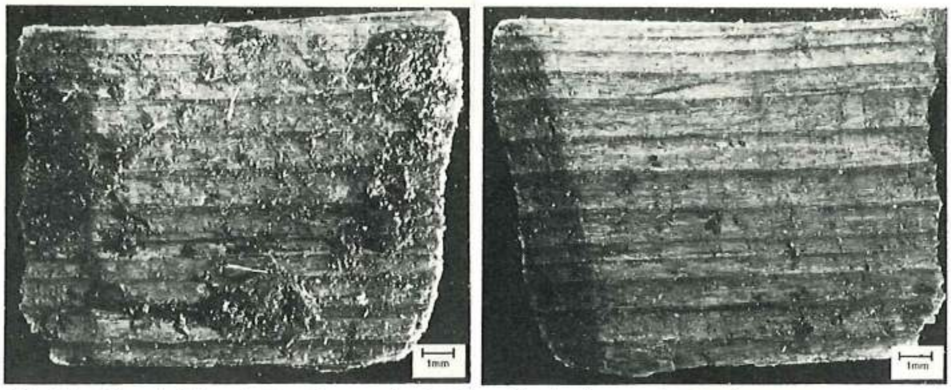


Fig 14 Wood-chip of pine from unit 5. The chip is the result of axing across the wood fibres

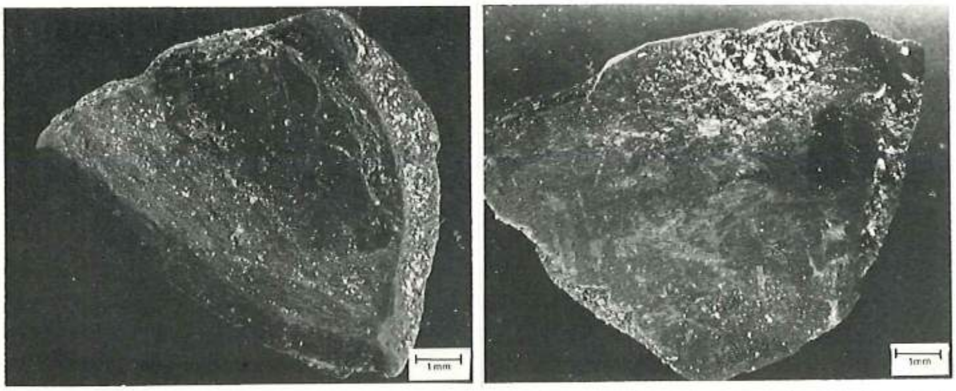


Fig 15 Hazelnut shell fragment from unit 5. The fragment is about 1/8 of the shell and is partly carbonized on the convex side

Unit 5 has been dated by fraction dates of sample 2 (top) and sample 3 (bottom part) (table 1, fig 13). The humic acid fraction of sample 2, T-3785A, produced a ^{14}C-date of 1320 ± 70 BP T-3785B, the particulate matter (NaOH insoluble fraction) of the same sample, produced an age of 1380 ± 70 years BP. The stable isotope $\delta\ ^{13}C$ is -26.2 and -27.9‰. The Masca correction suggests a deposition of this gytja layer to AD 650 ± 80 and AD 605 ± 65 respectively. Calibration according to Stuiver (1982) gives AD 680 ± 80 and AD 650 ± 80.

Sample 3, humic acid fraction (T-4179A), produced the date 1250 ± 70 ^{14}C years BP ($\delta\ ^{13}C = -19.9$‰ PDB.) Masca calibration is AD 730 ± 90. Calibration according to Stuiver (1982) gives AD 730 ± 80. The insoluble fraction (T-4179B) produced 1410 ± 80 years BP with $\delta\ ^{13}C$ content of -23.5‰ PDB. Masca calibrated age is AD 570 ± 80, and the Stuiver calibration gives AD 640 ± 80.

As demonstrated on fig 17, the ^{14}C content of T-3785A is representative of the period AD 650–780, while T-3785B can represent AD 600–680. Likewise, on fig 18, the dates T-4179A and T-4179B are plotted. T-4179A can represent the activity during the period AD 680–880, while T-4179B represents the period

AD 550–680. It is likely that the deposition of this layer, at this spot, is sometime after AD 600 but most possibly before AD 800. There is no significant discrepancy between the dates treated individually. Based on both fractions of the two samples, the dates suggest a short deposition period as the top and bottom of the layer produced approximately the same dates with overlapping standard deviations. The soluble fractions of the date suggest a deposition period of maximum 200 years. It can be concluded from the ^{14}C dates alone that the layer was deposited over a short time.

Organic Unit 7

The composition of the deposit with dominance of wood-chips, hazelnuts and mosses clearly indicates that it is of terrestrial and anthropogeneous origin. The deposit by composition corresponds to the dumpings in Vågen described by Herteig (1969) and Krzywinski et al (1983). The mosses (used for hygienic purpose) (Krzywinski 1979) and eggs of *Trichuris trichiura* show that faecal remains are part of the sediment.

The pollen spectra in this diagram are contained in one pollen zone only as there are no significant changes in the pollen curves. The percentages of tree and herb pollen curves in the total diagram are of equal magnitude. The herb part characterizes the diagram with an extraordinarily high diversity of taxa among which cultivated plants and weeds are of great importance. Some of these such as broad bean (*Vicia faba*) and cornflower (*Centaurea cyanus*) (fig 19) are found in considerably higher quantities than in pollen diagrams from arable fields in

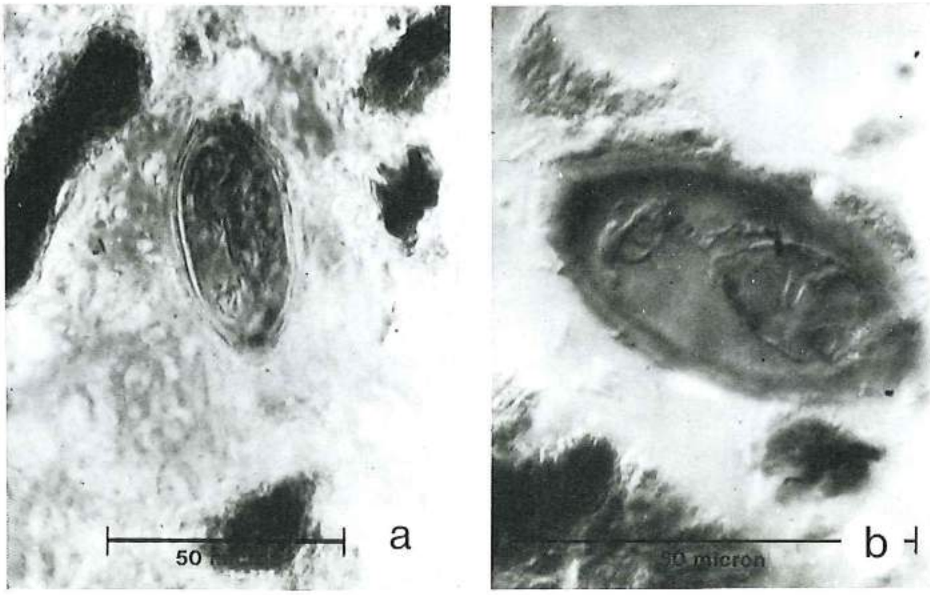


Fig 16 *Trichuris trichiura* eggs from unit 5, sample 7. A. Phase contrast microphotograph of cross section exposes cross-shaped holes. B. Differential interference contrast with deep focus, exposing the larvae inside the egg

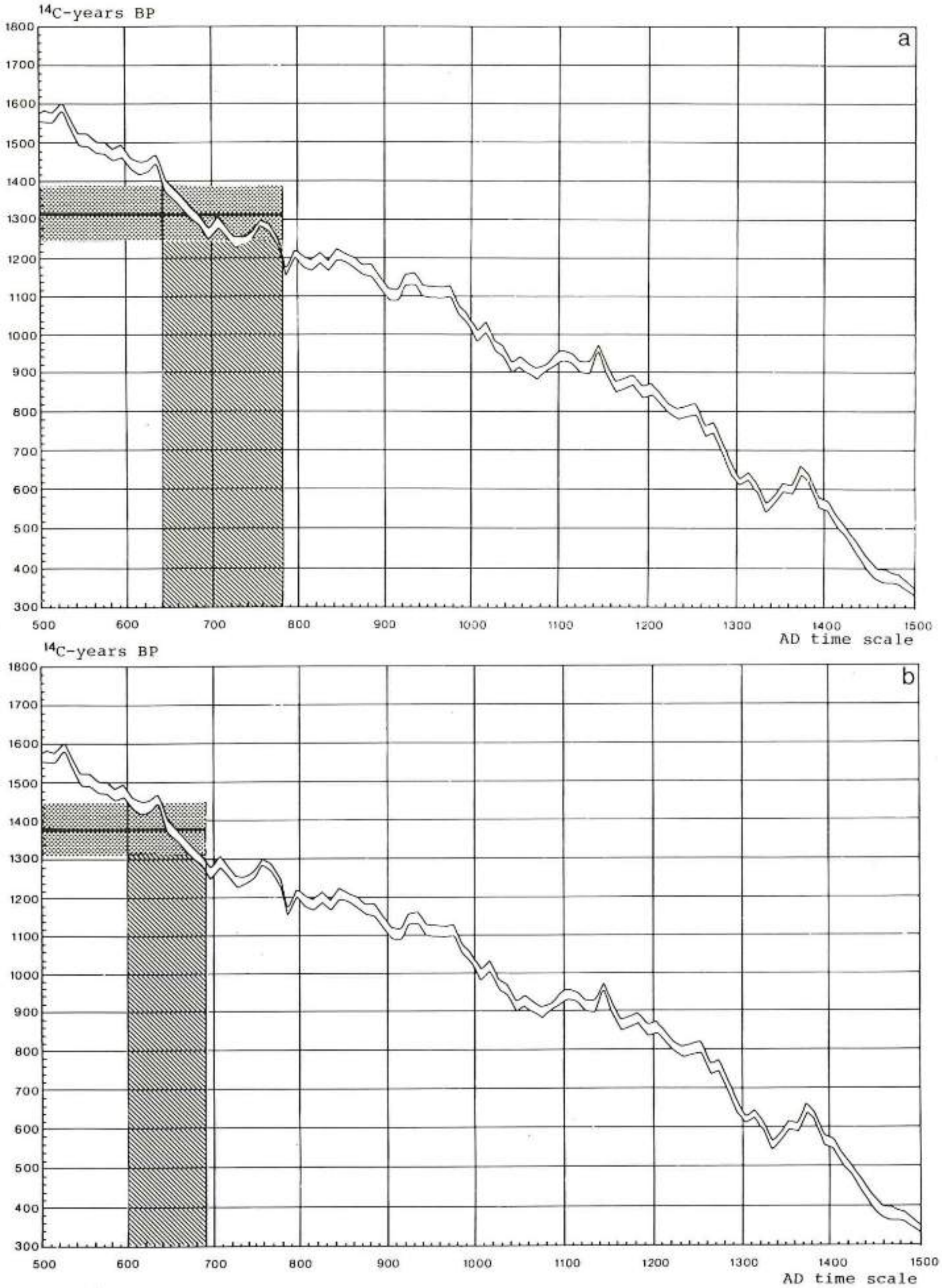


Fig 17 Comparison of remnant radiocarbon activity in sample 2 with the high precision calibration of the AD time scale by Stuiver (1982). The calculated ^{14}C age is plotted with one standard deviation and the period with similar remnant activity is read on the abscissa. A. is the ^{14}C sample T-3785A, B. is the ^{14}C sample T-3785B. The results overlap in the period 620 to 690 AD

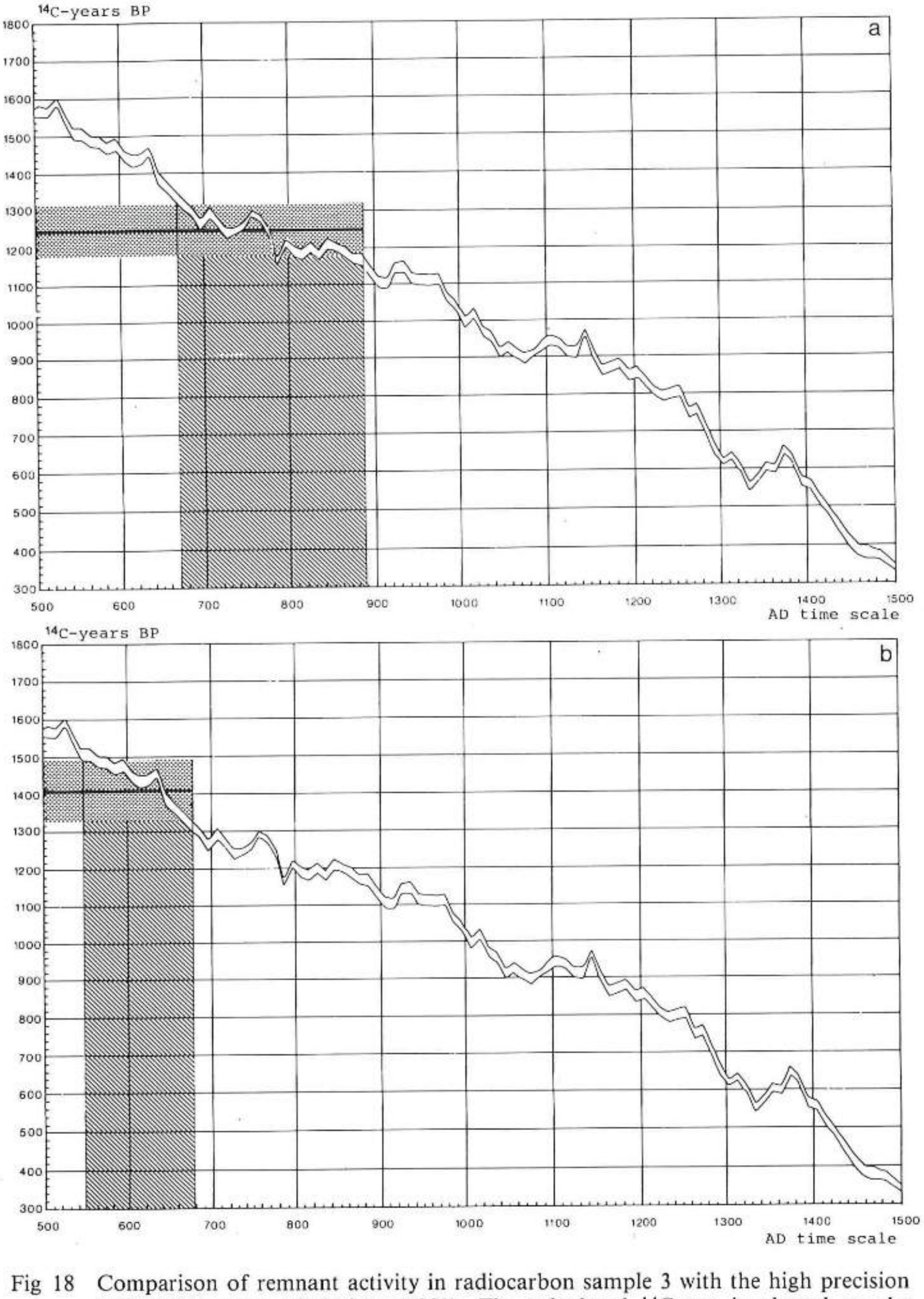


Fig 18 Comparison of remnant activity in radiocarbon sample 3 with the high precision calibration curve of Stuiver (1982). The calculated ^{14}C age is plotted on the ordinate. The period which can be responsible for this activity is read on the abscissa. A. is the T-4179A, B. is T-4179B

Western Norway (Berge 1978, Kvamme 1982). Pollen of barley (*Hordeum* type), rye (*Secale* type), oat (*Avena* type) and wheat (*Triticum* type) have been recorded. Of special importance is the find of *Helianthemum* pollen, cf fig 20. Pollen of taxa within *Fabaceae* (excl *Vicia faba*) are frequent through the deposit together with *Brassicaceae* pollen. Within the tree pollen alder (*Alnus*) is dominant (20–30%), birch (*Betula*) varies around 10% with pine (*Pinus*) mostly at 2%. The other tree species also have low frequencies. Pollen of *Myrica* has been found with 1–5% representation. The presence of small and scattered phytoplankton frequencies points towards a quick accumulation in a marine environment below present mean sea-level.

One radiocarbon date based on hazelnut shells has been obtained (T-3786), giving an age determination of 970 ± 40 BP. The stable isotope ^{13}C content is –24.0‰ PDB. Based on the standard Masca correction curve, the mean deposition of these nuts is set to AD 1005 ± 45. This is in agreement with the stratigraphic position. The refuse layer (7) underlies the wooden caisson which is dated to 1178 or possibly 1198 according to the established fire chronology of the site. The Stuiver (1982) calibration is AD 1030 ± 50 but according to the graph (fig 21) a longer period is indicated as a possible deposition period. Due to the atmospheric ^{14}C content at about AD 1120 the remnant activity in the samples can represent both the period 1000–1070 and 1090–1150 AD.

INTERPRETATION OF THE STRATIGRAPHIC RECORD

The subject of investigation is interpreted as a beach underlying the occupation deposits of the town. The section exposes a layered structure of which the stratigraphic base (unit 1) is glaciotectonically disturbed. The structures in this unit suggest a west or northwest direction of the iceflow. Grain size and roundness analysis indicate glaciofluvial genesis of this layer. This unit must have been deposited by the retreating glacier approximately 10000 ^{14}C years BP. At this time the sea-level was about 58 m above present sea-level (Undås 1945, Hagebø 1967). The deposit is therefore of glaciomarine or subglacial origin.

Above this glacial unit the deposit has a deltaic structure. The beach is built up as a delta with sublittoral deposition of coarse minerogeneous material, and with two organic fine grained layers incorporated. The underlying fore-set layers are dipping westwards with increasing angles and have been eroded by the regressing sea, while to the east the top of the fore-set series has been truncated by the top-set layer.

The transition (unit 2) between the delta and the glacial unit is diffuse. The lower part of unit 2 is coarser and less well sorted than the top of the unit. This can be due to Holocene reworking of the basal glacial deposit. Wave action on the lower part has changed its grain size distribution. The upper part, however, is related to the beach and delta development. The earlier lower organic deposit (unit 3) is truncated by the later upper top-set layer (9) during sea regression. Judging from its high content of marine phytoplankton the layer is marine. On the other hand, its pollen and fungal hyphae content suggests that a part of it is redeposited terrestrial soil. The high phytoplankton content is not compatible with deposition from a single earth slide. The lamination of the layer and the general trend of the pollen curves, together with differences of the ^{14}C-dates, suggest that the deposition took place during a period of some time. The deposit contains pollen of cultivated

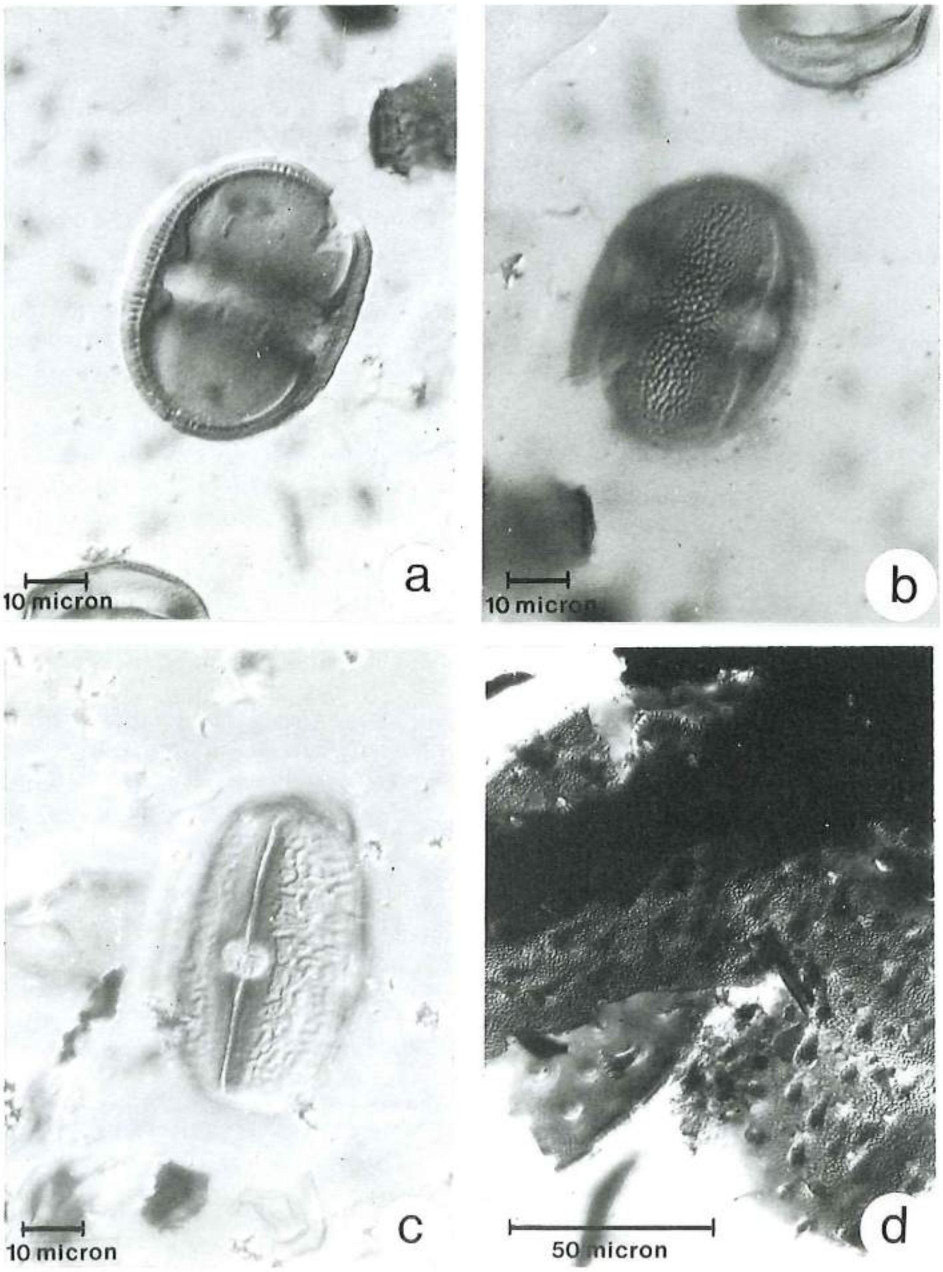


Fig 19 Microphotographs of pollen from unit 7 a and b *Centaurea cyanus*. A. Optical section showing costa equatorialis. B. High focus on tectum showing the sculpture. C. High focus of *Vicia faba*. D. Detail of *Malva* pollen (Differential interference contrast)

plants, which indicates redeposition of soil from agricultural activities in the drainage area of a stream.

Unit 3 is the basal layer of the delta formation in this investigated section. The minerogenic fore-set layers of unit 4 can all be classified as typical beach and delta deposits. They are partly bimodal and all well sorted. They are stratified, laminated and dipping westward at an increasing angle. The eastern and lower layers within the unit are truncated and the degree of truncation is decreasing westwards, due to the isostatic uplift in the late Holocene. The low organic content and the general coarse grain size indicate that the «fore-set» layers are secondarily sorted and redeposited glacial deposits. Erosion and redeposition might be due to the regressing sea, but it might also be erosion in terrestrial deposits by the stream. The increasing dip of the layering indicates that deposition and extension outwards of the delta has been into gradually increasing depth. In this way an underwater shelf has developed.

In contrast to the minerogenic layers, the unit 5 is far more fine-grained and heterogeneous. Its genesis and cultural significance are discussed below. The fine grained and organic component of this layer indicates a sheltered position on the beach or a massive deposition of organic and fine grained material at too fast a rate for reworking and washing by wave action.

Unit 6 is an analogous deposition to unit 4. A part of this unit is later disturbed by the wooden construction. The top-set layer can be related to unit 6, probably finally deposited at the same time. This means that the layers west and above unit 6 are deposited owing to human activities and no longer as a result of river-induced delta formation.

The units 7 and 8 are separated by a sand layer. They are both composed of wood-chips, hazelnuts and mosses and other human waste and refuse material. The parallel and horizontal arrangement of the larger particles, such as wood-chips, indicates deposition over a period of time. The wood-chips layer (unit 7) is in composition and structure identical to the later refuse layers in the bay. They are found below present sea-level and are the results of a conscious or unconscious but definite continuously dumping of organic waste in the bay. These layers are so well preserved that almost no decomposition can have occurred. The effective conservation of the organic material on the sea bottom is either a result of quick accumulation in an anaerobic environment, or an oxygen deficiency in the bottom water, perhaps both. Oxygen deficiency will occur when the quantity of nutrient input reaches a certain level. The dumping of organic waste may have exceeded this level.

The interpretation of the pollen content of such pure anthropogeneous deposits cannot be based on the same deposition models as used in natural deposits. In natural lake and bog sediments pollen is deposited on the surface and later incorporated in the sediment during accumulation. The pollen deposition is more or less even (Fægri and Iversen 1975, Tauber 1965, Krzywinski 1977, Birks & Birks 1980). Pollen from anemophilous plants has a fair chance of being quantatively represented and conclusions about vegetation composition can be drawn from natural deposits. In anthropogeneous deposits a large portion of the pollen is deposited adhering to other plant material, incorporated in animal or human faeces etc. and only a small portion is deposited by direct deposition on the sediment surface (Krzywinski et al 1983).

The quantity of marine phytoplankton in the unit 7 indicates that direct wind

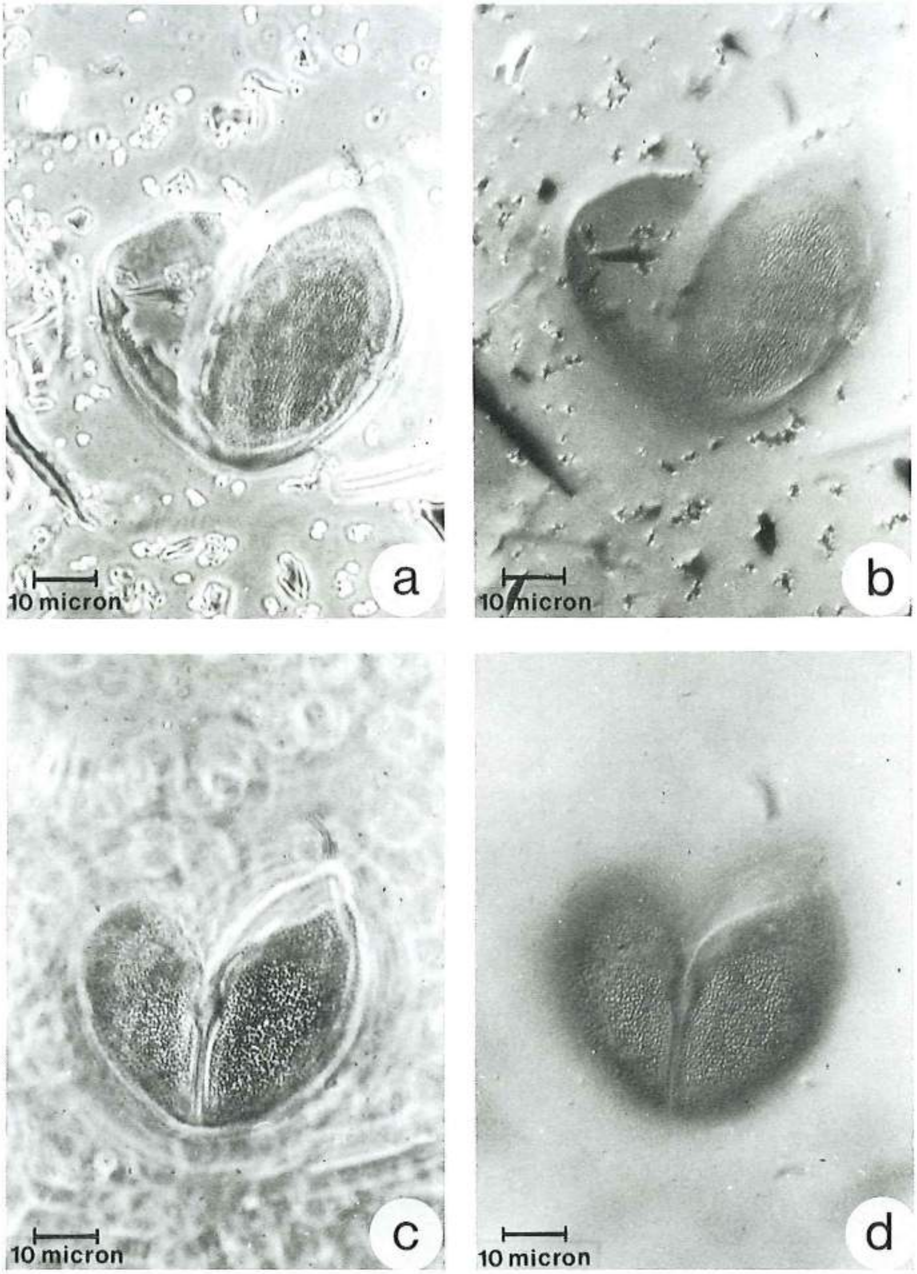


Fig 20 Microphotograph of *Helianthemum* pollen from unit 7 a and b. High focus of striaetum of the tectum and tiny perforations. c and d Lower focus exposing columella and the pore. (a and c phase contrast, b and d differential interference contrast)

deposition of pollen in this case must be low or negligible. It is only present as the background for the anthropogeneous pollen. Generally, the diversity in pollen spectra increases with the increasing influence of anthropogenous components and the tree pollen frequencies decrease. This is evident from the pollen diagram from unit 7.

The pollen diagram from unit 5 is different from unit 3 but is closely related to that from unit 7. Even though the diversity of taxa is high in unit 3 it increases through unit 5 and 7. The sum of the heterogeneous group of cultural indicator pollen is doubled from unit 3 to unit 5 but comparable in units 5 and 7. The clear similarities between the two diagrams are only possible if the genesis of the two units is closely related.

The macroscopic remains from unit 5 (mosses, wood-chips and hazelnut shells) also indicate an affinity to unit 7. The pollen diagram and the macroscopic remains indicate dumping of human waste obscured by the decomposed state of the deposit. It is possible that decomposition and the disintegration of the organic material is a product of better oxygen conditions in the bay generally or to the presence of the stream close to the investigation area. The stream will bring oxygen-saturated water in contact with the organic deposits and thereby induce decomposition of the waste. A smaller input of waste to the bay can also be a cause. Oxygen deficiency in the deeper water will not occur if the input of nutrient is below a certain level. The high decomposition and disintegration of the organic material in unit 5 obscure the fact that this layer is originally human waste material analogous to unit 7 and later phases. This implies that the activities producing this type of waste can be traced back to 7th century.

The material within the waste layer 5 is mostly of terrestrial origin. The content of mosses, wood fragments and wood-chips prove the cultural origin of this layer. However, it cannot be excluded that some of the organic carbon found might be redeposited, and therefore the dates, also from this layer, must be treated as maximum dates. The contamination by old carbon in the ^{14}C-dates must be small, and the most recent plausible age of this layer is not necessarily much later than AD 700.

In the pollen diagram of unit 5 *Alnus* is the main contributor. There is no reason to believe that this pollen component is anthropogeneous. Copses near the shore have dispersed their pollen in large quantities and *Alnus* might be over-represented in the pollen spectra. *Pinus* pollen is found with stable low frequencies below 5% throughout the diagram, indicating that no pine forest was situated near the site. This is one of the most dramatic changes which has taken place in the timespan between unit 3 and unit 5. *Corylus* and *Quercus*, on the other hand, might have been present in the open landscape of the hillsides.

A large portion of the pollen in the diagram is of anthropogenic origin, mainly the herb pollen with high frequencies of grain (Cerealia) and weeds. Some pollen types like grasses (*Poaceae*) and meadowsweet (*Filipendula*) on the other hand might be of mixed genesis. *Filipendula* is often found naturally in similar localities. In this diagram the frequencies are somewhat higher than expected. *Filipendula* has been utilized as a spice in mead (Troels-Smith pers comm, Dickson 1978, 1979).

It is also difficult to deduce what portion of the grass pollen was part of the air component, and what portion was brought to the site by other agencies, through animal dung or adhering to other plant material. Animal dung is the most effective agent, but no other indication of animal faeces has been observed. *Trichuris* species with animal hosts differ in ovum size from the human parasite. The *Trichuris* ova found are all between 48–52 microns long and can hardly be confused with those of other species. Parasite ova from later human latrines at Bryggen show that no change in size took place during fossilisation. A large portion of the *Poaceae* pollen can therefore represent meadows in the Bergen valley around AD 600–700.

In some important aspects unit 5 is clearly different from unit 7. The very exotic pollen types are lacking and no pollen of cornflower (*Centaurea cyanus*) is found. Moreover, broad bean (*Vicia faba*), which is very common in unit 7 and in samples from medieval Bryggen (Fægri & Iversen 1975, Krzywinski et al 1983) had not been introduced in the 7th century.

DEVELOPMENT OF THE CULTURAL LANDSCAPE AND THE HISTORY OF SETTLEMENT

The general vegetation history of the Bergen area has been investigated by pollen diagrams from the sediments of two lakes, Kristianborgs vann and Tveitevann, approximately 5 km south of Bryggen (Hagebø 1967). The diagrams indicate a dense mixed deciduous forest during the first part of the Subboreal. Later, the pollen frequency of the broadleaved deciduous tree species lime (*Tilia*), elm (*Ulmus*) and oak (*Quercus*) decreased as pine (*Pinus*) gradually became the most common tree species together with birch (*Betula*). An increase of herb pollen and the first appearance of pollen of cereals, *Plantago lanceolata* and other weeds are synchronous with the decrease of the broadleaved forest species. This indicates that agriculture was introduced in the middle part of Subboreal and that the farmers selectively changed parts of the broadleaved forest area to fields and meadows for the livestock. Unfortunately there are no reliable ^{14}C-datings from the Bergen area to date this important event. From other parts of Hordaland (Bakka & Kaland 1971, Kaland 1974, 1979, Berge 1978) the period of 3000–4000 years BP is most probable. Somewhat later the frequencies of pollen of heather, herbs and spores of *Sphagnum* moss increased. This change from a forested valley with limited open areas for fields and meadows to open heathland was the result of a gradual expansion of the farming intensity characteristic for the West Norwegian coast area. The pollen diagrams from Bergen lack a dating for this deforestation. Other datings from Hordaland (Kaland 1979) show that the deforestation was metachronous. The main deforestation period, however, was 2200–1000 ^{14}C-years before present. Hagebø's survey pollen diagrams from the Bergen area are in agreement with the archaeological and historical sources for the agrarian activities in the area before the foundation of the town in the 11th century. His survey cannot, however, be used to localize the farms.

The new pollen diagrams from Bryggen have been made from sediments which reflect human activities close to the site or in the catchment area. The diagrams therefore give very local information about the process which changed the eastern bank of Vågen into a town. The diagram from the oldest organic deposit (unit 3) documents both cereal production and pasture close to the shore in the Early Iron Age. The sediment is redeposited forest soil disturbed by the farmers establishing new fields. Later soil erosion on the hillside as a result of ploughing has transported the mixed soil to the sea. Similar redeposited sediments are very common in lakes both in Norway and on the British and Northern Isles (Pennington 1978a, 1978b, Johansen 1978, Kvamme 1982). Because a part of the sediment is redeposited, the information from the diagram reflects the vegetation partly at the time of primary soil formation, and partly at the time of soil erosion and redeposition.

The pollen diagram of unit 3 is dominated by high frequencies of tree species like pine (*Pinus*), birch (*Betula*) and alder (*Alnus*), while hazel (*Corylus*), oak (*Quercus*) and other broadleaved deciduous tree species have low pollen values. Even if a part of the pine pollen influx is due to marine over-representation, the sediment could still originate from a forest soil below a mixed pine/birch forest. From the Bergen area survey diagrams it appears that this forest community was an important part of the forest cover through the last part of the Subboreal period.

The vegetational situation east of Vågen is shown on fig 22A. The slopes were covered by mixed pine/birch forest with broadleaved deciduous tree communities on the most favorable soil. At the shore there were copses of blackalder (*Alnus glutinosa*). The section also illustrates the varying thickness of the glacigenic deposits on the slopes of the hillside, and the marine sediments deposited at the shore and in the sea until the late part of the Subboreal.

The cereal and weed pollen in the pollen diagram together with very high frequencies of charcoal dust in the soil indicates agricultural activity close to the shore or in the catchment area of the brooklet which reached the sea close to the investigated site. The farming activities have been dated to about 500 BC. This date is, however, a maximum date due to the fact that the sediment is a mixture of

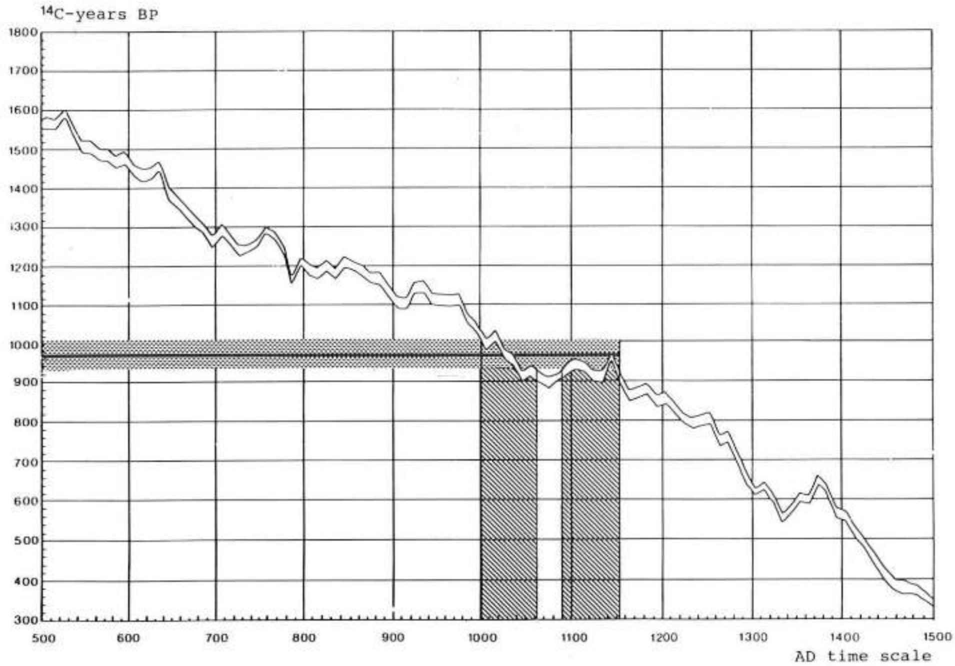


Fig 21 Comparison of remnant radiocarbon activity in sample 1 with high precision calibration curve of Stuiver (1982). The calculated ^{14}C age is plotted on the ordinate and the period which can be responsible for this activity is read on the abscissa

redeposited and primary terrestrial organic matter. In addition some marine organic matter has been mixed in. It is therefore impossible from the present material to give a more precise date than the pre-Roman or early Roman period. It is not possible from the present diagram alone to get information about the type of vegetation which surrounded the fields as the sediment is mixed. Future investigations of primary soils from the slopes behind the shore delta are therefore necessary to show how large an area was cleared in the earliest Iron Age.

Unfortunately no archaeological finds have been made which can give a more exact localization of the farm with its fields and buildings which must have existed not far from the investigated area. From comparative place-name studies, the 13th century form of the local place-name Bjorgvin, which later became Bjørgvin and finally Bergen, would indicate a farm. This farm has not yet been localized archaeologically, but Koren-Wiberg (1921) and others have suggested a localization on the slopes of the east bank of Vågen. The organic allochthonous culture deposit, unit 3, may be the first remnants found from this farm.

Until now, unit 3 is the oldest occupation deposit found at the Bryggen site. It is impossible to know the horizontal range of the layer as it was only studied in one section. It is likely or even most probable that this and other prehistoric occupation layers can have extended further below or beyond the deposits of the medieval town along the eastern bank of the bay. A tentative illustration of the cultural landscape and the marine deposits of the Early Iron Age is given in fig 22B.

After the transition between units 3 and 4 only minerogenic sediments were deposited along the section for a period of time. From a cultural-historical point of view it is important to point out that this lack of a continuity in deposition of the occupation material cannot be used as an indication for interruption in human activity. During the formation of the delta, the configuration and the exposure of the shore and the bed of the stream may have changed. The deposition area for fine grained minerogenic and organic material may therefore change with time. Such deposits may exist at other places outside this section. The farming activity on the hillside might have been continuous. What has been found till now gives only short glimpses into events within a long continuous period.

The organic unit 5 represents the next investigated deposit, dated to the 7th or 8th century. In unit 4 at the base of the section at 6 m an additional organic layer was found. Mechanical excavation also exposed a thick organic layer beneath the caissons north of the section. Unfortunately the layers were discovered too late during the rescue work to be sampled. The layers might represent other periods with deposition of fine grained material at a shallow depth along the beach. As described on p 18, 21 the sediment composition of the occupation material in unit 5 deviates in important ways from the sediment in unit 3. This sediment has a high content of disintegrated wood, wood-chips, hazelnut shells, charcoal and moss. The moss species found are those common in medieval latrines (Krzywinski 1979, Krzywinski et al 1983). Of special interest are the finds of whipworm (*Trichuris trichiura*) which proves that latrine material has been dumped in the bay.

The pollen diagram of the deposit shows that the area has undergone a considerable environmental change. All trees except *Alnus* have very low frequencies and the diagram therefore no longer gives positive evidence of a forested landscape. Both the pollen frequencies and the number of taxa that are favoured by farming have increased. These taxa are also normally found in latrine samples (Greig 1981) in refuse layers together with Cerealia (Krzywinski 1979, Høeg 1976) and as seeds in samples of carbonized cereal material. A similar pollen assemblage was found in modern barley porridge (Krzywinski & Fægri 1979, Krzywinski et al 1983). The assemblage therefore in this connection does not necessarily indicate agriculture but may derive from latrine material. There is no archaeological evidence for a settlement of the seventh century and one is therefore forced to discuss the localization and level of activity on the basis of the unit 5 alone.

An important question is whether the deposit represents activities of a farm situated in the close vicinity or a settlement with a denser population. If the settlement was an ordinary heathland farm, it would be bound to show a similar adaptation to the resources on land and sea as other farms situated in the inner part of the heathland zone along the coast. Surveys of such adaptation and application for medieval and prehistoric farms in Hordaland have recently been published by Myking (1973), Gjertsen (1975), P E Kaland (1974, 1979), S Kaland (1979), Randers (1981) and Kvamme (1982). Of importance for this discussion of unit 5 are two main problems for the heathland farmers:

1 The need for an intensive manuring of the fields
2 The lack of wood for building and for fuel

The fields of the heathland farms were used for crops every year and the farmers had a hard work manuring the intensively used soil. The system of «plaggenboden» is typical for the European heathland area and at the farm of Lurekalven (S Kaland 1979, Kvamme 1982) use of this method has been documented for the Late Merovingian period. The effort of obtaining sufficient manure for the fields must have been so great that the dumping of fertile latrine waste in the sea must be discounted. The latrine material in the sediments therefore indicates a larger population on the site than was necessary for manuring the fields. Human excrement must have become a problem for the prehistoric society in the Bryggen area and the pollutionary dumping in Vågen bay was started.

The occupation deposit of unit 5 has a high content of wood-chips. These are commonly found in the occupation layers of market settlements and towns of the Viking and medieval periods. Though layers with wood-chips cannot be disregarded as a possibility for ordinary heathland farms, it is most likely that burnable wood would be used for fuel. Layers containing wood-chips have never been found in connection with investigations of prehistoric farms in the heathland area of West Norway.

Eggs of whipworm have so far mostly been found in connection with urban latrine material. This does not imply that the farmers of the period did not suffer from this disease as no latrines have been analysed from farms and rural places. It is, however, possible that the frequencies of the disease will increase with the density of a population as the chance of re-infection increases.

As discussed on p 28, the macrofossil contents of layers 5 and 7 are closely related. The pollen content of the two layers also shows large similarities, and most possibly the waste material in the deposit is a result of a similar activity. The material in unit 5 is, however, more decomposed and disintegrated which may be due to a less active dumping of waste at the time of deposition of unit 5.

The total information from the analysis of layer 5 gives the impression that human activities have increased considerably. Pollen of cereals like oats (*Avena* type), wheat (*Triticum* type) and barley (*Hordeum* type) tells that different types of cereals have been cultivated or at least eaten. The latrine content in the deposit indicates a surplus of human excrement in relation to the fields. It is therefore most probable that the population of the settlement is higher than normal for an ordinary farm. The macrofossil content of the deposit is of similar type as later waste deposits from the urban period, but the quantity deposited is lower. This indicates a lower level of human activity than in the medieval period. The use of the Bryggen area in the 7th century is therefore likely to be a denser type of settlement than an ordinary heathland farm but less dense and with a lower activity level than a town. The waste reflects a type of settlement where activity connected with a secondary livelihood is of importance. A pre-urban coastal settlement is a type of settlement which can easily be responsible for the composition of unit 5. Koren-Wiberg (1908, 1921) suggested such a dense settlement which he referred to as a coastal village (*strandsted*), cf p 1. The refuse layer 5 supports this view of his and others. We find it difficult to classify it within the existing urban terminology in use in Norway. There is obviously need for an appropriate term for an intermediate preconstitutional urban phase in Norway. A tentative sketch of such settlement is shown on fig 22C.

The organic sediment unit 7 is the most recent of the deposits which were investigated during the rescue work. The most probable date is the 11th century, though the Stuiver calibration (fig 21) cannot exclude the possibility of a 12th century date. It is in any case stratigraphically older than the caisson construction dated by the relative fire chronology to 1178.

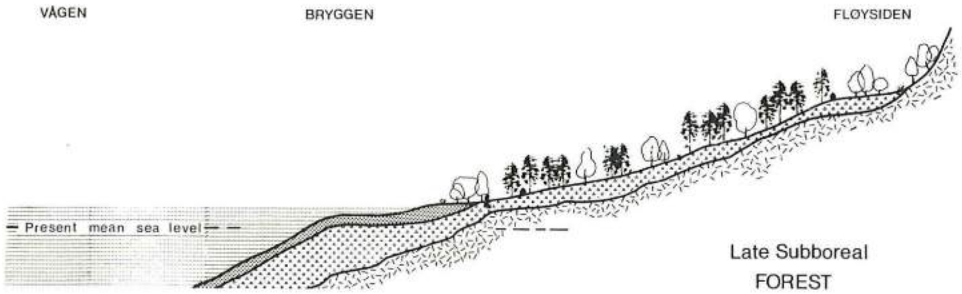
The composition of the deposit is identical with the later waste deposit of the medieval town. The pollen diagram is very similar to the diagram from unit 5 but contains an even higher number of taxa and frequencies of cultivated plants and anthropogenic weeds. In addition to the cereal taxa, *Vicia faba* has been introduced as a cultivated or eaten plant.

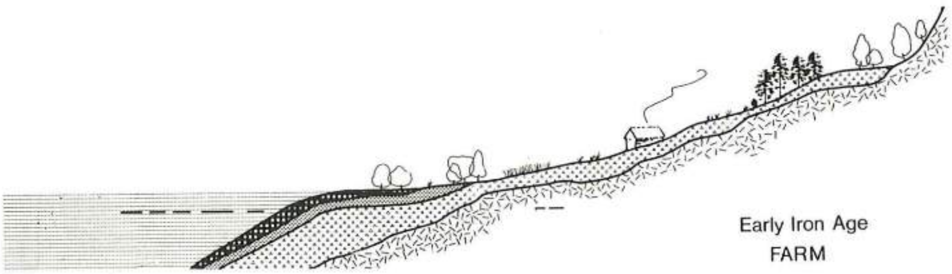
Of special importance is the find of the *Helianthemum* pollen. None of the European *Helianthemum* species grows in Norway, nor is it probable that they have grown here during late Holocene. The most probable species, *H. numularium*, is a weed connected to an open vegetation and may grow at the edges of grain fields. Its European distribution northwards reaches Scania and the British Isles. The pollen of *Helianthemum* cannot be understood in any other way than as a contamination in grain imported from abroad. It is the earliest evidence of foreign commerce at Bryggen found hitherto. In addition, unusually high frequencies of the weed of cultivation, cornflower (*Centaurea cyanus*), and a pollen find of the ruderal plant, mallow (*Malva*), give further indication of cereal import from more southern areas.

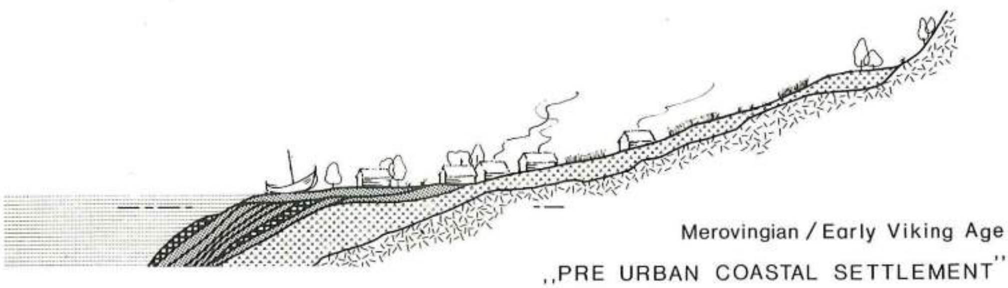
Latrine mosses and ova of whip-worm have been found in the occupation material. The considerable thickness of the layer and the sediment composition with a very high content of disintegrated wood-chips, hazelnut shells and mosses give clear evidence of a high human activity at the shore of the Bryggen area. The foreign weed *Helianthemum* is an indication that Bryggen at this time has started as an import harbour for grain. On the sediment evidence available it is clear that the spectrum of activities has been more diverse than the situation in the 7th century. It is also likely that the population has increased. A sketch of this situation is illustrated in fig 22D.

The deposit 8 was not collected during the rescue work because it was obviously part of the medieval urban occupation layers investigated in the earlier excavations. Now it was no longer possible to land ships at the shore, and pier

The history and development of the eastern bank of Vågen as interpreted from the marine beach deposits.







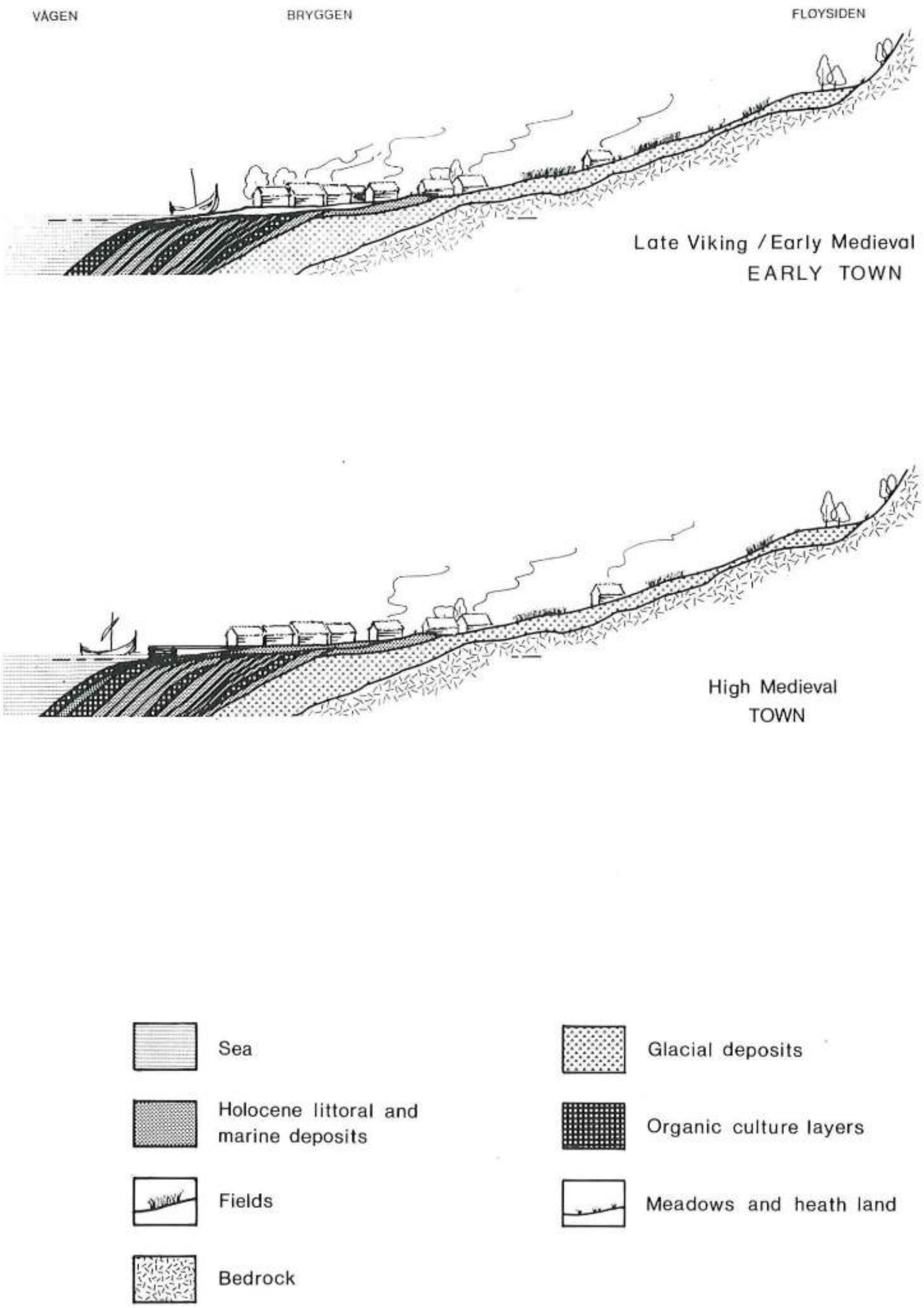


Fig 22 Suggested development of the marine delta, history of the cultural landscape and of the settlement to the east of the bay. The vertical and horizontal scales are not identical

constructions were built on the earlier refuse layers. A sketch of the town from the High Medieval period is shown in fig 22E.

The illustration, fig 22, is an attempt to visualize step by step the probable development of the marine delta, the changes of the cultural landscape and the history of settlement from the early part of the Iron Age until the established town of the 12th century. The deposits give short but informative glimpses of the process of urbanization. The complete lack of remains from the prehistoric period prevents an exact localizing of fields and houses. The reconstruction also suffers from the lack of pollen analysis from peat deposits from the hillside east of Vågen. On the other hand the organic layers of the delta provide physical evidence of settlement prior to the 12th century town. These have been situated on the gentle slopes of the catchment area close to the investigated site.

The Early Iron Age farm situated not far from the investigation area (fig 22B) gives strong support to the hypothesis of Koren-Wiberg and others, who suggested that the original farm of Bjorgvin was located within this area.

The later deposit of unit 5 (fig 22C) is a result of a larger settlement and is in accordance with the old hypothesis of a pre-urban community prior to the medieval town on the east side of the bay.

From the dates available it is not possible to decide whether the settlement indicated by layer 7 (fig 21D) is deposited before or after the formal foundation of the town of Bergen in the time of King Olav Kyrre (1066–1093). But it is clear that the settlement at the time of deposition had increased its size, activity and population considerably, and that this settlement is prior to or contemporaneous with the earliest buildings found during the archaeological excavations.

Anyhow, it is clear that the act of foundation by King Olav referred to in the saga version was not a physical creation of a town on unexploited land but was mainly of a formal, judicial nature.

The interdiciplinary investigation of the sub-beach sediments underlying the medieval town deposits has stressed the importance of waste deposits accumulated in wet anaerobic environments as a source for the history of settlement. Waste material deposited on the bottom of the sea or lakes is in most cases much better protected against stratigraphical disturbances and disintegration than terrestrial occupation deposits on well-drained ground. Careful studies of the bottom sediments may therefore provide a valuable check of the chronology established by the archaeological excavation and reduce the danger of drawing insecure conclusions from negative archaeological evidence.

The composition of the waste sediments also reflects the economic activity on land, as different types of activity produce different types of waste. Previously, some studies on the composition of deposits in lakes close to prehistoric and medieval farms have been undertaken in Western Norway. This is, however, the first time it has been possible to study the change in the composition of sediments from a settlement which has developed from a farming economy to one based on urban activities.

From a sedimentological point of view the sublittoral underwater shelf is not an optimal location to study the cultural waste deposits. It is important to study the stratigraphy of the central part of the Vågen basin to obtain a continuous record of the settlement. As indicated on fig 1 a small protected basin also existed north of the site (Veisan) which may contain valuable information about the early history of Bergen.

TABLE 1 ^{14}C Dates

No.	Lab ref no.	Material dated	Amount	^{14}C date BP	^{13}C ‰ PDB	MASCA calib	Stuiver calib (1982)
1	T-3786	Hazelnuts	6.8g	970 ± 40	-24.4	AD 1005 ± 45	1030 ± 50
2	T-3785B	Gytja	46.6g	1380 ± 70	-27.9	AD 605 ± 65	650 ± 80
2	T-3785A	Humic acid	17.8g	1320 ± 70	-26.2	AD 650 ± 8	680 ± 80
3	T-4179B	Gytja	29.8g	1410 ± 80	-23.5	AD 570 ± 80	640 ± 80
3	T-4197A	Humic acid	11.4g	1250 ± 70	-19.9	AD 730 ± 90	730 ± 80 (770 ± 70)
4	T-3784B	Gytja	76.0g	2310 ± 80	-18.8	BC 520 ± 120	
4	T-3784A	Humic acid	12.6g	2400 ± 80	-18.1	BC 590 ± 160	
5	T-4280B	Gytja	33.5g	2810 ± 80	-19.6	BC 1045 ± 135	
5	T-4280A	Humic acid	25.1g	2550 ± 70	-18.8	BC 775 ± 65	

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Absolute Dating of Medieval Occupation Layers at Rosenkrantzgate 4 by High Precision Radiocarbon Dates

BY KNUT KRZYWINSKI AND STEINAR GULLIKSEN

INTRODUCTION

Radiocarbon dates are not often used as independent correctives to the chronology in medieval urban excavations. It is generally argued that radiocarbon dating is not precise enough for solving problems with dating within this period. In addition there are problems in calibrating the radiocarbon date because of variations in the atmospheric carbon content at certain periods. Medieval archaeology often requires a level of dating precision to within a few dozen years or less and a more precise date is often available based on otherwise datable finds and on dendrochronology. The relative chronology established in the field is usually retained until closer or even absolute dates are provided by the finds or dendrochronological analysis. In the temperate broad-leaved deciduous forest region in Europe, oak timber is often used for constructions. Dendrochronological dating within this zone based on oak has been used successfully in medieval excavations. Further north in the coniferous region pine and spruce substitute for oak. So far dendrochronology based on coniferous trees has not been used to any extent. It may provide reliable dates within a limited area if a standard curve exists for the region, but working these out is time consuming and they scarcely exist at the moment.

For medieval towns written documents and other historical sources are usually of value for dating and correlating relative chronologies. In the Bryggen area, a chronology has been established based on written sources (Herteig 1969, Helle 1972, 1982). A major source of chronological correlation within the area are indications of former fires (ash-layers etc) which from time to time swept through Bryggen. The «fire layers» found during the excavation are the key to the dating of the different phases of the site and of the buildings and artefacts found in association with them. The correlation of the fire layers to the absolute chronology reflected in the written sources depends on the geographical distribution of both recorded and unrecorded fires, in addition to the completeness of the stratigraphical record. The possibility of hiatuses in the fire stratigraphy and the existence of local fires not mentioned by the chroniclers are always a danger. Such local fires may cause the dates of the other fires recognised on the site to be moved in time.

The «fire chronology» established by Herteig for his excavations (Table 1) is well documented. It is in principle relative, but it is useful within the Bryggen site where it should be possible, at least in principle, to correlate the fire layers recorded in different parts of the site to the historically documented fires. The transfer to absolute dates is done through an up-to-date reconsideration of the written sources, such as Helle (1979) has done in suggesting the areas devastated by each fire. Outside the main excavated area Herteig's fire chronology is less useful as the

TABLE 1 Fire stratigraphy at Bryggen 1170–1702 applied to Rosenkrantzgt 4

Fire Helle 1979	Herteig 1969 and pers comm	Lindh (op cit) Field chronology	Comments Mostly from Helle 1979
1702	I	(Ao)	The whole area destroyed in a large fire May 19th 1702 (The deposits were removed prior to the excavation in Rosenkrantzgt 4)
1527	I B		Affected only the northern area of Bryggen
1476	II	A	Most probably the whole Bryggen area was destroyed
1454		B	Straumrin was the only tenement affected by this fire and was not rebuilt
1429			Bryggen not affected
1413	III	C	The whole Bryggen area ruined
1393	III B		Not certain if the area was affected by this fire which is believed to have been restricted to the buildings in Vågsbotn
1332	IV		The fire started in the northern part of the Bryggen area and it is uncertain how far south it reached
1248	V	D	The fire started in the Straumrin tenement and the whole Bryggen area was destroyed
1198	VI		The whole Bryggen area was destroyed in a fire August 10th during the civil wars. The fire was deliberately started at three different places
1170/71	VII		Most probably the whole Bryggen area was destroyed, some time during the winter of 1170–1171

firelayers can only be dated if they are directly connected or by their stratigraphical position. A stratigraphical hiatus would change the dating.

New relative floating chronologies based on stratigraphy must be established for geographically separated excavations, eg the site in Rosenkrantzgt 4 only 150–200 m southeast of the earlier excavated area (fig 1). A main problem of this excavation has been the dating of the different phases. A general discussion is presented in Lindh (xerox).

Eight different building phases were found. The first three phases are different stages in the expansion of the town on artificially reclaimed land on layers of refuse thrown into the bay. The fourth phase is initiated by a fire recorded all over the excavated area. In the absence of absolute dates it is named fire D. Three later fires, C, B, and A, have also been documented, each initiating a new building phase. At present no dendrochronological dating is available although numerous samples have been taken for later study. Without dendrochronological dating and/or a thorough analysis of the finds it is difficult from the stratigraphy alone to deduce the time-span between fires D and A or the absolute dates of the fires.

In an attempt to correlate the archaeological record with historical events Lindh (op cit) discusses the written sources referring to the tenements in the surrounding area, based mainly on Koren-Wiberg (1908 and 1921) and Lorentzen (1952). According to Helle (1979) this area was most probably affected by fires in 1170/71, 1198, 1248, 1332, 1413, 1454, 1476, and 1702. With the exception of the fire in 1454 all the others are main fires in the Bryggen area. They are well-documented in the written sources and seem to have destroyed large areas of the medieval trade centre. The fire chronology established by Herteig is primarily based on these seven fires (Table 1). In Herteig's chronology (Herteig, in press) they are numbered VII to I. A fire in Bergen in 1429 is mentioned by some sources but most historians seem to agree that it did not affect the Bryggen area. The fire in 1454 is a local fire well-documented in written sources. The tenement Straumrinn, located exactly in the area of the Rosenkrantzgt 4 excavations (Koren-Wiberg 1921 and Lorentzen 1952) burnt down in 1454, but the fire was restricted to this tenement and does not seem to have affected the other tenements in the area. According to Helle (1979) another well-documented fire in 1393 is less likely to have affected this area. It is assumed that the fire did not reach so far north but was restricted to and destroyed an area southeast of Bryggen. The 1702 fire reached and devastated this area, but the evidence of this fire on the actual site was most probably removed by subsequent activities.

Since only four fires were recorded during excavation, traces of some fires mentioned in the written sources were not present or had been removed by mechanical excavation. These hiatuses in the fire stratigraphy make direct dating of the layers difficult, especially since no physical contact exists between the present site at Rosenkrantzgt 4 and the area excavated by Herteig. His fire chronology cannot therefore be applied. Lindh (op cit) using written sources concerning the tenements, found a possible correlation between the building phases and the fires on the site. The floating chronology A-D can be correlated to absolute chronology by numerous possibilities, some of which are presented and discussed on p 48. The possible correlation of the tenements and the fires primarily used by Lindh is presented in Table 1.

RADIOCARBON DATES

In an attempt to create an absolute chronology for the fires radiocarbon dates were obtained from the four fire horizons. In the south-eastern corner of the excavation, in what was assumed to be Straumrin, carbonized cereal grains, mainly *Hordeum,* were found in large quantities in the firelayers. The find indicates that brewing took place in this area and that the activity was resumed after each of the first three fires. The significance of the grain find is discussed in Krzywinski (1979) and

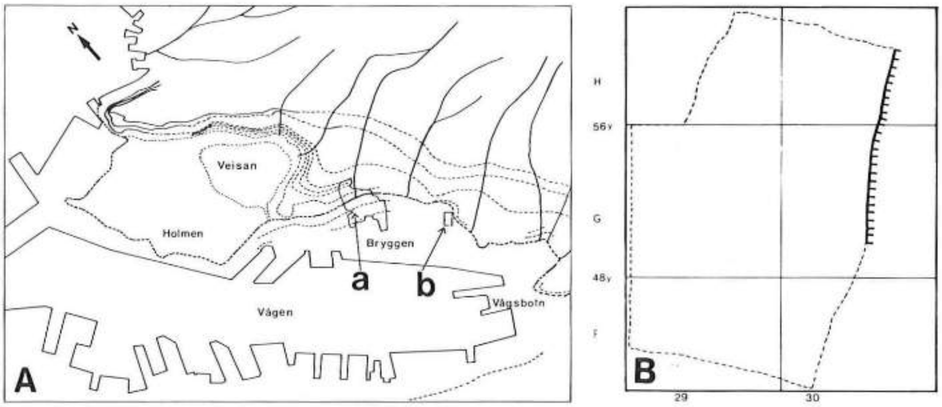

Fig 1 A. Main topographic features of the Bryggen area prior to the town's foundation. Investigated sites: a. Main excavation area at Bryggen, b. Rosenkrantzgt 4.
B. The excavated area in Rosenkrantzgt 4 with grid system. The investigated section is shown with a heavier line

Krzywinski & Soltvedt (forthcoming publication). Brewing started some time before fire D and continued through C and B. In fire layer A, however, less grain of *Hordeum* was found compared to layer B-D. Traces of carbonized seeds of *Secale* (rye) and *Vicia sativa* (common vetch) in addition to large quantities of carbonized hazelnuts were present (Krzywinski & Soltvedt op cit). The carbonized seeds in the four horizons provided, moreover, excellent radiocarbon dating material, being present in large quantities in a very clear stratigraphical context. Since no other absolute dating method was available it was tempting to date the fires by the radiocarbon method with the highest possible accuracy.

The four ^{14}C samples were taken from the section at 54-56y 223x. The samples were taken from parts of the stratigraphy where there was a large concentration of carbonized seeds. Each sample was dispersed in distilled water and gently sieved through a set of three sieves with meshes of 2.5, 1.0 and 0.25 mm to facilitate sorting. The sample was then dried at room temperature and carbonized grains of barley (*Hordeum vulgare*) were picked out. In the case of fire A carbonized hazelnuts (*Corylus avellana*) were used instead due to the shortage of *Hordeum*. The samples were then washed repeatedly in a hot 10% solution of potassium hydroxide (KOH) until no more humic acids could be extracted. The humic acids present in the samples can be regarded as a possible contaminant; they are often of more recent date having penetrated the sample from above. The sample was then washed in lukewarm water and dried at 60 degrees Celsius. The dry weight of the samples was: A = 5.7 g, B = 10.0 g, C = 12.1 g, and D = 4.9 g. The samples were processed and dated at the Radiocarbon Dating Laboratory in Trondheim, where they received further routine pretreatment before combustion. Each sample was washed in a hot 10% solution of sodium hydroxide (NaOH) to remove traces of humic acid followed by a 10% hydrochloric acid (HCl) treatment to remove carbonates. The samples were ignited in O_2 atmosphere and the CO_2 gas stored for one month to eliminate radon. The ^{14}C concentration was measured in a proportional counter for one week to obtain high accuracy.

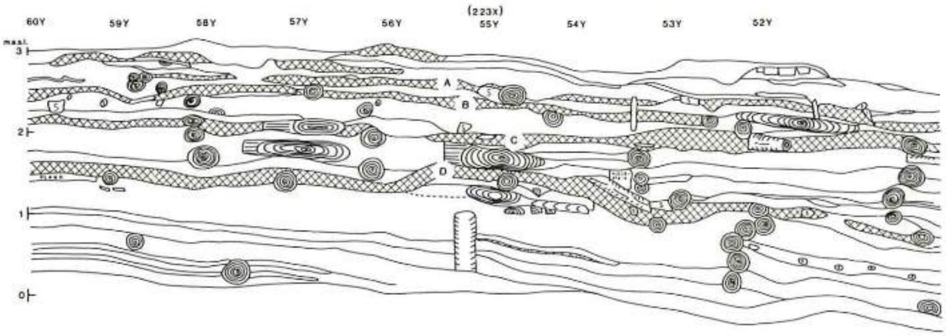

Fig 2 The investigated section. Fire layers with charred plant material cross-hatched

During the transfer of carbon from the atmosphere to organic materials, small shifts in the $^{14}C/^{12}C$ ratio will be caused by isotopic fractionation in the physical/chemical processes. These effects are reflected also in the sample content of ^{13}C, a stable isotope that can be measured in a mass spectrometer. Corrections for isotopic fractionation must be applied for high precision radiocarbon dates.

The calculation of conventional radiocarbon age is always based on the assumption that the radiocarbon concentration in the atmosphere has been constant back in time. Thus the age of a sample is given by calculating the length of time a known ^{14}C activity input to a sample must have suffered post-mortem decay to reach the remnant ^{14}C activity measured, using a half-life of 5570 calendar years.

Due to the fact that the atmospheric radiocarbon content has not been quite constant, radiocarbon age does not correspond with the calendar age. To obtain calendar dates it is necessary to calibrate the radiocarbon dates by using information of past variations in atmospheric radiocarbon given by measurements of the ^{14}C content in wood which has been dated dendrochronologically. A calibration curve is established by plotting the radiocarbon age of dendro samples against dendrochronological age, which is very close to their calendar age.

The MASCA calibration (Ralph et al 1973) is based on measurements of bristlecone pine (*Pinus longaeva*) using samples consisting of c 10 yearrings. The curve is plotted by using floating averages of nine measurements. This restrains the effect of measurement errors and gives a relatively smooth curve. The implication is, however, that minor and short lived fluctuations in atmospheric radiocarbon content will disappear, while main features and variations are incorporated. The MASCA calibration gives generally a good approximation of calendar years.

Recently Stuiver (1982) published a high precision calibration curve for the AD range. Ten-year samples from Douglas fir (*Pseudotsuga menziesie*) and sequoia (*Sequoiadendron giganteum*) have been measured with very high accuracy. The data is precise enough to describe also small and short-lived fluctuations. When the intention is to resolve chronologically fire structures by radiocarbon dating, it is necessary to use this calibration curve. Good correlation with European measurements ensures that it can be used for Norwegian material.

In table 2 four samples from the Rosenkrantzgate site are presented with the conventional radiocarbon ages corrected for isotopic fractionation, the ^{13}C content and calibrated ages according to the MASCA and Stuiver curves.

TABLE 2

Fire-layer	Lab ref no.	^{14}C age years (BP)	^{13}C ‰ rel (PDB)	Calibrated age, MASCA (AD)	Calibrated age, Stuiver (AD)	Material
A	T-3776	600 ± 30	–26.1	1340 ± 40	$1325\begin{cases}+5\\-25\end{cases}$	Carbonized hazel nuts
					$1360\begin{cases}+10\\-20\end{cases}$	
					1390 ± 10	
B	T-4253	700 ± 30	–23.0	1265 ± 35	1285 ± 10	Carbonized barley seeds
C	T-4254	600 ± 30	–22.4	1340 ± 40	$1325\begin{cases}+5\\-25\end{cases}$	Carbonized barley seeds
					1360 ± 10	
					1390 ± 10	
D	T-3777	750 ± 30	–24.5	1215 ± 25	$1270\begin{cases}+15\\-10\end{cases}$	Carbonized barley seeds

TABLE 3

Fire layer	Lab ref no.	^{14}C age (BP)	Calibrated range Stuiver (1982) (AD)
A	T-3776	600 ± 45	1295-1410
B	T-4253	700 ± 45	1265-1295
			1370-1380
C	T-4254	600 ± 45	1295-1410
D	T-3777	750 ± 45	1230-1285

The uncertainties are given as $\pm 1\ \sigma$ (standard deviation), including uncertainties in ^{14}C measurements and fractionation corrections. The uncertainties given with the calibrated ages also include uncertainties in the calibration curve.

Neither the radiocarbon ages nor the MASCA calibrated ages are in chronological order compared to the stratigraphy. This discrepancy is quite certainly caused by short-lived fluctuations in atmospheric radiocarbon content. Stuiver's calibration curve shows that such conditions exist within the actual period and

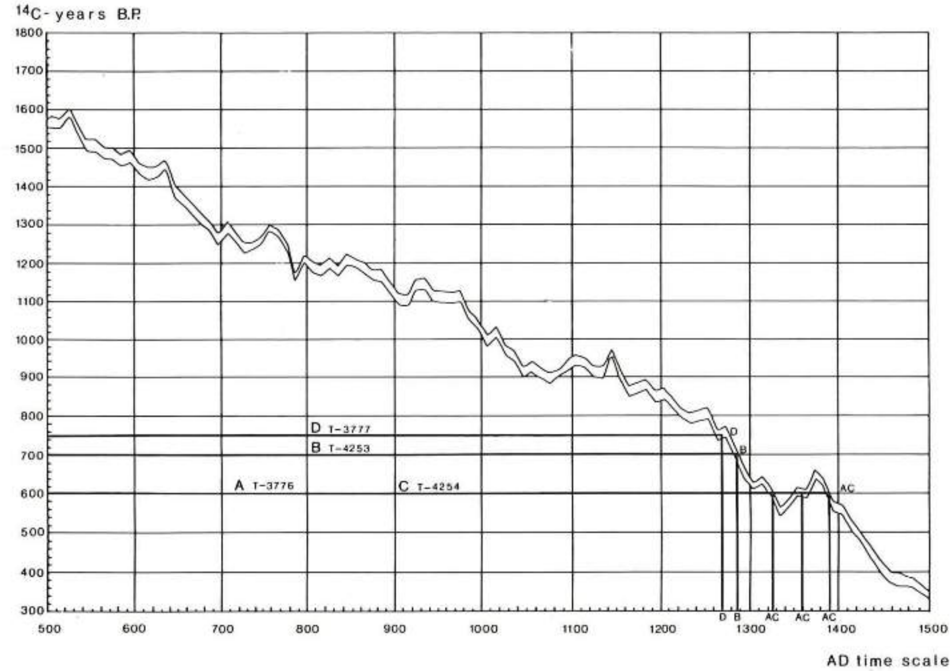

Fig 3 Calibration of the radiocarbon dates according to Stuiver 1982. Letters refer to the fire layers

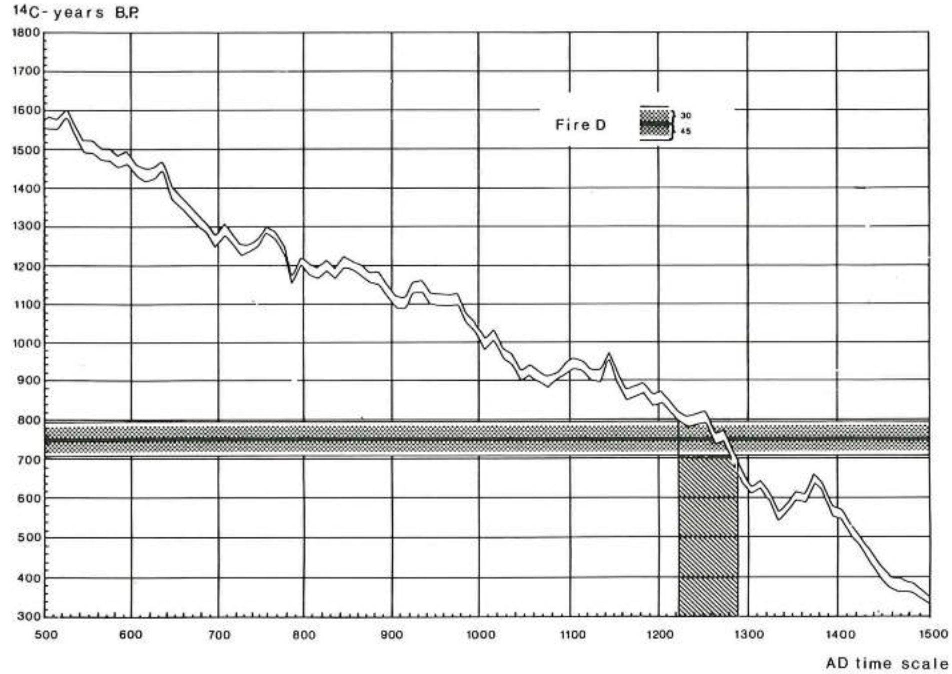

Fig 4 Calibration of the radiocarbon dates from fire layer D

three different calendar dates can be obtained for samples A and C. Fig 3 shows how these can be read on the abscissa of the calibration curve.

Correlation between dates and stratigraphy is, however, still not possible: the fire layer B is dated earlier than all possible dates for the underlying C layer.

CALIBRATION OF DATES WITH INCREASED UNCERTAINTY

When giving a date with an uncertainty of $\pm 1\ \sigma$ (standard deviation) there is a 68% probability that the true value lies within the corresponding range or, in other words, for one out of three dates it is outside. Extending the range to that given by $\pm 2\ \sigma$ increases the probalility to 95%. To resolve the fire chronology it is vital that no calibration possibility escapes our attention, but by applying very large (and «safe») uncertainty intervals it is easy to lose some of the information given by the dates. As a compromise the uncertainty of the radiocarbon ages is increased to 1.5 σ, giving a range that contains the true value at a confidence level of 86%.

One reason for using a larger interval of uncertainty is the fact that both hazel nuts and seeds are single year growths and they could thus reflect different atmospheric radiocarbon levels from that measured in a ten-year sample. Earlier investigations have pointed out that such deviations can be of considerable magnitude. Stuiver examines this problem by careful and precise measurements on annual tree-rings and finds no evidence for year-to-year variability exceeding measuring precision. His investigation does not, however, reject the fact that it might be wise to allow for possible small deviations when single year material is dated. In table 3 the four samples are given with the conventional radiocarbon ages with $\pm 1.5\ \sigma$ uncertainty intervals and the corresponding AD ranges according to the Stuiver calibration curve (figs 4, 5, 6).

For fire layers A and C the three possible calendar dates obtained with $\pm 1\ \sigma$ uncertainty, have now become linked together in a rather long possible range, AD 1295–1410 (fig 5).

A new calibration possibility appears for fire layer B (fig 6). In the years around AD 1375 the atmospheric content of radiocarbon was so low that material formed in these years received the same radiocarbon content as that left in material which died c 100 years earlier. Consequently the same radiocarbon age will be obtained when dating these materials today.

It is now possible to choose calibrated dates which correlate with the stratigraphic sequence. Still the dates are open for several interpretations and comparisons with historical data are necessary.

TABLE 4

Firelayer Rosenkr.	Historically recorded fire (AD)	Firelevel Bryggen	Estimated ^{14}C age (BP)	Measured ^{14}C age (BP)
A	1413	III	535 ± 20	600 ± 45
B	1393	III B	580 ± 15	700 ± 45
C	1332	IV	570 ± 15	600 ± 45
D	1248	V	800 ± 20	750 ± 45

CORRELATION WITH HISTORICAL EVIDENCE

If the fires are fixed in their stratigraphy, the total time span between D and A can be as short as 1285–1295 or as long as 1230–1410. The fire-layers A-D are found all over the site in Rosenkrantzgt 4 and should represent main fires in the area. However, it must be kept in mind that one or more of the four fires can be local and not mentioned in the chronicles.

1 As a first approach, the fire-layers in Rosenkrantzgt 4 may be adapted to the general fire stratigraphy of Bryggen, regardless of the ^{14}C dates. Since the 1702-fire was not recorded, fire A should correspond to Herteig's II, ie 1476 and successively B = III = 1413, C = IV = 1332, and D = V = 1248. In principle this is a possible correlation, but both written sources and the general stratigraphy contradict this.

2 The local fire in 1454 is well-documented (Helle 1979) and should be represented on the site especially since the fire was restricted to this tenement. A correlation might then be A = 1476, B = 1454, C = 1413, D = 1332.

3 On the other hand fire D heralds the main building phase with wooden foundations constructed on the sea-bed out in the bay (cf Lindh 1979, 27-30). From the type of constructions (cf Herteig 1969) and building phases (Lindh 1979), it is unlikely that this fire is later than fire V ie 1248. With this as a reference point fire C would be equal to IV = 1332, B = III = 1413, and A = II = 1454.

4 The 1332 fire is only mentioned in connection with the northern part of the area and it is not unlikely that it was restricted to this area and did not affect the Rosenkrantzgt 4 site at all. The fire sequence would then be: D = 1248, C = 1413, B = 1454 and A = 1476 which was actually the tentative correlation used during excavation.

The ^{14}C dates obtained indicate that even fire A, and consequently the other fires, should be older than the fires in late 15th century (1454 and 1476), and suggest that these dates could be excluded as possible correlations. The radiocarbon date of D indicates the period 1230–1285. In this period only one main fire is recorded viz V (1248). This fire is in agreement with the calibrated date for the $\pm 1\ \sigma$ interval (Table 2).

Due to the shape of the Stuiver curve the remnant radioactivity reading of fire layer C covers a long time-span (AD 1295-1410), comprising both fire IV and III. The remnant activity of fire layer B, however, can be representative for samples from both 1265–1295 and 1370–1380, but not for the period in between. Close to these two periods only one fire is known from written sources, the fire in 1393 when the *Vitalienbrüder* attacked and set fire to Bryggen. However, it has been the general opinion among historians that this fire only destroyed the area around Vågsbotn, south of Rosenkrantzgt 4. This is based on the assumption that the tenement of the English merchants, which according to the sources was burnt by the pirates, was situated in Vågsbotn. It appears now that this fire may have been more extensive than previously considered and furthermore that the tenement of the English at that time may even have been situated further north on Bryggen (Herteig pers comm). In Herteig's revised chronology this fire horizon is numbered IIIB and seems to be present at least in the southern half of the Bryggen area

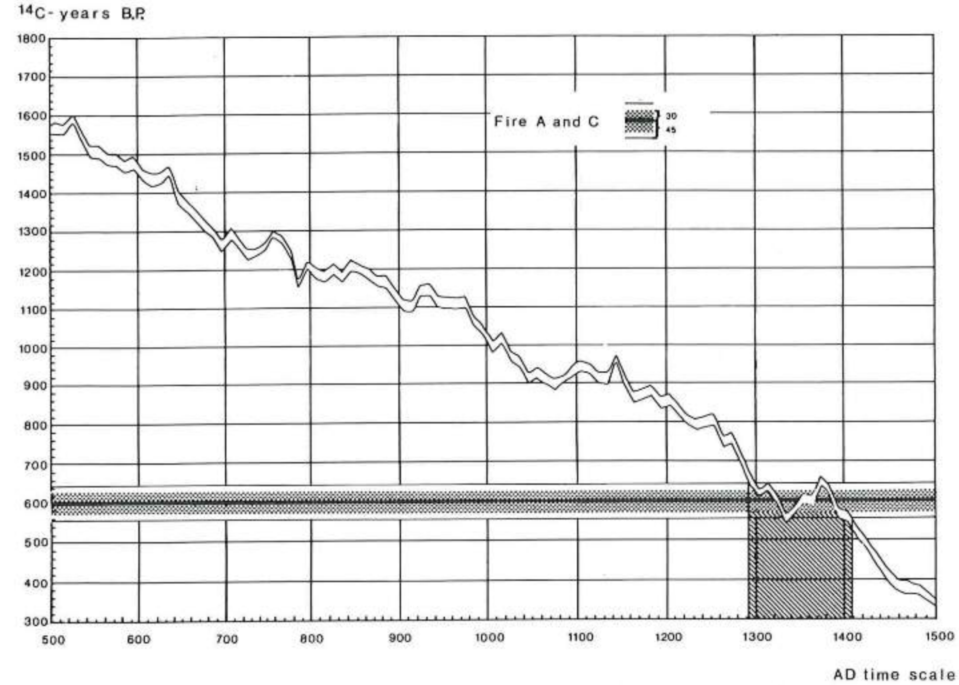

Fig 5 Calibration of the radiocarbon dates from fire layer A and C

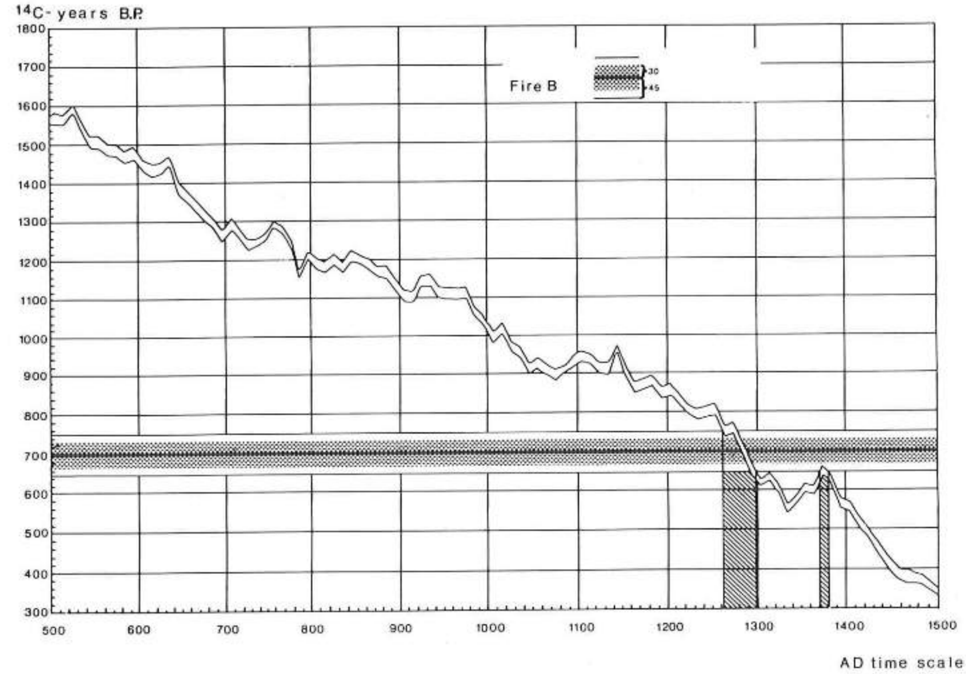

Fig 6 Calibration of the radiocarbon dates from fire layer B

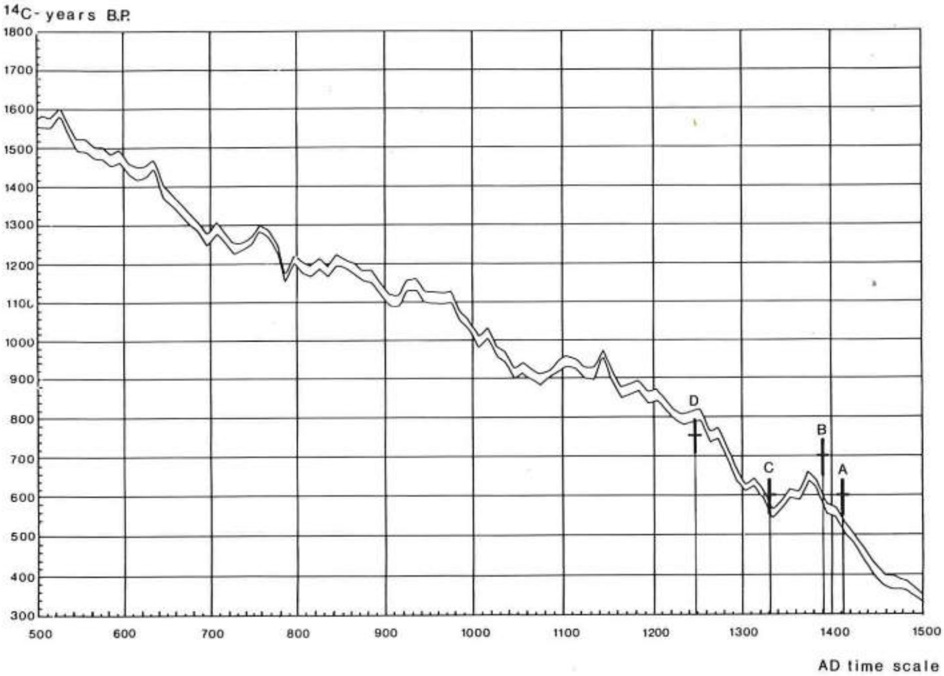

Fig 7 Correlation of radiocarbon dates with historically known fires

(documented on an independent basis). B must then be the 1393 fire. Deposits from fires A and C have a remnant activity which can be representative for the whole period 1295-1410. A must, however, be later than B and C, and the only correlation to known fires would be III (AD 1413). The time span for the four fires from D to A is thus fixed to the period 1230–1410, ie 180 years. Within these years the fires 1248, 1332, 1393 and 1413 are documented.

If we plot the fires from known written sources against the ^{14}C dates (fig 7), we obtain a close fit if fire D is 1248, C is 1332, B is 1393, and A is 1413. This is the largest time-span commensurable with the ^{14}C dates and the established fire chronology. The assumption of a shorter time-span e g 1230- 1300 would imply that at least two unknown fires must have devastated the area during that period without being recorded in the written sources. In fact no other direct correlation is possible. On the basis of the available information and the ^{14}C dates obtained it is suggested that the fires in Rosenkrantzgt 4 can be correlated to the fire chronology at Bryggen as shown in table 4, unless dendrochronology or other independent dating methods subsequently prove otherwise.

The estimated ^{14}C age (table 4) is the ^{14}C age which Stuiver's curve would give for material from the four historically dated fires. The measured ^{14}C age is the ^{14}C age of the material from the four firelayers on the site. Uncertainties are $\pm 1.5\ \sigma$.

The high level of precision required in the chronology of medieval archaeology needs the control of independent dating methods. The present study indicates that high precision radiocarbon dates may also be a useful corrective within this period. It is hoped that more ^{14}C dates from Bryggen will make correlation of the floating chronologies with absolute dates easier and more reliable.

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Coin Finds from Bryggen

BY KOLBJØRN SKAARE

A HOARD OF COINS FROM THE GRAVEYARD AREA

During the 1968 season of excavations at Bryggen, an old graveyard was discovered stretching towards Mariakirken. In one of the c 200 graves a clump of coins was found with the burial, supposedly a purse of money. On this find the director of the excavations, Asbjørn E Herteig, M A (1969, 102), in his popular book on the Bryggen excavations 1955-68 has given the following comments:

> «The graves were orientated east-west in the Christian fashion and, as usual in such burials, lacked additional gravegoods. Personal belongings, a purse of some 50 coins, were found with only one of the c 200 burials. Seen against the Bryggen milieu as a whole, so poor in coins, this seems so remarkable that it is possibly a coincidence: the coins, for example, could have been concealed in the clothing of the person buried. Furthermore, the supposed owner was buried in a mass grave, which may indicate plague or war. If it was the latter case, this may explain why a sum of current money had been safely hidden away.
> The only coin identified so far was struck under King Magnus Erlingsson (1161-1184), which reminds us not only of a time of unrest, but also that the followers of Magnus Erlingsson had easier access to such items of value than the opposite party, the *birkebeiner*. The many local conflicts between the two factions provide the most natural explanation to the mass grave with the coin find. The sagas even tell that these dramatic disputes were often settled in Mariakirken's graveyard. For archaeological as well as for historical reasons it is tempting to use the coin find as a direct and absolute dating of the grave to the 1180's, at the latest.»

In this paragraph Asbjørn Herteig touches upon problems connected with coin finds in general and with the coin finds from the Bryggen area in particular.

As the excavations on the site of the 1955 fire in Bryggen proceeded through the late fifties and into the sixties, one often wondered why so few coins were actually found at this important centre of national and international commercial activities. The very low number of coins turning up during the Bryggen excavations made a striking contrast to the very rich numismatic harvest gained by archaeological investigations under the small stave churches and other medieval churches in the Norwegian countryside. In addition to commercial reasons, there may, of course, be other explanations why coins are brought to and left in a church. Offerings, and not only the ordinary offerings to the church and the clergy, but some kind of private offerings of a magic character, may have led to coins being placed under the church floor and left there unnoticed for a long time. Even so, the rich church finds indicate that coins must have been rather common among country people in

TABLE 1

Church	When excavated	Number of coins	Earliest and latest coins	Number of medieval (pre-1537) coins
Lom Stave Church, Lom, Oppland[1]	1973	2280	c 1000/50-1969	2177
Ål Stave Church ruins, Ål, Buskerud[2]	1959	1078	c 1180-1942	993
Kaupanger Stave Church, Sogndal, Sogn & Fjordane[3]	1964-65	1428	c 1065/80-1809	1288
Borgund Stave Church, Lærdal, Sogn & Fjordane[4]	1969	686	c 1180-1953	627
Mære Church, Sparbu, Nord-Trøndelag[5]	1966-67	579	c 991/7-1876	543
Alstahaug Church Alstahaug, Nordland[6]	1967-69	514	c 1220-1875	281
		6565		5909

Norway during long periods in the Middle Ages, especially in the thirteenth and the fourteenth centuries.

Table 1 shows some examples from two churches in Eastern Norway, two in Western Norway and two in Mid/Northern Norway.

Let us now return to the coin finds from Bryggen and try first of all to get something from the little clump from the mass grave.

In 1977, the present writer had the opportunity to examine this clump of coins. The leader of the Bergen museum laboratory, Mr Kristen Michelsen, had from observation and preliminary tests found its state of preservation very poor. A number of very thin coins, so-called bracteates, were tightly stuck together in a lump. Mr Michelsen's advice, therefore, was that we should work our way together through the clump, he as a technologist and the present writer as a numismatist – with a photographer standing by.

This process took place on 28 April 1977 in the Bergen museum laboratory. After a surface cleaning, the clump, in which some 40 individual coins were visible, had a total weight of 15.5 grammes. The dirt that kept the coins together would account for some of this weight and the weight of an empty half-hazelnutshell which the clump appeared to contain must also be subtracted. By the thorough and somewhat destructive examination of the clump, 94 coins were recorded, albeit the major part of them in a fragmentary condition. This may be balanced by a great number of tiny fragments and crumbs impossible to fix with any accuracy, deriving chiefly, we must believe, from the very same coins.

All the coins were one-sided strikings, ie bracteates. They may be summarized as follows:

TABLE 2

	Type and reference	Number of specimens
1-65	Letter B with a dot on the left side in the field, surrounded by two circles; Schive VII, 26 (Schive 1865)	65
66-69	Letter R (minuscle of K), surrounded by two circles; Schive VII, 32	4
70-71	Letter ᚺ, surrounded by two circles; Schive VII, 45	2
72	Letter S, surrounded by two (ᚺ?) circles; cf Schive VII, 1	1
73-94	Type not identified	22
		94

All these fragments were not individually weighed. One complete specimen of the Letter B type weighed 0.144 grammes. Previous studies of well-preserved specimens of bracteates of this one-letter type have given two different groupings, one around 0.12 grammes, another around 0.06 grammes.

Even this tiny difference is of great importance, as it most probably indicates two different coin denominations, the halfpenny and the farthing (quarter penny) of the Norwegian coinage at the end of the twelfth century.

The 1840 hoard from Dæli, Stavsjø, Nes, Hedemark[7], is of crucial importance to our dating and attribution of the bracteate group. This hoard containing nearly 5000 altogether, has the year 1194 as its *terminus post quem*, shown by the latest German coins. Therefore, the bulk of the more than 4000 pieces of Norwegian provenance, mostly bracteates of the one-letter type and related groups, must have been issued by King Sverre Sigurdsson (1177–1202), probably in the later part of his reign. The time of King Sverre, and not that of his opponent Magnus Erlingsson (1161–1184), must therefore be the date of the hoard of coins from the mass grave in Bryggen between the quay and Mariakirken.

In a recent study of the late twelfth century Norwegian coinage, the present writer has drawn this conclusion (Skaare 1982, 93-109).

King Sverre Sigurdsson seems to have begun his coinage shortly after 1180 (c 1181) by issuing pennies to a standard of c 0.44 grammes. We can sort out three types of coins of the penny weight group but they seem to have been subjected to an increasing practice of cutting the pieces into halfpennies and farthings. At the same time the silver content was declining from above 90 percent Ag down to about 50–60 percent Ag (according to analyses by neutron activation). The smaller bracteates, among the smallest coins ever known, grouping around the weights of 0.12 and 0.06 grammes respectively, must have been issued – nominally – as halfpennies and quarter pennies. Even within the bracteate types, we have observed by means of analyses that some of the latest types have a silver content of c 60 percent Ag, against the usual level of c 90 percent Ag. The conclusion must be that King Sverre made an attempt to issue pieces corresponding to the «weighed penny» of the Norwegian silver weight system. It seems that he failed to maintain this coin standard, established as it was some hundred years before. Thirteenth century Norway inherited a coinage, where small bracteates (quarter pennies) were the only pieces struck, until the reign of Magnus Lagabøter (1263–1280).

HOW DOES OUR HOARD OF COINS FIT INTO THIS PICTURE?

Compared with the huge Dæli hoard, a parcel of some 94 bracteates must be regarded as a modest sum of money. On the other hand, the Dæli find was quite a unique hoard, the most numerous medieval hoard ever found in Norwegian ground. Do we have finds parallel to the Bryggen hoard?

Within the same district as Dæli, in the surroundings of the medieval and present town of Hamar, a small hoard has been found consisting of 60 pieces of the same kind of bracteates. This hoard was found in the parish of Vang, Hedmark, possibly in the grounds of the vicarage, according to some notes written in 1707 by Rev Nils Sverdrup, the parish parson (Skaare 1979, 13-25). From Birkeland in Birkenes parish, Aust-Agder is reported a find of «20 - possibly more - bracteates of the same kind as the Dæli bracteates», discovered c 1845 (Holst 1936, 15, no. IV 5).

Twenty years later, in 1865, a larger find consisting of nearly 600 bracteates was unearthed in Trondheim Cathedral at the southeastern corner of the transept. These coins, found with a silver buckle, were situated nearby or beside a skeleton («ved Siden af et Skelet»). At a depth of c 1.5 meters («2 1/2 alen») this is most probably the components of a grave, which makes the parallel with the Bryggen hoard even closer.

The bracteate find from Trondheim Cathedral was published by C A Holmboe in a short paper read in September 1866 to the Norwegian Academy of Science and Letters (Holmboe 1867, 281-84). Professor Holmboe, who since 1830 had been the director of the University coin collection at Christiania (Oslo), had also in 1841

TABLE 3

Crowned bust to right (two varieties)			10 specimens
Letter			223 specimens
A			1
B	(two varieties)		125
G			1
H	(one variety)		2
K	(one variety)		8
M	(three varieties)		13
N	(five varieties)		9
S	(two varieties)		24
V	(one variety)		40
			223
Cross (thirteen varieties)			143 specimens
Two or three concentric circles with or without dot in centre (four varieties)		«about»	205 specimens
		«about»	581 specimens

published the Dæli hoard (Holmboe 1841). Since about 1840 he also worked closely together with the learned amateur numismatist C I Schive on the preliminary work and studies for Mr Schive's great monograph on the medieval coins of Norway, to which Holmboe wrote a comprehensive introduction (Schive 1865).

When preparing his paper on the Trondheim Cathedral find, Holmboe had at his disposal a report on the find with drawings of the coins by C A Müller, dean of the Trondheim Cathedral School. Mr Müller also sent 71 specimens as duplicates to the University coin collection. The result of Holmboe's examination of these bracteates in original and/or from drawings may be summarized in this way, as regards types, cf Table 3.

That this Trondheim find, more than six times as numerous as the Bryggen find, is that much richer in types and varieties should not in itself be very remarkable. Moreover, we must bear in mind that in nearly a quarter of the Bryggen specimens the type could not be identified.

A striking feature of both these finds is the dominance of the bracteates with the letter B. This is the more interesting when we turn to the question of what these letters mean. Holmboe and Schive (Schive 1865, 50-60, plates VI-VII), interpreted the letters as initials, sometimes rulers' names (M = Magnus Erlingsson; G = Guttorm Sigurdsson, king of Norway 1204), sometimes mint names (A = Asloia, ie Oslo; B = either Bergen or Borg, the present Sarpsborg; K = Konghelle, near the present Kungälv, Bohuslän, Sweden; N = Nidaros, ie Trondheim; T = Tunsberg, the present Tønsberg). Some letters were given alternative interpretations, one to each of these two groups (H = Håkon Sverresson, king of Norway 1202–1204, alternatively Hamar; S = Sverre Sigurdsson or Stavanger). One letter, by Holmboe read as an uncial M (= Magnus Erlingsson), by Schive turned 90 degrees counterclockwise and read as an uncial E (∈), was by the latter interpreted as the initial of the name Eirik, indicating the archbishop Eirik Ivarsson (1188–1205). Following the death of Sverre Sigurdsson in 1202, Archbishop Eirik returned home after twelve years in exile in Denmark to reconcile himself with the successor on the throne, Håkon Sverresson.

In his 1936 survey on the medieval coinage of Norway, Hans Holst dismissed the theory of interpreting the bracteate letters as initials of rulers and mints and suggested that the principal meaning of these letters was of a magical character (Holst 1936, 93-138). However, in corroboration of this theory he could quote very few or no parallels.

Later studies of the Dæli coins suggested an earlier date than Holmboe and Schive believed. Their *terminus post quem*, «1198, possibly even 1202» was moved back to the year 1194. The absence of certain Swedish, Danish and German coins in this huge hoard speaks against the deposit being later than the death of King Sverre, which occurred in Bergen on 8 March 1202. It seems, therefore, improbable that the Dæli hoard should contain coins late enough to have been issued by the succeeding kings Håkon Sverresson (1202–1204) and Guttorm Sigurdsson (1204). The same arguments may be used against possible bracteates issued after 1202 by Archbishop Eirik Ivarsson after his return from his long exile, leaving aside the question, whether the Norwegian archbishops did coin at all before c 1220, since the earliest confirmation of their right to do so is in a letter from King Håkon Håkonsson (1217–1263), (DN III, no. 1).

The theory of the letters being initials of mint names seems to have the strongest support, even if the homogeneity in style and fabric presents a problem. There are also earlier (c 1170) and later (time of Håkon Håkonsson) examples of Norwegian bracteates struck with single letters as a main type. Certain letters, namely B, K, N and T, are the only ones continuously present. These four letters correspond very nicely with names of important Norwegian centres: Bergen, Konghelle, Nidaros, and Tunsberg (Skaare 1982, 103-104).

Let us now return to the Bryggen hoard of coins, whose contents we remember with pleasure: 65 bracteates with the letter B (70 percent of the total number, 90 percent of the specimens identified to types), the four K-bracteates, the two И-bracteates and the single S-bracteate being only trace elements. However, we also recall the strong element of B-bracteates in the Trondheim Cathedral find: 125 specimens (21 percent of the total number, 56 percent of all the bracteates of the one-letter type), while there were only 9 specimens of N («Nidaros» = Trondheim) in the find.

What does the Dæli hoard tell us about the frequency of the different types within the one-letter bracteate group? Here we must regret that the large quantities of native bracteates in this hoard led Professor Holmboe to use a system of degrees of rarity in his publication of the hoard, instead of giving the exact number for each type and variety. As hundreds of bracteates were subsequently dispersed by exchange with public and even private collections all over Europe, we are now unable to reconstruct the original number of one-letter types or of most of the other Norwegian bracteate types in the Dæli hoard.

We know that the hoard contained more B-bracteates than N-bracteates, but we cannot bring this comparison further than to say that the B-bracteates with their six varieties accounted for more than 195 specimens altogether, and that the five varieties of N-bracteates amounted to more than 92 specimens, with 165 specimens as a maximum.

The cumulative finds from church floors may give us a better indication of the frequency of these two bracteate types. These church finds have yielded 75 B-bracteates from thirteen churches (Lom, Ringebu, Høre, Ål, Uvdal, Sandar, Berg, Eidsborg, Hylestad, Hoprekstad, Kaupanger, Borgund, Urnes), while the N-bracteates are only known in three specimens from as many churches (Hylestad, Mære, Ranem), two of them, however, in the district of Trøndelag.

If we limit ourselves to a comparison of the varieties of the B-bracteates in the Bryggen and the Trondheim Cathedral finds, some interesting features appear. The Bryggen specimens are all, as far as one can see, from one and the same variety (Schive VII, 26). Five of the Trondheim Cathedral specimens are also of that very variety, but the bulk of the B-bracteates in this find, 120 specimens, belongs to another variety: B with one dot on either side (Schive VII, 27-28). This variety occurs also much more frequently in the church finds – 30 specimens from nine churches, the Bryggen variety (Schive VII, 26) being known in only one specimen from one church (Uvdal).

We may conclude this examination in the following way:
The hoard of coins from the mass grave in the Bryggen grave yard consisted of c 94 Norwegian bracteates of types associated with the coinage of Sverre Sigurdsson (1177–1202), probably in the later half of his reign. Coins of this bracteate group circulated widely in our country at this time. The somewhat odd composition, considered statistically, of this moderate sum of money may be due to local conditions, far the major part of it being coins probably struck in Bergen itself. Against this background, if the archaeological circumstances allow it, we would prefer to explain this find as a sum of money which was – incidently? – buried with

its owner and not a hoard of savings which was deliberately deposited in the graveyard.

A runic inscription from the Bryggen area[8] may have some relevance to this chapter of the Bergen coin history. This inscription, cut on a stick that was found above a layer of timber from a construction built after the 1198 fire, runs:

þorkœll myntœre senter þer pipar or in standard Norse: *þorkell myntari sendir þér pipar*

Translation:

«Torkjel the moneyer sends you pepper»

There is every reason to believe that this moneyer Torkjel was operating in Bergen. However, the spelling of his professional title, *myntœre* for *myntari*, indicates that the person who cut these runes was from Eastern Norway. A moneyer with his specialized skill, we can imagine, would from time to time be called in from other regions of the country - or even from abroad - to perform his work in the king's service when required. These circumstances could also, to a certain degree, explain the homogeneity of coins struck at different mints.

Some epigraphic elements in this runic inscription, for instance the dotted letter ᛔ for the sound *p* and l for ᛐ for sound *d* - speak for an early date, back to the late 1100's. The moneyer Torkjel of Bergen can therefore be associated with the Bergen issues in (the later part of) King Sverre Sigurdsson's reign. It may be worth mentioning, even if it is perhaps nothing more than a mere curiosity, that the B-bracteates of that period also include ᛔ, dotted in the same way as the rune B, see Schive VII, 29-31.

Torkjel - if we have been correct in placing him chronologically - was not the only moneyer of King Sverre. In Sverre's saga there is a reference to a moneyer Hagbard, who was celebrating his wedding in Nidaros/Trondheim in November 1181[9].

Among the finds from Bryggen there is another runic inscription which has a bearing on the monetary history of this period. On a stick of wood found under the level of the 1248 fire in the tenement of Søndre Engelgården this inscription was carved:

G(oldit): Bárðr: trauðan halfan annan eyrir. Vidi. Heinrekr: tvær ertogar. brek í. Vidi. Ingimundr sauðr: halfa þridju ertog. Vidi.

Translation:

«Paid: Bård: scarcely one and a half *øyre. Vidi.* Henrik: two *ertog*, debased (underweight). *Vidi.* Ingemund the sheep: two and a half *ertog. Vidi.*»

These payments were sums of money called in by a collector who then presented the account to the person who had assigned the task. The latter has written his *vidi* as the receipt for each sum, even though two of them were apparently somewhat reduced.

The first entry was probably paid in weighed, non-monetary silver. The word *trauð*, meaning «scarce», indicates that Bård had paid a little less than the intended sum of one and a half *øyre*, c 40.2 grammes of silver. Henrik, who from his name may have been a German, paid two *ertoger*. In weighed silver that would have given 17.8 grammes. But the additional expression *brek í*, meaning «in fraud» or «treacherous», probably suggests that the silver in question had been debased. We would therefore prefer to regard this sum of money as paid in coins, but in coins struck from an alloy where the silver had been debased by adding copper to it. Among the latest bracteate types of Sverre Sigurdsson there are some that were struck with a silver content of only c 60 percent Ag. The earliest bracteates of Håkon Håkonsson (1217–1263) had a silver content of about the same level, but fairly soon the silver content of Håkon's bracteates had dropped to c 30 percent Ag as an average (Skaare 1970b, 23).

The third man, Ingemund the sheep – whether his cognomen is supposed to indicate his intelligence or his kindness, we do not know – paid a sum, about which the collector had nothing to complain. It is difficult to say whether he paid in silver or in coins. If he paid in coins, it may be of some interest to notice that it would amount to some 50 pennies – or some 100 halfpennies. That is a sum very close to those 94 mainly halfpennies that the bracteate group from Mariakirken's graveyard appeared to contain.

Generally, the medieval currency both in Bergen and elsewhere in Norway seems to have been a combination of coins and non-monetary silver. Some figures to illustrate this – quantified, in proportion and even with some regional differences – can be established from the 1327 account of sexennial tithe *(denarii Sancti Petri)* to the Holy See (Munch 1864, 19-24). In this account kept by the papal collectors in Norway the different kinds of payment are even evaluated in *parva pecunia Noricana* or «small Norwegian money». The proportion in value of the different kinds of payment within each diocese, therefore, is fairly easy to express. Here the figures are arranged in a table.

TABLE 4

Diocese	Total census	I % «Small Norwegian money»	II % «(Non monetary silver)»	III % Other means of payment	Remarks on III
Oslo	5082½ mark ½ øre	67	10	23	English sterlings: £185 6s 4d
Hamar	1553 mark	99	1	–	
Nidaros (=Trondheim)	4208 mark 2 øre	46	52	2	Gold, walrus teeth, 9 leather belts and 1 silk belt
Bergen	2700 mark	84	13	3	80 golden florins
Stavanger	1494 mark (but only 518 mark 3 øre were paid in the first hand)	100	–	–	
Total	14957½ mark 2½ øre (13981½ mark 5½ øre)	68	22	10	

Also within the Bergen entry the big quantity of «small Norwegian money» is overwhelmingly dominating. This vast amount small Norwegian coins of bad silver content (c 25 percent) weighed nearly half a ton (c 485 kgs) compared with some 20 kgs of non-monetary silver and the c 280 grammes of gold that the florins are supposed to have contained altogether. We must regret that the Norwegian coins are not specified any further. Even so we think we are not far from the truth in assuming that there may have been something close to one million pieces. A sum of money where the coins are much better specified, partly even down to the very type, is recorded in a Bergen diploma of 20 September 1305 . The text refers to (a part of?) a septennial (1294–1300) tithe, *denarius Sancti Petri,* collected by the late bishop Narve of Bergen. The crucial paragraph runs:

> *«--inprimis de subtili moneta Vagha sylfr dicta quinque marchas et sex oras ponderis Noricani. item in grossis Erici septem marchas ponderis ejusdem, item in obolis nigris et quadrantibus ejusdem, ducentas sexaginta tres marchas cum dimidia ponderis ejusdem, item in albis rosatis sex oras cum uno solido, ponderis ejusdem, item in nigris coronatis sexaginta sex marchas ponderis sepedicti.--»*

If we put this sum of money into a table, the details become more evident. The Latin denominations have been translated and the weight in metric units have been added, together with an estimate of the number of specimens within each group.

TABLE 5

Denomination		Old Norse weight Kgs	Estimated number of specimens
subtilis moneta/Vagha/sylfr[10] («light money»/«weighed silver»)	5 mark 6 øre	1232	4100
grossi Erici[11] («groats of Eric»)	7 mark	1500	1150
oboli nigri[12] *et quadrantes*[13] *ejusdem* («black halfpennies and farthings of the same»)	273 1/2 mark	56373	53600
albi rosati[14] («white rose pennies»)	6 øre 1 solidus (ertog)	0169	280
nigri coronati[15] («black crown pennies»)	66 mark	14145	10800
	353 mark 1 ertog	73419	123530

This very important source to the numismatics and the coin history of King Eirik Magnusson (1280–1299) will not be explored to its full extent here. We simply present it here as an example of coins being physically present in Bergen at the end of the thirteenth century and suggest that they may reflect the coin circulation within the whole Bergen diocese.

TABLE 6

COIN FINDS FROM BRYGGEN

Inv no.			
111	«Coin, copper, Danish»		
813	«Coin»		
814 (a)	German casting-counter (*Rechenpfennig*) Nuremberg, by Jörg Schultes, master 1515, died 1559		
(b)	German casting-counter (*Rechenpfennig*) Nuremberg, by Hans Krauwinckel, c 1580-1610		
(c)	French or German casting-counter (*Rechenpfennig*) Stamp completely worn out		
	Previous inv no.	No. in Univ Coin Coll's letter of 15.6.1956	
	K 2051	4	French or German casting-counter
	K 2053	9	(*Rechenpfennig*), Stamp completely worn out
	K 2054	1	German casting-counter (*Rechenpfennig*) Nuremberg 16th century. No master signature
	K 2058	5	French late-medieval casting-counter (*Rechenpfennig*) of *Fleur-de-lys* type
	K 2060	8	French casting-counter c 1450-1550 Crowned shield of Fleur-de-lys
	K 2061	10	French late-medieval casting-counter of the *Chatel-tournois* type
	K 2063	11	French late-medieval casting-counter. Shield of *Fleur-de lys*
	K 2064	16	French late-medieval casting-counter. Shield of *Fleur-de-lys*
	(K 2065	12	Spangle)
	(K 2066	13	Seguin or Spangle, probably French work)
815	German casting-counter (*Rechenpfennig*) Nuremberg, 16th cent No master signature		
816	French late-medieval casting-counter *Chatel-tournois* type		
817	French late medieval casting-counter *Fleur-de-lys-square* type		
857	«Coin»		
23003	«Silver coin»		
23004	«Silver coin»		
23005	Brandenburg-Franken, Margrave Frederik the Elder of Ansbach (1495-1551). Gulden 1512		

817	French late medieval casting-counter *Fleur-de-lys-square* type	
857	«Coin»	
23003	«Silver coin»	
23004	«Silver coin»	
23005	Brandenburg-Franken, Margrave Frederik the Elder of Ansbach (1495-1551). Gulden 1512	
24853	«Casting-counter»	
25537	Imitation of English penny («sterling») of the Edward type of 1279-1344. Pierced *o* near the centre	
52425	«Coin»	
59919	Roman Empire. Claudius II Gothicus (268-270), Antoninian	1.887 grammes
64995	«Skilling of 1655»	
66678	Denmark, Erik of Pomerania (1396-1439) Gros 1430's	
68474	Denmark, Christopher of Bavaria (1442-1448) or Christian I (1448-1481), Hvid	
68480	England, Edward I-III (1272-1377), Penny («sterling») of the 1279-1344 type (or some Continental imitation of the same)	
68641	«Coin (of silver?)»	
68642	«Coin (of silver?)»	
68760	«Coin (of silver?)»	
68761	«Coin (of silver)»	
71948	German casting-counter (*Rechenpfennig*), Nuremberg, by Hans Krauwinckel, c 1580-1610, Barnard, 214, no. 36	
73386	Norway, Sverre Sigurdsson (1177-1202), 94 bracteates (halfpennies?): Schive VII, 26 (65 specimens), Schive VII, 32(4), Schive VII, 45(2), cf Schive VII, 1(1), not identified to Schive variety(22). Found stuck together in a lump in the remnants of a purse in a mass grave, see pp xx-xx	
75823	Unidentified coin, Late medieval or Early Modern? Diameter 22 millimetres, weight	0.968 grammes

75965 (a)	Norwegian Archbishops, Olav Engelbrektsson (1523-1537), Skilling, Schive XVIII, 20, Schou 3	1.854 grammes
(b)	Norwegian Archbishops Olav Engelbrektsson (1523-1537), Skilling, Schive XVIII, 2, Schou 8	1.421 grammes
(c)	Denmark, Fredrik II, Two skilling 1561, Schou 4, Hede 11	2.090 grammes
(d)	Schleswig, Johann Adolph, 1/64 Taler 1596, Lange I, 308 var	1.070 grammes
(e)	Lübeck, Sechsling 155x, Jesse	1.119 grammes
(f)	Wismar, Sechsling 154x, Grimm 496, var	0.997 grammes
(g)	Mecklenburg, Johann Albert, Doppelschilling 1552, Cf Evers II, 79, Pierced *o*	1.937 grammes
76118	Lübeck, Before 1379, Viertelwitten, Jesse 312	0.237 grammes
76144 (a)	Dorpat, Bishop Dietrich III Damerov (1379-1400), Artig 1390-1400, A Molvygin, Nordisk Numismatisk Årsskrift 1969, 43, Plate I, 18	0.778 grammes
(b)	Denmark, Erik of Pomerania (1396-1439), Næstved, Sterling c 1405-20, Lindahl 16-31, Galster 4	0.387 grammes
76158	Denmark, Erik of Pomerania (1396-1439), Bracteate («Hole penny») c 1405-20, Lindahl 33, Galster 5	0.237 grammes
76173 (a)	Reval, Beginning of 14th cent, Artig, Voionmaa, fig 20	0.150 grammes
(b)	Gotland, Gote 1420-40, Lagerqvist, C, 4	0.332 grammes
(c)	Denmark, Erik of Pomerania (1396-1439), Lund, Sterling c 1405-20, Lindahl 7, Galster 9	0.515 grammes
87523	«Coin»	
88058	«Bracteate (coin)»	

Leaving aside the hoard of 94 bracteates from the mass grave, the total numismatic harvest from the Bryggen excavations seems to amount to not more than some fifty pieces. Some of these pieces are still in need of further identification but we can already see that at least one third of this total consists of pieces that are not ordinary coins. They are so-called casting-counters or *Rechenpfennige* to use the German expression or *jetons* in French. These pieces were primarily intended for use on the counterboard in order to do calculations and arithmetical operations in a quick and practical way. This was an old system inherited from antiquity where it had been developed for calculating with Roman numerals[17]. Casting-counters were produced at several places but fairly soon the German town of Nuremberg became the centre for their manufacture. Here regular dynasties of *Rechenpfennig*-makers arose. The first to sign his products was the Nuremberg master Jörg Schultes c 1520. Both he (814 (a)) and Hans Krauwinckel (814 (b) and 71948), the most prolific of the Nuremberg masters, are represented in the Bryggen finds.

In a paper published in 1943 Hans Holst gave a survey of the Norwegian finds of casting-counters known at the time (Holst 1943, 140-50).

From the geographical distribution of these 50 finds we can see that such pieces have been present in all parts of the country, even if they are most frequently found in towns, especially in Oslo[18] and Bergen (Holst 1943, 147-49 nos 35-41). At both these places, it seems likely that the counter board and casting-counters were in extensive use. However, we may not exclude the possibility that the casting-counters under certain circumstances could even have attained the status of money. We know of separate examples among the rich series of coins from beneath our church floors[19] and they also occur in other connections where they may have played a role as coins (Holst 1943, 145 no. 25, 147 no. 31, 149 no. 45. Cf Rønning 1981, 211).

The ordinary coins from the Bryggen finds are not able to give any adequate account of the Bergen coin history. Apart from the B-bracteates from the mass grave hoard with their possible Bergen origin, no Bergen striking has so far been identified among the Bryggen finds. From extant series preserved in Norwegian and foreign collections we know of the following issues from the Bergen mint:

Eirik Magnusson (1280–1299): pennies[20], farthings[21] c 1280-85

Håkon V (1299–1319): pennies[22]

Hans (1483–1513): guldens[23], skillings[24], halfskillings[25] and hvids[26],

Frederik I (1524–1533): skillings[27], hvids[28] c 1527/28, skillings[29] 1530

Christian III (1536–1559): skillings[30] 1537

Frederik II (1559–1588): hvids[31] 1574-78

Even when we turn to the question of coin circulation the Bryggen finds provide little in the way of new information. We cannot be satisfied by the information given by the Bryggen finds. The Roman antoninian (59919) is certainly a secondary find in this context, a mere curiosity from far more recent times. As for the important influx of foreign coins into Norway during the Late Middle Ages and Early Modern Period, the Bryggen finds give us some slight indications.

From the written sources as well as from Norwegian finds of the coins themselves we know that English pennies, under the name of *sterlings,* were a leading means of payment and even a standard of money reckoning in this country from the late thirteenth century and for the next hundred years. We are left with traces of this development in the Edward penny (68640) and the imitation of such a type (25537).

It may be of some interest to notice that the largest Norwegian find of these English pennies came from the island of Havnøy, Rødøy, on the coast of Nordland[32]. This hoard of 188 pennies (three Irish, three Scottish and four Continental imitations included) deposited c 1255 is supposed to have reached this little northern island via Bergen (Skaare 1960, 23, 29).

When the Norwegian mints were reopened by King Hans (1483–1513), they had most probably been idle for a hundred years or so. In this period coins from

Denmark, Sweden (with Gotland) and Northern Germany (with the Baltic territories), mostly coins of inferior silver and of the lower denominations, came into circulation in Norway (Skaare 1982, 136-46).

Representative for this import are five Danish coins – the four from Erik from Pomerania (68385, 76144(b), 76158, and 76173(c)) and the *hvid* from Christopher of Bavaria/Christian I (68474). Further, we have the Gotland coin (76173(b)), the earlier Lübeck one (76118) and the two Baltic strikings (76144(a) and 76173(a)). From the find circumstances these coins even seem to have been partly associated with each other.

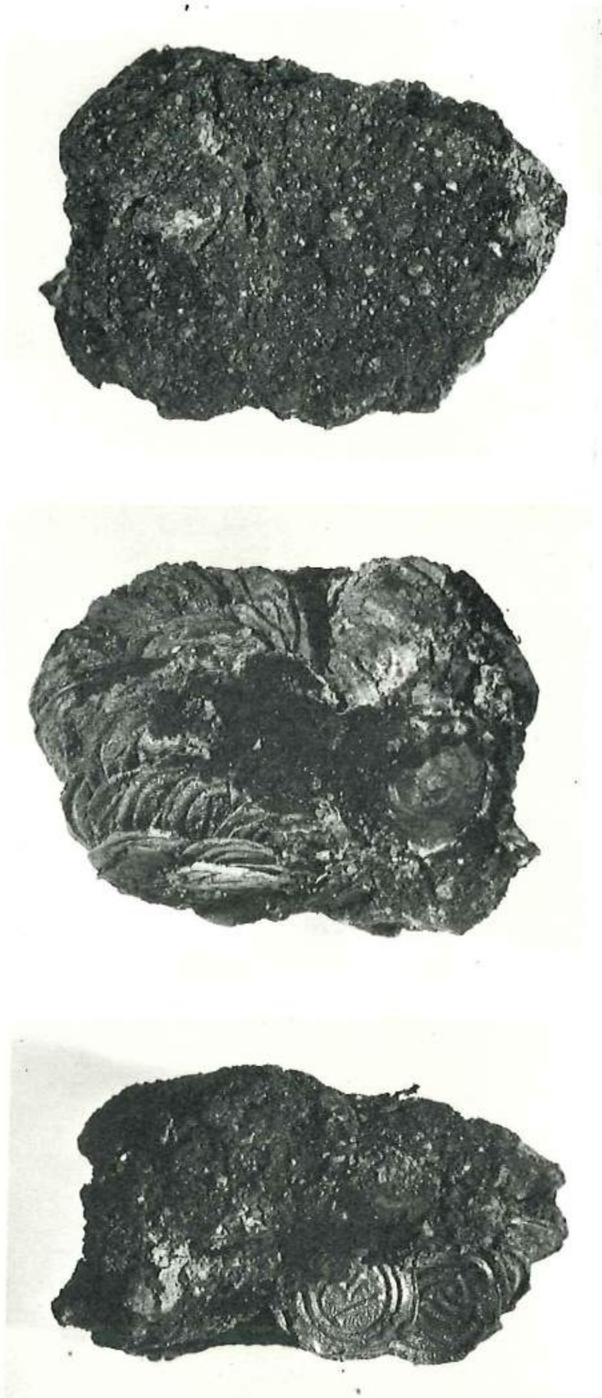
Gold coins played an important part in late medieval commerce and coin reckoning. From the later part of the fourteenth century the English *noble* and the Continental *gulden* were the most important coins of this category in Northern Europe, even if several French gold coins also made themselves felt. Within the Bryggen finds we are left with our single gold coin, the Brandenburg-Franken gulden of the year 1512 (23005 or 813?). From ten previous Bergen finds we know of 92 guldens altogether (Holst 1938a, 89-108, 103-105), among these the largest Norwegian find of such coins – 63 guldens of Utrecht (Bishop David of Burgundy, 1455–1496) found in a jar or pot in Bergenhus castle in the year 1900 (Holst 1938b, 104 no. 63). Another hoard, from Strandgaten 14, contained 21 guldens struck in the period 1410/37–1525 (Holst 1938c, 104-105 no. 166).

Even the period between the 1536/37 Reformation and the opening in 1628 of the Christiania (Oslo) mint to strike coins in silver from the recently discovered Kongsberg mines was a time when Norwegian mints were mostly inactive. The exceptions were two short coining periods, the first at Skien (Gimsøy) 1543–1546 (Hede 1964, 111 Christian III, nos 1-4) the second in Bergen 1574–1578 (cf Note 25). No wonder that in this period foreign coins were also widely used in Norway. In this connection it is of interest to look at the seven coins of the entry 75965.

Here two pre-1537 Norwegian coins are associated with five other later coins of approximately the same size, one Danish 1561 and four German 154x-96.

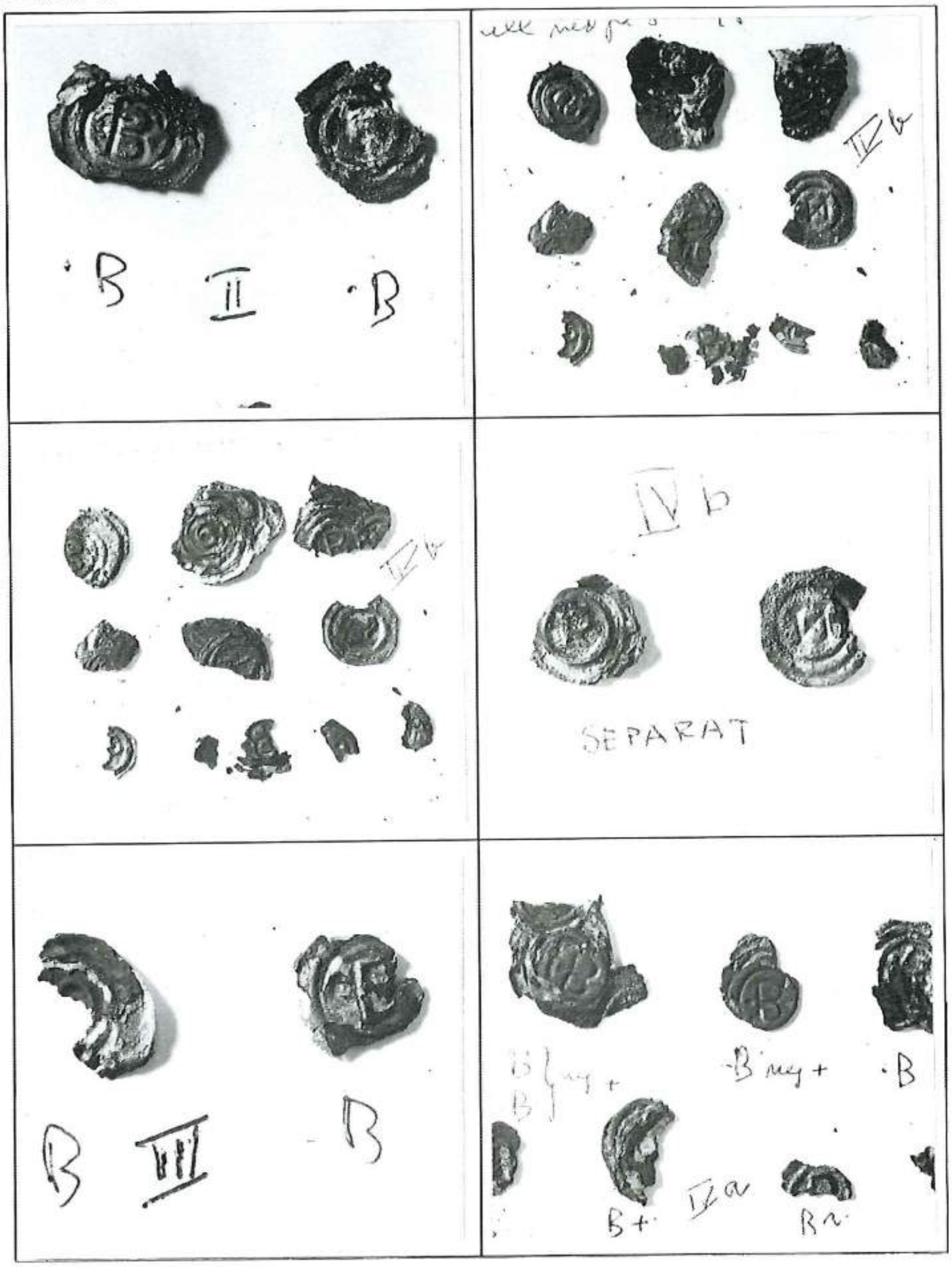
The two latest coins in the whole population, the (Danish or Norwegian?) skilling 1685 (64995) and the Danish copper skilling 1771 (66678, cf also 111), do not call for very much comment. Both were very common, current coins in Denmark and Norway. We have almost the right to expect them statistically to be represented among these finds.

PLATE I

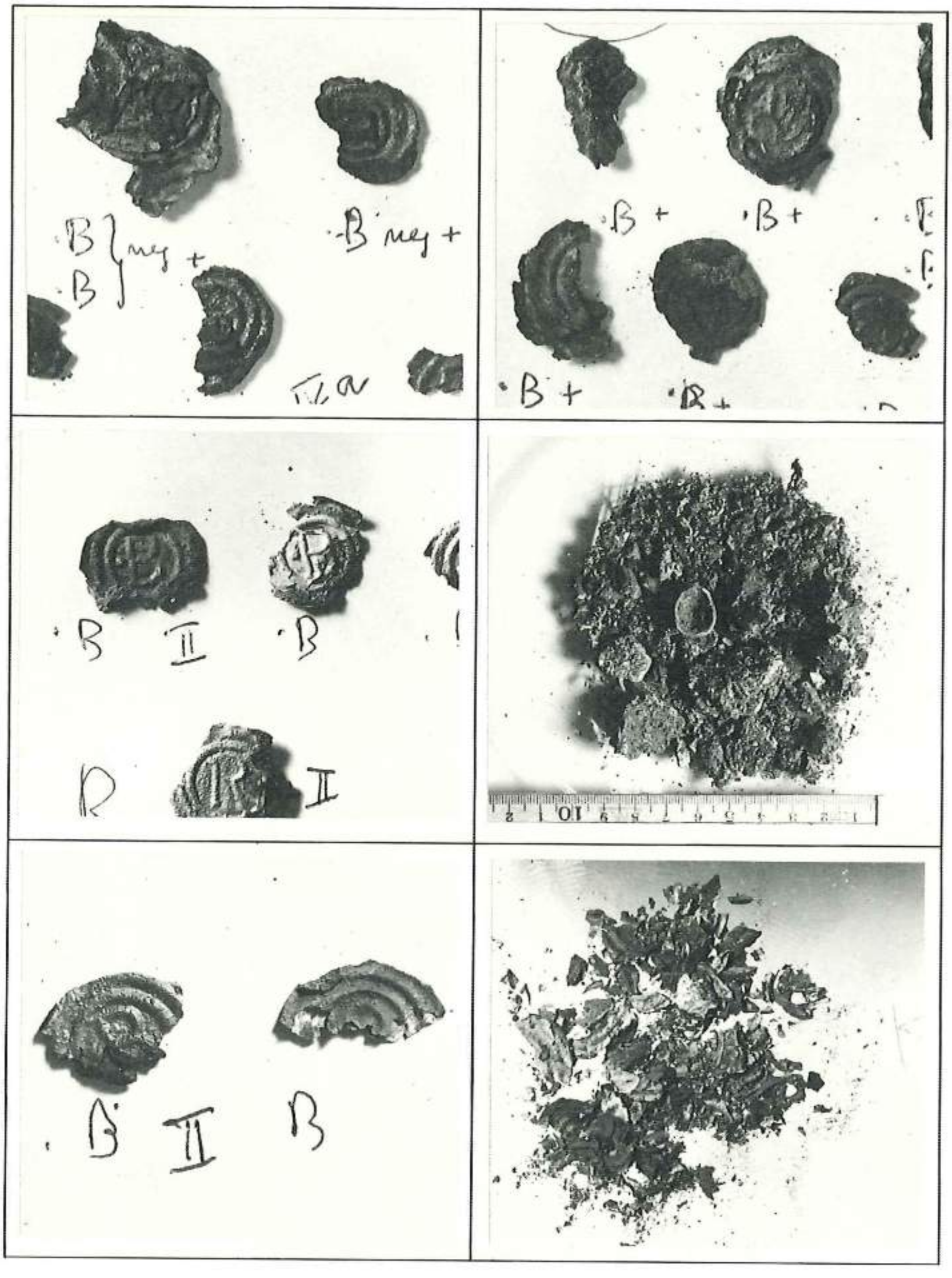


The clump of coins found in a grave at Bryggen

PLATE II



Coins and coin fragments from the clump



Coins and coin fragments from the clump

PLATE IV

NOTES

1 Skaare, K 1978 113-30

2 Skaare, K, 1965, 92-102

3 Skaare, K, 1969, 63-70

4 Skaare, K, 1970, 244-58, 255-57

5 Detaljert fortegnelse over funnmyntene, i Universitetets Myntkabinetts arkiv

6 Skaare, K, 1970, 251-53

7 Holmboe, C A, 1841, Cf Holst, H, 1936, 5-26, 14 no. 1

8 Dr Ingrid Sanness Johnsen, Oslo, who is working on this group of runic inscriptions in the Bryggen find material, has kindly allowed me to read the appropriate parts of her manuscript. The epigraphical and linguistic arguments here are taken from her study

9 Sverris Saga, from Cod AM 327, 4°, ed Indrebø, G, 1920, chapter 62, 6-13

10 Bracteates, probably of the crowned bust facing-type, Schive XI, 72-78, XII, 1-17, 19, 26-37

11 Heavy pennies, of the sterling type (Schive IX 10-15) and/or more probably of the coat-of-arms type (Schive IX, 24-28)

12 Halfpennies of the coat-of-arms type, Schive IX, 29-34

13 Farthings (quarter pennies) of the coat-of-arms type (Schive IX, 35-6), perhaps also of the sterling type (Schive IX, 16-8)

14 Pennies of higher silver content (c 50 percent Ag) and with a rosette in reverse cross angles (Schive IX, 19-23)

15 Pennies of lower silver content (c 10 percent Ag) and with a crown on the obverse (Schive IX, 37-40)

16 In this catalogue the following reference works are cited:

Barnard, F P, 1916

Evers, C F, 1797-98

Galster, G, 1972

Grimm, E, 1905

Hede, H, 1964

Jesse, W, 1928 und 1967

Lagerqvist, L O, 1970

Lange, C, 1908-12

Lindahl, F, 1957, 73-92

Molvygin, A, 1969, 37-65

Schive, C I, 1865

Schou, H H, 1926

Voionmaa, J, 1945

17 Barnard, passim

Holst, H, 1943, 139-72

Cf Rønning, B R, 1981, 211-17

18 Holst, H, 1943, 141-45 nos. 11–24; Skaare, K, Myntfunn fra Gamlebyen (in press); For a find of 37 casting-counters (1554/1601-1677/68, 1650/70) with their original container from early Christiania, See Rønning op cit

19 Holst, H, 1955, 4 (Rødenes Church, Østfold), 7 (Hedal Stave Church, Oppland), 26 (Trondheim Cathedral); Skaare, K, 1969, 63-70, 67 (Kaupanger Stave Church, Sogn og Fjordane); Skaare, K, 1968, 238-52, 281 (Dønnes Church, Nordland). Among the coin finds from Ringebu Church, Opp land, not yet published, there was also one Nuremberg casting-counter

20 Schive IX, 10-13

21 Schive XVIII, 27 (only one specimen known)

22 Schive X, 35-39, 7-10

23 Nordbø, J H, 1968, 5-6, 51 (only one specimen known)

24 Schou 92, Galster 148

25 Schive XIV, 1-2, Galster 149-50

26 Schive XIV, 3-4, 6-11, Galster 151-54

27 Schive XVI, 14-17, Galster 170

28 Schive XVI, 18, Galster 171

29 Schive XVI, 8-10, Galster 169

30 Schive XVII, 10-13, Galster 176, The year (15) 33 on the same type, cf Galster 176, must be a 'misprint' by the die-engraver

31 Hede, III, Fredrik II, no. 1

32 Skaare, K, 1960, 7-29

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ABBREVIATIONS

DN	Diplomatarium Norvegicum
NNÅ	Nordisk Numismatisk Årsskrift

The Hair Products

BY ELLEN SCHJØLBERG

INTRODUCTION

From the excavations at Bryggen in Bergen we have nearly 340 finds of hair products, here defined as animal skin fibre products other than those made of sheep wool. Some parallel finds made from sheep wool will be mentioned for their relationship to the hair products. Otherwise these are very characteristic find groups, nearly exclusively made from hair, specially the textiles, the braided cords and the coarsest caulking cords.

Nearly all the finds are fragments found here and there in fillings and rubbish, and they are spread both in time and space throughout the excavated area without any system, except that they are strikingly more numerous in the Later Middle Ages than earlier, when compared with the time distribution of comparable find groups from Bryggen, such as sheep wool textiles and bast ropes.

THE FIBRE MATERIAL

The fibre identification work is based on the standard book of Wildman (1954) and a collection of modern animal fibres. The method used is the basic one with preparations of whole mounted fibres on glass slides for microscopic examination of the diagnostic features revealed by the profile picture of the fibres. No cross sections of the fibres and very few casts of the fibre cuticular scale pattern were made. This has worked satisfactory for most of the finds, namely those which clearly are made from goat hair. For the rest of the finds this technique cannot determine whether the fibres are goat hair or the nearest possible alternative which from the general fibre structures would seem to be cattle hair. For some loose hair finds other fibre types could also be possible. Other methods will later be applied to these finds.

In practically all the fibre preparations from the different finds, long and slender fibre tip ends are present on a lot of the fibres. In most of the preparations there are also intact root ends, but usually relatively few in each preparation, and more often on coarse hairs than on finer ones.

The root ends show different grades of condition. Quite usual is the club/brush-like form, specially on the coarse hairs. This is the natural form and shows that the actual fibre has been shed by natural shedding (Ryder 1966, 1978). In relatively few of the preparations the fibres have typical narrow tapering root ends, which is the form they get when they are pulled from the skin of a dead animal (Ryder 1966). The root ends in quite a lot of the finds have less typical forms, more or less reduced, and usually most of the fibres have no root ends. The presence of root ends is easily seen in the preparations because they are usually stained a strong reddish brown colour by the humic acids, very much stronger than the hair shafts.

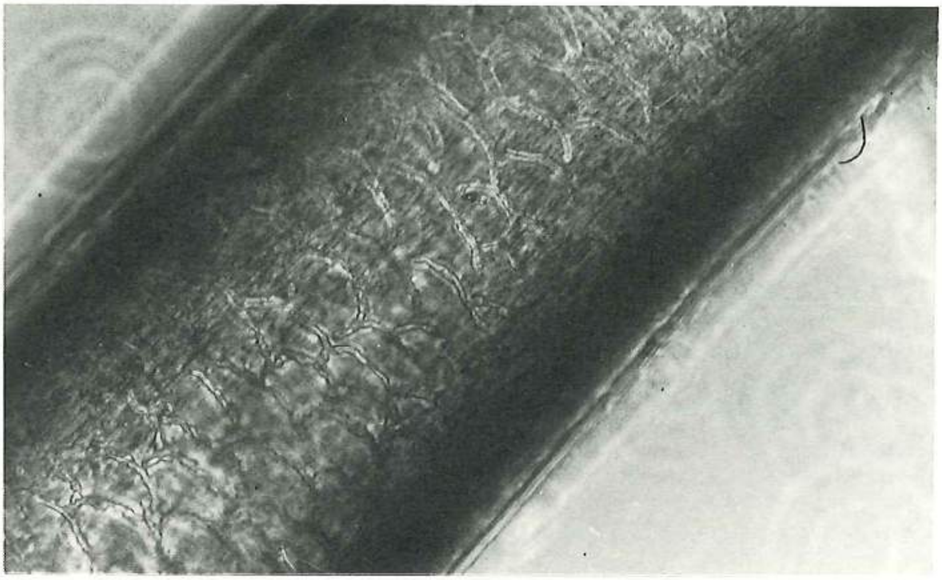

Fig 1 Goat hair kemp ca 90 microns thick. The wall pattern of the medullary spaces is clearly seen under the thin streaky cortex. The outer shell structure is not seen. Phase-contrast photo from textile no. 16274a (K Krzywinski)

Their presence shows that the hair was not cut from the skin of the animal.

In all the preparations the variation in diameter from fibre to fibre is very great. Also the content and diameter of *medullae* vary considerably among both coarse fibres and fine ones. It is quite usual to find that dark pigmented fibres have relatively narrower medullae than light ones.

The pigmentation of most of the fibre material is estimated as sparse-to-medium; only a few finds are dominated by highly pigmented fibres.

To the eye the fibre material looks homogeneous in each find (except some of the caulking cords) but varies slightly from one find to the next.

The raw material had not been too well prepared before use. Even in some of the textiles it is possible to find tufts of fibres with their root and tip ends still assembled in groups just as they came from the animal fleece.

The identification of the goat hair material is based on the presence of kemps (usually unpigmented very coarse and often ribbonlike brittle fibres) and other coarse hairs. While the coarse hairs usually have wide latticed medullae (longitudinal central structures with gas-filled spaces) – often wider for instance than in cow hair, this is always the case with the kemps. The profile pattern of the medullary spaces, when well developed, is very characteristic for just goat hairs, and they are easily recognised when the mounting medium used in the preparation penetrates the spaces and makes them transparent (fig 1).

The brittle kemps are often present as broken pieces between finer fibres, and this is a great help in the identification of such material, particularly for the textiles where the finer fibres have often been preferred, while the coarse outer coat hairs are more sparsely present. In most of the medullated fibres the medulla pattern is not so characteristic and has often completely collapsed.

Other features of diagnostic value are the cuticular scale pattern, a rather streaky pigment distribution,and the cortical cell layer which is often visible as strong longitudinal striations under the cuticula in light pigmented fibres. Small tufts of extremely fine bottom wool down to 8 microns in fibre diameter are also indicative for goat fibre material. On the other hand there are seldom signs of the granulation so typical for cow hair medullae. But these small details are difficult to interpret correctly on fibres which are seldom in really good condition, and the question will be kept open so far for the finds without typical coarse fibres. Further comments on the fibre types will be given under the different find groups.

UNWORKED HAIR MATERIAL

Skin pieces

Ten of the fourteen finds are small pieces of fell with solid skin bottom. No. 38996 is a little bundle about 8 cm in diameter of small fell pieces tied around with a leather strip. Four finds are scrapings looking like fell pieces but with very thin and fragmentary skin bottom, probably waste from leather production.

Most of the finds consist of more than one fell piece, with sizes from a few centimeters in each direction up to 32 cm x 14 cm. Nos 24690 and 25781 are both full of tar between the hairs, still black and sticky. They may have been used during work with tar.

Nine of the finds are goat skin and two are goat skin scrapings. Most of them seem to have been blackhaired with dark or lighter pigmented bottom wool. A few must have been grey and one piece has very light pigmented fibres with black tips. The hairs are up to 8 cm long. One little piece is dominated by bottom wool and may come from the animal's belly. One piece is nearly free from bottom wool and the rest of the skin pieces are dominated by coarser hairs. Only one preparation from these eleven goat skin finds shows a high content of unspecific fibres.

There is also one piece of sheep skin and one find of sheep skin scrapings. The last find among the fourteen finds in this group, no. 77906, is a fell piece with coarse black fibres, up to 7 cm long. There is no fine bottom wool in the preparation. The cuticular scale and medullary cell pattern seem to be quite like cow hair.

Loose hair finds

Four of the fourteen finds are lumps of goat hair without any order and two finds are a mixture of goat hair and sheep wool. No. 41522 is a bundle of black horse mane hair (Wildman 1954) together with some small tufts of body hair, lightly pigmented, which could very well be horse body hairs. The last seven finds are loose tufts of sheep wool.

CAULKING CORDS

This is a group of loosely spun, and often just as loosely plied, porous coarse cords, 151 finds altogether.

Only three of them are found in connections which show their original usage, as caulking between boat planks (nos 34717, 38088, 38250). About forty finds are still

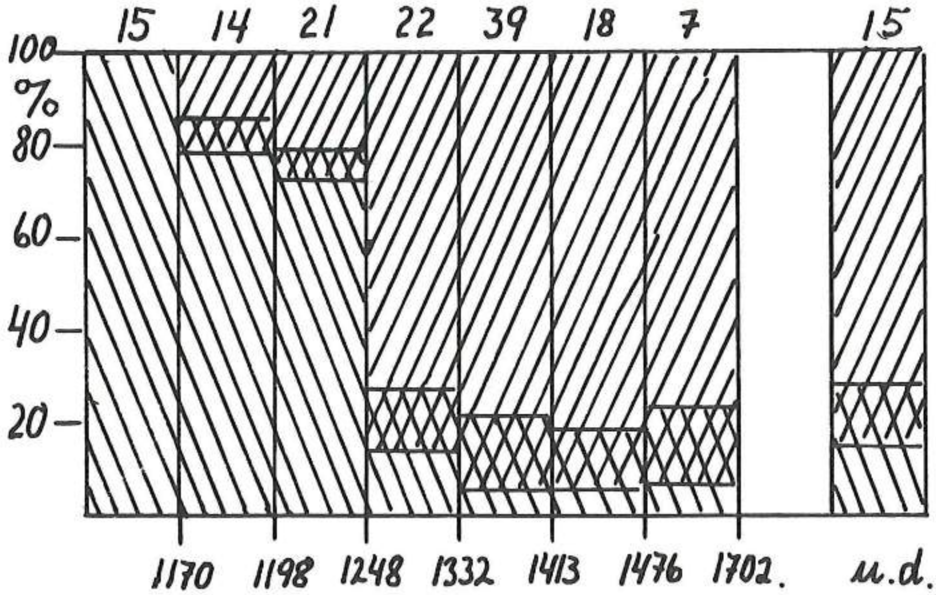

Fig 2 Percentage distribution of caulking cords of different fibre materials in the main fire intervals at Bryggen. The cross-hatched part of each column represents cords of mixed hair and sheep wool, the lower part represents pure sheep wool cords and the upper part represents hair cords. The actual find numbers are placed at the top of the diagram

pressed completely flat from use, and many of these still have tar in them. A few show nail impressions along one of the flat pressed edges, but only one find (no. 40468) seems to have had the nails straight through it. More than half of the finds show no signs of having been used.

Forty-nine of the cord finds are made from sheep wool and twenty finds from a mixture of sheep wool and hair. These 69 finds must be discussed here in contrast to the 82 hair cord finds. Fig 2 shows the distribution percent of the cords made from the different materials for the various fire intervals at Bryggen. It seems clear that the hair fibres rather suddenly take over as raw material for these products some time around 1248.

The hair material is mostly goat hair, but there is often a mixture with other hair materials, most probably cow hair. Often whole tufts of hair are spun into the cords with their root ends still assembled.

S-spin is the normal for the single yarns of the cords, only four finds are z-spun. This means that the spiral direction of the spun elements in the yarn, when this is kept vertical, conforms to the slant of the central portion of the letters S and Z. The plying direction, when two or more single yarns are twisted together, is normally the opposite of the spinning direction (Emery 1966).

Around the fire layer dated to 1248 there is a rather abrupt change in the cord type. Before this the cords were usually (85%) plied from bundles of at least three and up to ten single strands, each of which was often rather finely spun. Only seven of the fifty dated cords from before 1248 are made of really coarse strands. Three of these are 2-plied, and two of them are just single-ply. After 1248 only 16% of the

86 dated finds are plied from more than two strands. Fig 3 shows the change in the practice through the Middle Ages.

The diameter of the cords also changes from 5–12 mm before 1248 to 10–20 mm after, regardless of the number of strands involved.

In all respects the earlier cords, mostly made from sheep wool, represent a more careful and time-consuming work than the later ones. It is tempting to look at the earlier ones as traditional home craft and the later ones as a more commercialised product.

FELTS

We have ten finds of felt from Bryggen. Of these only one is made from pure sheep wool, and one from mainly sheep wool mixed with a little goat hair. Two finds are made mainly from hair with a little sheep wool in them, and the other six finds are made exclusively from hair fibres. Three of these are clearly made from goat hair and the other three look very like them. Sheep wool is considered to have much better felting capacity. There are no traces of seams or holes from threads in any of them. No. 24341b has a sharp shorn edge with a row of small perpendicular even wrinkles along it. No. 29631 has the shape of a 23 cm long sole with shorn edges. The rest of the finds, all small pieces, show clear, but never straight, cuttings along one or more edges.

The felts vary in thickness between 2.5 to 5 mm. Eight of them are about 5 mm thick, including the one made from sheep wool.

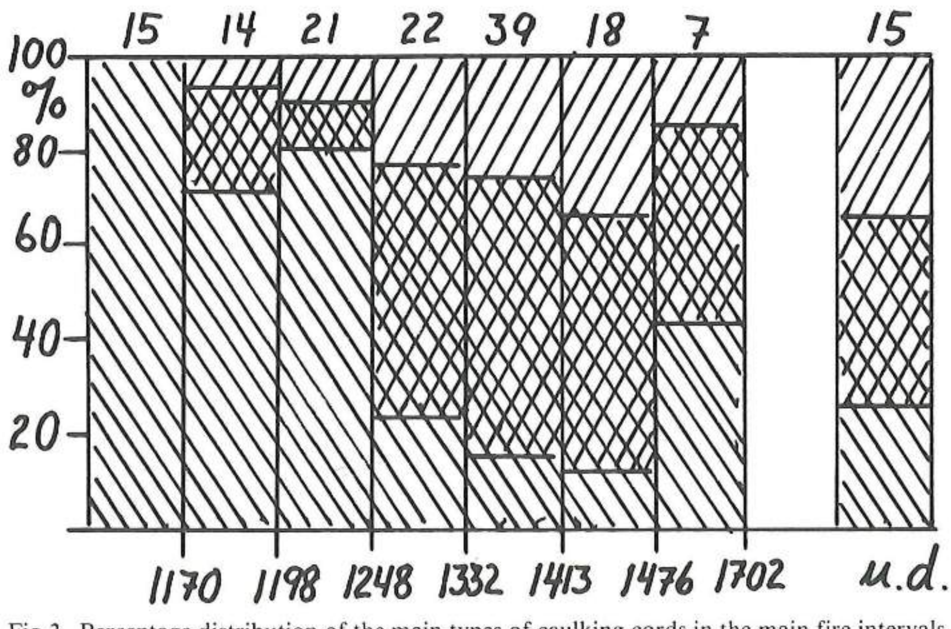

Fig 3 Percentage distribution of the main types of caulking cords in the main fire intervals at Bryggen. The cross-hatched part of the column represents 2-plied cords, the lower part represents 3-or-more-plied cords and the upper part represents single cords. The actual find numbers are placed at the top of the diagram

Fig 4 Schematic drawing of braided cord in black and white goat hair yarn bundles

YARN PRODUCTS OTHER THAN WOVEN TEXTILES

Loose yarn finds

Of the total twenty-one finds of yarns all except one are 2-plied yarns. Eleven of them are S-plied and the rest are Z-plied (See explanation under «Caulking cords»). The Z-plied yarns have diameters from 2 to 6 mm and the S-plied yarns have diameters from 1.5 to 6 mm. The single-ply yarn is z-spun and varies from 2 to 4 mm in diameter. Among the yarn products described later there is only one find with yarns as thick as 5 mm, and only a few with yarns thicker than 4 mm. So it is likely that the thicker loose yarn finds are meant as thin cords, not as elements in other products.

In quality they vary from well made and even yarns to loose and uneven ones. Some of them show signs of being unravelled textiles. Most of them are rather small pieces, but one find is 73 cm long and one find more than 100 cm long.

The fibre material is hair. Only two of the yarn finds have some sheep wool mixed into the hair fibres. Ten of the finds are made from goat hair, and the rest look very much the same, but three can possibly have some cow hair in them.

Plied cords

Six of the nine finds in this group are 5 to 8 mm thick cords made of two lengths of 2-ply yarn. Two of these finds have the yarn doubling point preserved and show that the cords were re-plied from one yarn length. Two finds are made from four lengths of 2-ply yarn.These are 10 mm and ca 13 mm in diameter.

Three of these finds are clearly made from goat hair, and three other also seem to be goat hair. Two finds can possibly have cow hair in them.

In addition to these comes no. 3034d, which is a loosely plied cord, about 8 mm thick, with fourteen finely S-spun single goat hair yarns, each about 1.5 mm thick. It is very even, and so it does not resemble the many-plied caulking cords.

Braided cords

We have eleven finds in this group, ten of them made from bundles of Z-plied yarns. The yarns are 2 to 3 mm in diameter. One find is an ordinary 3-braided cord, 15 mm thick. The rest are braidings made from 4 or 8 bundles of yarn, and they are from 10 to 18 mm in diameter. The type is shown in fig 4, where the eye is 4-braided and the rest is 8-braided, so-called four and eight strand square sinnets (Ashley 1947). This type where a 4-braided eye is preserved is represented by seven finds, all of them made from bundles of black and white yarn. Six of these are made from goat hair, and the last one looks exactly the same. In two of the other finds there can be some cow hair present, and in one there is a little sheep wool. There is also one find of 8-braiding from Bryggen made of white sheep wool. Here the yarns are S-plied.

Plaited band

Two tiny fragments in find no. 84678c have obliquely interlaced yarns along a closed edge and are most likely fragments of an ordinary obliquely plaited band. The yarns are Z-plied, about 2.5 mm in diameter and made from dark hairs, possibly goat hair.

THE WOVEN TEXTILES

General

The 193 finds of hair textiles are very different from the sheep wool textiles from Bryggen. They are strikingly coarse, and their yarns are usually of the 2-plied type in contrast to the single yarns of the other textiles. They are all in tabby weave, the simplest binding system where the threads pass over and under one thread at a time in the crossing thread system (fig 5). The textile terminology used here is adjusted from Burnham (1981).

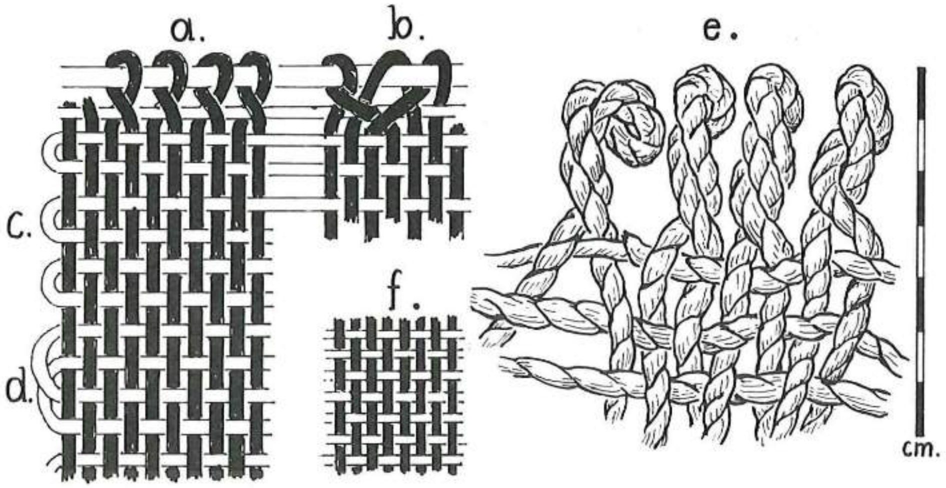

Fig 5 The hair tabby textiles. Same scale. (a, b, e) transverse selvages, (b) represents a fault, (c, d) side selvages. (a, e) Medium and coarse tabby, group A. (f) Medium tabby, group B

Most of the hair textiles are now slightly lighter and more reddish brown in colour than the sheep wool textiles. They were found here and there as stray finds in the excavations, in all the layers, and make up about 12% of the total number of textile finds. Their frequency increases in proportion to the other textiles in the later part of the Middle Ages. Fig 6 demonstrates the distribution in time of the hair textiles as a percent of the total number of dated textile finds. When we analyse the different areas of the excavations at Bryggen, we find that this picture changes a little from place to place, but the principle is everywhere the same, at some places accentuated, at other places less clear. The richest finds of textiles from Bryggen came from the deepest layers in the middle area of «Gullskoen». As an example we can look at the four grid-squares N5 + 6 and 05 + 6. From here we have 224 textile finds from before the fire in 1198, but none of them is a hair tabby, while from the layer between 1198 and the fire in 1248 we have only one hair tabby find.

The distribution problems will be taken up more thoroughly in connection with the other textile finds.

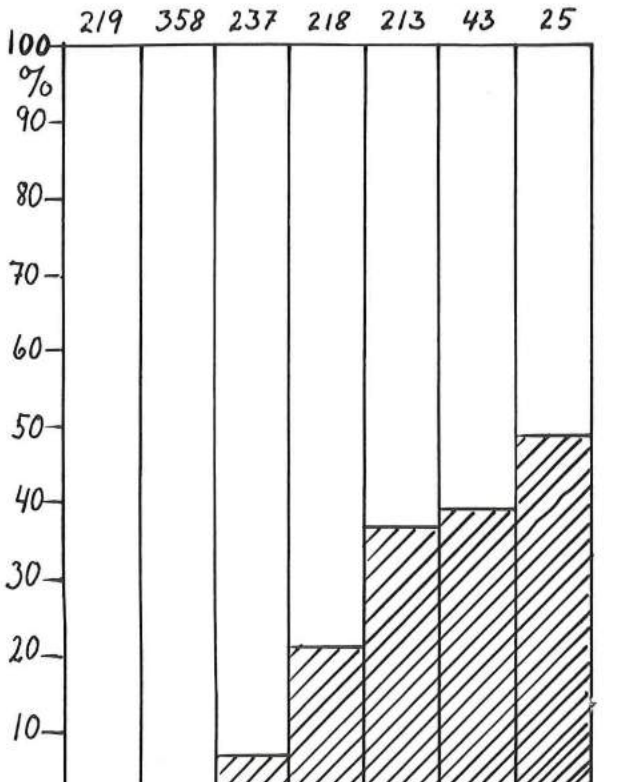

Fig 6 Frequency of hair tabby textiles as a percent of the total number of dated textiles found in the main fire intervals at Bryggen. The total number of dated textile finds is at the top of each column

Ninety-four of the hair textile finds have intact *side selvages* on one or more of the fragments. This is a much higher frequency than for the other textile groups, and can possibly mean that the type was usually rather narrow across the weave. Ten finds have both side selvages preserved. Seven of these are bands (nos 1171, 8528a, 16274a, 24341a, 27270a, 27795, 28510a), and they are from 7 to 10 cm across the weave. No. 16120 is 19 cm, no. 4932 is 82 cm and no. 8215 is 115 cm wide. Three rather big pieces with only one side selvage have minimum widths of 50 cm (no. 26864), 55 cm (no. 26207) and 75 cm (no. 28389).

Normally the weft passes directly from one shed to the next in the side selvage (fig 5c). In one find (no. 8416b) two wefts were used alternatively (fig 5d). There are only four examples of strengthened selvages. Nos 14920, 38131a and 38531 have one doubled warp outmost along the edge, and no. 38255 has a quadrupled one. Since in this last find the threads pass straight out of the weave, around the quadruple yarn and back again without any crossings, this selvage is interpreted as a side selvage, not as a corded transverse selvage.

At least six, but most possibly nine, finds have transverse selvages. Four of these (nos 1787, 6044a, 8416b, and one find whose number is lost) are of the corded starting edge type with the warp thread bent around a cord in the edge, crossing itself and then running back in the cloth as the next warp thread (fig 5a). Such selvages are usually interpreted as starting borders for weaving on the warp-weighted loom (Hoffman 1964). The cords here consist of the actual weaving yarn trebled or quadrupled. No. 1787 and the find with no number have a second doubled cord next to the first, but also here the typical crossings of the warp threads are between the topmost heading cord and the next one. The selvages are from 15 to 27 cm long, all with the same regular crossings, only no. 8416b has a fault at one place (fig 5b). As is typical for this type of starting edge, the warp threads are very unevenly spread along the heading cord, with two or three pairs tightly packed between open spaces of 1 to 1.5 cm, which represent the holes from the cord used for sewing the warp threads on the heading cord to the beam on the loom (Hoffman 1964).

Five finds have fringed selvages, with one thread system running out from the cloth as neighbour thread pairs in closed loops, now resembling fringes (fig 5e). Nos 1444 and 16242a have this fringed edge transversely to an ordinary side selvage, and are then clearly defined as transverse selvages. The fringe loops in these two finds are 3 cm and 3.5–5.5 cm long respectively.

Three other finds (nos 2361a, 26973 and one with no number) have respectively 4.5, 6.5 and 10 cm long loops measured from the point of the last surviving transverse thread. These pieces are very fragmental with respectively four, two and only one loop intact (fig 5e). There is every reason to believe that there have originally been many more transverse threads and that the loops then were much shorter. Such fringed borders are known from other textile finds as well and represent an unsolved problem (Hoffman 1964). Both types of transverse selvages are found up to the fire of 1413.

Finishing and use

Usually these textiles are rather open in the weave with no traces of any finishing process, but the finds nos 5166, 7176, 8416b and 8597 have been fulled. Only no. 26651 shows signs of planned rounded cutting. All the rest of the finds are without any traces of planned cuttings or seams. It is most likely that this textile type was usually utilized as unsewn lengths of cloth.

Yarn types and textile groups

The hair textiles can be divided into two main groups according to the spinning direction in the weaving yarns. This is usually the same in both thread systems in the hair fabrics. The one main group (111 finds), group A, has S-spun and normally Z-plied yarns at least in the warp direction. The other group (82 finds), group B, has Z-spun/S-plied yarns at least in the warp direction. The difference in spinning practice is striking, because spinning in the Middle Ages seems to have been strictly traditional. Now both S- and Z-spinning were known everywhere, since nearly all the sheep wool textiles from the Middle Ages have the warp threads Z-spun and the weft threads S-spun.

Still, there may be some special reason behind the two spinning traditions in the hair fabrics, for instance different geographical backgrounds. The two groups also differ in some other features.

Group A Textiles with S-spun/normally Z-plied yarns

Here we find the coarsest of all the hair textiles, for instance no. 2361a (fig 5e). The whole group tends to be coarser than the group B and only a few are finer than the medium type there. The coarsest of them are usually made from coarser fibre material as well, and the fibres are often more darkly pigmented. Some of the coarsest also have a very tight warp thread system which nearly conceals the weft threads. Five of the seven bands are of this type. All the rest of the textiles of group A are of the open sack cloth type, including the other two bands.

Ninety-nine of the 111 finds are perfectly regular with S-spun/Z-plied yarns in both thread systems. Four of the remaining finds show smaller variations, as two have 3-plied instead of 2-plied weft yarns, one has some S-plied threads in the warp system, and one has some warp threads where the one of the strands in the plied thread has disappeared. The lost strands were probably made from plant fibres.

Another four of the twelve irregular finds include one with some single weft threads and one with a Z-spun single weft thread system. Two finds are extended tabbies, one with paired warp threads moving together through the weave, the other with paired weft threads.

The last four irregular finds have single S-spun yarns in both thread systems. These textiles are also rather coarse. Among them we find no. 16120, the one already mentioned which measures only 19 cm from one side selvage to the other.

The fringed transverse selvages are all found in group A, and also two corded transverse selvages.

Group B Textiles with Z-spun/S-plied yarns

This group is generally much finer in the yarn and weave than group A. The finest of them are made from very well prepared and nearly white finely fibred material, which in many cases lacks the easily identifiable coarse fibres.

They are all rather open in the weave, with no examples of a warp system concealing the weft threads (except along side selvages, where there is often a crowding of warp threads which is quite usual in handwoven textiles).

Seventy-nine of the eighty-two finds are regular with Z-spun/S-plied yarns in both thread systems. Of the remaining three finds, one has some Z-ply threads in both systems, and one is an extended tabby with paired weft threads moving together through the weave.

The third irregular find (no. 8215) must be specially mentioned. It is the biggest hair textile find from Bryggen. One piece is 115 cm broad between the side selvages, another piece of the same find is 240 cm along one selvage. It has Z-plied weft threads, but otherwise it is very typical for the nearly white and finely woven textile type of group B. The pieces were found on the sea-bed under conditions which seem to show that they are from a level above the fire in 1332.

Two finds with corded transverse selvages belong to group B.

The textile analysis

Because the hair textile finds from Bryggen as a group form an unusually large homogeneous group of comparable finds, the work will here be focused on a comparative analysis instead of descriptions of individual finds in an attempt to find standard relations in spinning and weaving features of these products. The standard routine for analysing textiles is to count the number of threads per unit of

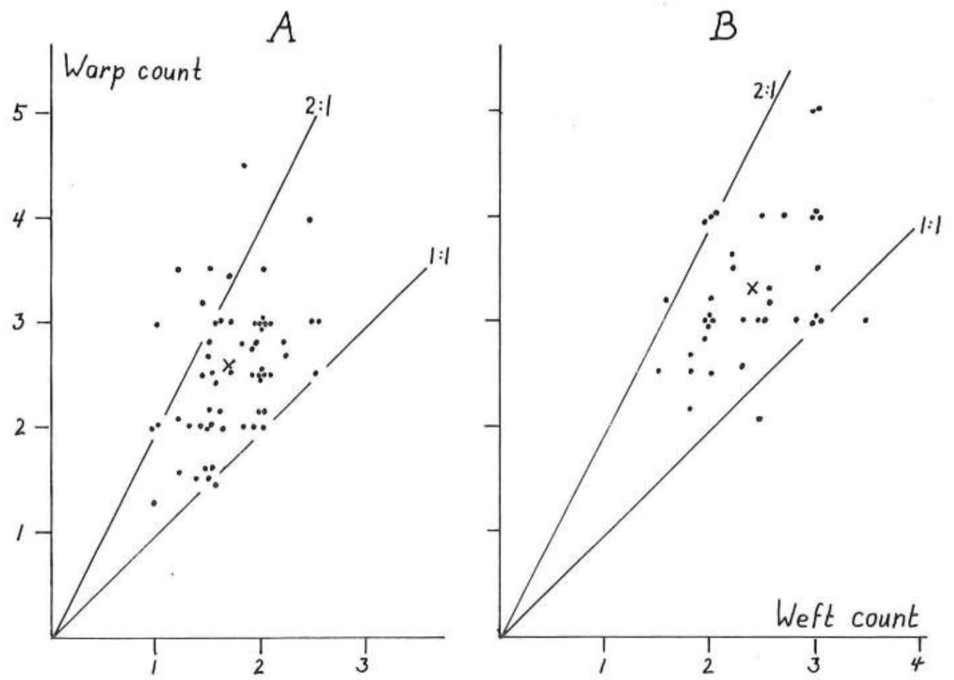

Fig 7 The relationship of the warp and weft thread counts. (A) Textiles with Z-ply yarns. (B) Textiles with S-ply yarns

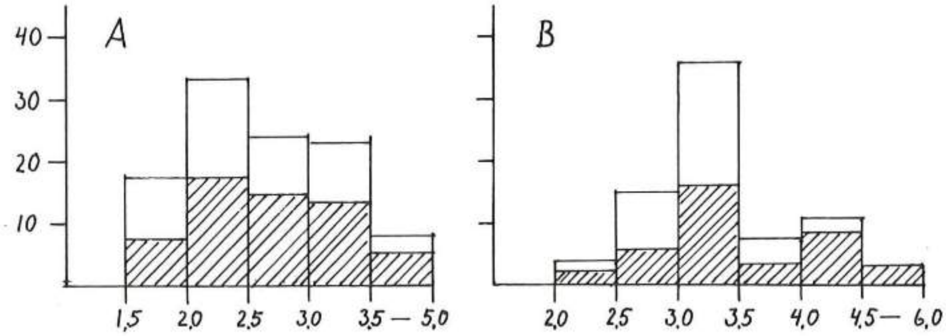

Fig 8 The number of hair textiles in increasing warp thread count groups. (A) Textiles with Z-ply yarns. (B) Textiles with S-ply yarns

measure in each of the two thread systems in a fabric. The unit most used, at least in Scandinavia, is 1 cm. This gives the thread count. For these coarse textiles it was found necessary to count the threads over 10 cm in each direction (if possible), and reduce the counts to the values per cm.

It seems that the yarns are normally the same in both thread systems, but for control the diameters of 10 threads in a row in each system were measured (at the same spot where the thread count was made), and the mean thread diameter in mm calculated.

These two values were compared for the groups of dated textiles with defined warp direction from the different phases at Bryggen (only 7.5% of the hair textiles are still undated). No recognisable change could be found in the thread and weaving mean values among these phase groups, and the textiles are therefore analysed here without respect to the excavation phases.

There seems to be no essential difference in time distribution between the A and B groups.

For comparative analysis of the textiles in the two groups, and between the groups, only textiles with clearly defined warp directions can be used, that is textiles with selvages, and a few with weft gores, ie weft threads which over a shorter distance are used to straighten out an uneven weave in a simple loom operated without a beater. Fifty-eight finds are used in group A, and thirty-seven in group B.

To get a picture of the relationship of the warp/weft thread counts both within the groups and between them, these values for each find have been combined and plotted as points in the two scatter diagrams of fig 7. Group A is plotted in diagram A, and group B in diagram B. The vertical axis represents the warp thread counts and the horizontal axis represents the weft thread counts. The points with the same thread counts in each thread system are represented by the diagonal line 1:1, and the points for warp counts which are twice the weft counts are represented by the line 2:1. The cross in each diagram shows the mean value point for each group.

For group A the mean values are 2.6 warp threads x 1.7 weft threads per square cm. For group B the mean values are 3.3 warp threads x 2.4 weft threads per square cm. So that the difference between these mean value points may be visualised, they have been schematically drawn at the same scale in fig 5a (for group A) and 5f (for group B) (including the extremely coarse find no. 2361a of group A.)

From the diagrams of fig 7 we can read that it is normal for the warp thread system to have a higher thread count than the weft system, and slightly more so for group A than for group B. In finds without selvages we can then be relatively certain if we interpret a tighter system as the warp, and more so when the difference in the counts is larger. If the counts are nearly the same in both thread systems they cannot safely be used in this way, because of the often rather uneven weave structure.

To see how the rest of the regular finds (those without selvages) would behave if interpreted in this way, their thread counts were plotted into the diagrams. This is not shown here. The picture of group A did not change at all, but for group B there was a certain crowding of points relatively near to the line 1:1. So it seems likely that group B as a whole tends to be more square in the thread counts than appears from diagram B of fig 7.

The mean values of the thread counts were also calculated according to this interpretation for all the regular finds in the two groups respectively and they turned out to be amazingly constant. Group A (99 finds) had the values 2.5 warp threads x 1.7 weft threads and group B (79 finds) had the values 3.1 warp threads x 2.4 weft threads per square cm. Then it seems likely that fig 7 really demonstrates both the norms for and the variation in the thread counts of the hair textiles in general.

In a broad sense we can say that the two thread counts in a hair fabric have a rather linear relationship, the higher the warp count, the higher also the weft count. To clarify the difference in the distribution of the warp thread counts in the two groups, fig 8 shows the number of textiles in increasing warp thread count groups

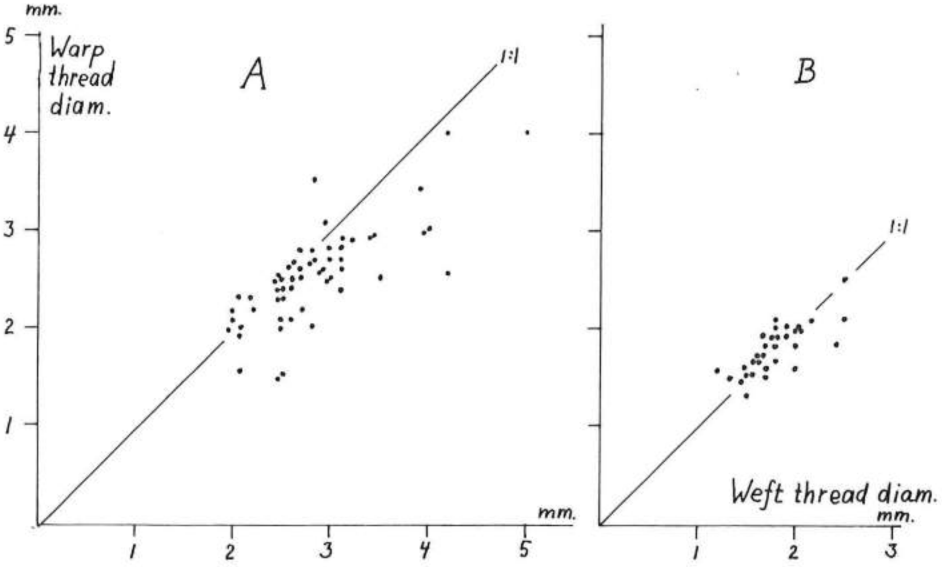

Fig 9 The relationship of warp and weft thread mean diameters. (A) Textiles with Z-ply yarns. (B) Textiles with S-ply yarns

for the A and B textile groups. The hatched parts of the columns represent the textiles with a defined warp system, the white parts represent those with an interpreted warp system. It is clear from this figure that group B is dominated by a standard with respect to the warp thread count, while group A is more varied. This is also the impression one gets from a visual study of these textiles. But since they are so coarse and open in texture, the individual finds are rather difficult to describe with words other than just coarse and open. Fig 8 seems then to be an extra help in making relative descriptions for group B textiles, but of little help in group A.

Another important factor for the texture of a fabric is, of course, the yarn thickness. A fabric with, for instance, a high thread count can be very open in texture if the yarns used are thin, or compact with thick yarns. To see how the yarn diameters are related and vary within the groups A and B, as well as between them, the mean values from each thread system are combined and plotted as points in the two scatter diagrams of fig 9, diagram A for group A and diagram B for group B. Only the finds with a defined warp system are used. The vertical axis represents the mean warp thread diameter, the horizontal axis represents the mean weft thread diameter and the diagonal line 1:1 represents the points for the same diameters in both thread systems.

From these two diagrams we learn first of all what we already knew from studying the hair textiles, namely that the yarns usually are of the same type in both thread systems in such a fabric. But we get a clearer picture of the difference between the two groups. Group A is on the whole much more varied with respect to the yarn diameters than group B, which really has rather standardised yarns, finer than most of the yarns in group A.

The warp thread mean diameter for group A is 2.5 mm and the weft thread mean diameter is 2.8 mm. Group B has the same mean diameter for both thread systems, namely 1.7 mm.

It has been mentioned that most of the hair textiles are open and sackcloth-like in structure and that this feature is a product of the thread counts and the thread thicknesses. If we multiply the warp thread count by the warp thread mean value, and do the same with the weft system in each find, we get values which show how many millimeters of the centimeter is covered by the actual thread systems (in reality, the thread system expressed as a percent of the textile area). This has been done for the hair textiles and the results plotted in scatter diagrams. These did not tell much more than we knew, namely that with normally the same thread thickness in both thread systems and a higher warp count, the warp system has to be closer than the weft system.

But the diagrams gave a clearer picture of some features in the group A. Textiles with relatively thick weft threads fell out of the point cluster with a slightly more compact system than the warp system. And the textiles with a warp system which nearly conceals the weft threads were also sorted out in this way. So even such diagrams can be a help for a relative description of separate finds.

By multiplying the mean values for thread counts and thread thicknesses for the whole groups A and B respectively, we can show that the warp system in the A group on average covers 6.5 mm of one centimeter or 65% of the cloth area, and the weft system covers 4.8 mm of one centimeter or 48% of the cloth area. The textiles in the A group with very close warp systems have a covering of from 75 to 100% for the warp, and from 30 to 50% for the weft. The corresponding mean values for the B group are 56% for the warp system and 42% for the weft system.

It is then quite clear that the textiles of group B are generally more open in the weave structure than group A.

DISCUSSION

It was found natural to collect these rather different find groups (textiles, cords, caulking cords, skin pieces etc) in one paper, because of their relationship based on the raw material.

There is every reason to expect goat hair specially, but also coarse sheep wool, cow hair and other spinnable hair types, to be found as raw material for such coarse products as those treated in this work. However, the identification work has demonstrated that sheep wool is practically absent, and that goat hair is the dominating source of hair fibre. How was the hair material procured? Because of intact root ends the hair cannot have been shorn from the living animals. Hair wastage from leather production could have been used as far as it had spinning properties, ie that they were both long and fine enough, though strong, elastic, and with a surface giving a certain frictional resistance to lengthwise slipping (Matthews 1947). Actually some few finds, even among the textiles, show typical root ends from the «pulling» procedure involved in leather production. Autumn is the traditional slaughtering time for domestic animals, comprising also the surplus of the yearlings. Kids and calves have much finer hairs than the adult animals and these fibres can thus be relevant in this connection. On the other hand, at least the goat skin from adult animals has very little fine fibres in the autumn, being completely dominated at that time by the coarser hairs (Ryder 1966). This explains the pieces of goat skin found, which mostly have coarse hairs and very little woolly fibres on them.

Now most of the finds are made from a rather woolly material, variably fine-fibred and medullated, and with well-kept roots, mostly on the coarser fibres.

It seems possible that at least goat hair can have been collected during the spring shedding season. The outer coat coarse hairs in the goat fell are shed first (Ryder 1966), and when the woollier undercoat loosens, the new-grown coarse hairs are firmly anchored, and only remnants of the older coarse ones will naturally follow the wool shedding. Now Ryder has found signs that the woolly part of the coat of goats seems to break off above the root ends rather than loosen with intact root ends, and this can explain that most of the finer fibres in the preparations have no intact root ends.

However, much of the goat hair material is woollier than expected. How can this be explained? We have reports about the natural phenomenon that goats which are kept outdoors the whole year round grow a much woollier coat than those kept indoors during the winter. This has also been checked by Ryder (1966). And we know that in Norway it was usual along the west coast up to last century to keep goats in this way (Reinton 1960). This was surely a custom in most areas with mild winters, and seems to be the best explanation for the relatively fine-fibred goat hair products from Bryggen.

It is quite clear from the finds that it was not the custom to mix hair fibres with sheep wool. The special properties of the hair material seem to have been preferred for these coarse products. Only for the hair felt finds is this a little surprising, since sheep wool is considered to have much better felting capacity.

That the hair yarns had to be plied in contrast to the sheep wool yarns seems to have been more or less beyond dispute. This is also the case for such yarns today in areas where they are still used (for instance in the Near East), due to the poorer binding properties of the hair fibre material.

It is a possibility that the two traditions with Z-plied and S-plied yarns instead of being geographically based can depend on strictly technical reasons. The relatively fine and even Z-spun strands of the S-plied yarns are often made from a softer and maybe better prepared fibre material than the coarser and often more uneven strands of the Z-plied yarns. The strands of the S-ply yarns can very well be a product of the drop spindle method with the «spindle and whorl», where it is enough with a little snap with the fingers of the right hand on top of the spindle to give it enough turning momentum. This gives normally Z-spun yarn.

On the other hand the heavier S-spun strands of the Z-plied yarn must have offered greater resistance during spinning, and they are clearly not spun with the drop spindle method. From a Scandinavian point of view the old hooked spindle specially used just for hair spinning in Scandinavia down to our time (Nordland 1961) is the likely implement used for this type of yarn, and even for the caulking cords, which also traditionally in later times were spun with this implement (Nordland 1961). The hooked spindle is the whole time turned by the fingers. This method gives a better draft during spinning with coarse materials.

The traditional Scandinavian hair yarn products in knotless netting, spun with «the hook», have, so far as the author has seen and judging from pictures of such products (Nordland 1961), normally S-spun/Z-plied yarns. From own experience the easiest way of spinning coarse material with the hook is to turn it clockwise which gives S-turn to the fibres and so the S-spun single yarn. And this is the yarn in practically all the hair products from Bryggen except the textiles of group B.

For the spinning of the coarse single strands in the caulking cords we have also the possibility that the fibres can have been spun in an extremely primitive way, namely by rolling the fibres against the right thigh in direction of the knee, which also results in S-spun yarn. This method was used for the spinning of thick single caulking cords from short cut tufts of reused hemp fibres in Stockholm down to last century (Wickström 1944).

The tabby hair textile type seems to be found in nearly all medieval urban excavations in Northern Europe. In Norway they are also found in Trondheim and Oslo, and they are known from Denmark (Kjellberg 1979, 1981). They are described from Lund (Blomqvist 1961, Lindström 1976) and from Söderköping (Franzén and Geijer 1968) in Sweden, and they have also turned up in other Swedish town excavations. Nahlik (1963) has described some finds from Novgorod. From Germany they are described by Tidow (1978, 1982) and from the Netherlands by Vons-Comis (1981). They are found in London (Pritchard 1981), and they are described from several other places in England (Crowfoot 1976). They are also known from Scotland (Vons-Comis 1981).

Everywhere the group A textiles with Z-ply yarns seem to dominate as they do at Bryggen, while from Novgorod, the Netherlands and England only this textile type is mentioned. From this it seeems that the group B textiles (with S-ply yarns) were a North German-Scandinavian type, but we have to await more finds before we can draw such conclusions.

Vons-Comis (1981) comments about the high frequency of side selvages also found in the material from the Netherlands and thinks that the cloth was narrow and/or hardly cut. This is also the conclusion drawn for the material from Bergen. Some finds from Lund (11th century) have been used as coverings over the dead in graves, and also some of the English finds are from graves, in this case clerical ones. The finds from the Netherlands are frequent in layers from the 14th till 16th century (Vons-Comis 1981).

Two of the Swedish and some of the English finds are thought to be goat hair, otherwise they are described as being made from coarse wool. The German ones are thought to have been made from wool of some old breed of double-coated sheep (Tidow 1978).

Is it possible to recognise this hair cloth in earlier references? Kjellberg (1943) has collected a lot of information about hair tabbies from the Middle Ages, with reference to Swedish sources, and it is quite clear that such a product was well known in commercial connections, specially in Hanseatic trade, for instance as wrapping for finer textiles. Also Hoffman (1964) has collected a lot of information about old textile terms, specially from Icelandic sources, where the term «pakka-einskefta» is found in the later sources, meaning a coarse tabby product made from bad sheep wool and intended as packing material.

Nowhere in textile reports from excavations are there signs of any common coarse tabby product of sheepwool which is so simple that it would only have been used as packing material. Still it is highly probable that such a material also was produced from bad wool, specially in Iceland where goats seem to have been few, at least in the Later Middle Ages (Benediktsson 1960). But such a product has not turned up at Bryggen.

From the Swedish sources (Kjellberg 1943) it is evident that the hair tabbies were also used for other purposes than packing material, for instance for straining milk, beer and glues, and as underwear for hermits and monks. Even Thomas Beckett was wrapped in hair cloth (full of lice) as a real martyr for God (Sveinbjarnardottir and Buckland 1982). Also St Olaf, king of Norway, used hair cloth under his shirt (Falk 1919).

It should be mentioned that the decorative square braided black and white sinnet type is also found other places, for instance, at Lödöse in Sweden, and that one single find among all the textiles has a decorative purpose, namely the band no. 27795, along the middle part of which are arranged eight warp threads alternatively black and white, giving in the weave transverse black and white stripes.

It will be natural to take up more general aspects on these find groups, specially the yarn products, in connection with other textile and rope finds from Bryggen. Specially the textiles will be discussed concerning their distribution at Bryggen and their place in spinning/weaving traditions. Also the problems around home craft contra commercial products, and local production contra import will then be discussed more thoroughly.

SUMMARY

The hair fibre material is defined here as animal fibres other than sheep wool and silk. Most of it is goat hair products. The finds are dominated by caulking cords and coarse tabby textiles made from 2-ply yarns. The hair finds clearly have a higher frequency in Later Middle Ages than earlier. The tabby textile type is found in most medieval town excavations in Northern Europe. They have not usually been used for clothing, but more possibly as, for instance, wrapping material and for straining of fluids.

ACKNOWLEDGEMENTS

I am grateful to the excavation project leader Senior Curator Asbjørn E Herteig for the opportunity to work with this material and for help with the manuscript. And I will express my thanks to the director of the Botanic Institute of the University in Bergen, Solveig Åsheim, and to professor Peter Emil Kaland for allowing me to work in their laboratories. Then thanks also to my colleagues Marta Hoffmann and Anne Kjellberg for their great interest in my work, and also to Margareta Nockert and Märta Lindström for letting me see the Swedish material.

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Bergen Seal Jugs

BY H E JEAN LE PATOUREL

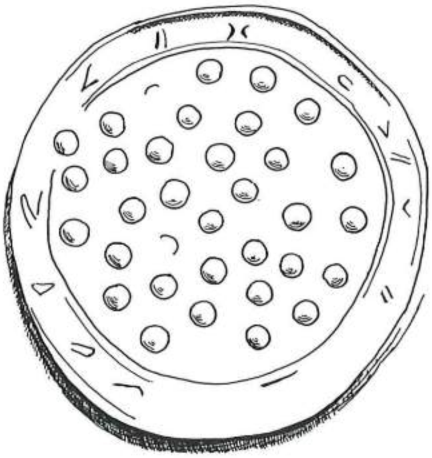
Imports to Bergen from England include sherds from six jugs decorated with roundels which enclose a stamped device resembling a medieval seal. Similar jugs found in England have a somewhat restricted distribution. Their manufacture appears to be confined to the counties of Norfolk and Yorkshire though there have been isolated specimens from Carlisle and Newcastle[1]. Of the illustrated Bergen jugs nos 1-3 are in Grimstonware[2] a fabric made in quantity a few miles east of Kings Lynn, from which port they are likely to have been shipped. No. 4 is in a fabric known provisionally as York White ware[3] for which no kiln has yet been found but whose distribution appears to radiate outwards from York City. This was probably exported through Hull or just possibly through Scarborough[4].

The decoration was produced by applying a pad of clay to the jug on or near its shoulder, on to which a stamp was pressed at the right stage of the drying out process to take a clear impression. It seems to have been difficult to judge the optimum moment for part of the stamp is often slurred because of over-wet clay as in fig no. 2, or part fails to make any impression at all because the pad was overdry as in no. 3. The jugs usually have four, occasionally three, equally spaced roundels. The stamps fall into four groups.

Group 1 comprises representations of medieval personal seals. An inner circle encloses human, animal or bird motifs outside which is an encircling band for an inscription. Almost certainly a genuine seal matrix was used as a stamp. It was possible to buy seal matrices in town markets with the band for the inscription left blank, to be filled in to a purchaser's requirements[5]. The legend usually begins with a cross, followed by the word *sigillum*, sometimes abbreviated, and then by a personal name. Occasionally on these jugs the band for the inscription is left blank; not infrequently it is provided with a few meaningless squiggles in place of the usual Lombardic lettering, a reminder that both potter and purchaser must often have been illiterate. Group 1 seal stamps have hitherto been confined to Yorkshire. The Bergen jugs are the first indication that they were made also in Norfolk.

Group 2 stamps bear the same motifs as those of Group 1 but the engraved device covers the whole of the roundel, without a band for an inscription. This type is known both in Norfolk and Yorkshire but has not been found among the Bergen examples.

Group 3 comprises roundels with non-representational motifs within the inner circle surrounded by a band as in Group 1, which may have an inscription which includes the word *sigillum*, or may have a legend of a different type such as the jugs inscribed THOMAS ME FECIT which have been found in East Yorkshire and the city of York[6]. Medieval personal seals themselves often bear inscriptions which do not include the formula beginning with *sigillum*. Group 3 motifs include pellets, as in fig no. 5, scales, simple or intersecting lines, or a combination of any of these. So far their distribution has been confined to Yorkshire.



DESCRIPTION

1 1635, 3587. Two identical seals from a Group 1 Grimstonware jug. Reduced fabric with dark green glaze and zones of brown scales adjacent to the seals. 3587 has been trimmed after breakage, perhaps to make a gaming piece. The lion passant is encircled by the legend SIGILL SIMON FIL HUGONIS

2 76/12654. Group 1 seal stamp in Grimstonware from a jug with an applied arm with six-fingered hand of the sort usually associated with beard jugs. Only SIGIL can be deciphered of the inscription that surrounds the lamb and flag device. The fabric is reduced, but the green glaze is lighter than that of no. 1.

3 8773. Group 1 seal from a Grimstonware jug. A crude lamb and flag is surrounded by an indecipherable legend. Reduced fabric with mid-green glaze. There have been vertical lines of brown pellets on the body of the jug. An identical stamp (16446) came from a different Grimstonware jug.

4 39340, 39349, 39519. Group 3 seal stamp from a jug in York white ware. The marks within the inscription band do not appear to be genuine lettering. Oxidised fabric with light green glaze. An identical seal came from a second jug in this fabric (39678, 40348, 40111). This jug had small supplementary handles rising from the shoulder.

Group 4 designs are identical to those of Group 3, but the roundels lack a band for an inscription.

It will be realised that the decorative devices of Groups 1 and 2 represent themes which, like the seals from which they derive, belong to the common stock of medieval decorative art as it is applied by craftsmen to such different materials as stone, metal, wood, leather and ceramic tiles. It is possible to pinpoint surviving examples of all the motifs found on the seal jugs in one or other of these different media within the areas served by the Yorkshire and Norfolk potters. The lamb and flag and the lion passant of the Bergen jugs are likely to derive, nevertheless, directly from the seal engravers rather than from other crafts because of the presence of the inscription band, whether used or unused, on pots of Groups 1 and 3. Groups 3 and 4, with their non-representational themes show an adaptation of the seals to a form more directly in keeping with ceramic tradition.

Dating. As with all highly decorated pottery, there is difficulty in dating the seal jugs. It is tempting to see the four groups as a typoligical series, beginning with the true seals of Group 1 and ending with the degenerate form of Group 4, but there is in fact no positive evidence to show that they were not all contemporary and the Bergen evidence shows Groups 1 and 3 in the same horizon.

In England most of the seal jugs have been found in unstratified contexts. The few exceptions suggest that manufacture spans the later 13th and the whole of the 14th century. A sherd from a Group 3 jug was among 500 others in a horners' pit in the city of York[7], a collection which included no recognisable 14th century material, yet another of the same group from Kirkstall Abbey, though not so securely stratified, was included in a 14th century assemblage[8], while a complete Group 2 jug, also from York, was assigned a 14th century date[9]. Fig no. 2, with its residual arm alongside the seal, could link the jugs to anthropomorphic decoration of the later 14th century at a Cowick kiln[10], but the Bergen find is in Grimston ware and we do not yet know how the York and the Norfolk series relate to one another chronologically.

Study of the seals themselves does not take us much further. The Lombardic lettering of the inscriptions could belong either to the 13th or to the 14th century. Personal seals of non-armorial character such as these are known to have been used by town burgesses in the first half of the 13th century[11] and were in widespread use a century later when the matrices were readily available to all. One scrap of evidence points to use very late in the 13th century, if not later still. There are seal jugs in York which carry the de Quinci seal in various stages of degeneration. Neither Saer nor Roger, the last representatives of the family which died out in 1264, is known to have any connection with York. It seems *prima facie* unlikely that the seal would have been put to use by the potters until a somewhat later date.

The dating of highly-decorated pottery is a matter of current controversy. The evidence of the seal jugs, as far as it goes, seems to point back to the traditional dating from mid 13th to mid 14th century for at least one form of sophisticated ornament. The Bergen material would fit well into such a bracket.

NOTES

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A Floating Tree-Ring Chronology from Bryggen in Bergen Based upon Dendrochronological Studies of 42 Pine Logs

BY TERJE THUN

During the excavations carried out at Bryggen in Bergen after the fire in 1955 samples from around 1600 logs have been collected. All samples treated dendrochronologically up to now have been of pine *(Pinus sylvestris).*

The measurement of the tree-ring widths and also an internal cross correlation of the tree-ring curves for the logs being dealt with here was carried out in 1973 by Dr philos Nils Brandt when working at the University of Oslo. Since Brandt's dendrochronological work stopped in 1975, no further work was carried out until the re-establishment of the activity by the author in Trondheim in 1981. The correlation of the logs in question has been examined also by means of the data processing program being used in Trondheim (fig 2). This implies that the tree-ring indices have been treated according to the «Student's t» correlation, described by

Fig 1 Sketch map of the excavation site at Bryggen in Bergen

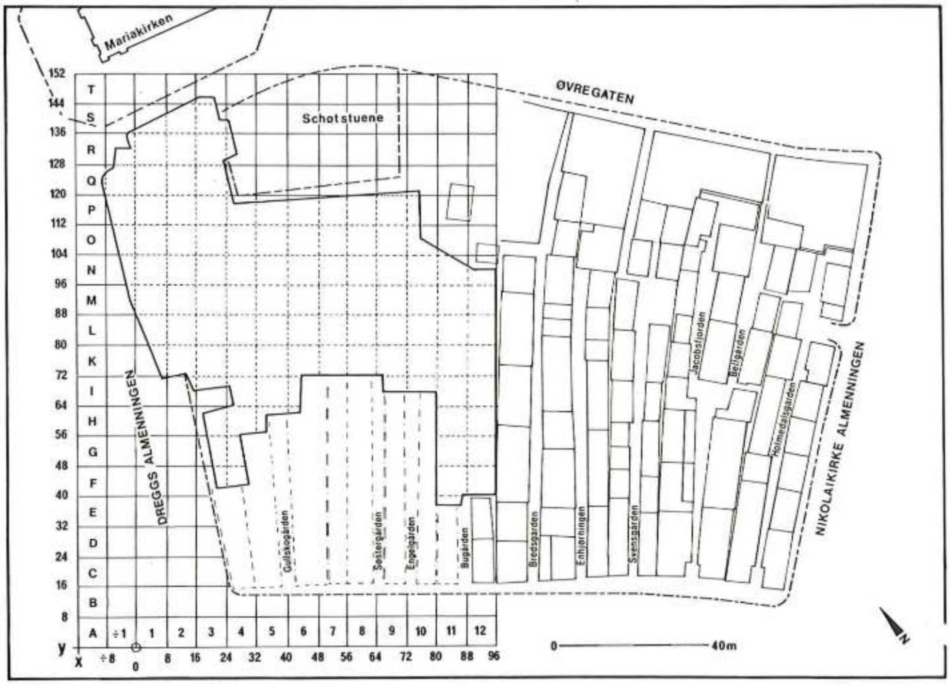


Table 1 Indices for the mean tree-ring curve for the 42 logs from the excavation site in Bergen (shown at the bottom of fig 2)

	0	1	2	3	4	5	6	7	8	9
1– 9		106	95	106	96	104	95	101	108	95
10– 19	96	98	106	92	117	87	109	83	123	82
20– 29	111	105	94	109	100	78	106	102	115	81
30– 39	98	111	100	90	95	94	121	101	75	123
40– 49	89	98	84	113	113	87	99	103	100	101
50– 59	107	86	97	109	104	97	94	87	117	95
60– 69	109	92	105	92	107	96	103	97	99	109
70– 79	97	89	109	97	110	83	97	109	104	82
80– 89	115	96	99	99	105	93	93	107	108	87
90– 99	107	87	118	95	101	95	107	99	91	101
100–109	97	106	91	102	89	112	110	86	98	106
110–119	89	111	95	97	107	100	92	105	101	89
120–129	116	81	123	95	77	107	108	100	96	97
130–139	96	112	88	92	116	90	113	90	95	105
140–149	102	95	94	114	98	92	92	112	103	83
150–159	95	121	82	101	107	101	90	115	84	109
160–169	97	100	101	96	105	94	104	95	101	97
170–179	115	84	109	83	118	87	101	104	100	99
180–189	96	109	85	107	98	105	98	100	97	105
190–199	91	104	96	94	107	88	106	103	102	96
200–209	107	89	105	94	105	105	85	90	128	89
210–219	87	95	116	96	97	108	88	100	102	91
220–229	113	100	96	107	91	93	110	90	98	121
230–239	82	97	106	88	109	102	107	80	106	106
240–249	82	112	98	106	100	95	103	102	88	116
250–259	81	95	102	92	111	100	99	87	113	94
260–269	109	84	127	81	98	101	102	114	97	101
270–279	75	102	87	128	94	69	124	90	95	116
280–289	114	67	97	106	119	82	99	94	85	133
290–299	85	85	133	81	73	119	107	95	95	90
300–304	119	78	105	99	111					

Baillie and Pilcher (1973), and to the degree of parallel variation («Gleichläufigkeit») discussed by Eckstein and Bauch (1969).

The mean value of each corresponding tree-ring of the overlapping parts of the curves has been calculated and used for constructing a mean tree-ring curve covering 304 years (see the curve at the bottom of fig 2). It should be mentioned that the mean curve thus obtained represents only a floating chronology, giving only the internal chronological position of each log and not the absolute dating (age before present) of the logs involved. Because the logs being studied represent untrimmed timber, the last tree-ring of each curve should indicate the last growing season before felling (see the relative felling year given at the end of each curve in fig 2).

The excavation site is shown in fig 1 and the location of each log is indicated at the lefthand side in fig 2, by its individual number and coordinates. The stratigraphical position of each log relative to the various fire layers at Bryggen was recorded during the excavation.

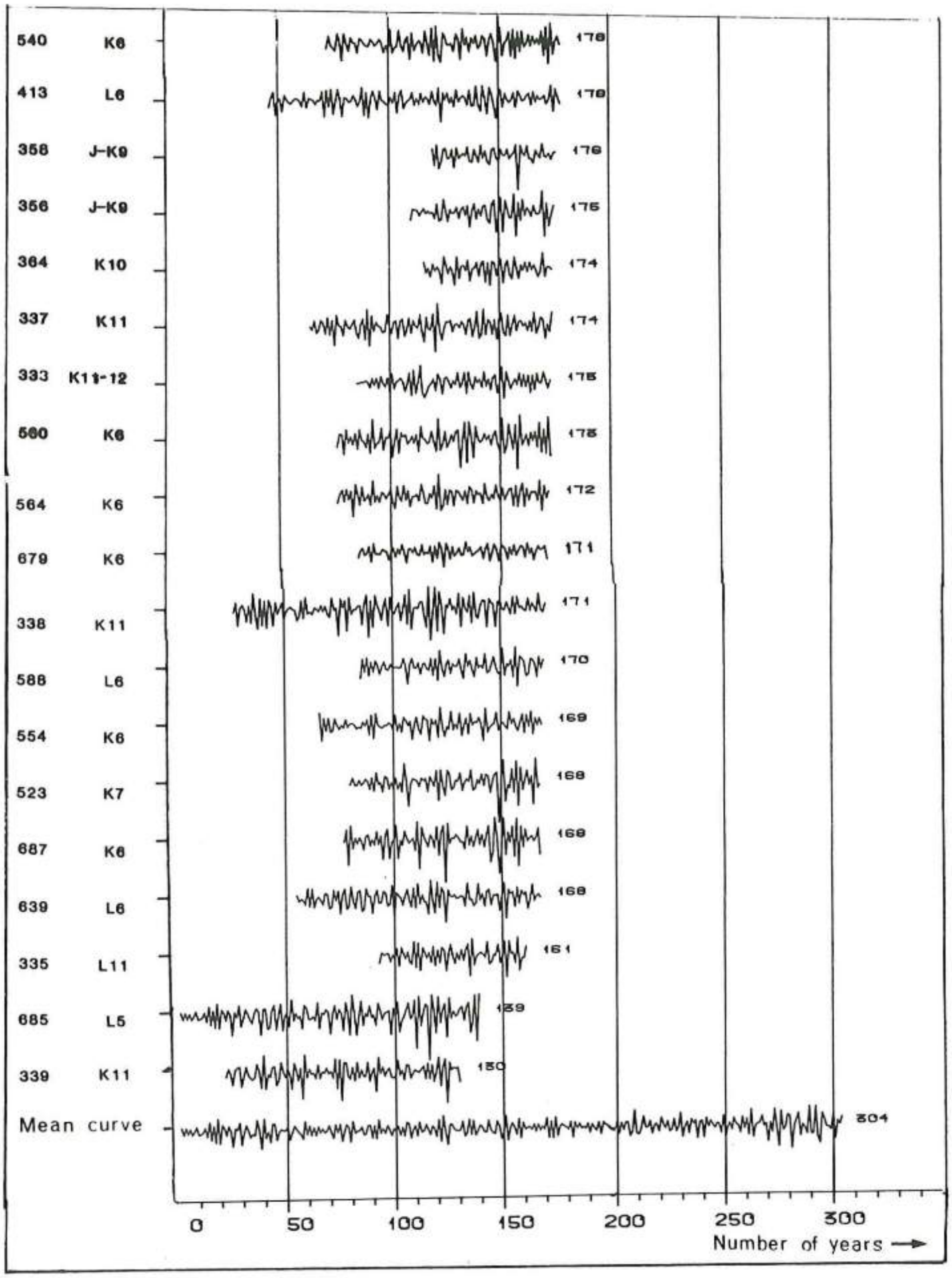
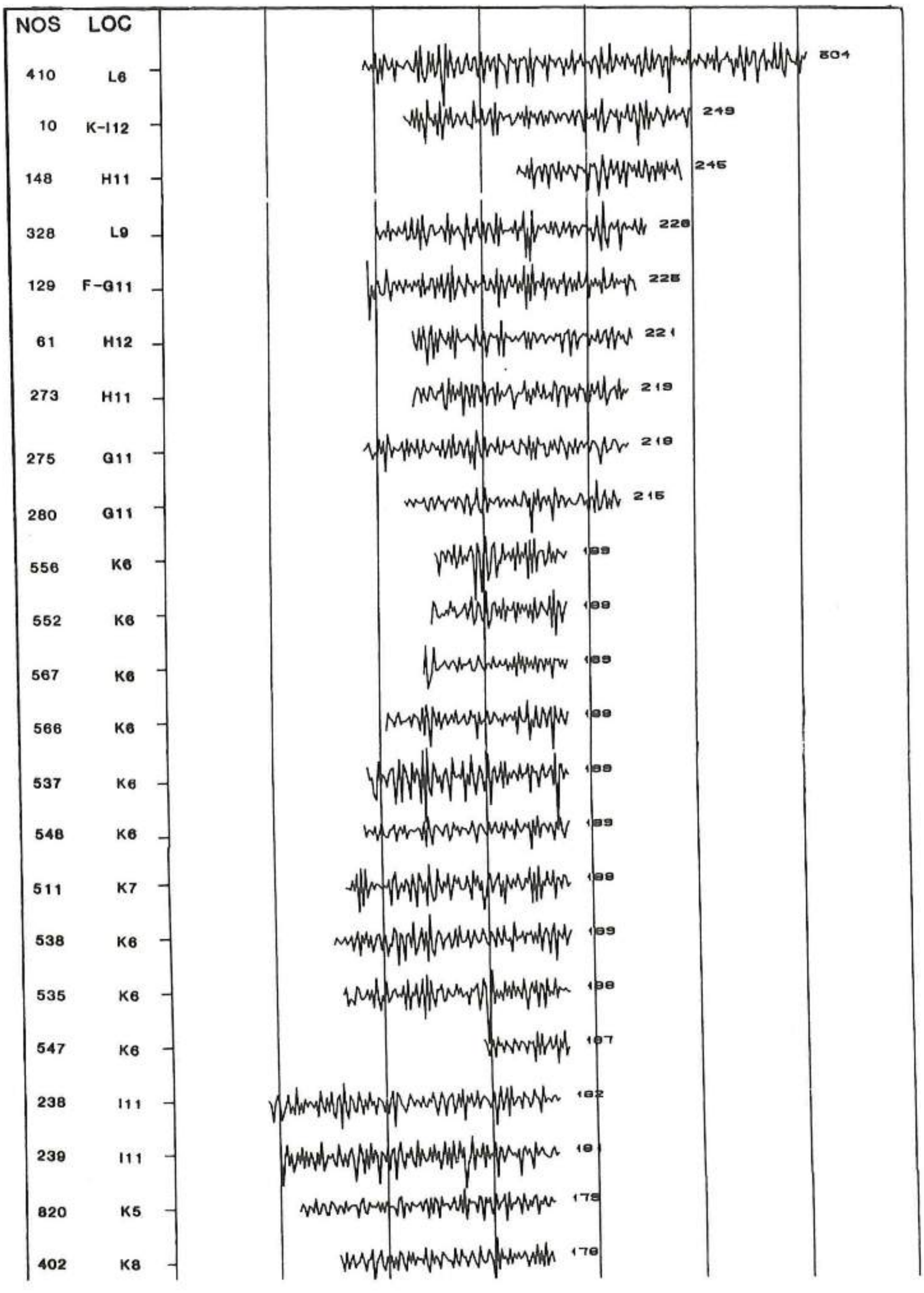


Fig 2 Tree-ring curves for the 42 relatively dated pine logs from the Bryggen excavation in Bergen, presented in chronological order and with the mean tree-ring curve at the base. The column to the left gives the number and the location coordinates (see fig 1) of each log


NOS LOC
410 L6 304
10 K-I12 249
148 H11 246
328 L9 226
129 F-G11 225
61 H12 221
273 H11 219
275 G11 218
280 G11 215
556 K6
552 K6
567 K6
566 K6
537 K6
548 K6
511 K7
538 K6
535 K6 198
547 K6 197
238 I11 182
239 I11 181
820 K5 179
402 K8 178

THE TREE-RING CHRONOLOGY RELATED TO THE BRYGGEN FIRES

The long series of logs being felled mostly within a 20 years period in the interval between 150 and 200 years (fig 2), were all found above fire layer no. VI, which corresponds to the historically known fire in 1198. This also concerns the two lowermost logs (nos 338 and 685). Logs nos 588, 820, 239 and 238 (listed from below) are reported to be found below fire layer no. IV, which corresponds to 1332. Logs nos 239 and 238 are supposed to be burned by a fire prior to fire no. IV (fire no. V in 1248) and reused during the succeeding rebuilding.

The group of logs at the top of fig 2, being felled in the interval between 200 and 250 years, were all, except log no. 148, found below fire layer no. IV at 1332. The relative dating of log no. 148 – reported by the archaeologists to have been used after fire no. IV – can be explained only by being reused after the fire in 1332.

If fire no. IV in 1332 is indicated at the relative year 250 or later and fire no. VI before the relative year 130 (log no. 339, at the base of fig 2), fire no. V in 1248 would be located immediately before the long series of logs being felled within the 20 years period in the 150–200 years interval, mentioned above. This implies, however, that log no. 410 at the top of fig 2, which was reported to have been used after fire no. III in 1413, must have been reused after fire no. III.

The relative tree-ring chronology established on the basis of the 42 overlapping pine logs from the Bryggen excavation in Bergen has been found to fit in well with the chronology proposed on historical basis for the fire layers recorded at the excavation site.

ACKNOWLEDGEMENTS

The author is indebted to Professor Ulf Hafsten, at Trondheim University, who has taken part in many discussions during the work and in preparing the manuscript. Warm thanks also go to cand mag Thoralf Nordtømme for constructing computer programs applicable to the tree-ring work being undertaken in Trondheim. The work has been supported financially by the Norwegian Research Council for Science and the Humanities (NAVF).

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THE BRYGGEN PAPERS is a series of publications giving a scholarly presentation of the archaeological finds from the excavations at Bryggen – The German Wharf – in Bergen, which took place between 1955 and 1968. Bryggen was the economic centre of the old Norwegian capital. Later – in Hanseatic times – Bergen became one of the largest and most important seaports and commercial centres in Northern Europe. The excavations at Bryggen have revealed extensive material which gives valuable information about the development of the city as well as European cultural history in general.

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ISBN 82-00-07119-7

9 788200 071198