THE BRYGGEN PAPERS

Supplementary Series No 3

UNIVERSITY OF BERGEN

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THE BRYGGEN PAPERS

Supplementary Series

The Bryggen Papers

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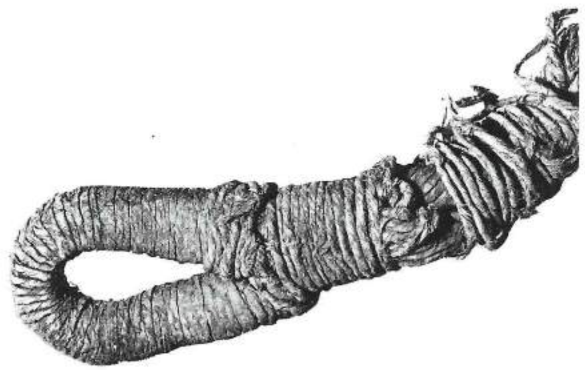

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FOREWORD

On the basis of grain recovered from successive fire layers on the same property at Rosenkrantzgate No. 4, Knut Krzywinski demonstrates in his paper "A Medieval Brewery (1200–1450) at Bryggen" the existence of a specific occupation and its continuity over a long period of time. The activity involved the storage and the intentional malting of barley as the first stage in brewing ale. Proof of brewing has also been shown by the presence of various plants used for flavouring, while the analysis and identification of the associated flora indicates the source of these imported raw materials.

Ellen Schjølberg's article on "Cordage and Similar Products" from Bryggen is an extensive investigation into a group of finds which has seldom found a place in archaeological literature. It has therefore been necessary to devise a classification scheme for these objects, based naturally on the raw material such as twigs, stems, strips of bast and wood of various kinds. Taking each category in turn, Ellen Schjølberg has made a careful study of the production processes from the raw material to the finished products, which range from he finest cord to the heaviest of ship's mooring ropes.

While these two articles illustrate major occupations, Kari Johnsen's paper "Sound Tools from Bryggen" reflects the development of more spiritual activities. With this article she makes an important contribution to our otherwise limited acquaintance with the musical instruments of the Medieval period.

The Editorial Committee responsible for the publication of the series consists of Professor Knut Helle, Dept of History, University of Bergen; Asbjørn E Herteig, Senior Curator, Dept of Archaeology (Medieval Collection), Historical Museum, University of Bergen; and Svein Indrelid, Dr philos, Dept of Archaeology, Historical Museum, University of Bergen.

The articles have been translated with the assistance of Clifford Long.

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Bergen, November 1987

Asbjørn E Herteig
Chief Editor

A Medieval Brewery (1200–1450) at Bryggen, Bergen

BY K KRZYWINSKI & E C SOLTVEDT

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ABSTRACT

Evidence of brewing from malt has been substantiated by a combined macro- and micro-fossil analysis of samples taken from an exposed section in the excavation at Rosenkrantzgate 4, Bergen. Charred malt occurred in three of the four layers of fire debris, equated with the historically recorded fires of 1248, 1332, and 1393, indicating that brewing was resumed on the same site after each fire, but was discontinued or moved to another part of the site after the 1413 fire. The disputed location of the medieval tenement of Straumrinn is also reconsidered in the light of these results.

The criteria for identifying the material as carbonized malt rather than incidentally sprouted grain are presented and discussed on the basis of the malting process and tradition. The imported barley-malt was generally of good quality and in every case four-row barley had been used. Varying amounts of other grain were also present, in particular oats and rye. The 1248 layer contained much oats; rye formed the dominant contamination in the 1332 layer, but in the malt from the 1393 layer there were no appreciable amounts of any other grain.

There were indications that the local beer was flavoured with *Myrica gale* throughout the whole period, even though *Humulus lupulus* was also present.

Both the grain types and the weed assemblages supported the view that around 1300 there was a change in the source of imports from areas of oceanic climate round the North Sea to more continental areas round the Baltic.

INTRODUCTION

The archaeological background

The first to carry out archaeological investigations in the medieval part of Bergen was Koren-Wiberg (1908), followed in the 1930s and 1940s by G Fisher (unpubl). However, systematic excavations were not effected until after the disastrous fire in 1955 which destroyed many of the eighteenth-century buildings within the medieval merchants' area at Bryggen (Herteig 1984). The excavations revealed thick deposits of occupation material lying on the original sea-bed and a complicated stratigraphy of buildings and constructions proving that the town had expanded step by step into the former harbour (Herteig 1969, 1984; Krzywinski & Kaland 1984). The remains of earlier structures partly served as foundations for later buildings, and the strata underneath were thereby protected from later disturbance.

The permanently anaerobic and waterlogged deposits provided ideal conditions for the preservation of delicate organic material. This included the remains of stored food and food waste and of merchandise which had been stored in the warehouses, providing information that could hardly be obtained from other sources.

The deposits comprise autochthonous (ie produced in the place they are recovered) occupation layers, primary and secondary refuse layers (fill). In practice it is often difficult to distinguish between them. Primary refuse layers are undisturbed litter and waste deposits from an undefined area but representing a definite span of time. If the deposits have subsequently been moved, being used for construction work or otherwise physically disturbed, they are classified as secondary refuse deposits and it is difficult to relate the plant material in them to specific activities either in time or space. Occupation layers and primary deposits are more informative, and the ethnobotanical investigations should therefore concentrate especially on these.

The extensive fires at Bryggen are documented both in the historical sources (Helle 1979 passim) and in the layers of ashes and burnt remains encountered during the excavations ("fire-layers"). They provide a chronological system for the preliminary dating of the deposits (Herteig 1984). The composition of finds within the individual fire-layers reflect the function of the respective buildings immediately preceding the fire. Though the fires destroyed most of the houses, the degree of destruction of their content depends on the character of the material and on the intensity of the fire. If the fire-layer has not been disturbed by later activity, the distribution of (mainly carbonized) plant material within the layer enables one to understand the function of the building. In addition to the local aspects, the ethnobotanical material may also contribute to an evaluation of agrarian history and trade connections in a wider context.

The cereal trade in Bergen in the Middle Ages – the historical and archaeological evidence

According to written sources Bergen was a trading centre of European importance in the Middle Ages. In addition to export of fish and fish products, the trade was mainly based on the import of grain and grain products in transit to and from the area further north. The imported grain products were to a certain extent supplemented by grain of local origin. As well as being the site of a royal residence, which received levies in kind, the town also functioned as an ecclesiastical centre receiving revenue in agrarian products (Helle 1982, 330). In the written sources (Sølvberg 1976, Helle 1982) corn (ie barley), flour (probably from wheat), rye, oats and malt are mentioned. The trade in grain and grain products has been considered one of the most important factors in the economy of medieval Bergen.

Archaeologically, foreign contacts are evidenced by pottery and other imported objects, but the more perishable cereal products have so far not been investigated. If they can be recovered, they may provide information about whether there were changes in the trade with time, whether the supplies were exclusively of foreign origin, or whether local grain was also stored here.

Nedkvitne (1983, 166) has estimated that in the Late Middle Ages (fourteenth century) approximately 3000 tons of grain were imported yearly. To estimate the annual imports in earlier centuries is difficult, but there can be no doubt that it was considerable (Helle 1982, 312–14). So far, the historical and archaeological sources have been somewhat at variance. Charred grain has been found during excavation, but not so frequently or in such quantities as to suggest a trade on the scale estimated. Assuming that the quantity of stored grain was related to the magnitude of import, its low incidence in the finds is difficult to understand.

In general grain will not be recovered or recorded in the archaeological material unless previously carbonized. Under the conditions pertaining at Bryggen, the grain recovered represents a situation immediately before the fire. The low quantities found may mean that the fires occurred at a time when the warehouse happened to be empty. This is possible, as import and re-export were concentrated to a limited period of the year, generally in the summer-time.

Another simple and perhaps more likely explanation of the absence of grain could be that such material has been overlooked during excavation and that the samples collected are not at all representative of the quantities present at the sites. Charred grain may have been missed by non-specialists or less trained field-workers. However, while this might be the case with stray finds of grain lost during other activities, stored products in warehouses should give massive layers of pure grain, which one would presume were easily observable even by inexperienced field-workers.

A third explanation is based on the carbonization which is a prerequisite for preservation, as grain in the natural state is perishable. Carbonization takes place under relatively low temperature in the absence of or under a low concentration of oxygen. In an intensive fire, ie one with high temperatures and ample oxygen, the grain ignites and burns to ash. It is probable that fires at Bryggen, which occurred in densely built-up areas with wooden houses, created too high temperatures for carbonization, although the texture and structure of grain stores should in themselves keep the oxygen concentration down. If buildings collapsed and the turfed roof fell into the fire, it may have excluded the air and created favourable conditions for carbonization of the remains of the grain store. The large fires in this area must have caused different rates of destruction of the grain at different places. A comparison between the quantity of (charred) grain found and the quantity of grain generally stored at Bryggen is therefore difficult, if not impossible. Neither undersampling nor different carbonization rates can alone be responsible for the discrepancy between the expected and the found frequencies of cereal grains. Perhaps the reason lies in a combination of effects, but this must be the subject of a future study. In future excavations in this area more attention must be paid to carbonized plant material than hitherto.

It is not always clear whether the imported cereal products mentioned in historical sources were in the form of grain or flour. Flour would be even more difficult to find in an excavation than grain, and was certainly not looked for. What flour would look like if at all preserved under these conditions is less known. Humidity and exclusion of air which would benefit the preservation of grain may not have been beneficial in preserving flour. If a larger part of the cereal products was imported as flour, this could explain the lack of grain in the deposits.

At present we must conclude that the import of grain at Bryggen is not properly reflected in the archaeological record. Even though the frequency of grain found is less than expected, individual finds are larger and purer than those normally found elsewhere.

Previous finds of grain in Norway

Until recently, there have been few reports of cereals in archaeological context in Norway. Subfossil grain has been reported from the Neolithic, viz grain impressions of wheat and barley from Kråkerøy, S E Norway (Johansen 1957). According to Griffin (1981), an impression of barley on a potsherd found at Salthidleren can be later than the Neolithic. In Rana, a few grains of barley have been reported (Hultgren *et al* 1985) and finally there are fifteen grains of barley (Hordeum vulgare var. nudum) from a late Neolithic site in Rugland, SW Norway (Bakkevig 1982). Hordeum type pollen has been reported from Norwegian Neolithic deposits (Bakka & Kaland 1971, Vorren 1979).

The most important and extensive find from the Iron Age is the one from the Migration period farm at Ullandhaug, Stavanger (Lundeberg 1972). In Lofoten, N Norway, barley has been found at Borg (Soltvedt unpubl). The main type of cereal grain in this period is hulled barley. A few additional minor finds of barley are mentioned by Griffin (1981). The find in Oseberg is the only one of wheat for the Iron Age and the only grain reported from the Oseberg excavation (Holmboe 1921).

Medieval finds of grain are more frequent. Griffin (1977) found barley in a house in medieval Oslo dated to 1300, and barley has also been found in medieval Stavanger (Lillehammer 1972). Jessen (1956) reports four-row barley from Hamarhus dated to 1567, and Griffin (1981) has identified barley and oats in Skien dated to around 1600.

In W Norway two medieval farms have been excavated with pollen evidence for the cultivation of barley and oats (Berge 1978, Kvamme 1982, Randers 1981, S Kaland 1979, P E Kaland 1979). These finds of Hordeum pollen from the Bergen district suggest that barley was cultivated in W Norway during medieval times. Today, grain growing in W Norway is insignificant and when grain was grown more intensively (50 years ago) the preferred species in the outer districts was oats.

By pollen analysis it is difficult to prove that specific grain types were cultivated in the Middle Ages on farms near Bergen. So far it has only been shown that oats and barley were present. According to S Kaland (1979), Kvamme (1982) and Randers (1981), the Iron Age fields were intensively manured. The manure may have contained large quantities of cereal pollen (Krzywinski & Fægri 1979, Krzywinski *et al* 1983, and Krzywinski & Kaland 1984). The pollen found in analysis of the fields may therefore have come from grain introduced with the manure and not from grain cultivation. As

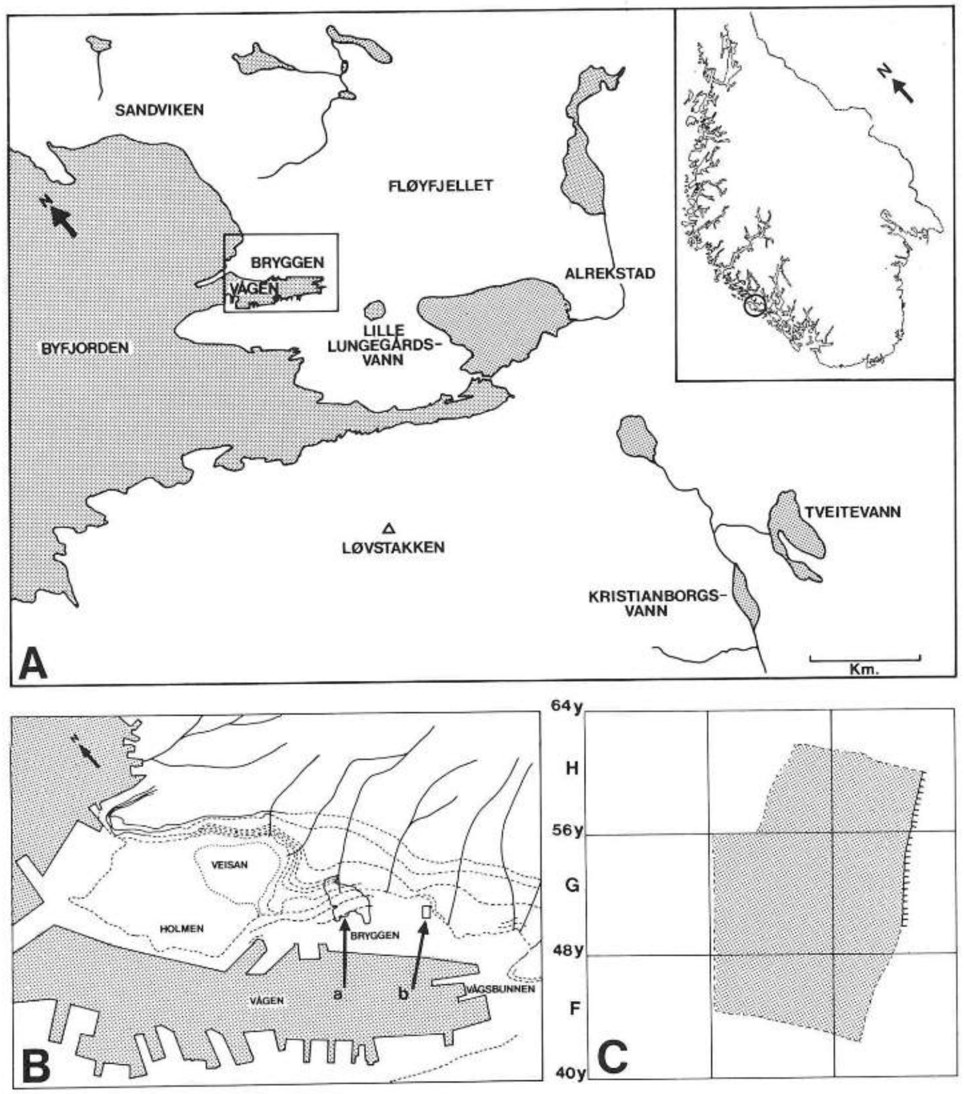


Fig 1 A. Map of the Bergen area with present topography.
B. The Bryggen area with tentative topography at the time of the town foundation. The main excavated area, a, and the Rosenkrantzgaten site, b, is shown.
C. The site itself with grid system and the profile marked with heavy line.

a matter of fact, the former possibility is the more likely, as a major part of the pollen produced by cereals is spread with straw, husks, etc (Greig 1982).

Oats *(Avena sativa)* are found from about 1000 BC on the Continent (Switzerland, Denmark and Germany), but do not seem to be important as a cereal crop until the first millenium AD (Helbæk 1957, 1960). Finds of rye *(Secale cereale)* are frequent at Late Iron Age sites in NW Europe (Hjelmquist 1969). From the middle of the thirteenth century onwards large quantities of rye were imported to Norway. Baltic rye was the most important product imported from Lübeck to Bergen from the thirteenth century onwards (Sølvberg 1976, 41, Nedkvitne 1977, 35, Helle 1982, 324). Rye is also recorded from the Bergen district (Fægri 1979) during the medieval period.

In some of the sagas it is mentioned that wheat *(Triticum sp.)* was imported to Norway. The importation of English wheat is also mentioned in other written sources from the 1180s up to the first part of the fourteenth century (Helle 1982, 312). In Norway no find of *Triticum* grain has so far been reported from the medieval period (Grøn 1927, Jessen 1962, 172–173, Sølvberg 1976, 41).

In addition to grain anf flour, a third cereal product, viz malt, was of importance. Malt is mentioned in the written sources from Bergen (Sølvberg 1976, 41, Nedkvitne 1977, Helle 1982, 312). Imported malt was mainly used for brewing light beer. Few finds of fossil malt have been reported. Helbæk (1938, 1964 and 1966) refers to fossil malt from Öland and Jutland.

The site: identification and chronology

In the 1980s a new building was erected in Rosenkrantzgate 4 south-east of the main excavation area at Bryggen (fig 1B, C). The site had been unoccupied since the last wooden buildings were torn down at the turn of the century. The area was investigated in 1978–79 under the direction of Jan Lindh (Lindh 1979 and in prep). The site covered 800 sq m, and several successive building phases were recorded. Since the site was physically separated from the main Bryggen excavations, the fire-chronology established for the latter could not be used directly. A preliminary relative chronology was therefore introduced, based on four successive continuous fire-layers labelled from above A, B, C and D. Lindh tried to correlate these fires with those mentioned in written sources and in the written evidence concerning the tenement which he associated with the site.

The identity of the tenements (one or two rows of houses running perpendicularly to the shore line) in this particular area, however, has been a matter of some controversy (Koren-Wiberg 1921, 126–130, Lorentzen 1952, Lindh 1979) cf fig 2. The original conception (Koren-Wiberg) postulated identity with the tenements known in contemporary documents as Fatten and Straumrinn.

Helle (1982) has recently re-examined the arguments and suggests that Straumrinn may have been situated 15–20 m further south (cf fig 2). Between Fatten to the north and Straumrinn he postulates a new nameless tenement. According to Helle, Lindh's excavations may have involved this nameless tenement and not Straumrinn itself.

Straumrinn is mentioned as the place where the extensive fire of 1248 started and again in connection with a local fire in 1454, which was just restricted to this property. Straumrinn was not rebuilt after this fire and the site became part of the neighbouring properties. On the basis of his preliminary chronology Lindh concluded that the tenement he had excavated was the successor of Straumrinn. However, the radiocarbon dates of carbonized plant material published by Krzywinski & Gulliksen (1984) indicated that the four fire-layers could be correlated with historically recorded fires as follows: A = 1413, B = 1393, C = 1332 and D = 1248. They would thus represent fires in

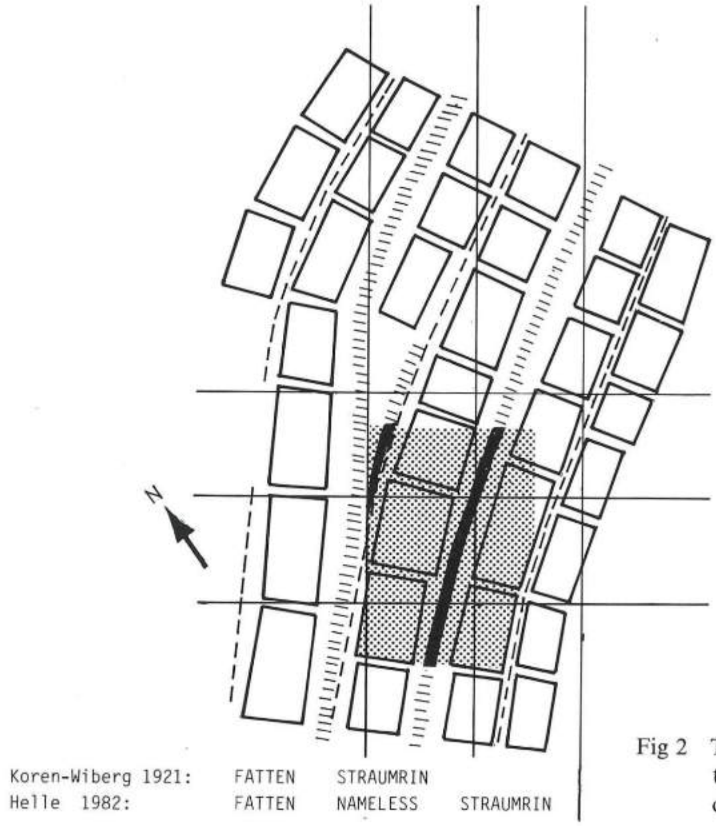


Fig 2 The site related to the tenements of the area cf text.

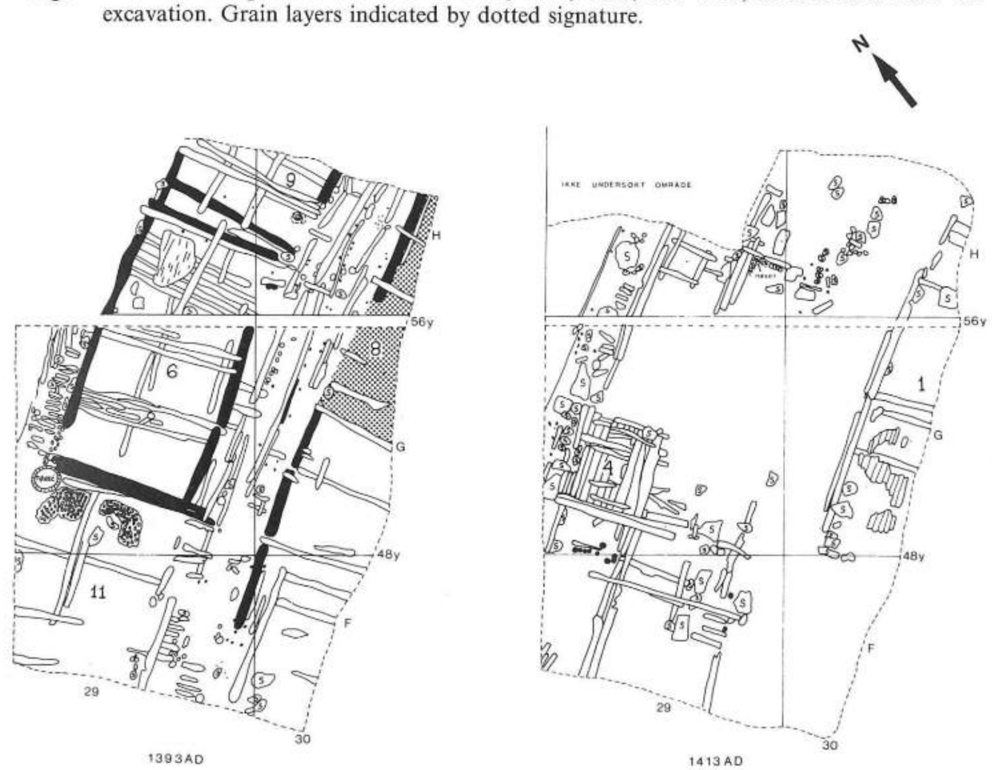
Straumrinn, or the nameless tenement prior to the establishment the new building plan in 1454.

THE GRAIN DEPOSITS AND THEIR ANALYSIS

Several small and three large deposits of carbonized cereal grain were found during this excavation. The three large finds were made inside three superimposed structures (nos 26, 18, and 8) occupying the same site and associated with fire-layers B, C and D (fig 1C). A passage was located outside them and remnants of barrels were found there. The charred grain was consistently restricted to inside the buildings south-east of the passage (fig 3). These buildings were cut by the section shown on fig 1C. The major part had been build upon in modern times and was not part of the present excavation. The grain was recovered from the section wall. The layers of grain decreased in thickness upwards.

If the quantity of grain found in the section is representative, the total quantity stored in the successive buildings would have been several tons. Such large quantities suggest a continuous activity based on grain kept in store. In a preliminary paper Krzywinski (Krzywinski & Fægri 1979) suggested that the finds of barley within the building indicated brewing. The aim of the present investigation is to elucidate the specific local significance and origin of the grain found. The results will later be incorporated in a comprehensive study of macroscopic cereal remains and foreign trade indications in the medieval period.

Fig 3 The situation prior to the fires in 1248, 1332, 1393, and 1413, as recovered from the excavation. Grain layers indicated by dotted signature.



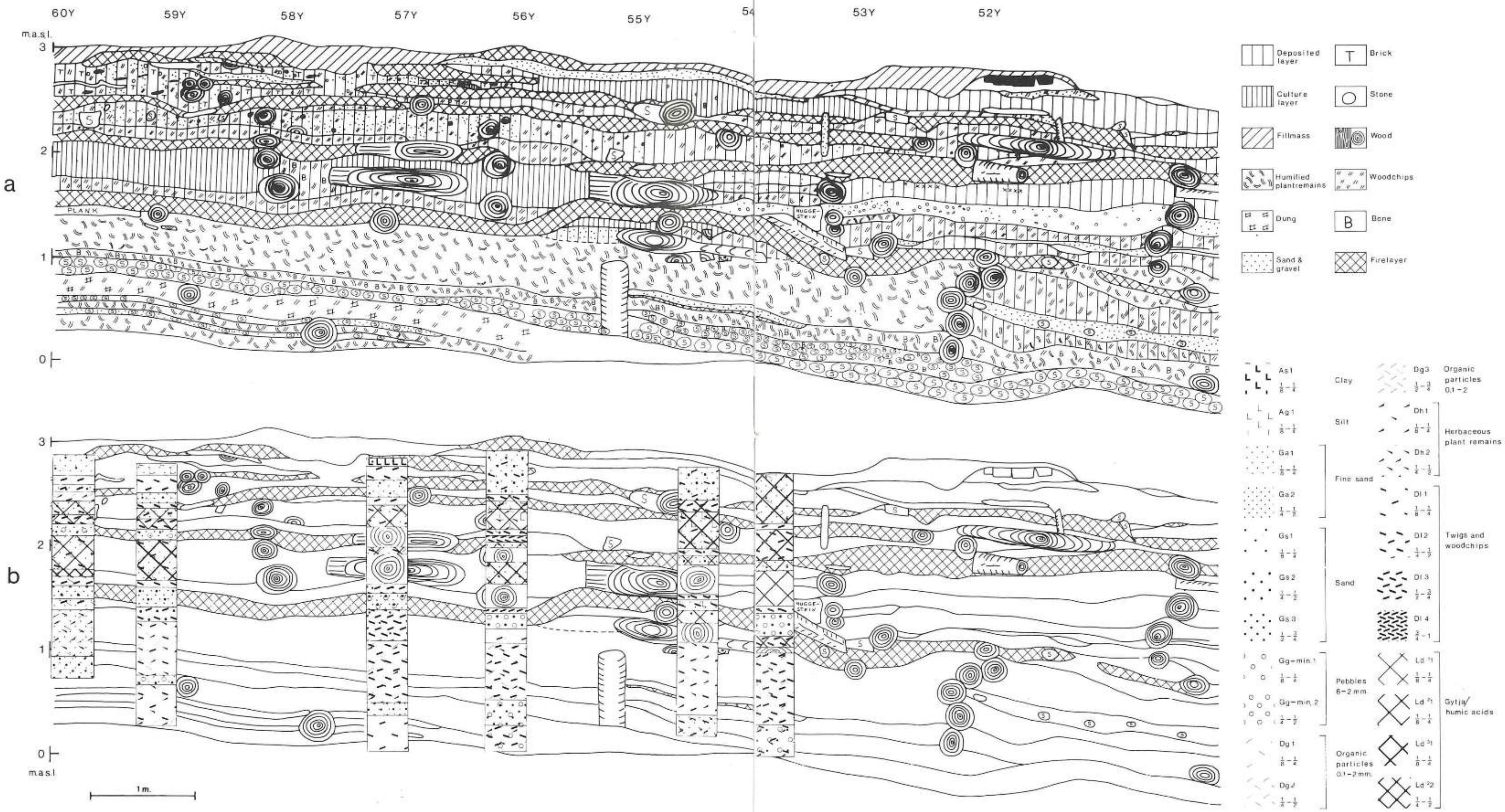


Fig 4 The investigated section. a. The section drawn during excavation. b. Sediment description based on Troels-Smith (1955) illustrated in columns. The fire-layers indicated by crossing lines.

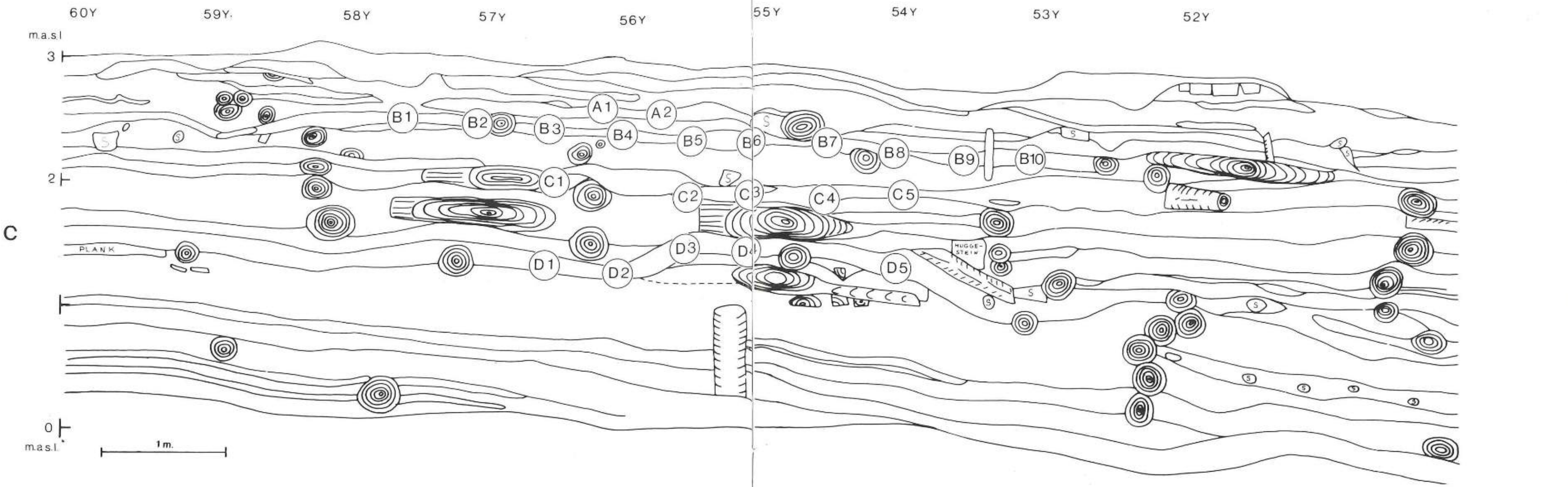


Fig 5 Sample of macro remains taken from the section. The samples are labelled according to the fire-layers A–D respectively. The layer discrimination indicated refers to those shown in fig 4.

Pollen and macro-fossil analyses were carried on in addition to radiocarbon dating and stratigraphic description. Some aspects of this kind of combined analysis technique have been discussed in Soltvedt (1982) and Krzywinski, Fjelldal & Soltvedt (1983).

The excavation had, on the whole, been completed before the grain stores were considered. Our main source of the stratigraphic information therefore was the still standing section (fig 4a).

An independent lithostratigraphic analysis based on Troels-Smith's classification system (1955) was carried out, and on the whole it supported Lindh's analysis. Owing to the large variation, especially in the layers between the fire-layers, the description has been based on discrete description points 1–2 m apart. This analysis is presented in fig 4b.

The stratigraphic analysis was made in the field and no laboratory tests have been carried out on the material.

In a deposit of this origin the current pollen rain concept is meaningless: the theoretical basis for a relative pollen diagram of an urban deposit is a matter for future study. A preliminary model is presented in Krzywinski *et al.* (1983), where pollen input in an urban deposit is considered dependent on the deposition mechanism and on activities connected with the environment. With a caveat for circular reasoning, conclusions may, at least in theory, be drawn about activity and environment.

The methods of pollen and macro-fossil analysis applied

The pollen analysis was based on homogenized samples of each defined stratum in the section at 56 y (cf fig 10). Methods used were those of Fægri & Iversen (1975). All samples were acetolysed and treated with hydrofluoric acid. Pollen identification was made with oil immersion phase contrast objectives, mainly at 500 × magnification. Critical identification was made under 1400 × magnification. Cereal pollen was identified according to Beug (1961) and Andersen & Bertelsen (1972). Discrimination within coryloid pollen grains (*Corylus* vs. *Myrica*) is easy in phase contrast on the basis of aperture morphology and sculpturing.

The carbonized seeds in the four fire-layers have been identified and the results presented in tables 3–5. Macro-fossil analysis was based on a sample grid in the section from 60 y to 50 y(fig 5), to test the homogeneity within each fire-layer and possible differences in composition between the layers. No secondary mixing could be detected in this part of the section (cf fig 4). If the building had been used for the storage of supplies or merchandise for various purposes, differences in the macro-fossil assemblage should be expected both within and between layers. Homogeneity of samples indicates a single function of the building prior to each fire. Forty-nine samples were taken from the fire-layers, 22 of which were analysed, viz 5 samples from layer D, 5 from layer C and 10 from layer B (fig 5). As fire-layer A was clearly different from the others with no observable concentration of grains, only two very large samples were taken from this layer. As it is difficult to deduce the conditions during the fire, quantity of grain per unit of volume or weight of deposit would be meaningless. The number of analysed seeds in each sample is also of little use, except for comparative purposes between samples. In the case of fires B, C and D the material consisted mainly of carbonized barley. The purity and quantity of the stored grain could therefore be calculated from the relative quantity of foreign seeds, which is independent of sample size etc.

The samples were stored in double plastic bags at +4°C until processed. They were sieved under a gentle spray of lukewarm water through 3 strainers with mesh ranging from 2.5 to 0.1 mm. The material in each size range was dried at 80°C and sorted under a binocular microscope.

Identification

Seeds were identified with the aid of the relevant literature: (Beijerinck 1974, Berggren 1969, Bertsch 1941, Brouwer & Stahlin 1975, von Heinish 1955, Katts, Katts & Kipani 1965, Korsmo 1935, Lhotska & Chrtkova 1978, Martin & Barkley 1961, Montgomery 1977). They were then compared with the reference collection of the Botanical Institute.

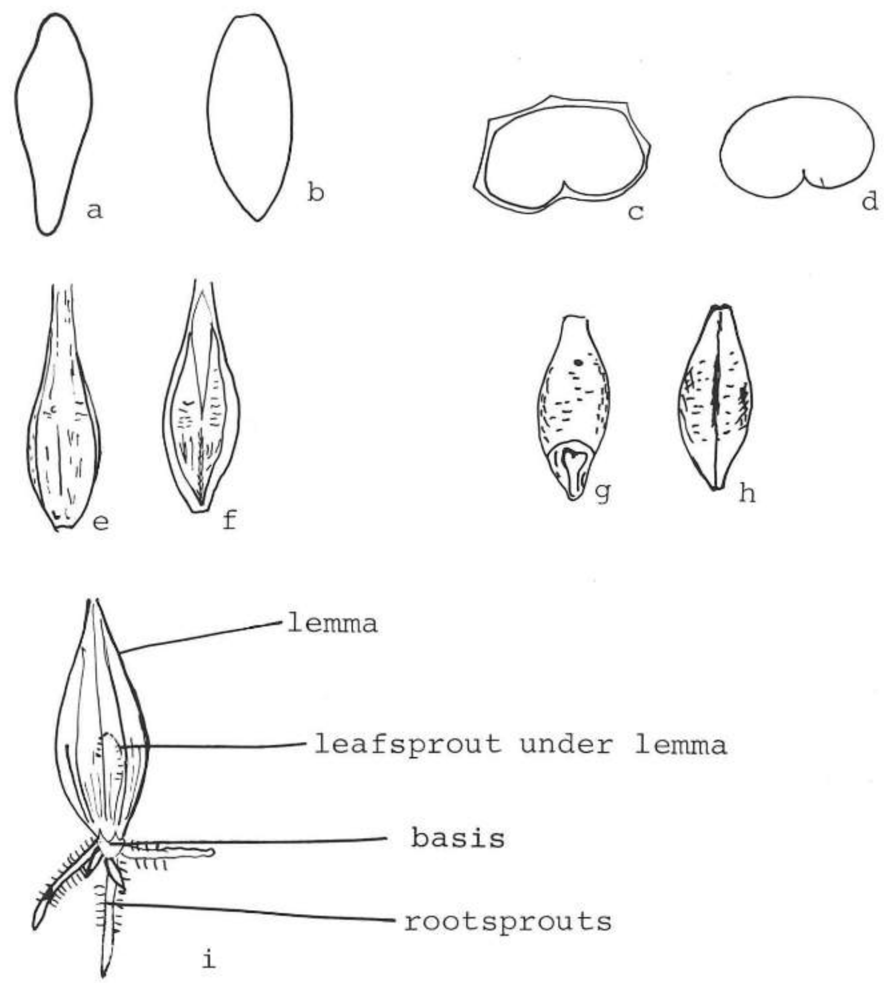


Fig 6 Characters of *Hordeum*. a. Lateral outline of *Hordeum* caryopsis. Dorsal side left. b. Dorsal outline of *Hordeum*. c. Cross-section of hulled variant and d. cross-section of naked variant e. Dorsal view of hulled barley. f. Ventral view of hulled barley. g–h. Dorsal and ventral view of barley. i. Germinated barley.

In critical cases comparison was made with modern seeds carbonized by heating in fine sand at 300°C for 3–5 hours or treated with hot 10% NaOH solution until the outer structures had disintegrated.

In the literature quoted above the taxonomy of cereals is not consistent. In this paper the taxonomy of *Hordeum (H. vulgare ssp. hexastichum* and *ssp. tetrastichum, H. distichum)* is based on Schieman (1948).

Grains more or less elliptical in shape with a broad or truncated top (fig 6). Where glumes are present, the grain narrows towards a relative broad base. Where glumes are absent, the caryopsis is characterized by a pointed base. Naked barley has a rounded cross-section, while hulled grains are somewhat angular. The caryopsis of the hulled types carries impressions of the lemma nerves on the dorsal face of the grain, and on ripe grains remains of the palea are found inside the ventral furrow. It is sometimes possible to detect the characteristic folding of the palea in this furrow (Körber-Grohne 1967). The dorsal face of a naked grain is faintly wrinkled.

According to van Zeist (1970), the shape of the depression at the base of the lemma discriminates between taxa with short and long internodes. A narrow lens-shaped depression is found in the *ssp. hexastichum* (short internodes), while it is horseshoe-shaped in *ssp. tetrastichum* and *H. distichum* (long internodes). This feature can only be used for samples containing many well-preserved specimens (fig 7). *Ssp. tetrastichum* is characterized by mostly long internodes (longer than 2.5 mm) (Schieman 1948, van Zeist 1970). The top of the internode is straight, and the palea is oriented towards the

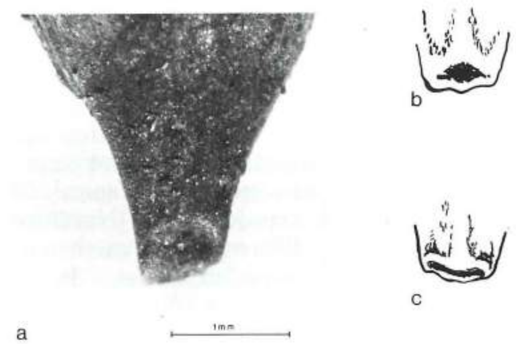


Fig 7 Scar (depression) near the base of *Hordeum* grain.
a and b. *Hordeum tetrastichum*.
c. *H. hexastichum*.

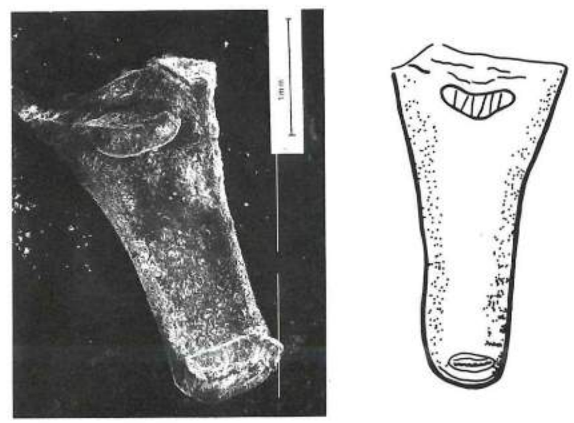


Fig 8 Internode of *Hordeum*.

Fig 9 Assymetric *Hordeum* grain.

centre of the spikelet (fig 8). Ca 70% of the grains are assymmetric (fig 9), but this character is often indistinct on grains that are not well preserved. *Ssp. hexastichum*, on the other hand, usually has short internodes (less than 2.5 mm) and the grains are symmetric. *H. distichum* has no asymmetric grains and the internodes are of varying length. According to Helbæk (1960), sterile side flowers must be present for sure identification.

Malt

The seed starch in grain cannot be fermented directly but must first be broken down to maltose. Germinating grain produces the enzyme diastase, which converts the starch to maltose that can be fermented to ethanol. Malting is mostly done by soaking the grain in water with subsequent germination after 4–6 days. When the leaf sprout has reached a certain length, the seed is killed by drying and the root sprouts removed mechanically. If the sprouting or malting goes too far, maltose is used in the development of the embryo. The processes run parallel and it is important to interupt germination at the right point. If the sprout is too short, it is considered uneconomical. Of old a mean sprout length of two-thirds of the grain was considered best (Nordland 1969, 20, Opedal 1948, 52). According to historical sources, different cereals can be and have been utilized in brewing, but to-day as in the past barley is preferred. Oats *(Avena)* with their high concentration of lipids contain too much fat and rye *(Secale)* has too high protein content; both give an inferior beer. Visually it is difficult to distinguish carbonized malted barley from ordinary grains (cf fig 26A), which might be the reason why reports of malt are rare. Sprouted barley grains are, however, reported from Öland and from Jutland (Helbæk 1938, 1964 and 1966). Helbæk refers to this as malt, but as the root sprouts had not been removed, it is possible that the sprouting was accidental (Soltvedt 1982) (cf fig 6i).

POLLEN ANALYSIS

The pollen diagram from the site is reproduced in fig 10. Lithostratigraphically the section could be divided into 17 layers, of which layers 5, 7 and 9 contained so little pollen that no spectrum could be obtained. Nor is layer 1 (the top spectrum) represented in the diagram. The lithostratigraphy was strictly local, some of the layers being no more than discontinuous lenses in the section (cf fig 5).

The pollen record has been divided into four assemblage zones, RK1–4, with some similarity between RK4 and RK2 and also between RK3 and RK1. In the total diagram barley and bog myrtle *(Myrica)* have been grouped separately as "brewing indicators".

Assemblage RK4 is represented only by the bottom layer 17 (pollen spectrum no. 13), which consisted of woodchips from the period of reconstruction after fire D (1248) (Krzywinski & Gulliksen 1984), with admixture of older material. The pollen content was low, and the preparation contained large quantities of charcoal dust. The pollen mainly represents the period before the fire. There were high frequencies of *Hordeum* and *Myrica; Vicia faba* (broad bean) and grass pollen are other noteworthy constituents. Tree pollen is less than 40%, with *Betula* (birch) as the main constituent.

Pollen spectra 12–11, representing layers 16 and 15, constitute assemblage zone RK3. Layer 16 consisted mainly of birch bark, probably from the period of building, birch bark being used under the turf covering the roofs. Layer 15 consisted of animal dung and straw. The pollen content of layer 16 may come from or at any rate have been mixed with pollen coming from the dung layer above. The pollen content in zone RK3 was mainly characterized by low quantities of Cerealia, *Myrica* and tree pollen. Grass pollen was high, and there was also a fairly high incidence of *Calluna* (heather), which indicates that the material came from a non-urban environment.

The spectra 10-4 are grouped together as zone RK2. The origin of the material is heterogeneous. Layers 13 and 7 were both distinct fire-layers, consisting of carbonized grain mixed with some charcoal, and have been identified as recording the fires of 1332 and 1393. The layers in between were woodchip-layers. The quantity of woodchips, however, decreased from one layer to the next upwards, while humification increased. Over the fire-layer, again, the woodchip-layer consisted of pure chips which had hardly decomposed at all (layers 12 and 6). These layers were typical of the area and have been interpreted as the result of wood-working during rebuilding. Layers 11-8, on the other hand, must have accumulated over some time and been subjected to aerobic disintegration.

Spectrum 10 represents the highly humified layer 14. Arboreal pollen was about 20%, and the spectrum was characterized by equally high values of the brewing indicators (*Hordeum* and *Myrica*). The layer has been interpreted as an earthen floor, the material for which originally came from agricultural land. The high values of bog myrtle, barley and other cerealia pollen must originate from activities inside the building. In relation to the site, spectrum 10 consisted of a mixture of both allochthonic elements, introduced with the soil used for the floor, and autochthonic elements derived from activities inside the house.

Layer 13 consisted of charred barley mixed with some grains of rye. The pollen composition of this spectrum 9 was very similar to that of spectrum 10 further down. High values of pollen from weeds *(Rumex, Centaurea cyanus* and *Brassicaceae)*, *Hordeum* and *Myrica* relate the pollen deposit to activities taking place in the building.

Through the following spectra the assemblage only changed slightly. What process formed the layer 11-8 is uncertain. One possibility is that the building in the period between fires C and B had been rebuilt with the resultant accumulation of wood-chips. However, the high state of disintegration of the wood-chips in these layers indicates that they more likely represent a gradual accumulation during the use of the premises. It seems to be characteristic for deposits under buildings at Bryggen that wood-chips and other organic debris accumulated under the floors (rat's nests, etc), and slowly decomposed in an aerobic environment. In the pollen diagram *Myrica* pollen decreased through the assemblage zone, but was still present in the reconstruction layer 6 (pollen spectrum 4), which seems to have been formed during the reconstruction of the building after the next fire (B) in 1393. As in the other layers on top of a fire-layer, the pollen

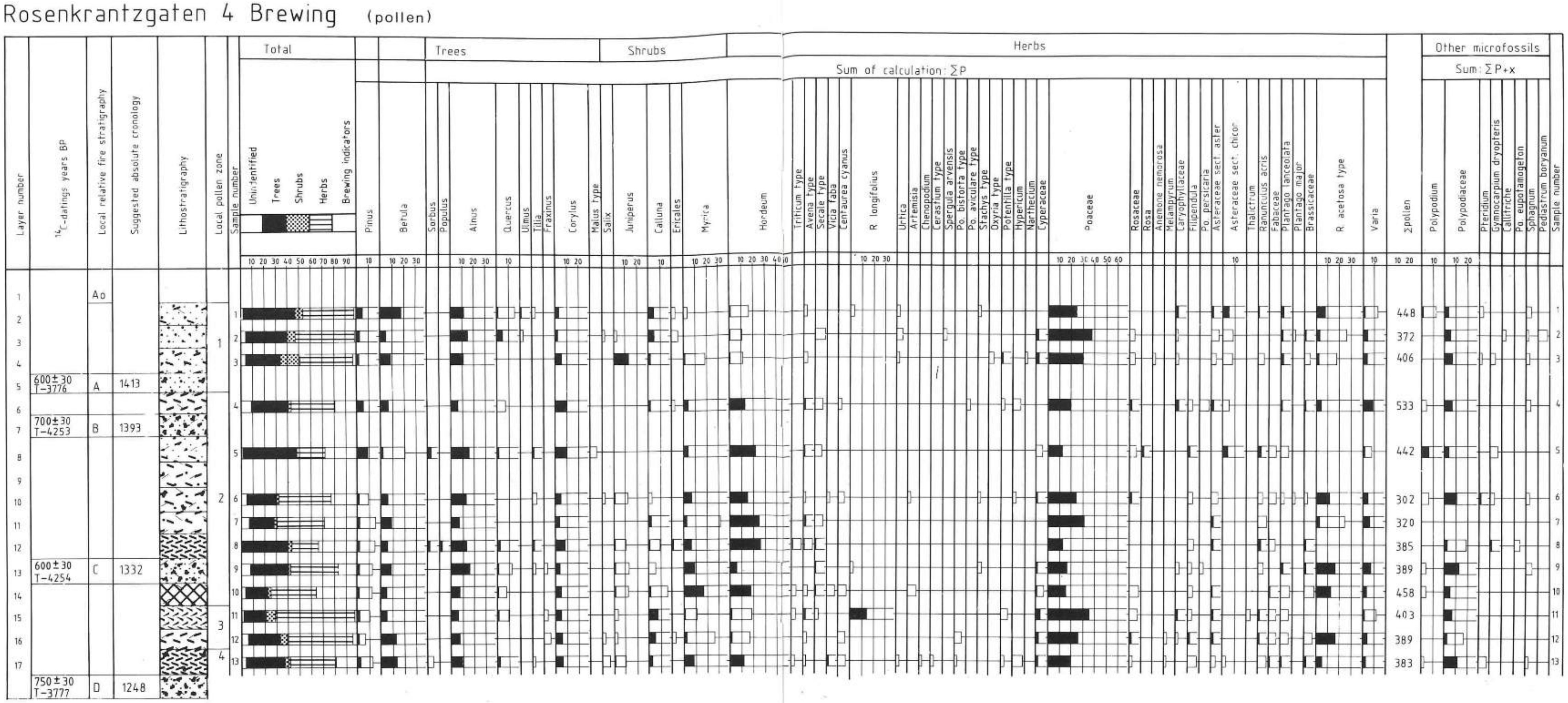


Fig 10 Pollen diagram from the investigated section. Chronostratigraphy according to Krzywinski & Gulliksen (1984).

content of layer 6 possibly derived from activities prior to the fire mixed into the woodchips during rebuilding work.

The pollen content of zone RK1, which accumulated during the use of the building in the period after fire A, is different. Barley and *Myrica* pollen are largely absent. Other cereal pollen types are still present, but scattered and with low values. Pollen spectrum 2 (layer 3) was characterized by high frequencies of juniper pollen. The presence of *Callitriche* pollen and the chlorophycean *Pediastrum* is of special interest.

Layer 3 was a grey sand without visible humus or other organic components. This sand is either a primary fluvial deposit or may be redeposited (if it was introduced for some purpose on the site). Stratigraphically there was no indications of the latter. The lacustrine indicators suggest that the sand came from a freshwater or river sediment. Apart from high values of *Juniperus* the pollen content of the zone did not differ significantly from one spectrum to the other within the layers. The incidence of Cyperaceae pollen in spectra 3 and 2 also suggest a wet environment. If the layer represented redeposited sand, it must have come either from a locality in the neighbourhood or from a similar environment. Layer 3 at least and possibly more of RK1, had most likely accumulated in situ and may have been deposited from a small brook. The upper layer 2 contained the same general pollen assemblage.

Apart from spectra from local lenses of bark and straw (layers 14 and 15), the lower part of the pollen diagram showed a strong correlation between *Myrica* and *Hordeum*. This correlation lasted from fire D to fire A and was possibly related to local activity, while above fire A the diagram showed no such affinity. The presence of freshwater plant pollen in layer 12 must be seen in relation to the presence of macro remains of water plants (cf page 33) and may indicate the use of water inside the building.

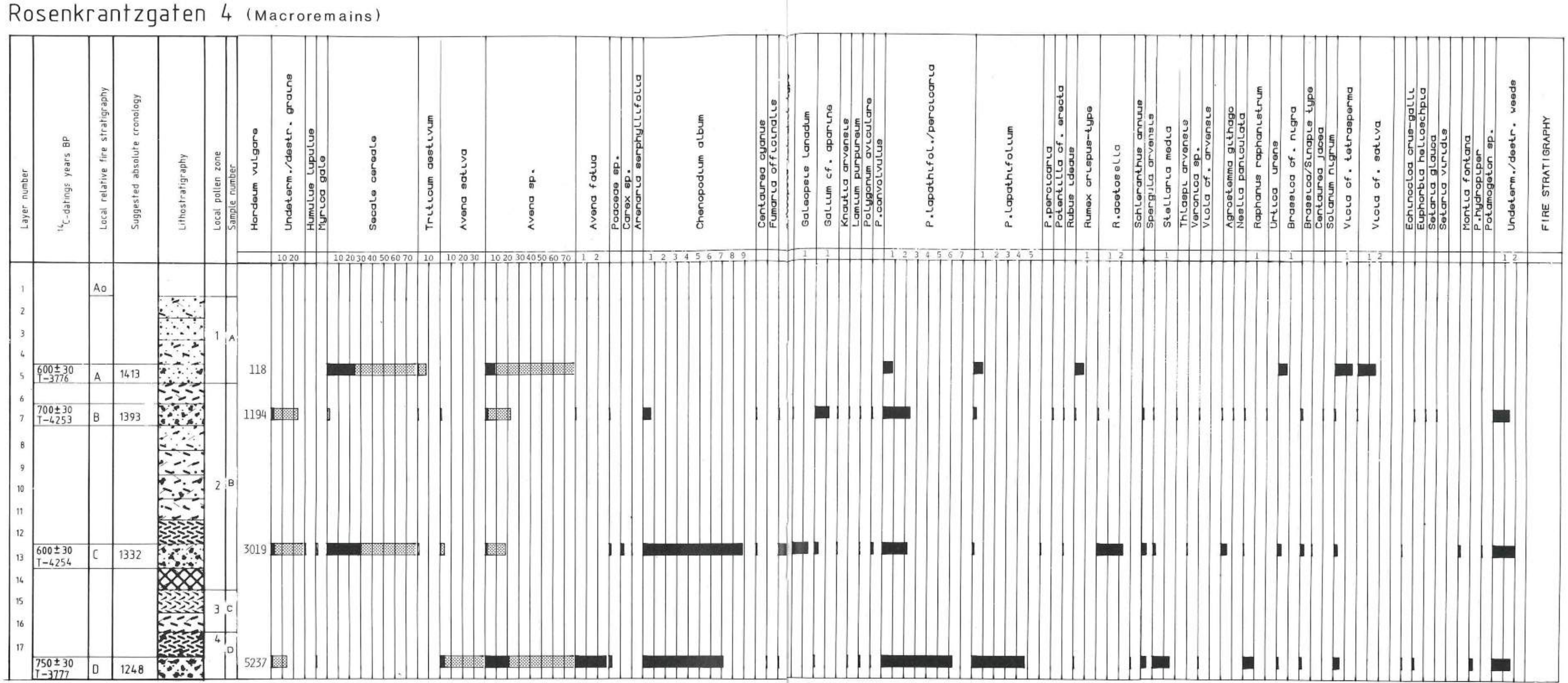


Fig 11 Diagram illustrating the variation of macro remains (mainly seeds) at different fire-layers related to the content of *Hordeum*. Due to general differences the low content of barley in fire A the upper histogram can not be compared with the other layers.

CHARRED SEEDS AND FRUITS IN THE FIRE-LAYERS

The seeds and fruits found in the fire-layers are presented in tables 3–5 and fig 11. The main component is *Hordeum* (tables 3–5). The relative frequencies of other fossils in fig 11 have been calculated as percentages of their own total number plus *Hordeum*.

Hordeum (barley)

Three groups were distinguished on the basis of the degree of destruction of the grains.

I Glumes intact, grains well preserved, some grains with longitudinal and transversal secondary fissures.

II Partly broken grains where at least the basis of the glume was missing but the caryopsis was intact. The basal part of the glume was often broken or worn off. Remnants of the glumes were usually present. If the glumes were totally missing, impressions of their nerves could be seen on the dorsal side of the grain (fig 12a). The embryo was often visible.

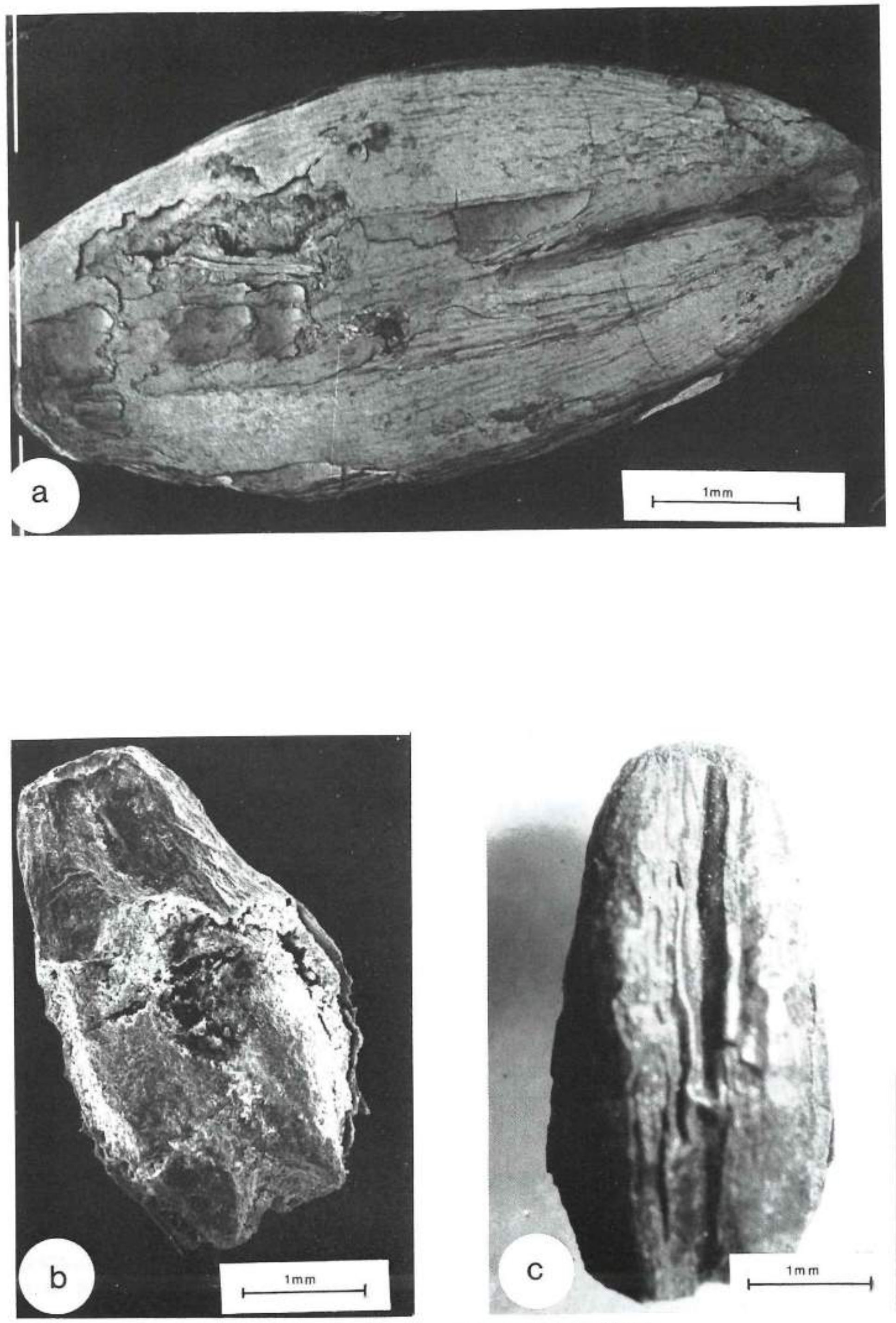


Fig 12 Different preservation in the *Hordeum* grain material, cf text.

TABLE 1

Hordeum	No. of grains investigated	No. of sym grains	No. of asym grains	No. of internodes	Internodal length
Fire B (1393)	677	262 (38.7%)	415 (61.2%)	–	–
Fire C (1332)	499	262 (52.5%)	237 (47.5%)	22	2.5 cm
Fire D (1248)	463	184 (39.7%)	279 (60.2%)	12	3.1 cm

III Badly preserved grains which could still be identified as barley, but further identification uncertain (fig 12b-c).

The grains in groups I and II were measured (tables 5 and 6). Generally the grains which were dated to fire B (1393) were largest, while the firelayer C (1332) had the smallest grains.

If large parts or the whole of the epidermis was missing, it was difficult to decide whether the barley was hulled or not. Positive evidence of the presence of naked barley was not found in the material. On most of the grains without glumes it was possible to find the impression of the palea on the ventral side of the epidermis or the three strong lemma nerves on the dorsal side, indicating the presence of hulled barley.

Hordeum distichum can be excluded. No sterile spikelets were observed. A clear tendency towards asymmetric shape (as in four-row barley) was noted (fig 9). The incidence of symmetric grains is shown in table 1. In fire B it was not possible to find enough grains with intact glumes for measurement and the data also include grains without.

The ratio of symmetry in the grains which were present was as to be expected in four-row barley (cf Behre 1976, Körber-Grohne 1967, van Zeist 1970). The few internodes which were found also suggest this. Only one internode from layer C and none from D was shorter than 2.5 mm.

Avena (oats)

A relatively high number of *Avena* grains was found in the material. Grains both with and without glumes were found. The group of grains with glumes consisted of both *A.*

Fig 13 Lower grain in the spikelet of *Avena sativa.* 1mm

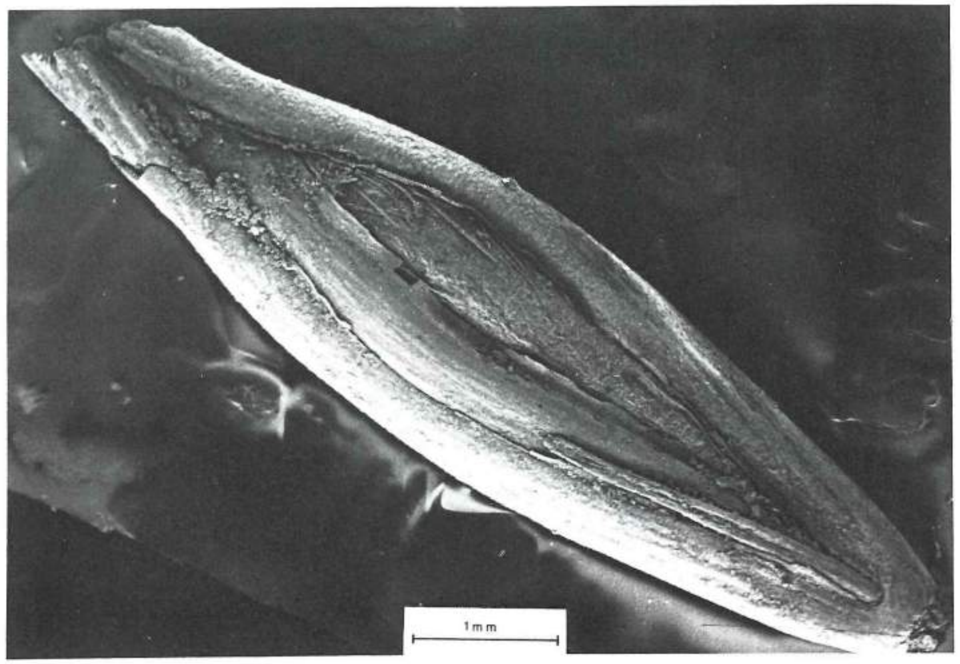


Fig 14 Upper grain in the spikelet of *Avena sativa.*

sativa and *A. fatua* (Wild oats). Both of these have parallel depressed nerves on the lemma. The top of the glume was often broken and the hairs on the caryopsis were exposed. Grains with convex sides and a transverse scar on the base are recorded as *A. sativa*. Most of these had no scar from the awn on the dorsal side. The lower and upper grain in the spikelet were represented, the lower being relatively large, 8.48 mm long, 2.46 mm broad and with a broad base (0.77 mm) (fig 13). Approximately 25% of these had the scar from the awn on the dorsal side. The upper grain (fig 14) had a narrow base, 0.38 mm, and was shorter and thinner (7.5×0.95 mm). None of these had an awn scar on the dorsal face.

A. fatua seeds have parallel sides and a scar from the awn on the dorsal side. Most grains had a distinct circular scar at the base (fig 15). In many seeds the base was broken, but nevertheless there were sufficient remains to suggest that the scar had been circular. The basal brushes were not preserved.

Grains without glumes could only be recorded as *Avena sp*. *Avena* caryopsis have a thin testa and pericarp. They are therefore easily damaged or deformed during carbonization (Körber-Grohne 1967). However, three different groups were distinguished:

I Grains with parallel sides and an intact furrow, which was broad on the top and narrow at the base. These might be *A. fatua* (fig 16).

II Small grains with a convex profile which was broadest near the centre. These are most likely the caryopsis of *A. sativa* (fig 17).

III A third form, which was broadest on the top, was also found, but its taxonomical significance is uncertain. This also applies to the other groups without glumes. The frequency of these groups has not been calculated.

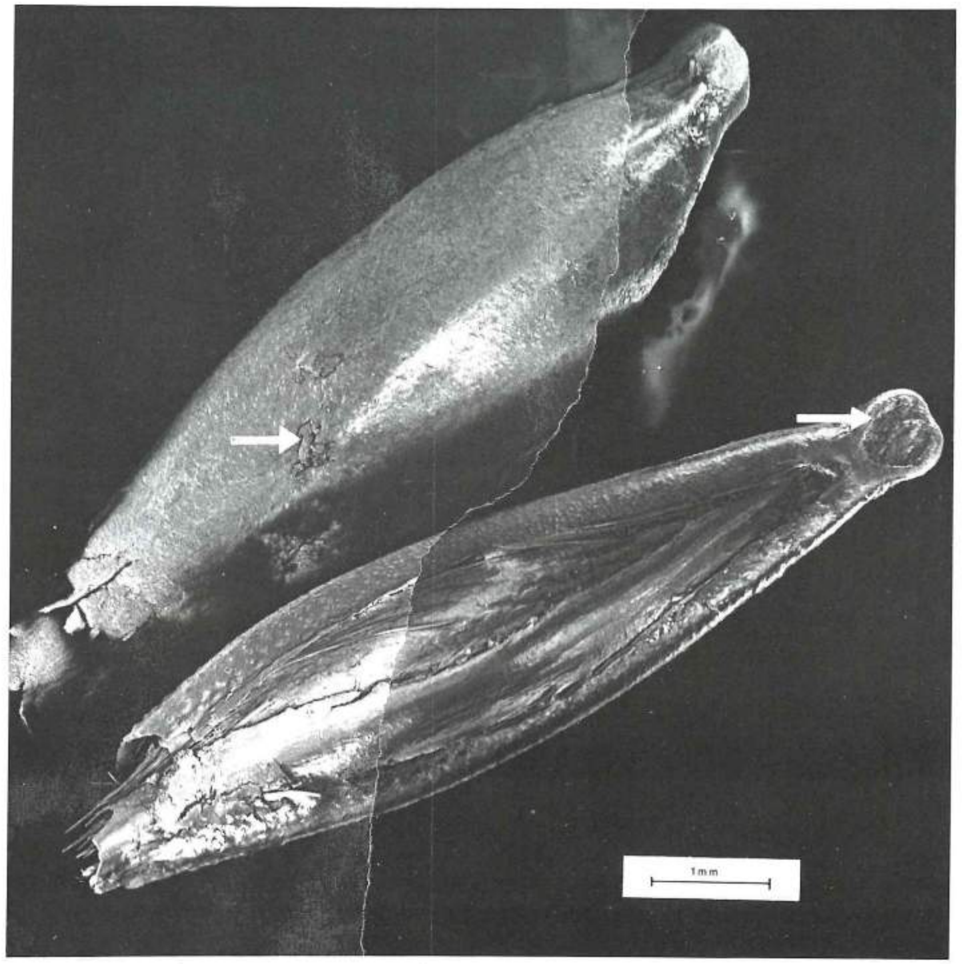


Fig 15 *Avena fatua.* The upper grain in dorsal view exposing the scar of the awn. The lower grain in ventral view.

No positive evidence was found for the presence of *A. strigosa*.

A. fatua has more resistant glumes than *A. sativa*, and since the identification was done on grains with intact glumes, *A. fatua* will be overrepresented (Helbæk 1957). This is corroborated by the casyopses, which mostly have the shape of *A. sativa*. Therefore the actual proportion of the latter is probably in excess of 2 : 3. By far the greatest number of *Avena* grains were found in fire-layer D.

Secale (rye)

Secale cereale (rye) grains were found, especially in fire-layer C, where they amounted to 44% of the number of *Hordeum* grains, but also in D (cf tables 3–5). Rye caryopsis were of varying size, both long and narrow, short and broad (fig 18); 88 grains were measured (table 8). The triangular cross-section was characteristic, and most of the

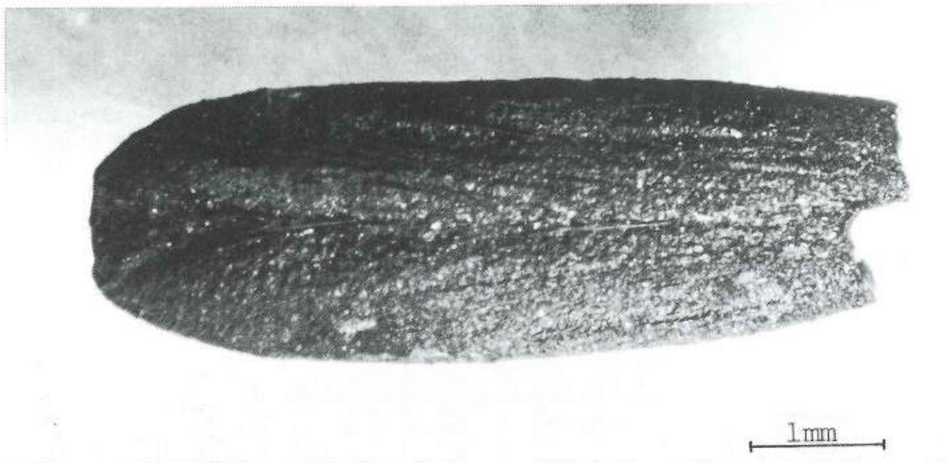


Fig 16 Caryopsis of *Avena fatua.*

grains had a shiny smooth epidermis. The best preserved ones had a distinct transversely undulating surface.

Triticum (wheat)

Wheat was very rare in the samples, cf tables 3–5. One of the grains is shown in fig 19 with its typical form and with the hairs surrounding the top of the grain. Wheat, most probably *T. aestivum*, were found in layers, B and C.

Malt

On some grains in *Hordeum* groups I and II (cf above) the lemma was absent and a leaf-shoot could be distinguished directly (cf figs 20–22). Detached leaf-shoots were also observed (fig 23). On the first examination of the best-preserved grains in groups I and II, 21% of the barley in fire-layer B was found to have germinated, 5% in C and

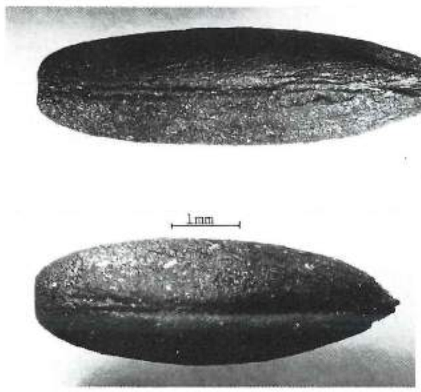


Fig 17 Caryopsis of *Avena sativa.*

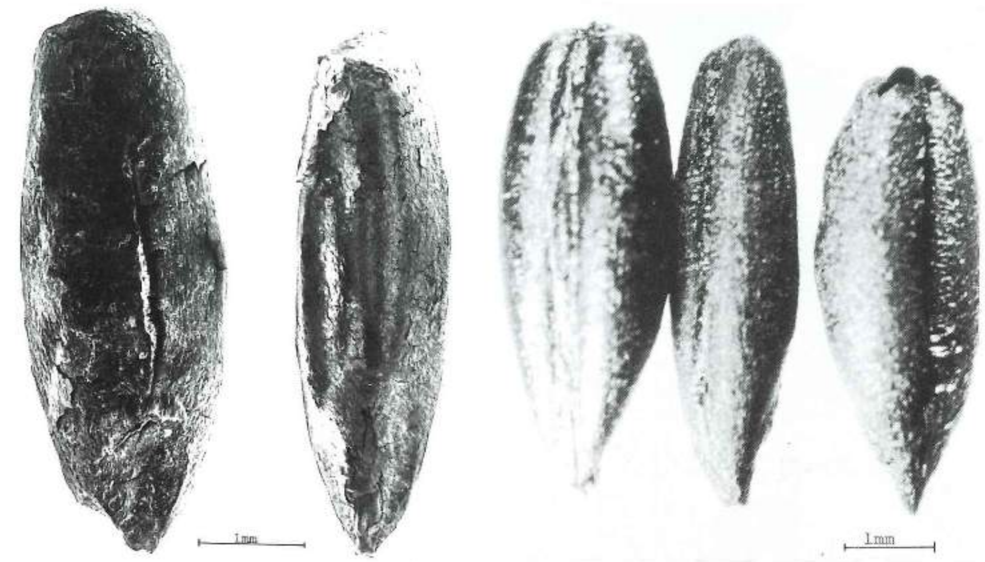
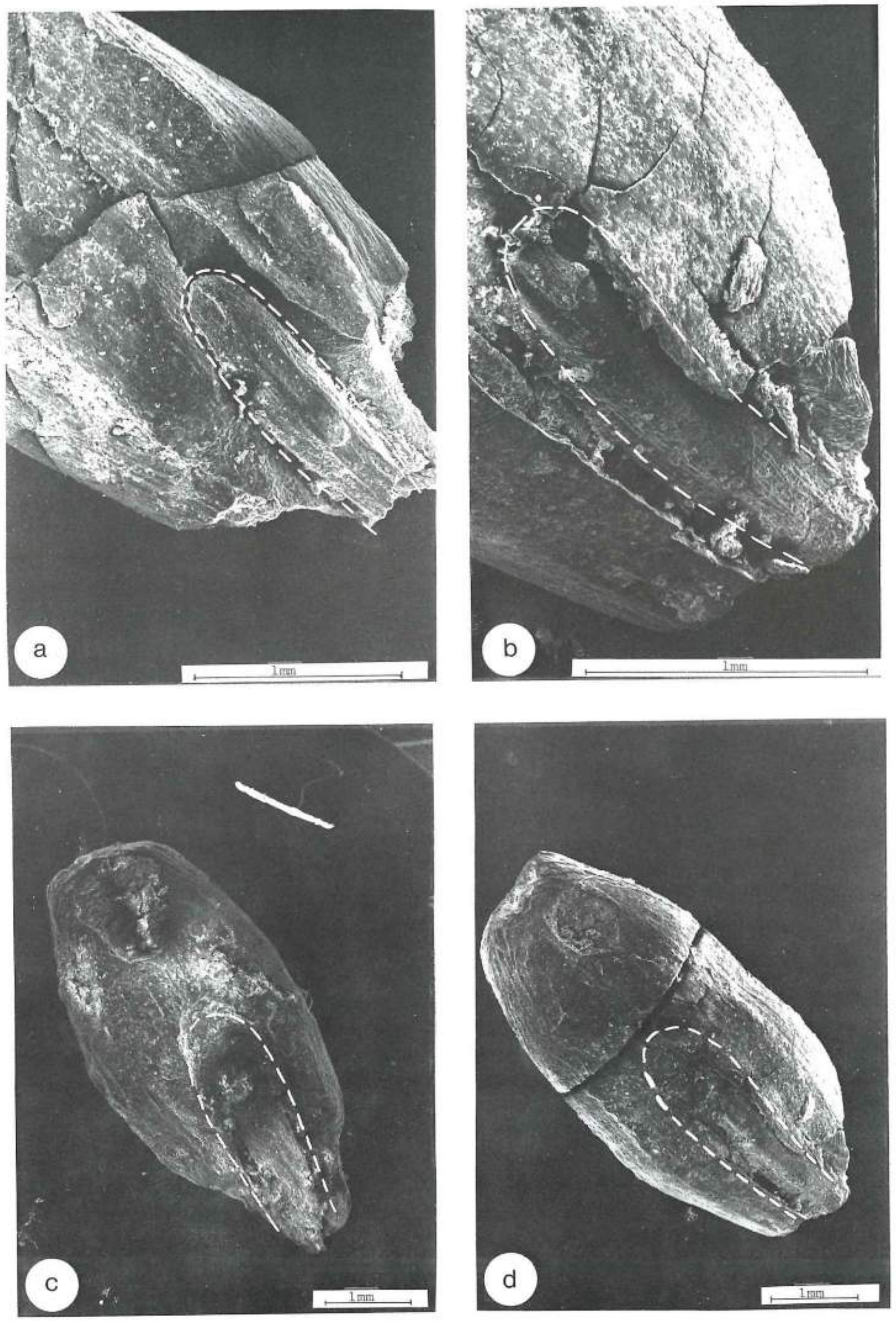


Fig 18 *Secale cereale* Grains to the left in SEM.

3% in D. Fire B had the largest amount of damaged grains and also the largest amount of sprouted grains.

A large percentage of the grains from group III was also damaged in the same way as in groups I–II. On the grains without the embryo the basal third was missing, and there was a depression on the dorsal side of the grain (cf fig 24). The possibility remained that a large proportion of the undamaged grains could still have a germ under the intact lemma. Furthermore, the damaged grains of group III could also have germinated without this being observable. From each fire-layer 150 grains with intact lemmas were examined to see whether this could be possible. They were glued to a sheet of paper with the ventral side down, and the lemma was removed with a dental drill, exposing the embryo (fig 25). In four samples from fire-layer B 63%, 78%, 89% and 90% (mean 77%) had germinated. In two samples from fire-layer C the germination percentage was 74% and 81% (mean 77%), and in two samples from fire-layer D germination percentages of 71% and 80% (mean 79%) were found. It is clear that the

Fig 19 *Triticum aestivum.*



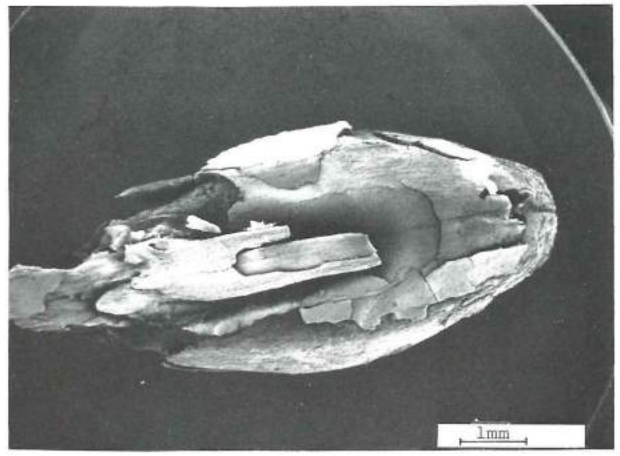


Fig 21 SEM microphoto of destroyed *Hordeum* grain with long leaf sprout exposed.

percentage of sprouted grain based on observable cases is too low, as only undamaged grains could be examined this way.

If the broken grains of group III (above) were destroyed by or because of germination, the frequency of germination can be estimated by adding their numbers to that of grains with visible sprouting + grains with sprouts concealed by the glumes. An estimate on this basis gives a figure of 97% in fire-layer B, 89% in fire-layer C and 92% in D.

The sprout lengths of the grains were from 1 to 3 mm, ie half the length of the grain, but an evaluation of the lengths was not possible, as the sprouts shrink relatively more during carbonization than the grains. The length of the depression in the grain is a better indication of sprout length. In the investigated material the mean length of the sprout depression was ½ to ⅔ of the grain length. Root sprouts were not found in any of the samples examined, but on a few exceptionally well-preserved grains fissures were found at the base of the lemma, where the root sprouts have penetrated the glume (cf fig 26).

The percentage of sprouted grains of oats and rye was significantly lower than that of barley. Sprouted grains of oats (fig 27) were relatively far more frequent than those of rye. Most of the rye grains had very short sprouts, 1–2 mm, and only one was significantly large (fig 28). The sprouts on oat grains were longer.

Myrica gale (bog myrtle, sweet gale) (fig 29)

Fruits, male catkins, leaf fragments and other parts of *Myrica* were found in fire-layers C and D, with the largest frequency in C.

Bog myrtle is common in wet bogs in W Norway. In medieval documents various uses are mentioned, the most important being as flavouring for beer (Behre 1984, Fægri 1970, von Hofsten 1960, Høeg 1968, 1975). Around 1300 the trade in *Myrica* was considerable. The import of hops increased during the medieval period but the use of *Myrica* continued, in some places until recent times.

Fig 20 Different examples of sprouted barley grains (SEM). a. Grain with destroyed lemma and basal part of leaf sprout visible. b. Leaf sprout partly visible and fissured lemma. c. Sprout partly visible and the lemma partly exposed at the basal part. d. Leaf sprout visible under fissured lemma.

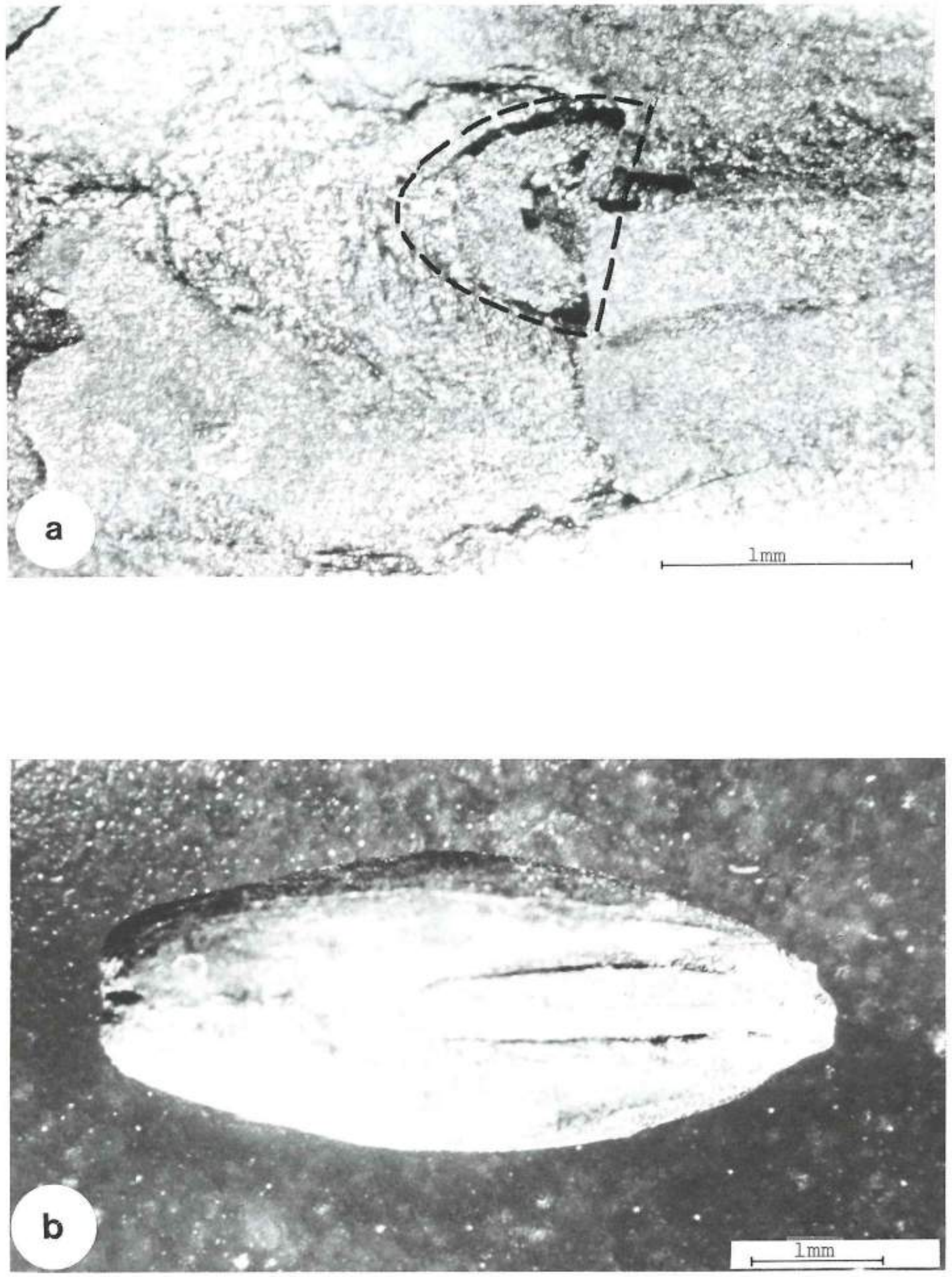


Fig 22 a. Leaf sprout tip exposed under destroyed lemma. b. Sprouted grain with lemma worn off (imprint of lemmae nerves visible).

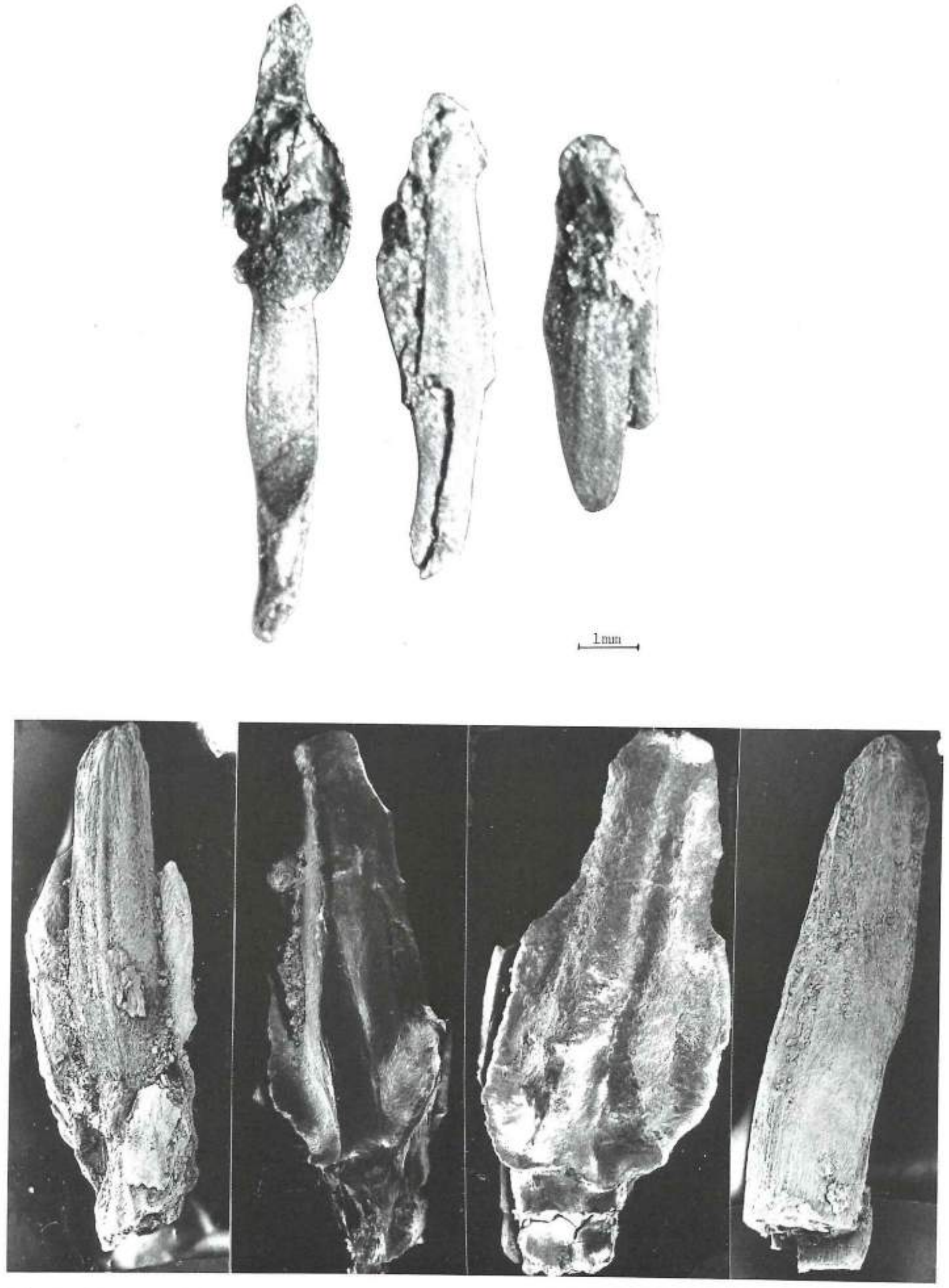
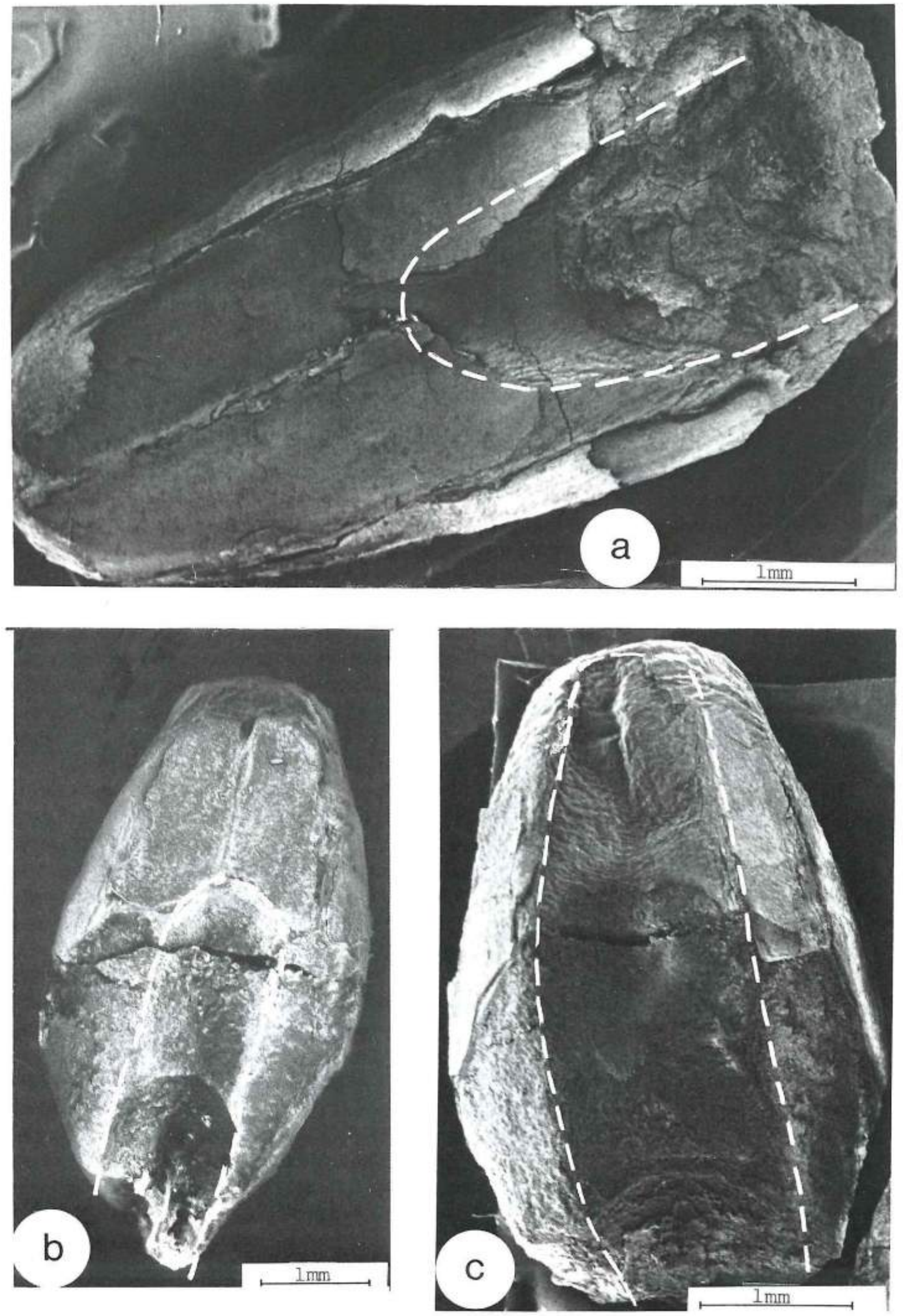


Fig 23 Separate leaf sprouts.



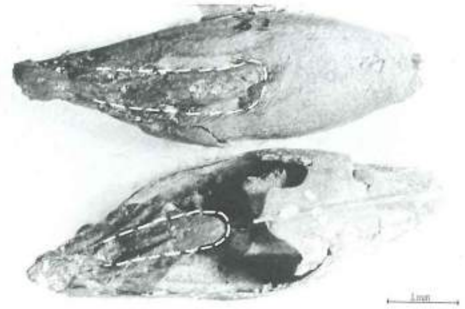


Fig 25 Removing lemma from *Hordeum* grains. The intact grains were glued to paper, ventral side down. Lemma were carefully drilled away, exposing the sprouts.

Humulus lupulus (hop) (fig 30)

Hop seeds were found in fire-layer C. They were characterized by circular shape and asymmetrical cross-section. The base is also asymmetric and the surface smooth. The mean size was 2 × 2.1 mm. The seed is fragile and easily broken. The early use of *Humulus* in W Europe seems primarily to have been for medical purpose (von Hofsten 1960, 7). The use of hops in brewing is not clearly documented until the ninth century (Wilson 1975, 644). In Denmark cultivation of the plant is known from the first part of the thirteenth century. Hops were imported into Norway about 1350, while cultivation in Norwegian monasteries is noted right from the beginning of the fourteenth century (von Hofsten 1960, 9). Only female flowers are used in brewing, but as the flowers are collected before the seeds develop, one cannot expect to find much hop seeds in a brewing context.

Weeds – general remarks

Seeds of weeds of cultivation found in the samples provide further information about the ecological and agricultural conditions of the grain fields. In addition to available written information about weeds in grain fields, the present-day geographical distribution of some species provided clues to the geographical origin of the grain. Many taxa are of little geographical or ecological significance, since they are ubiquitous and found as weeds in any field. They are discussed below under the heading of "general weeds". However, several of the species of which remains were recovered are rare or extinct as grain field weeds within the area from which the grain may have come. Previously they were common and sometimes troublesome. Modern agricultural techniques have reduced their significance. They are discussed in detail below under the heading of "ancient weeds".

There was a rather peculiar group of aquatic plants or plants growing in very wet places mixed with the grain. The presence of these plants parallels the pollen of aquatic plants and phytoplankton found in the pollen spectra (cf p 19). These plants do not

Fig 24 Destroyed *Hordeum* grains. The grains have sprouted but the sprouts are lost, leaving a depression on the dorsal side. a. Sprout length less than half the length of the grain. b. Sprout length slightly more than half of the grain length. c. Sprout length more than ⅔ of the grain.

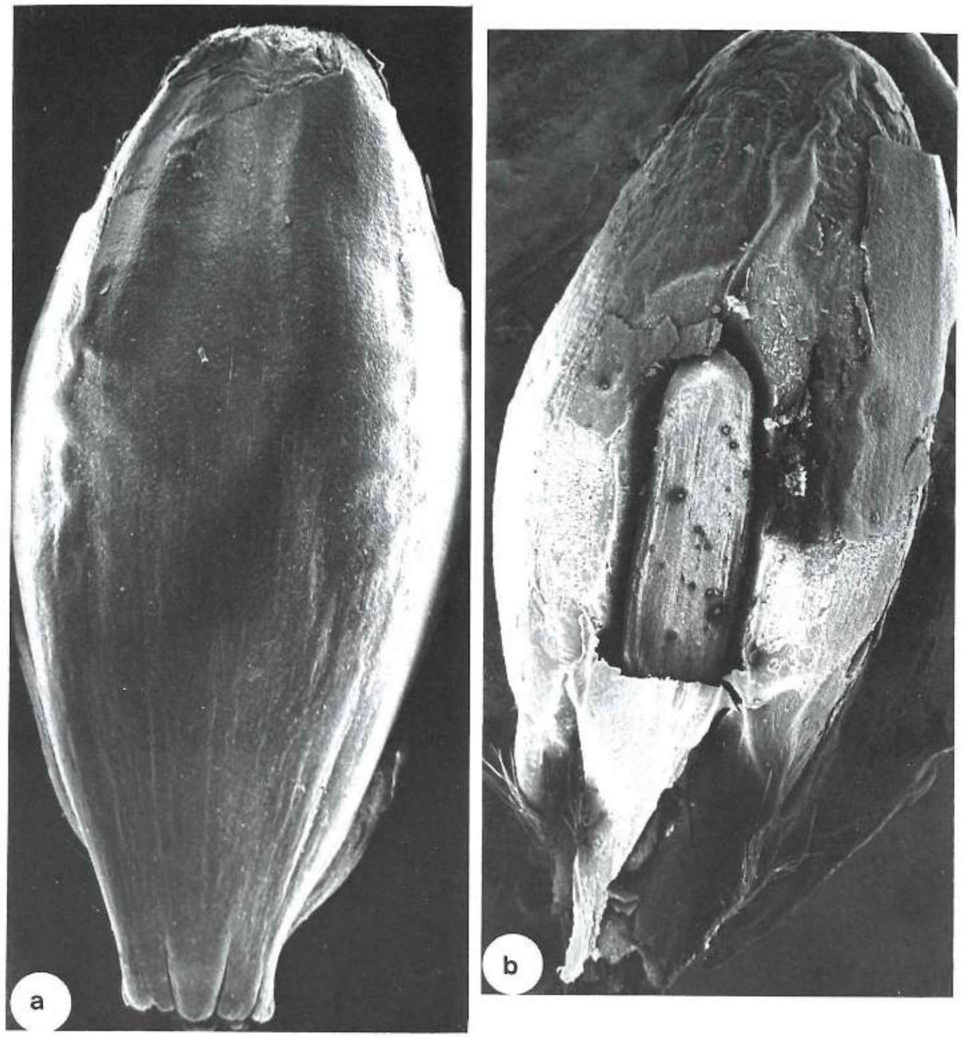


Fig 26 Recent malt (SEM). a. Only visible sign of malting is small fissures in the glumes at the base, where leaf sprout has penetrated (dorsal view). b. Lemma partly removed exposing the sprout in the depression in the caryopsis (dorsal view).

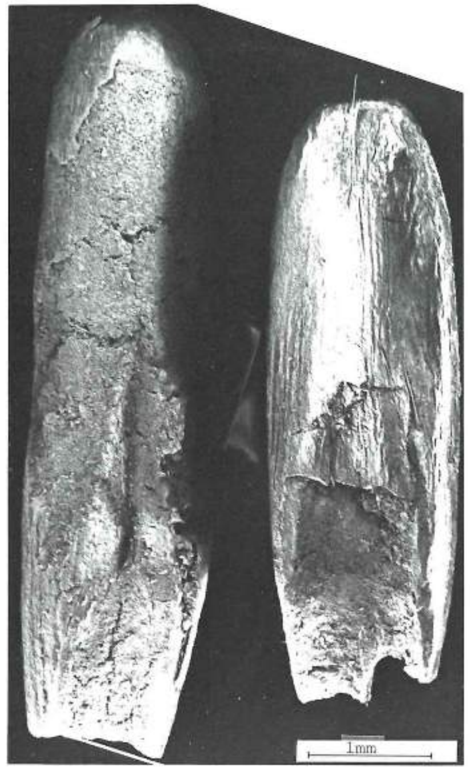


Fig 27 Sprouted and partly destroyed caryopsis of *Avena*.

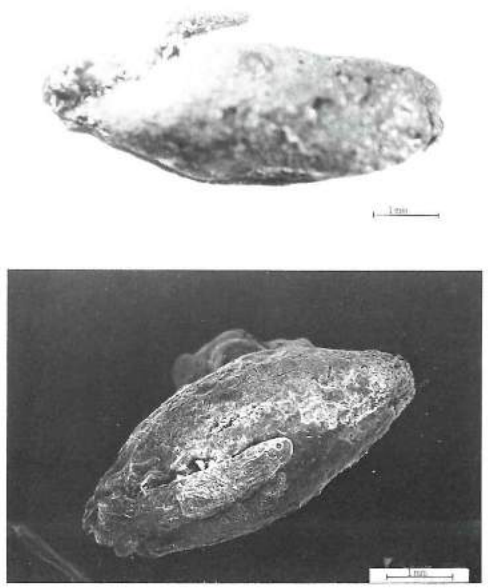


Fig 28 Rye grains with long sprouts.

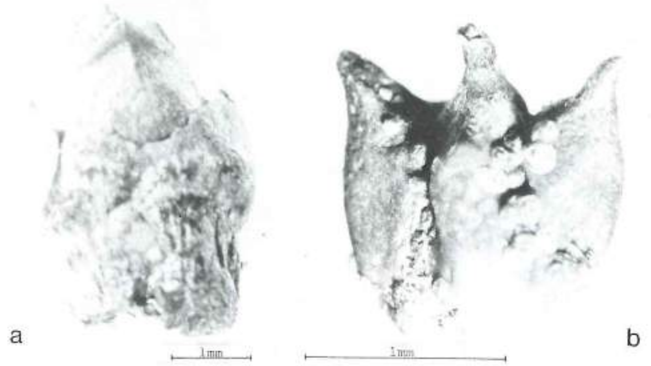


Fig 29 *Myrica gale.*
a. Male catkins.
b. Fruit with glands.

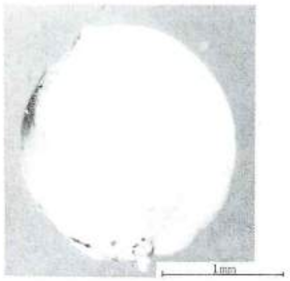


Fig 30 *Humulus lupulus* seed.

Fig 31 *Arenaria serpyllifolium* seed.

belong to regular grain fields but some of them might be found in very wet fields or at the edge of drier ground.

Another group of macro-remains found during this analysis are from plants which are rare or absent in W Norway and as far as we know have always been so. They have a more easterly distribution and are far more common in the southern part of Scandinavia and on the Continent. Their occurrence suggests that the grain with which they were found had been imported. Some of these species are more indicative than the others; as they have only occasionally been found in Scandinavia (most often near mills or where ballast was dumped), their exotic character speaks strongly in favour of import.

General weeds

Arenaria serpyllifolia (fig 31)
The seeds are oval (0.8 × 1 mm) with a shiny epidermis of elongated and elevated cells arranged in a regular pattern. The plant is mainly found on dry soil rich in lime where the competition is low. It was frequently present in fire-layer C.

Chenopodium album (fig 32)
Seeds vary in size, 1.3 × 1.4 (±0.2)mm, and are almost circular with a short radicle. The testa is thick, black and shiny. *C. album* prefers soil rich in nitrogen (Kroll 1975),

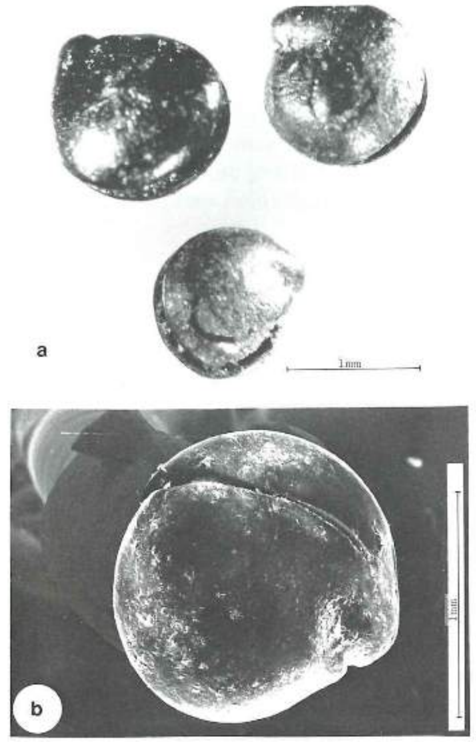


Fig 32 *Chenopodium album.*
a. LM exposing the shining surface.
b. SEM.

and it is found in almost any sample of carbonized grain from the Neolithic to the Middle Ages. It prefers open grain fields and is now less frequent in such fields owing to the dense structure of modern fields (Korsmo 1954). The large seed production of *C. album* has been utilized for food (Jessen & Helbæk 1944). High frequencies were found in fire-layers C and D, but surprisingly few in fire-layer B.

Centaurea cyanus (fig 33)
The seeds are elongated, with a circular cross-section. The lower third is characterized by a concave depression. Seeds are found with or without testa. The surface of the caryopse is smooth, the seed epidermis has pores, three stripes run from the middle to the top of the seed. Formerly, *C. cyanus* was numerous in grain fields, especially among the winter-sown grain. Its occurrence in W Norway is not known. The seed occurred in some samples from fire-layer B, in four out of five samples in C, but is absent from D.

Fumaria officinalis (fig 34)
The seeds are heart-shaped, with an elliptical cross-section, 1.9 × 2.2 mm. On each side of the remnant of the pistil a little circular depression is found. The seed is compressed from the sides and the surface is scabrid. *Fumaria* is still found in open grain fields but avoids too acidic soil (Ellenberg 1978, Korsmo 1936, 1954). It was only found in low frequency in fire-layer D.

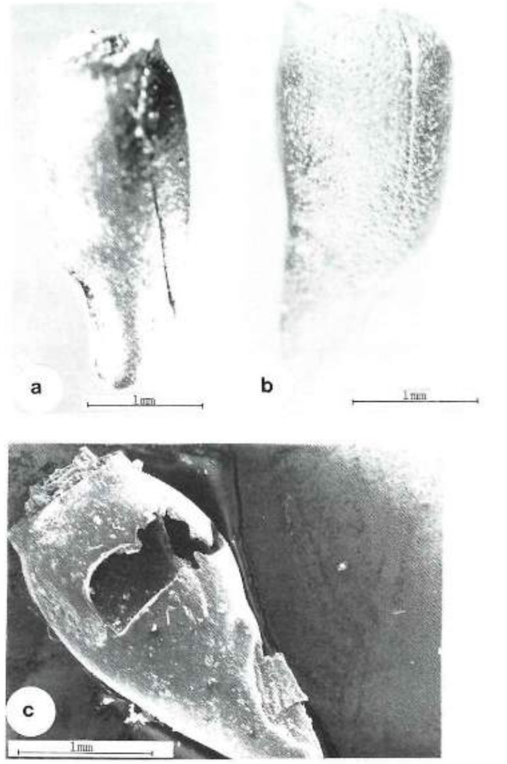


Fig 33 *Centaurea cyanus*. a. LM of seed with testa. b. Without testa. c. SEM of seed with testa.

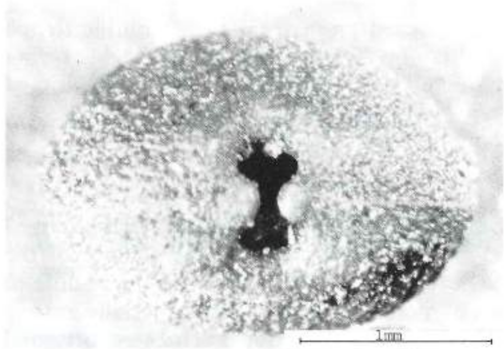


Fig 34 *Fumaria officinales* seed.

Galeopsis tetrahit type (fig 35)
The seeds of *Galeopsis* species are obovate and the cross-section usually trigonous. Occasionally one keel is flattened, giving an elliptical cross-section. At the pointed end a scar is found. The seed of *G. tetrahit, G. speciosa* and *G. bifida* are difficult to distinguish (Helbæk 1955, Behre 1976, Körber-Grohne 1967). These seeds are relatively large (2.7×2.2 mm) with a broad base and a relatively large and angular scar. The

three species are common and troublesome weeds also on poor soil, while *G. ladanum* is more rare. Both *G. tetrahit* and *G. ladanum* were mainly present in fire-layer C with fairly high frequencies.

Galeopsis ladanum (fig 36)
The fruit of *G. ladanum* is smaller, with a more pointed base, the scar is smaller and the upper part of the grain is rounder than in the *G. tetrahit* group. According to Kroll (1975), it indicates fields with soils rich in nitrogen.

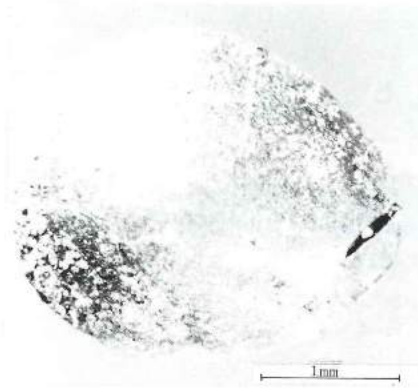


Fig 35 *Galeopsis tetrahit* type seed.

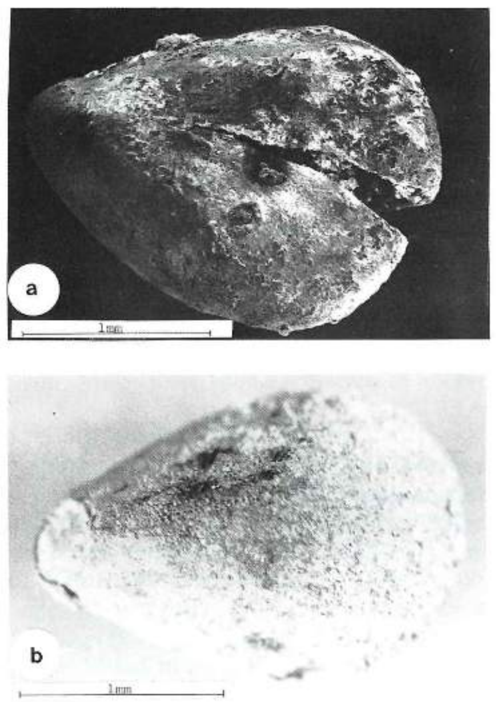


Fig 36 *Galeopsis ladanum*. a. SEM. b. LM.

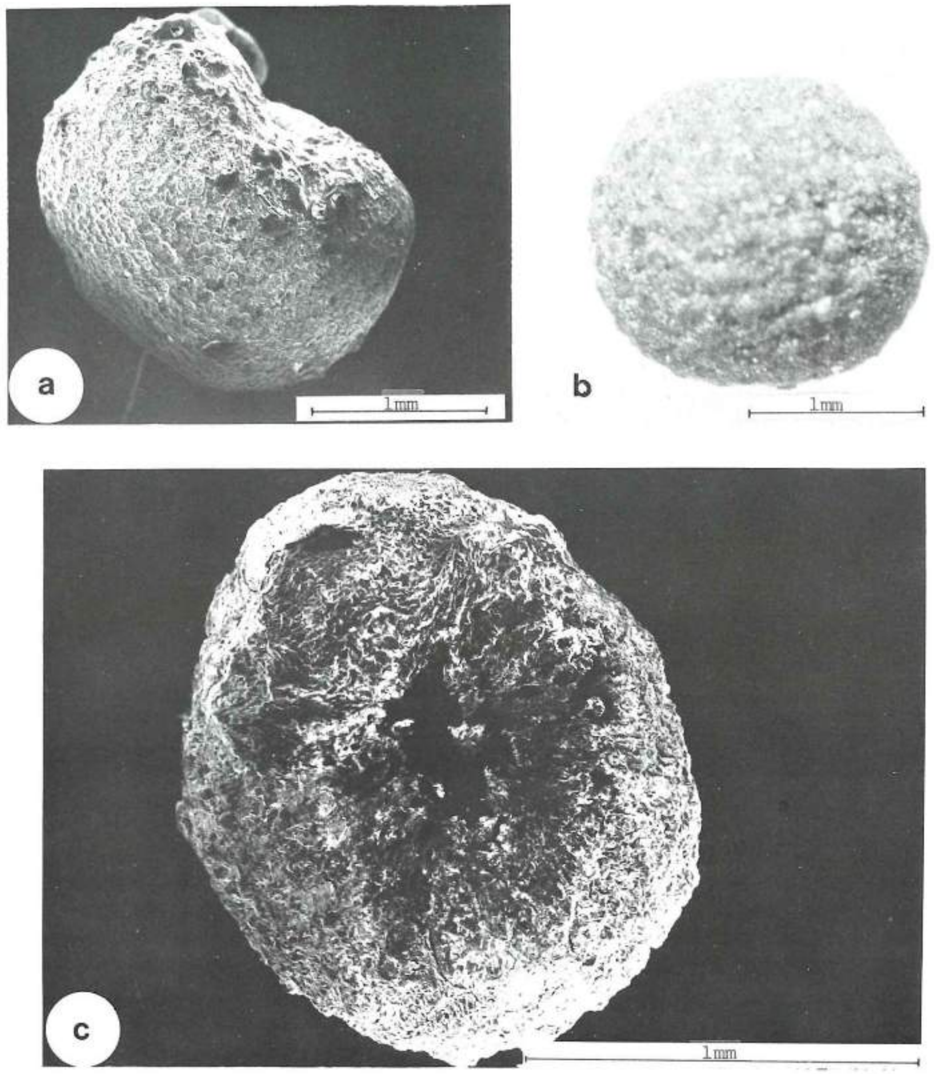


Fig 37 *Galium cf. aparine*. a and c. SEM. b. LM.

Galium cf aparine (fig 37)
The seeds of *Galium aparine* and *G. spurium* are very similar both in size and morphology (Lundeberg 1972). The fruit is spherical with an elliptical depression. The surface, if present, is covered by hooked bristles, becoming verrucate with erosion, and reticulate when the coat is lost. Diameter 1.5–2.4 mm. The species are troublesome weeds on light, warm and rich soils (Korsmo 1954). *G. cf aparine* fruits were mainly found in fire-layers A, B and C. In layer D they were very scarce.

Knautia arvensis (fig 38)
The fruits are elongated, somewhat narrower at one end, the cross-section rhomboid,

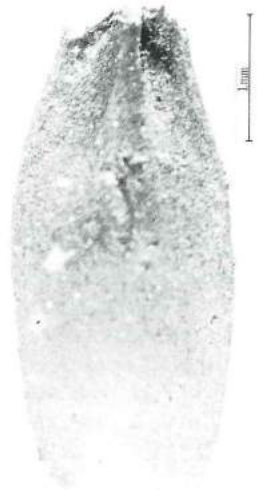


Fig 38 *Knautia arvensis*. Fruit. LM.

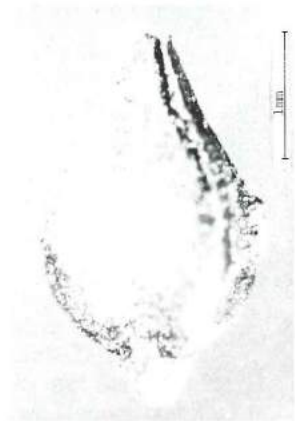


Fig 39 *Polygonum aviculare*. Seed. LM.

4.2 × 1.8 mm. It was found in fire-layers B and C. *K. arvensis* is common in grain fields but not frequent in areas with oceanic climate.

Lamium purpureum (not illustrated)
One coccus was found in each of samples B9 and D5. It is elongated, 2.2 × 1.2 mm, with a triangular cross-section. The dorsal side is somewhat convex and a keel runs from the base on the ventral side, dividing after two-thirds of the length and diverging to each side of the fruit. *L. purpureum* is a common and troublesome plant in fields and gardens. It was recorded in fire-layers B and C.

Polygonum aviculare coll. (fig 39)
The fruits are elongated, 3 × 1.6 mm. The base is rounded, the top pointed, and the largest width below the middle of the fruit. The cross-section is irregularly triangular. The surfaces have coarse sculpturing, which is orientated along the length of the fruit. *P. aviculare* is not a typical weed of arable fields, but is frequent on hard, trampled soil; courtyards, road verges etc. It makes low demands on the nutrient condition of the soil. Fruits were found scattered in all fire-layers.

Polygonum convolvulus (fig 40)
The fruits are elongated, 2.9 × 2.2 mm, with the broadest part in the middle, and narrower towards the ends. The cross-section is regularly triangular. The edges are smooth and the surface has long cells aligned parallel with the long axis. *P. convolvulus* is found in grain fields and used to be a troublesome weed. According to Jessen & Lind (1922), it inhibited the growth of the grain. It is not clear whether it prefers winter or spring sown fields, but Behre (1976) is of the opinion that *P. convolvulus* like *Agrostemma githago* (Corn Cockle, fig 51) rather prefers the winter-sown grain fields. Scattered fruits were found in all fire-layers, but they were slightly more frequent in fire-layers B and C.

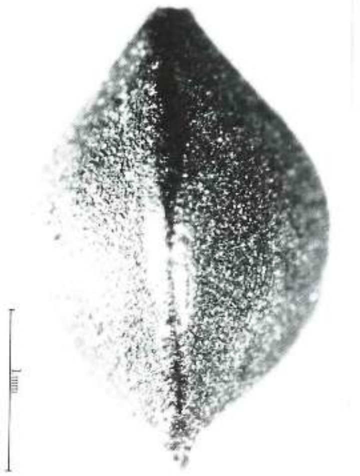


Fig 40 *Polygonum convolvulus*. Seed. LM.

Polygonum lapathifolium/P. persicaria (fig 41)
The fruits of *P. lapathifolium* (coll.) are rounded, broad at the base, and both carpels are concave. One of the carpels has an elongated central rib, giving the fruits a trigonous cross-section. They measure 2.4 × 3 mm. The fruits of *P. persicaria* are very similar to

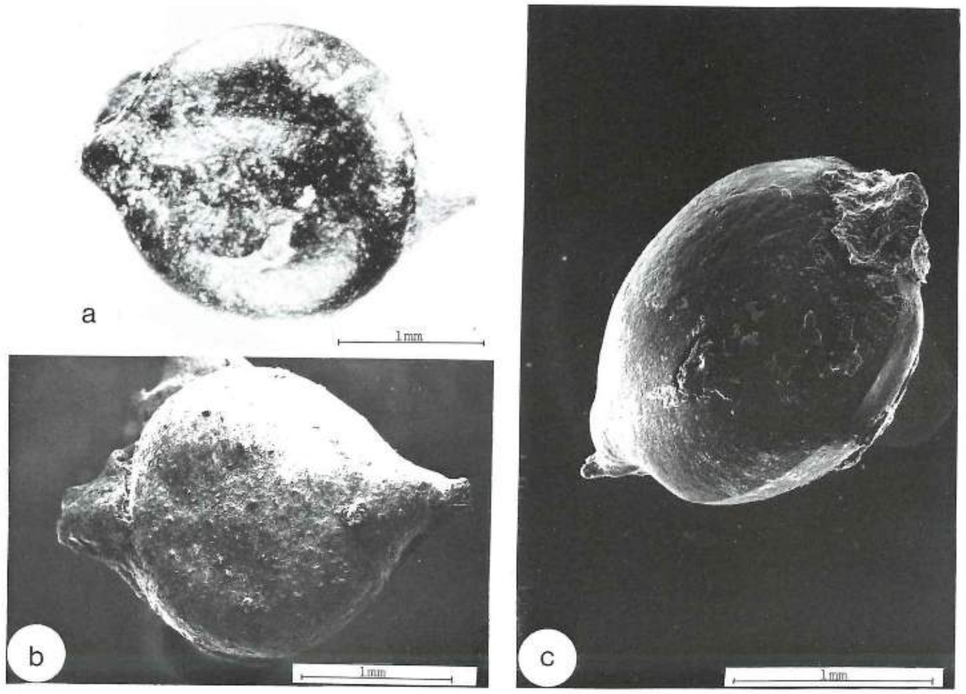


Fig 41 *Polygonum lapathifolium/persicaria* type seed (a. LM, b, c. SEM).

TABLE 2

Fire	P. lapathifolium/persicaria	P. lapathifolium	P. persicaria
B	88 (1.7%)	54 (1.1%)	9 /0.2%)
C	64 (2.5%)	5 (0.2%)	3 (0.1%)
D	355 (7.9%)	166 (3.7%)	10 (0.2%)

those of *P. lapathifolium* but are somewhat smaller, narrower and pointed at the base, and one of the carpels can be a little convex. The critical characteristics are easily destroyed during carbonization because the fruits puff up. A large portion has therefore only been determined to *P. lapathifolium/persicaria* type. The distribution of the *Polygonum* fruits within each fire-layer is given in table 2.

They occur as grain-field weeds on rather wet somewhat acid soil (Jessen & Lind 1922). According to Kroll (1975), *P. persicaria* is more common in finds older than the Viking Age, after which *P. lapathifolium* is found with higher frequencies.

Potentilla cf. erecta (fig 42)
The seeds are hemispherical. The ventral side is flat and the surface has elongated ribs orientated across the seed. Size 1.2 × 2.5 mm. *P. erecta* is a very common plant in hay fields, pastures etc, but poorly competitive, especially in the shade, and is not found in grain fields. It has no special demands concerning soil conditions. It occurred in fire-layer B.

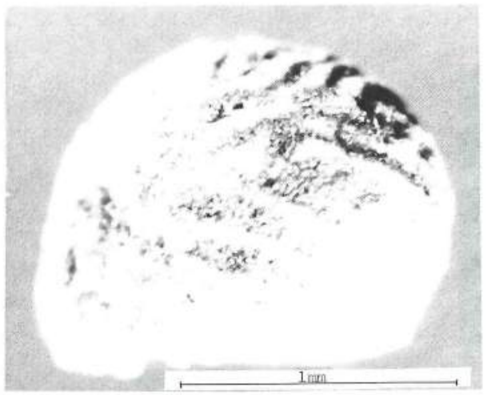


Fig 42 *Potentilla cf. erecta* seed. LM.

Fig 43 *Rubus idaeus* seed. LM.

Rubus idaeus (fig 43)
The seeds of *R. idaeus* are reniform (kidney-shaped), 1.5 × 2.2 mm. The surface has ribs forming a coarse reticulum. The geographical distribution of *R. idaeus* is extensive, and it occurs in a wide range of ecological situations (Fægri 1970). It was found in fire-layers B and C.

Rumex acetosella (fig 44)
The fruit has a characteristic triquetrous cross-section with rounded edges. The epidermis cells have corrugated walls characteristic in high magnification. The fruits are small, 0.8 × 1.5 mm. *R. acetosella* grows in poor and infertile soils. Its occurrence in a cultivated field is a sign that the field is in bad condition (Fægri 1970). Few seeds were recorded in fire-layers B and C, except sample 63 where they were plentiful.

Rumex cf. cripus (fig 45)
The fruits of *R. crispus* are ovate-cordate and the cross-section is triquetrous, with marked edges and a smooth surface, 2.2 × 1.2 mm. The larger *Rumex* species (subgen. Lapathum) are found in wet fields and on well-fertilized soil (Fægri 1970). Seeds were found in fire-layers B and C.

Scleranthus annuus (fig 46)
Diaspores of *Scleranthus* were found. The calyx is elongated, 1.5 × 1.1 mm, round in cross-section and with eight high ribs orientated along the long axis. The calyx teeth of *S. annuus* are long and narrow, those of *S. perennis* short and broad. The calyx teeth of the fossil *Scleranthus* disapores are broken, but the base is small, and they have therefore been assigned to *S. annuus*. The epidermis was destroyed during carbonization

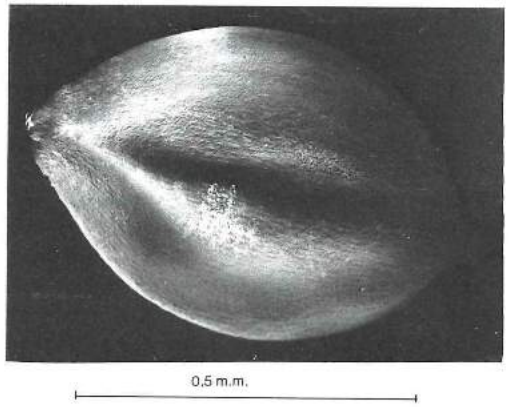


Fig 44 *Rumex acetosella* seed. SEM.

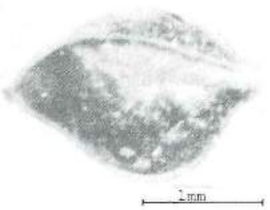


Fig 45 *Rumex crispus* seed. LM.

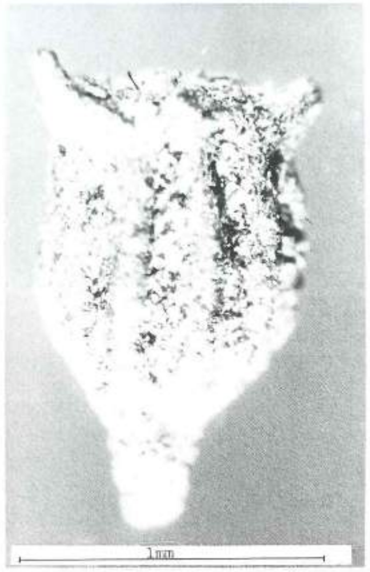


Fig 46 *Scleranthus annuus* diaspore. LM.

and it is possible to see a fine striation on the ribs. *S. annuus* is a weed on sandy acid soil and is more common on pasture ground than in grain fields. The calyx has been found together with grain in other investigations (Kroll 1975, Behre 1976) and it seems to have been a more important weed previously. It was found in fire-layers D and was present in all but one of the sub-samples.

Spergula arvensis (not illustrated)
The seeds are small, 1 × 1 mm, and biconvex. Along the edge runs a rib. The surface is tuberculate. *S. arvensis* is a common and highly competitive weed on acid sandy soils. Scattered finds of *S. arvensis* were made in all fire-layers.

Stellaria media (fig 47)
The seeds are flat and rounded but weakly angular, a characteristic form for many of

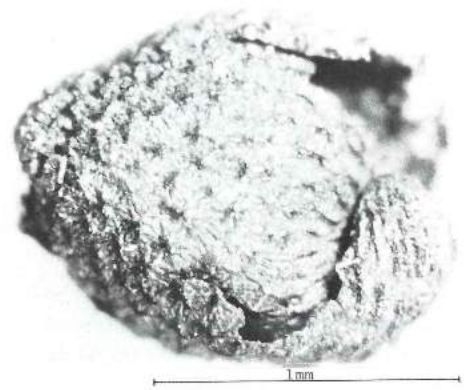


Fig 47 *Stellaria media* seed. LM.

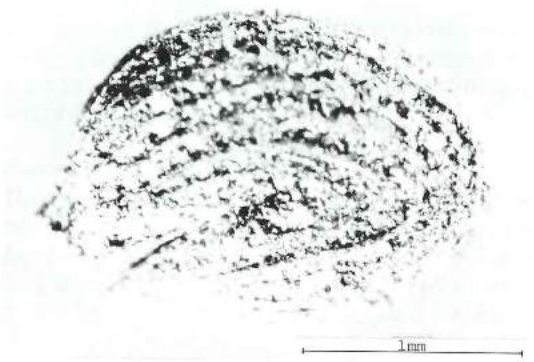


Fig 48 *Thlaspi arvense* seed. LM.

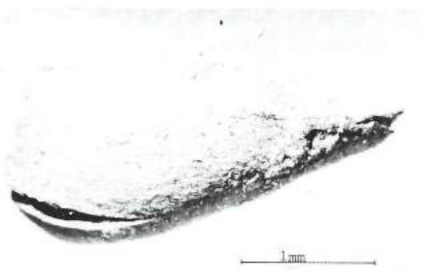


Fig 49 *Veronica* sp. capsule LM.

the caryophyllaceae species. The epidermis cells are elongated and lie in rows around the scar of attachment. The size is approximately 1.3 × 1.2 mm. *S. media* is a common weed on poor as well as richer soils. It prefers moist places and shade. It was mostly found in fire-layer D.

Thlaspi arvense (fig 48)
The seeds are flat and oval. The embryo is bent and ribs ocur on the surface running parallel with this curvature. It was only found in sample 88, 2.1 × 1.6 mm. *T. arvense* is an old weed with a very wide geographical distribution. It grows on rich fine-grained to clayey soils (Kroll 1975).

Veronica sp. (fig 49)
Half a capsule was found in C3. It has been cordate (heart-shaped), with a non-glossy surface.

Viola cf. arvensis (not illustrated)
One seed was found. It is ovate with a small depression from the elaiosome. *V. arvensis* is a very common weed in grain fields.

Poaceae (fig 50)
Except for the cereals and some exotic taxa, grass seeds were not identified further than to family, with the exception of *Avena fatua* (Wild oats) cf p 24. Poaceae seeds are difficult to identify in carbonized material. Low frequencies of various grass seeds were found in fire-layers B, C and D.

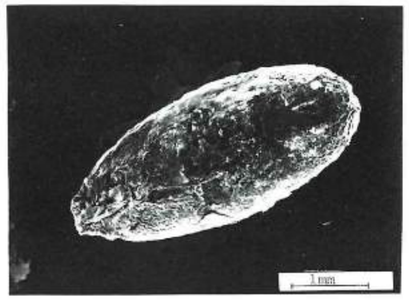


Fig 50 Grass seed. SEM.

Ancient weeds

Agrostemma githago (fig 51)
The seeds of *A. githago* have a typical caryophyllaceae-form (cf figs 46–47 above). They are broadly obovate but the edge of some seeds have been broken during carbonization. The epidermis is black and non-glossy. The surface cells are star-shaped and elevated in the middle, the elevations forming rows. The size of the *A. githago* seeds distinguishes them from those of other caryophyllaceae species; in the present material they are 2–2.3 × 2.1–2.4 mm. According to Korsmo (1935), the size of recent seeds is 3.0 × 2.6 mm. Behre (1969) has found *A. githago* measuring 2.4 × 2.6 mm. It demands good soil conditions and will not grow in sandy or wet soil. It prefers winter-sown fields and used to grow over most of the world where grain was cultivated, but apparently was not found in Europe before rye was introduced (Kroll 1975). It became adapted to grain cultivation. It was collected together with the grain. During threshing its seeds were mixed with and later sown with the grain. The seeds contain githagin, which in large concentrations is poisonous to man. Efforts to get rid of this dangerous and troublesome weed have lead to its practical eradication. In the present material it was absent from fire-layer D and most frequent in fire-layer C.

Neslia paniculata (fig 52)
The globular silique has a thick wall and the surface is coarsely reticulated. It measures 2.5 × 2.8 mm and across the fruit approximately 5 reticula are found. It is broad and

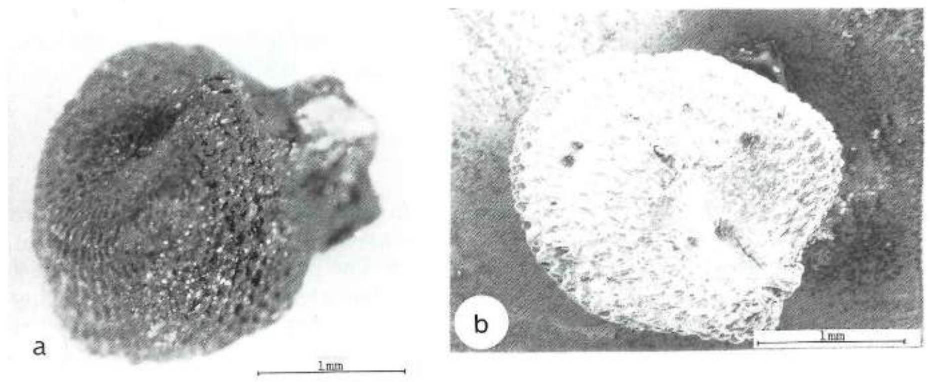


Fig 51 *Agrostemma githago* seed. LM.

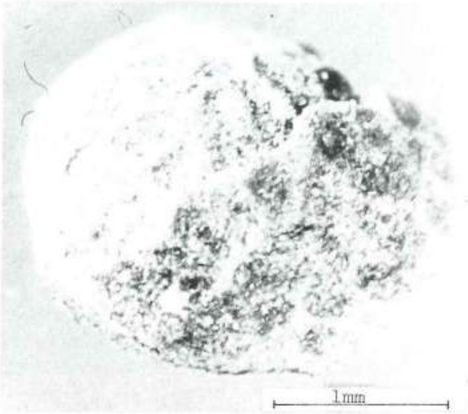


Fig 52 *Neslia paniculata* seed. LM.

heart-shaped. *N. paniculata* was adapted to flax cultures *(Linum usitatissimum)*. When flax cultivation was reduced, *Neslia* also disappeared from the fields and today is a rare plant (Fægri 1970). It does not really belong to the cereal weeds but its occurrence indicates that the plant earlier had a larger distribution. Scattered finds of *Neslia* were made only in the samples from fire-layer D.

Raphanus raphanistrum (fig 53)
The silique fragments of *R. raphanistrum* are long and cupiform (barrel shaped), 3.5×2 mm, with high ribs running along the axis (fig 53a, b). They were found partly whole and partly somewhat broken with a smooth inside. Seeds were also found; they are oval with a delicately reticulate surface. The plant is often found as a weed on sandy and acid soil, and it is counted among the weeds that grow in grain fields in bad condition (Ellenberg 1950). The siliques are very tough. They are collected together with the grain and are broken up during threshing. The seeds are dispersed with the grains and thus resown. High frequencies were found in fire-layer D.

Urtica urens (fig 54)
The fruit is flat and broadly obovate, 2.1×1.8 mm. The fruit of *U. dioica* (Stinging Nettle) is smaller and pointed at both ends. In the present material the epidermis had disappeared during carbonization and the surface of the seed had pores. It was present in fire-layer B. According to Kroll (1975), *U. urens* is found in nutrient-rich habitats; in Norway it is now restricted to out of the way places.

Water and wet community plants

Montia fontana (fig 55)
The seeds are small, 0.9×0.9 mm, and round with visible circular radicula. In form and size they are rather similar to those of *Chenopodium album* (cf fig 32). The epidermis cells are large, elongated, and in a very clear pattern. The plants grow on wet or moist soil (Lid 1974) or at temporary puddles. It is also characteristic for soaks, especially saprotrophic ones, and may have grown at the leaking outlet of some water supply at Bryggen itself. It was recorded rather frequently in one sample (C7).

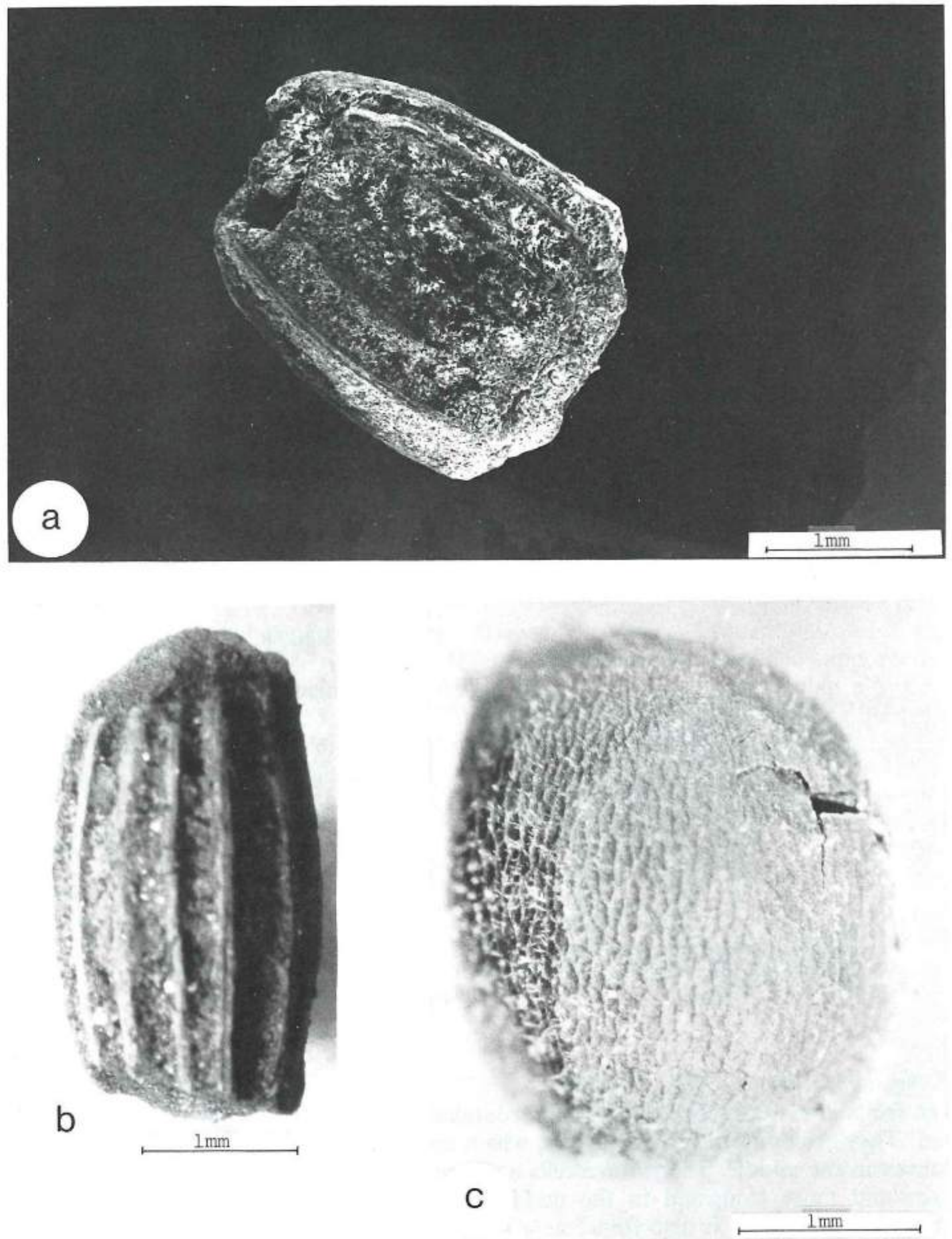


Fig 53 *Raphanus raphanistrum*. a. silique fragment (SEM), b. silique fragment (LM), c. seed (LM).

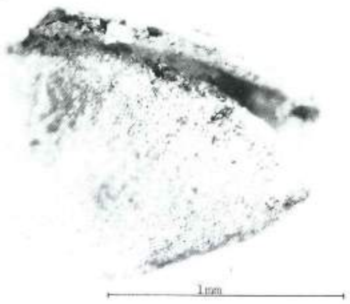


Fig 54 *Urtica urens* seed. LM.

Fig 55 *Montia fontana* seeds. LM.

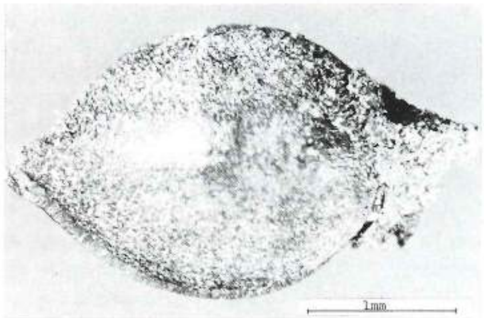


Fig 56 *Polygonum hydropiper* seed. LM.

Polygonum hydropiper (figs 56–57)
The fruits are elongated, 3.3 × 2.3 mm, rounded at the base, and pointed at the upper end. They are built up of two carpels, which are weakly convex. One of them is more convex in the middle. The surface cells are coarse towards the edges of the capels and finer and more elongated in the middle, like *Montia, P. hydropiper* grows in wet nutritious places but is also found as a weed in cultivated fields on moist soil (Fægri 1970). It was mainly found in fire-layer D.

Potamogeton sp. (Pondweed) (fig 58)
Both pollen and seeds were found in fire-layer C. The seeds are somewhat elongated. On one side the fruit has an elongated flap. The surface is non-glossy. All *Potamogeton* species are exclusive water plants. There are two possible origins of this material. It may have followed the malt after soaking in some water with *Potamogeton* growth.

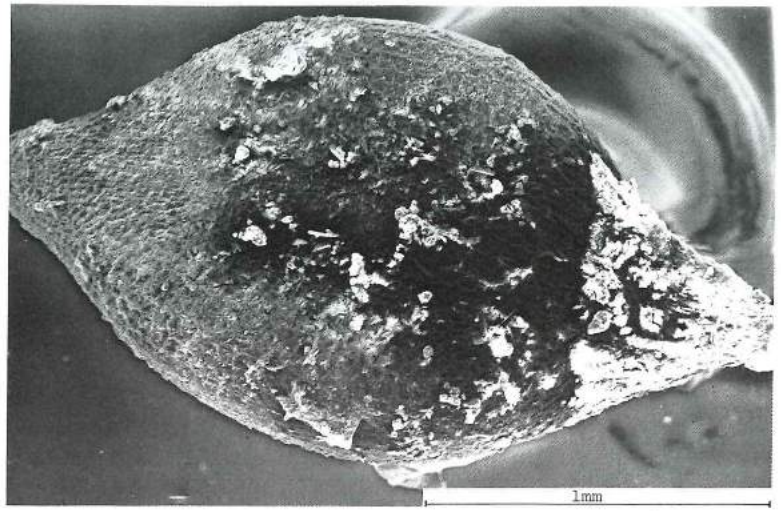


Fig 57 *Polygonum hydropiper* seed. SEM.

Alternatively, it may have come with the *Myrica*. *P. oblongus* frequently grows in very small and shallow bodies of water near *Myrica*. The occurrence of pollen supports this. The seeds could not be specifically identified, but there is a great resemblance to those of *P. oblongus* (cf Jessen 1955, Aalto 1970). Other *P.* species of local origin are improbable, as there is no room for a body of water, even of moderate size, in the steep mountain-side behind Bryggen.

Weeds with south-eastern distribution

Brassica cf. nigra and Brassica/Sinapis group (figs 59–60)
Seeds which are assigned to *Brassica cf. nigra* are round, approximately 1.4 × 1.2 mm, and the surface has a coarse polygonal pattern. Brassicaceae is a large family, and the seeds are mostly distinguishable, but both *Brassica* and *Sinapis* have spherical seeds.

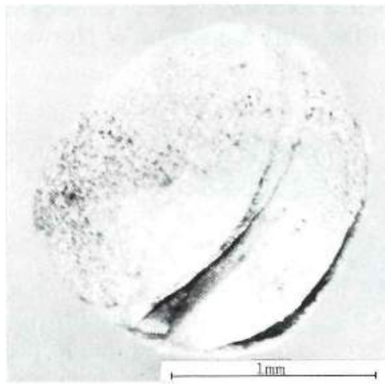
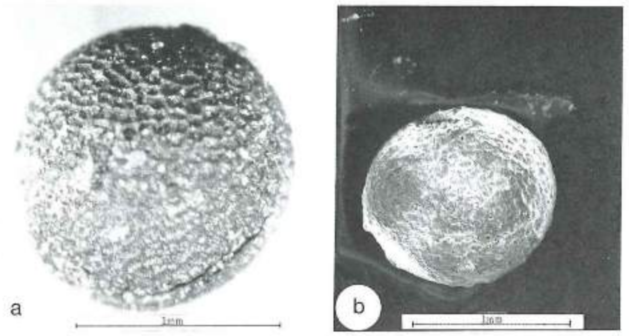


Fig 58 *Potamogeton sp. seed.* LM.



a b

Fig 59 *Brassica cf. nigra* seed. a. LM, b. SEM.

Fig 60 *Brassica/Sinapsis* seed. LM.

Some surface cells are higher than others, which produces the polygonal pattern. It is difficult to distinguish the species within the two genera. *Brassica nigra* can be identified as the polygonal areas are larger (60 micron), but *B. campestris* also has rather large polygonal areas and the identification is therefore somewhat uncertain. *Brassica nigra* is a weed, which is often ruderal in Norway. According to Schübeler (1886), the species originated in South and Central Europe. It has spread to some places along the coast of Norway between Oslo and Kristiansund (Fægri 1970). Seeds were found in all the fire-layers.

Centaurea jacea (not illustrated)
The fruit is very like that of *C. cyanus* but is smaller and the concave depression at the base is different. *C. jacea* grows in the lowland areas of E Norway spreading into the lower valleys and is also found in the inland parts of the fjord districts of W Norway (Fægri 1970). It was found in fire-layer C.

Solanum nigrum (not illustrated)
The seeds are flat and irregularly oval with elongated radicula. The surface has pores. *S. nigrum* is a weed found on rich, freshly ploughed fields. According to Korsmo (1954), it is not common in W Norway. It was found in fire-layer B.

Vicia cf. tetrasperma (fig 61)
Some seeds have been referred to this group because they are round and somewhat flattened at the sides. They have a non-glossy surface without sculpturing. it is difficult to measure the length of the hilum because the epidermis is often fissured due to the carbonization. The size varies: length 1.6–2.4 mm, width 1.6–2.2 mm, and thickness

Fig 61 *Vicia cf. tetrasperma* seeds. LM.

1.1–1.9 mm. The form of the seeds is characteristic of both *Lathyrus* and *Vicia*. They may be seeds of *V. tetrasperma, V. hirsuta* or *V. angustifolia*. Recent seeds of *V. tetrasperma* are the smallest, the seeds of the other two somewhat larger. From their size the seeds have been identified as *V. cf. tetrapserma*. *V. hirsuta* prefers meagre, sandy fields (Fægri 1970) and is a troublesome weed, especially in winter rye fields. It is far more common in more southerly areas (Korsmo 1954). *V. tetrasperma* is a close relative, with similar requirements. It grows in E Norway and in the inner Fjord districts in W Norway. *V. angustifolia* grows in cultivated areas close to the coast and is rare in the area from Oslo to Trondheim (Lid 1974). Seeds of this group were found in all the fire-layers.

Vicia cf. sativa (not illustrated)
The seeds identified as *V. cf. sativa* are lens-shaped, 5.5 × 5.0 mm and 4.0 × 4.3 mm. The surface is as described for *V. cf. tetrasperma*. The most characteristic feature of these *Vicia* seeds is their large size. They were recorded only in fire-layers A and B.

Import indicators

Echinochloa crus-galli (fig 62)
These seeds have been identified as *E. crus-galli*, as the epidermis cells of the glumes do not have verrucae such as are found in *Setaria*, and the ventral side is flat and not convex, which is typical of *Panicum*. The seeds of *E. crus-galli* are elongated, 2.8 × 1.5 mm, and narrower in relation to length than both *Setaria* and *Panicum* seeds. The lemma and palea are curved along the edge of the ventral side. In Central Europe it is

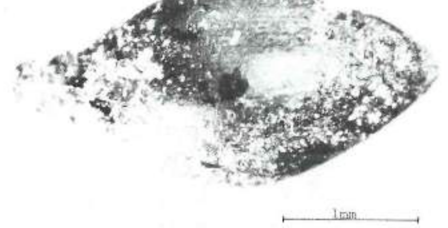


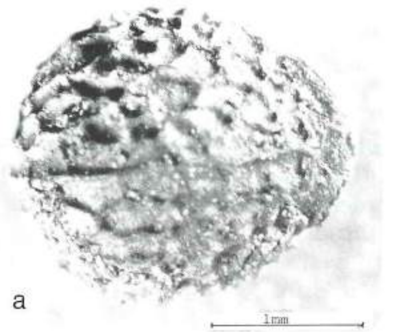
Fig 62 *Echinocloa crus-galli* seed. LM.

common in wet grain fields and in gardens. The dispersal of this plant has been favoured by man. According to Jessen & Lind (1922), it can often be a very troublesome weed. In Sweden it is a rare plant, found in agricultural areas and on ballast heaps from Skåne to Nordland (*ibid*).

In Norway the species has been found in dumping places (Lid 1974). Jessen & Lind (1922) mention that in Denmark it is possibly more common now than before the middle of the last century. The seeds were found in fire-layers C and D.

Euphorbia helioscopia (fig 63)
The seeds are obovate and the surface is coarsely reticulate, except at the pointed end, which is somewhat truncated. On one side there is a central rib. The seed is very characteristic. It measures 2.3 × 1.9 mm. They were present in fire-layers B and D. It is typical of gardens and grain fields and is most often found in summer-sown fields and on gravelly sandy soil (Behre 1976). According to Kroll (1975), it is an indicator species of clayey soil.

Setaria glauca (not illustrated)
Caryopses with lemma and palea were found and identified as *Setaria* from the epidermis cells on the glumes which are verrucate. The verrucae are orientated across the



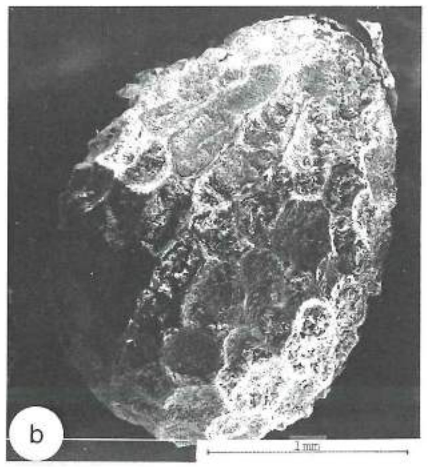


Fig 63 *Euphorbia helioscopica* seeds.
a. LM, b. SEM.

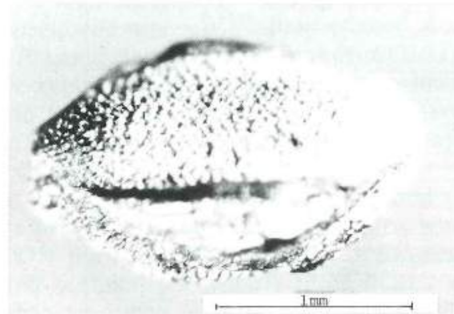


Fig 64 *Setaria viridis* seed. LM.

grain. In *S. glauca* the caryopsis is an elongated semi-ovoid (2 × 1.6 mm) and the ventral side is weakly convex. Compared with the other *Setaria* species, *S. glauca* has larger and coarser verrucae, so that the glumes apparently have ribs. *Setaria* is not common in Norway (Lid 1974). Its occurrence is similar to *Echinocloa crus-galli* (see above). It was found in fire-layer B.

Setaria cf. viridis (Green Bristle-grass) (fig 64)
Seeds of 2 × 1.2 mm were found with the same form as *Setaria glauca*, but the verrucae on the epidermis cells are much smaller and not so dominating. These can be seeds of *S. viridis* or *S. italica*, but on comparison with recent seeds a closer similarity with *S. viridis* was found. Recent seeds of *S. italica* are rounder than the fossil ones, and they swell and become even rounder during carbonization. *S. viridis* does not belong to the natural flora of the Nordic countries, but can be found on rubbish heaps and near mills in Norway (Lid 1974). It grows on light sandy soils and is mostly found in N Germany (Jessen & Lind 1922). One seed was found in fire-layer B.

HOMOGENEITY OF SUBSAMPLES

The homogeneity of the layers and of the grain deposits was investigated (cf fig 5), as it was expected that the specialized function of the buildings would lead to greater homogeneity in the subsamples than would non-specialized storage.

The distribution of some of the more frequent macro-remains of grain and weeds in the subsamples is represented in the diagram in fig 65. The most significant species with regard to homogeneity and variation within fire-layers B–D have been included. The frequency is calculated as a percentage of the total: number of *Hordeum*, plus relevant taxon.

Fire-layer B (1393), subsamples B1–B10, is presented in the upper part of the graph. The samples from the middle of the building had the lowerst percentage of damaged grains. *Avena* and *Secale* were infrequent and equally present in all ten samples. The frequency of wild plants and weeds in five of the samples analysed was 7–8%, while in B5, B6 and B7 it was somewhat lower. *Polygonum lapathifolium/persicaria* was present in all samples. *Galium cf aparine* was found in nine, while *Chenopodium album* was found in eight samples.

In fire-layer C (1332) the grain density was great. *Avena* was present in all five samples but with few grains. Most of the grains were not specifically determinable. *Secale* was frequent in all samples, with the largest number in C2, C3 and C4. C3 had

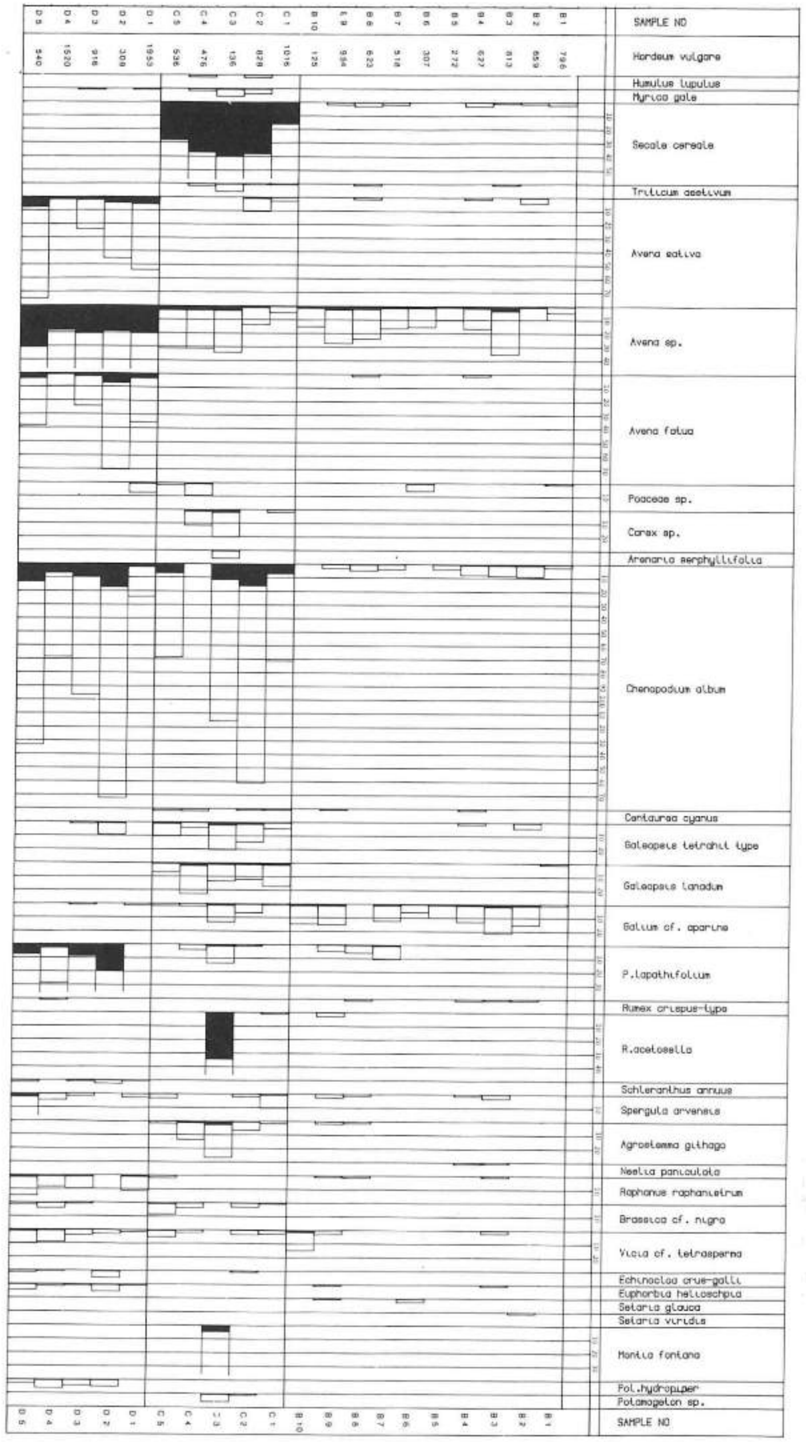


Fig 65 The seed content of the subsamples from fire-layers B, C, and D expressed as % of *Hordeum* seeds, illustrating the homogeneity of each layer.

the highest frequenty of *Secale* but contained a smaller total number of grains. *Rumex acetosella* was very well represented, and seven seeds of *Montia fontana* and a fruit of *Potamogeton* were also found in C3. The samples showed great similarities, with the exception of *Chenopodium album*, which was not found in C4, though it was common in the other samples from the layer. Seeds of *Humulus lupulus* were found in C2 and C4, while seeds, fruits, catkins and leaf fragments of *Myrica* occurred in C2, C3 and C4.

Fire-layer D (1248) was thick, and the grain density was great. *Avena* represented about 25% in most of the samples, while an even higher density (47%) was found in D5. Both *Avena fatua* and *A. sativa* were present and glumes of *Avena* were found in all samples, particularly those of *A. sativa*. This might be related to the number of broken grains, since *Avena sativa* easily falls apart. Seeds of *Myrica* were found in D1 and D3.

Comparing the subsamples it can be concluded that with few exceptions only minor differences occur between samples of the same layer, whereas samples from different fire-layers are significantly different.

The high homogeneity within each layer can be used to postulate that the building had a uniform function, which lasted from before 1248 until a change after 1393.

DISCUSSION

The large concentration of grain from the excavations in Rosenkrantzgate 4 indicated that a building on this site had been used for the same function from before 1248 until 1393, during which time it had burnt down and been rebuilt three times (Krzywinski & Gulliksen 1984). Observations on the site and during the early post-excavation analysis suggested that it had not been a storehouse for grain, but was connected in some way with brewing (Krzywinski & Fægri 1979). When it was rebuilt after the fire in 1393, it seems to have been used for general storage, not specifically connected with brewing.

Both the homogeneity of the samples reflecting the actual material stored or used in the building, and the material itself provide conclusive evidence of brewing. Furthermore, the detailed analysis of the material has thrown light on certain aspects of the cereal trade, such as the origin of imported grain.

Malt

Almost all the barley grains in the layers had germinated, which strongly supports the brewing hypothesis. Germination does not invariably indicate that the grains have been malted: storage conditions may have been so bad that germination took place spontaneously. Very few finds of germinated grains have been reported from other investigations (Helbæk 1938, 1964, 1966). Helbæk concluded that grains from Öland were malted, because germinated grain had rarely been found in archaeological deposits elsewere. The root sprouts were preserved in the material from Öland, while root sprouts were absent in the Bryggen material. The presence of root sprouts is assumed to indicate spontaneous germination, since root sprouts are more likely to have been removed from malted grains. The shoots on the Bryggen material in the three fire-layers were about the same length. Bad storage conditions would most probably have lasted for more than a few days and a greater variation in the lengths of the shoots would have been expected than was the case in Rosenkrantzgaten. An even sprout length for all grains would be rather unlikely if the sprouting were due to storage conditions. It is also unlikely that the grain in all three fire-layers had been subjected to accidental sprouting conditions for the same length of time. The constant length of the sprout would only be possible if the germ was killed after a certain time, in malting done by the quick drying of the malt.

If storage conditions are bad and germination is spontaneous within a densely packed stock of grain, the outer parts germinate quickly while grains further in suffer from oxygen deficiency. As a result germination is inhibited in the inner areas. To ensure even germination the grain must be treated carefully so that the whole material is exposed to the same temperature and oxygen concentration. This used to be done by carefully stirring the grain during the process (Olufsen 1912).

The low frequency of internodes and other parts of the inflorescence also indicates that the grain had been subjected to some treatment after threshing. The malting process includes soaking the grain in water before and removal of roots after germination (Olufsen *ibid*). Both processes yield a cleaner product. The cleanness of the grain from all three fire-layers at Rosenkrantzgate therefore also suggests that it had been intentionally malted and was not a product of accidental germination.

The sprouted grain on Öland (Helbæk 1966) was different. If this was malt, either the Öland people made a lower quality beer than those at Bryggen, or the process of malting had not been properly finished. The grain from Öland had probably germinated accidentally. Helbæk (1938) refers to sprouted grains from Jutland found in a vessel. The shoots were up to 6 mm long, and at the bottom of the vessel there were also thousands of loose shoots and embryos. Helbæk suggested that the grain had sprouted for two or three days and had been germinated intentionally because in the same building unsprouted grain was also found. This argument is rather weak, since conditions inside a vessel were certainly different from those in the rest of the place. Compared with these two finds the material from Rosenkrantzgate 4 is obviously the best evidence of proper malting. Helbæk (1971) also refers to a find of rye and spelt in a state of two to three days' germination – "in other words, malt". It is possible that this was correctly interpreted, but from an ethnobotanical point of view it is important to consider the process by which malt is the end product. It is likely that the sprouted rye and spelt had germinated accidentally. The fact that it has been difficult to separate hulled barley from malt in a fossil carbonized state, may be the reason why reports of carbonized malt are few or almost absent.

It seems that the need for malt in medieval Norwegian towns was mainly covered by imports. Customs lists from about 1300 from Lynn in E England showed that malt was the most common article exported to Norway after cloth and textiles (Blom 1966). According to Helle (1974, 314), the import of goods aiming at a broader social group was common, including grain, flour and malt. The subsequent increase in the import of grain products has been interpreted as a result of a shortage of grain due to the expansion of a non-agrarian population in towns and fishing districts. Imported grain was of better quality than Norwegian grain and it was also cheaper.

Beer-flavouring indicators

Pollen analysis has shown that in the period 1248–1393, there were large quantities of *Myrica* pollen in the Rosenkrantzgaten deposit, with a close correlation between the *Hordeum* and *Myrica* pollen in the diagram. Bog myrtle had a wide range of uses in

medieval times but was most important as a flavour for beer (Høeg 1968). Both the leaves and the aromatic catkins were used. Documents from the time of Håkon V and Håkon VI show that around 1300 bog myrtle was an important article of trade in Norway (von Hofsten 1960, 27). The use of bog myrtle has been common even after hops were introduced. Fruits of bog myrtle were found in fire-layer D; in fire-layer C there were fruits, catkins and leaves. As *Myrica* grows on acid bogs, especially in coastal areas, it cannot have come in with the grain from fields. Moreover the plant is weakly hemerophobic, and the remains cannot have been introduced from plants growing at or near the site. Above we have shown that the *Potamogeton* remains may have been introduced with *Myrica*. At any rate *Myrica* must have been specifically gathered and brought to the site.

Bog myrtle has been found in other and different contexts at Bryggen, including pure layers. In these deposits twigs, leaves and mature as well as immature catkins, both male and female, have been found, proving that bog myrtle was collected all through the season and stored for use or for sale. The composition of this stored material is different from the purity to be expected – and actually found – in a place where utilization was prevalent.

Hops can have grown close to the grain fields, but loose seeds would most likely have fallen to the ground and probably not have been brought in with the harvest. It is hardly likely that the malt had been mixed with hops before it was brought to Bergen. Hops represents a separate import. The perianth and bracts of the hop flower with the glands containing lupilin are used in beer, both for flavouring and for preservation. The flowers are harvested before they are fully open, and it is therefore improbable that there would be a large number of hop seeds mixed with the malt, even though stored or used in the same building. As *Humulus lupulus* is dioeceous, one would not expect to find *Humulus* pollen associated with the malt. The presence of *Humulus* seeds in several samples is therefore decisive.

Among the supposed malt reported by Helbæk (1938, 1964, 1966) there were no remains of any plants used for beer flavouring, which again runs counter to the assumption that these grains should represent malt.

CONCLUSION

The existence of a brewery

The investigation showed that in certain buildings on the Rosenkrantzgaten site malt had been stored during the period 1248–1393. There was no indication of any other type of merchandise and no evidence to suggest that the sprouting of the grain had occurred accidentally. *Myrica gale* and *Humulus lupulus* were also present at the same time, which would indicate that brewing had gone on in the building itself or in the close vicinity when these plants were used as flavouring for the beer. Finally, the evidence of pollen and seeds from water plants in the samples is signficant, since great quantities of fresh water are needed in brewing. The three important raw materials for beer production (malt, beer flavouring, and water, cf below) were thus present in the building.

An alternative interpretation of the finds would be that the buildings in question were not the actual brewing premises, but store-rooms for malt and beer-flavouring products, which would naturally be purchased together. The malt at Rosenkrantzgaten might represent goods unloaded from ships to be sold later in smaller quantities, but the homogeneity of the layers contradict this explanation. The quantity of plants for flavouring appears to be small, but they were nevertheless found in sufficient quantity for this purpose, as they were only added in small quantities.

Only building 26 (cf fig 3) had an earthen floor (Krzywinski & Fægri 1979), nor were any traces of wooden floors found in either of the other two buildings, 18 and 8. If building 26 had been used for storage, a dry wooden floor would have been necessary to prevent the malt or grain from decomposing in the damp local climate at Bryggen, a consideration not valid if the room(s) were used for production.

On the basis of available evidence it is therefore most likely that the malt was intended for beer production within the building itself. When building 26 burnt down in 1248, a new building was erected on the same site and with the same function. This happened twice during the period under discussion, but the building which was erected after fire B in 1393 was evidently used for other purposes. Malt, rye, hazelnuts and peas were found in it, suggesting that its function had changed to more general storage or at least that the brewing activity within the house had diminished or moved. This is supported by the pollen analysis, which shows that *Myrica* and *Hordeum* pollen lost their predominance at this level.

The building and the tenement

It is somewhat surprising that a brewery was located in the front part of the tenement, as the activity required both fire and a good supply of fresh water. According to the local bylaws, the use of fire was restricted to behind the densely built-up area of wooden buildings at Bryggen. However, in spite of this restriction excavations have revealed the existence of fire-places in several front buildings (Herteig 1969, 118).

The question of water supply is important. As stated above, the find of *Potamogeton* hardly indicates a local source, but the two other wet ground plants do. For brewing fresh clean water must have been available near at hand. Wells were found during excavation, although not close to the brewery, and moreover the water obtained from such wells cut through and into the deposits of dung and waste material would hardly be suitable for beer production. It is more likely that clean water was obtained from brooks. Several small brooks presumably ran down the mountain-side towards Bryggen, as indicated in fig 1 (cf Helle 1982). In the notoriously wet climate of Bergen even small rain-fed brooks were fairly reliable sources of water. Deltaic deposits were found further north in the Bryggen area, indicating the mouth of a more permanent stream in the neighbourhood (Krzywinski and Kaland 1984). It has previously been assumed that another brook ended close to the site of the excavation (fig 1). Koren-Wiberg (1921, 126–130) used its existence as an argument for locating the medieval tenement of Straumrinn here (cf fig 2). The name is derived from "Straum", ie stream, running water or brook. His opinion was based partly on observation of the topography including the brook itself further up the hillside, and partly on a document from 1725 which mentions a stream running into the tenement of Revelsgården which later occupied a site near by. He suggested that this property together with the adjacent Solegården (= Rosenkrantzgate 4) were the successors of Straumrinn. Following Koren-Wiberg, Fritzwold (originally from a report by Norsk Teknisk byggkontroll (Noteby 1976)) suggested that a brook was located 10–15 m south of the site (as indicated on fig 1). Helle's (1982, 136, 710) location of the Straumrinn tenement further south hardly changes the picture (cf fig 2).

The accuracy of maps like Fritzwold's must not be overestimated. It may be possible to identify the location of a brook in the hillside but not on the reclaimed land of Bryggen. The interpolation of the contour lines of the map (fig 1, originally based on Fritzwold) makes a slightly more northerly location of the brook also likely. The layer

of sand, layer 3, in the upper part of the section which was investigated (figs 4 & 10) is undoubtedly a fluvial or lacustrine sand, most possibly deposited in situ, and this could be evidence for a flood in the stream itself.

It is rather unlikely that the brewery should be located in a tenement in the vicinity of the brook and not have legal access to the water needed for the beer production. The eagerness to rebuild the brewery on the same site after each fire would hardly have been simply a matter of tradition: the necessary facilities were presumably present just here, including the supply of fresh water. Both the large fire in 1248 and a local one in 1454 started in the Straumrinn tenement. If the brewery was situated here, there may be some connection with the use of fire in the brewing process. If brewing continued even after the fire, it must have taken place in another part of the tenement. In the light of all this evidence the location of Straumrinn should now be reviewed.

THE MALT QUALITY AND THE SOURCE OF THE GRAIN

The charred malt provides information about the raw materials used and the brewing techniques of the time. The impurities in the malt represent an additional source of information, indicating where the grain came from and giving details of medieval agriculture. The quality of malt depends both on the malting process and on the quality of the grain (Olufsen 1812). It is crucial for the quality of the end product. It is impossible to make a good malt out of low quality grain or good beer out of low-grade malt. The quality of the grain used for malting depends both on permanent features, like the genetic factors of the grain, and on the ecological conditions of the grain.

The malt from Bryggen was charred when found, and it is therefore not possible to examine its quality directly. In the past it was important to use large grain for malting, since small underdeveloped seeds germinate badly and asynchronously, producing small quantities of diastase. According to Opedal (1948, 14) the heaviest grains were used for sowing, the lightest for food, while the medium-sized grains in a crop were used for brewing. Under otherwise similar conditions the weight of the grain is therefore an indicator of quality. Size measurement of carbonized material can not be used to assess the quality of the grain (cf discussions by Bowman in Lundeberg 1972, van Zeist & Palfenier-Vegter 1979, Jessen 1956, Helbæk 1957). Until more investigations have been made on experimental carbonization, it will not be possible to deduce any ecological or taxonomical differences based on variations in measurements, as most differences are below 1 mm in length, width or thickness. The volume of fossil grains has been calculated as percentage of modern material. According to this method, the malt from Bryggen is very small, being only 40% of the size of modern four-row barley. Reservations must be made for the variation in grain size between modern and ancient barley.

A small experiment in charring grain which was carried out by Hopf (1955) indicated that the grains get shorter, broader and thicker during carbonization. We have tested the different carbonization of grain and malt in a parallel experiment using recent grain and malt from a local brewery. Compared with the changes in the corresponding dimensions in grain, the length of malt decreased 4% less, the width increased 10% less, and the thickness increased 12% less. It seems that the form and size of malt does no change as much as those of grain during carbonization and a comparison of size frequencies is therefore not crucial in this discussion of quality.

A more elaborate experiment must be carried out to see whether it is possible to match the dimensions of grain and malt when they are carbonized under different conditions. In the meantime it is an open question whether the quality of grain from different sites or even different layers on the same site can be compared by measurements of this type.

The malting quality

Different criteria have been used to determine the point at which it is appropriate to stop the germination process (Opedal 1948, 52). One of these is the length of the leaf shoot, which should be about ⅔ of the grain length on most of the grains (cf page 16). This measurement is still used today as a measure of malting quality. It can in fact also be determined in carbonized material even though the shoot itself contracts during carbonization, as the leaf shoot leaves an impression on the grain which can be measured (cf page 29).

The length of the leaf shoots on the malt from Bryggen are appropriate and the variation is small. According to this criterion, the medieval malt would have been well suited for brewing. High quality malt was found in all three fire-layers. Moreover the purity of the malt increased as time went on, indicating an improvement in the quality of the malt during the period 1248–1393.

The quantity of weeds found is primarily a function of the ecological and climatic factors of the grain field and of the agricultural techniques applied. The weed assembly is also modified by the processes to which the grain has subsequently been subjected, such as harvesting, threshing and malting. Weeding and seed cleansing can be discounted, and the weed content will depend on which weeds had mature seeds at harvest time. Winter-sown grain would, of course, contain other weeds than grain sown in early summer in the same area.

Helbæk (1955) found that some prehistoric grain samples were almost free of weeds, the reason being that the crop was cut just below the spike and only plants of the same height as the cereals were harvested together with the grain. In some civilizations, grains were hand-collected. Later, during the Iron Age, other harvesting techniques were introduced and the cereals were cut closer to the ground so that more weeds were mixed with the harvest (and their seeds re-sown with the seed).

Harvesting methods are therefore co-responsible for the particular assemblage of weeds and wild plants associated with the freshly collected grain. Threshing and malting may modify this weed assembly to some degree. Malting involves first soaking the grain in water in order to start the sprouting process. Today soaking is done in large vats where the grain is simultaneously cleaned by flotation. Light material such as empty grains, weed seeds and plant debris floats to the surface and is removed. Although undesirable material will not be totally removed by this process, the resulting assemblage of weeds in malt will be different from the original grain material. If the grain was soaked in closed containers, eg a sack, this effect would be smaller to negligible. Soaking may result in a modification of the weed frequency. Differences would then be due to variations in flotation methods. It is possible that the malting technique changed in the course of time. The cleansing effect would increase with the amount of water added and by stirring the grain in the vat.

After sprouting, the grain is dried and the brittle shoots broken off by pounding or roughly stirring the malt. The roots and other small particles would then be crushed and could be winnowed away, together with smaller seeds of some weeds, but some grain would also be damaged. The more elaborate the cleaning operation, the more weeds and wild seeds will disappear during the process. Fire-layer B had the lowest quantity of weeds, no internodes, and the highest percentage of damaged grains. *Galium cf. aparine* is better represented than *Chenopodium album* in contrast to the other layers. This could be a result of rough stirring or pounding. The sample from fire-layer C contained mainly undamaged grains, most internodes and numerous weeds, which would indicate a softer treatment.

To what degree threshing could account for the variation in the number of weed seeds is not shown. It might cause reduction of the number of weeds or change the frequency to a certain degree, but should not lead to the introduction of new weeds. The weeds found in the analysed samples must therefore represent a selection of the weeds in the grain field, which again depends on environmental factors such as soil conditions and climate. *Chenopodium album* and *Polygonum lapathifolium/persicaria* were the most important weeds in all the fire-layers and must have been very common in the fields from which the grain came. Apart from these, the quantity of weed seeds and fruits and the number of species represented was rather different in the three fire-layers and the amount of other cereal grain (oats and rye) also varied. Such differences were not found within individual layers, and it can therefore be assumed that the malt found within each layer came from the same area, and may possibly represent the same consignment.

None of the weeds in the material from fire-layer D gave any indication of a rich soil. *Raphanus raphanistrum, Euphorbia helioscopia, Spergula arvensis* and *Scleranthus annuus* are all highly competitive on acid soils; the occurrence of *Chenopodium album* and *Galium cf. aparine* indicates that the soil could not have been the poorest.

In fire-layer C the weed flora is richer, with *Chenopodium album, Agrostemma githago* and *Galium cf. aparine* indicating fairly good soil conditions. *Polygonum lapathifolium, Spergula arvensis* and *Vicia cf. tetrasperma* belong to less nutrient-demanding communities.

In fire-layer B there is little *Chenopodium*, but individual finds of *Solanum nigrum, Centaurea cyanus* and *Urtica urens* indicate somewhat better soil conditions. Also in this fire-layer weed species from poor soils were found, such as *Euphorbia helioscopia* and *Vicia cf. tetrasperma.*

It is difficult to judge the nutrient status of the fields in which the grain from fire-layers B and C had been grown. It is, however, possible that the grain did not come from one specific place but was a mixture of crops growing in different fields and on different soils, as van Zeist & Palfenier-Vegter (1979) concluded from a similar type of weed mixture.

The three fire-layers also had a different admixture of other grain types than barley in the malt. Rye, oats and wheat were also used for beer production during the Middle Ages but produce miserable beer (Simonsen 1957, 282). In marginal agricultural areas in the northern and western parts of Norway where it may have been difficult to obtain good barley, the malt could consist of mixed barley and oats (Nordland 1969, 2). Many oat grains found among the malt in fire-layer D and the species of weeds from this layer indicate rather poor soil conditions. From the Viking Age onwards it was common to grow barley and oats together, especially in areas where the summers could be bad, for instance along the North Sea coast (Behre 1975, Körber-Grohne 1967, Kroll 1975, van Zeist & Palfenier-Vegter 1979). Barley production could be bad, and the need for grain would then be covered by oats (Kroll 1975) which ripened better in cooler summers.

The observed mixture of grain species might come about in three different ways: from a mixed crop in the field, from contamination during transport, and in the brewery. Of these possibilities, the last seems less probable: if this building was a brewery, there was no reason to bring into the room anything but barley. Since rye was undoubtedly the most important grain for bread, transport of both barley and rye on the same keel is very probable and a mixing might easily come about, eg by sacks bursting either in the exporters' warehouses or in the ship under transport or unloading.

Admixture of rye, either in the field or in transport would point to eastern Europe, from which area it is known (Helle 1982, 312–328, Nedkvitne 1983) that Bergen received a major part of the grain imported.

The weed flora reflects various, interdependent conditions: geographical area, climate, soil quality, crop and cultivation technique, especially autumn versus spring sowing. Rye and wheat are usually winter crops, whereas oats and barley (the latter with a short growing season) are more regular summer crops.

The strong presence of oats (28%) in the malt of fire-layer D (1248, proto-Hanseatic) strongly indicates that this grain was imported from coastal areas, the Netherlands or Great Britain. The virtual absence of oats and strong representation of rye (30%) in fire-layer C indicate a totally different origin. Mixture of rye and barley has not commonly been found in other paleoethnobotanical investigations. A few grains of rye were found in barley samples from 2000 BP and later (Behre 1969, 1973, Kroll 1975). One of the reasons why barley and rye are not often found together is that rye in contrast to barley is a typical winter-sown grain. About the same ratio between rye and barley observed in fire-layer C was also found in some samples by Kroll (1975). Helbæk reports finds of barley malt with non-sprouted rye. In addition to rye *Agrostemma githago* was best represented in layer C. This could indicate mixing of the grain. The weed assembly in fire-layer C generally pointed towards winter-sown fields. If barley was winter-sown, it might explain the composition of the weed assembly.

The malt in fire-layer C would fit in well with the historical sources if it was winter-sown in continental areas of Europe. The most important trade-routes for grain and grain products to Bergen at that time were from the Baltic area (Helle 1982, 312–328).

Rye germinates more quickly than barley. Most of the rye grains in the samples from fire-layer C had rather small sprouts, from 1 to 2 mm, and these would have been longer if the rye had been malted together with the barley. The short sprout length could, however, be a result of sprouting conditions which favoured the barley germination but not the rye.

In fire-layer B both rye and oats are sparingly represented and may represent accidental contamination during transport and storage. The purity of the samples and powerty of weed flora gives few indications of the provenance of the grain. The weed flora indicates import from the continent.

Setaria viridis, S. glauca and *Echinochloa crus-galli* are not natural constituents in the Nordic flora. Today they are only found in connection with mills and dumping places and do not reproduce or spread from these localities. It is not likely that they had any wider distribution in the past. In his flora from 1861 Blytt mentioned only *Setaria viridis*. Jessen & Lind (1922) were of the opinion that *Echinochloa crus-galli* had been even rarer in this region earlier. In addition to these foreign or exotic plants, other weeds that were identified have a small and especially eastern geographical distribution in Norway today: *Brassica nigra, Solanum nigrum, Agrostemma githago, Scleranthus annuus, Centaurea cyanus, Raphanus raphanistrum* and *Vicia tetrasperma* (Hulten 1971). A comparison with Blytt's observations (1874, 1876) confirms how recent the present-day distribution of these plants is, except for *Centaurea cyanus*, which was more common when grain was grown more extensively in Western Norway. *Avena fatua* also shows an eastern and southern distribution in Norway today, whereas according to Schübeler (1886) it had also been more widespread earlier when it was more common to cultivate grain in Norway.

Probably not all the plants which grew together with the grain are represented in the samples. The seeds and fruits of many weeds of cultivation could have disappeared before harvesting or when the grain was threshed and malted. If the grain consisted of a mixture of crops from different places with a different weed assembly, the mean weed

frequency would be lower than in each field. When small samples are taken for analysis, the probability of finding seeds of plants which did not dominate in the fields will be small. Seeds of plants that do not occur in our Norwegian flora and that have difficulty in developing seed today will be highly probable indicators that the material was imported.

There are indeed few finds of the exclusive foreign plants *Setaria viridis* and *S. glauca* in fire-layer B, but both these plants suggest that the grain was grown in a warmer climate. Other species with an eastern and southern distribution in Norway were very well represented in fire-layer B: *Agrostemma, Raphanus* and *Vicia cf. tetrasperma*. These indicate that the cereal had grown in a more continental climate than is found in Western Norway. In fire-layer C one seed of *Echinochloa* was found, while *Agrostemma* and *Brassica* were very well represented, showing that also the grain in this fire-layer was grown in a more continental climate. Four seeds of *Echinochloa* were found in fire-layer D, and *Raphanus* was also represented in this layer with many fragments. On the basis of this investigation it can be concluded that the grain from these three fire-layers had been imported to Norway.

There is a shift in foreign trade in the late thirteenth and early fourteenth century away from England and to the Baltic area, where it became dominated by the Germans. About 1300 there was a change in British agriculture with a decrease in grain production (Rafto 1958). The malt in fire-layer D (1248) was mixed with oats. This mixture is usual in coastal areas, and it is therefore probable that the grain was grown in the British Isles or along the coast of the North Sea, the Continent or the Channel.

The malt from fire-layer C is dated to 1332, after the change in foreign trade. In this layer there was a mixture of barley and rye, indicating winter-sowing. Rye gives a good crop when it is winter sown, but the winters should be cold and stable, as is typical in a continental climate. The associated weeds also indicated a more continental climate. The grain in fire-layer C therefore had more probably been grown in a continental area than the grain from fire-layer D. This is not in disagreement with a shift in foreign trade from England to the Baltic around 1300.

The grain in fire-layer B gives less information about provenance. The weed flora is nevertheless indicative of import from the continent.

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Cordage and Similar Products from Bryggen in Bergen

BY ELLEN SCHJØLBERG

CONTENTS

INTRODUCTION

The craft of cordage manufacture is mainly based on the principle of twisting tough fibrous materials to give them pliability and lengthwise strength and elasticity. The twisting process also makes it possible to lengthen the product smoothly without knots. The art of twisting seems from most indications to have been invented in Palaeolithic times, and the craft of making cordage appears to have been fully developed at least in the Mesolithic. In this paper we are thus dealing with some of the products of a well-established craft.

The term "cordage" is used here as "a common name for the industry as a whole, while the phrase 'piece of cordage' can be reserved for cordage items, whatever their structure or use" (Dixon 1957, 135). The phrase "similar products" is used of withe derivatives of different types.

The assemblage of finds from the main excavation at Bryggen presented here encompasses most of the artifacts, whatever their material or size, which were made by twisting and plying or plaiting more or less fibrous materials into cords that were considered suitable for tying, lashing and similar purposes (n = 673). A group of cords made from animal hair (n = 172), most of them intended for caulking purposes, has been described earlier (Schjølberg 1984, 78), and the woollen yarns will be dealt with later, together with the textiles. Practically all the cordage treated in this paper is made from plant materials. "Plants that yield fibers have without question been second only to food plants in their usefulness to man and their influence on the advancement of civilization" (Hill 1952, 18). Descriptions of two finds of plaited bands have been added in order to throw more light on certain aspects of the cordage material.

Most of the cords were found as fragments in wet anaerobic deposits. Such circumstances are well known from archaeological experience to be suitable for the preservation of certain plant materials. The deposits, especially those dating from the fire at Bryggen in 1172 and the later phases, have greater volume along the waterfront than on the landward side of the site, as the quays successively moved further out in the harbour basin (Herteig 1985). Accordingly the bulk of the cordage was found in the successive quay-front fillings. Relatively few cords were found in the occupation deposits on dry land and very few have survived in the actual fire-layers. The different fire-layers are well dated (Herteig 1985, 21–33) and the finds have been related to them, being dated to the intervals between the respective fires. The few finds from the fire-layers themselves are seen as belonging to the preceding fire interval. About 8% of the material is still undated. The excavations were only in peripheral contact with the more recent quay fronts and their respective deposits, and altogether about 90% of the dated cordage was found in levels below the fire-layer of 1332 (fig 3). Also most of the undated finds belong to the deeper layers. The earliest dated finds are from the middle of the twelfth century.

Only a few of the cords were found under circumstances which could provide direct

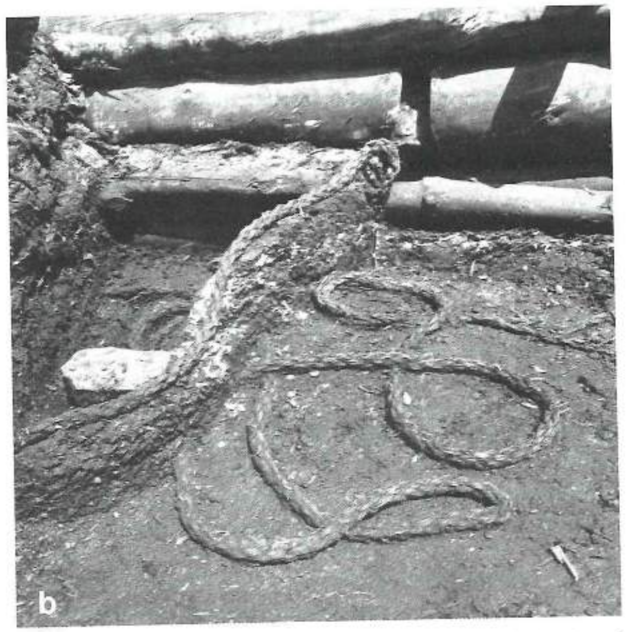


Fig 1 a. Mooring cord found in situ around the post of a quay built shortly after 1170. b. Cords lying on different sea-bed levels underneath several metres of deposits.

information about their original purpose. These few are mooring cords which, when found, were still connected to the front poles of some of the oldest quay constructions (fig 1a). The rest were found in secondary situations, thrown out as more or less useless fragments together with other rubbish, but many seem to have been thrown or lost singly on the sea-bed (fig 1b), probably during harbour work.

The classification key which has been constructed for the material is based on the different types of raw material used in the production. One single find is of an inorganic material (asbestos), and one is a leather band, otherwise all the finds are made from plant materials like twigs, stems and strips of bast or wood. Raw material was chosen as the basis of the classification, because it was considered that the properties of the different materials and the degree of technical processing before use are in themselves the key to a better understanding of the technical qualities of the cordage types, the actual construction of which mostly followed one common practice.

The characteristics of the different categories of raw material are relatively easily perceptible visually during the sorting process. It is hoped that the key will prove a helpful framework for future studies of similar assemblages of finds, even without the aid of the time-consuming microscopic analysis which has been used in the present work. This microscopic analysis of the raw materials was based on the works of Greguss (1945, 1955), Grosser (1977), Holtheide (1951), Körber-Grohne (1977), Mork (1966) and Wiesner (1927–28), together with a comparison with a collection of recent plant material.

The constructional details of the cordage are difficult to compare directly with those of modern professional cordage and modern terms. These details have therefore been described in accordance with a descriptive system worked out for anthropological studies of cordage (Dixon 1957, 134–36). The constructional practice is largely the same for most of the cordage types, and these features were therefore found to be of little value as distinguishing factors for the classification key. Yet the varying results of the common practice reveal a broad range of smaller methodological modifications, most of them connected to the raw material categories.

The study is based exclusively on the Bryggen cordage material. The further discussion of the types is, however, based on literary evidence, on the one hand on descriptions of comparative archaeological finds from other excavations, on the other on more recent popular traditions concerning comparative cordage production. The rich cordage material from the excavations at Haithabu is the only published comparative cordage assemblage so far known to the author (Behre 1969, von Brandt 1970, Körber-Grohne 1977). From other excavations there are only sporadic descriptions of cordage finds. The more recent popular traditions concerning the manufacture of cordage have, however, been the subject of a series of detailed studies, of which the Norwegian and Swedish ones in particular offer a vast amount of relevant information for an understanding of the Bryggen finds, especially the works of Granlund (1943–44), Hanssen & Lundestad (1932), Hanssen (1934), Høeg (1976a, 1976b), Modéer (1928), Molaug (1937), Nilsson (1961) and Olofsson (1936).

Since cordage as an archaeological find group has seldom formed the subject of a systematic study, it was found necessary to give a thorough classification and description of the rich material from Bryggen. Aided especially by the above-mentioned literary sources, an attempt has been made to place the finds in time and space in relation to the long traditions of the craft. The choice and treatment of the raw material categories, the technical level of the construction process, and the connected physical properties of the finished products are seen as a basis for a further interpretation of the material with regard to questions concerning small-scale domestic industry as opposed to a professional craft, possible indications of an evolutionary process in the industry, and the standardization of the products. An attempt to answer the question about the representativity of this collection of finds is made in connection with a discussion concerning the absence of hemp cordage among the finds.

The finds themselves and the literary sources do not throw much light on such questions as the role of the different types of cordage in the daily activities at Bryggen, to what degree the material or finished products were supplied as a general item of trade or to special order from the customers, whether cordage production was a central craft in the town as it was much later, or whether the finds are typical of a wider area in the Middle Ages. More finds from many places and more studies of the literary evidence are required for a better understanding of these and connected problems of the history of the cordage craft.

THE CLASSIFICATION SYSTEM

The finds of cordage from Bryggen are rather special seen in a modern perspective. Herbaceous plant tissues like hemp, for instance, have not been found. Practically all the finds are made of materials derived from Nordic trees and shrubs. In a modern listing of raw materials used in cordage manufacture all the Bryggen materials would fall into the group "miscellaneous" and then with practically no parallels even there.

As pointed out in the introduction, it is difficult to use modern terms charged with professional meanings for such a material. A descriptive hierarchic system based on the stages in the professional manufacture of modern cordage, but adjusted for anthropological studies of cordage, was proposed by Dixon (1957, 134–36). Unfortunately this system is not satisfactory for the purpose of classification, since the constructional features are common to most of our qualitatively different types and thus fail to separate them.

The main systematization of the cordage has therefore been based on easily identifiable differences between the raw material categories, and worked out like a simple key. In this key other types of information, such as the actual species of raw material involved, cordage dimensions and constructional features are not built in. On the other hand, the technical level of the preparatory processing of the raw material categories is one of the visible differences and thus a major distinguishing feature. The key has thus been organized according to the first step in cordage production: the choice of raw material.

The classification of the Bryggen cordage starts principally with the separation of three basic categories of raw materials, namely plant material, animal material and inorganic material. These basic categories are very unevenly represented in the Bryggen cordage finds, of which nearly all are made from plant materials. Animal materials are represented by some few cords made from hair (not treated in this work) and a small piece of a plaited leather strap as a dubious example of an expected group of cordage made from leather, hide, sinews, etc. Inorganic materials are represented by one find made from asbestos. The leather strap and the asbestos cord are described separately, and the classification of the Bryggen cordage starts directly with the key based on different plant raw material categories (fig 2).

The plant raw materials are first separated with regard to their initial preparation. The cordage is accordingly sorted into two types of classes, of which the first (A) comprises all cordage and similar products made from whole parts of plants without significant processing of the material, and the other (B) comprises all cordage made from special plant tissues separated from the plant structure by a preparatory processing.

	A. Unprocessed, whole plant parts						B. Processed plant tissues		
Raw material categories	Single shoots	Bundles of twigs / stems					Bundles of thin fibres	Fibrous strips	
Class:	Withes	Twig cordage type I	Twig cordage type II	Heather cordage	Hair moss cordage	Grass cordage	Coir cordage	Wood strip cordage	Bast strip cordage
z = 672	n = 112	n = 35	n = 56	n = 5	n = 4	n = 1	n = 1	n = 3	n = 455

Fig 2 Classification system for cordage, made from plant material.

These two types of classes are further divided into cordage classes defined by the relatively easily recognized special raw material categories used for their fabrication. The appellation "class" for the cordage made from the different categories has been chosen in accordance with the following definition (as opposed to the term "group"); "Classes are intentionally defined on the basis of formal features of objects; groups are 'defined' by enumerating and/or summarizing the members or by stating the temporal/spatial limits of the group. ... classes have distribution; groups have locations" (Dunnel 1971, 89). The definition is suitable for the cordage material from Bryggen, because the types are found elsewhere in both time and space, and the class criteria may therefore, in the author's opinion, be used for cordage from other places.

The first class of cordage made of unprocessed, whole plant parts consists of withes or withies, ie cordage-like items whose construction is based on the principle of twisting a single slender, flexible, wooden shoot (n = 112). The five other classes made of unprocessed plant parts can all be defined as real cordage (like those made of processed plant tissues), with the basic constructional elements made from bundles of more or less flexible raw materials. Thin twigs were used as raw material in two of the classes. In twig cordage type I (n = 35) bundles of twigs were used in their natural state for building up the constructional elements, whereas in twig cordage type II (n = 56) the

	Total n	Dated n	Fire intervals 1170	1198	1248	1332	1413	1476	1702
Withes	112	106	16	35	20	30	4	1	
Twig cordage type I	35	28	3	15	6	4			
Twig cordage type II	56	50	2	24	7	13	4		
Heather cordage	5	4				3	1		
Hair moss cordage	4	3	1			1	1		
Grass cordage	1	1				1			
Coir cordage	1	1					1		
Cordage made of shredded wood	3	3			2	1			
Bast cordage	455	425	44	113	80	135	42	8	3
Asbestos cordage	1	1							1
Sum	673	622	66	187	115	188	53	9	4

Fig 3 The number of different cordage finds in each fire interval at Bryggen.

twig bundles are tightly wrapped with strips split from thicker twigs. This wrapping of the elements is the only constructional feature included in the classification system, and it may thus seem illogical to use it. But this wrapping has in fact nothing to do with the main constructional system. It is easily recognized and distinguishes a good cordage class. Cords of the last three classes made of unprocessed plant parts are made from bundles of thin heather stems (n = 5), bundles of hair moss stems (n = 5) and grass (n = 1). We could also have expected cordage made from, for example, roots and reeds, but no such examples have turned up at Bryggen.

The first class of cordage made of processed plant tissues is made with strikingly fine-fibred material as compared to all the other cordage from Bryggen, with the exception of the otherwise very different piece made of asbestos. This class is represented by a single find made from coir, or coconut husk fibre, the only example of a cord made from an exotic material among the cordage from Bryggen. The two last classes of cordage are made from thin strips of plant tissue, and are usually easy to distinguish. The first of these, represented by only three finds, is made from shredded wood, and the products are consequently woody in appearance. The other, the most numerous class from Bryggen (n = 455), is the bast cordage, usually easily identified, since the bast material most often is rather soft, but it can sometimes be quite woody, so that the products closely resemble the cordage made form shredded wood. We could otherwise have expected cordage made, for example, from birch bark and from herbaceous bast fibres such as hemp, but no such finds have been recorded in the main excavations at Bryggen.

THE DESCRIPTIVE SYSTEM

Once the cordage finds were classified according to the key, the further descriptions of each individual find were based on several characteristics. These are the constructional features, such as the number of stages in the manufacture, the number of basic elements involved in the different stages, the diameter, the direction and degree of twist, presence of secondary features like knots, loops etc, and any other visible signs which are of importance for the combination of the different characteristica.

Most of the finds in each class can be assembled into identifiable groups with similar features and then described collectively. Individual descriptions are therefore given only for finds with specially interesting qualities; these are referred to by their accession numbers. A few finds have lost their original number and have been assigned X or T numbers, and a few numbers which are obviously wrong are placed in inverted commas.

In order to follow the same scheme for all descriptions, the analysis of the constructional features is based on Dixon's hierarchic system (1957, 135) as follows:

Stage I (yarn): a bundle of fibres spun or twisted in S- or Z- direction to give continuity.
Stage II (strand): 2 or more Stage I elements (or yarns) twisted together.
Stage III (rope): 2 or more Stage II elements (or strands) twisted together.
Stage IV (cable): 2 or more Stage III elements (or ropes) twisted together (rare in primitive cordage).

This system had to be changed somewhat for the Bryggen material. In the Stage I definition the word "fibre" is not adequate for the rough materials used in the cordage made of unprocessed, whole plants parts. Sometimes the raw material elements of Stage

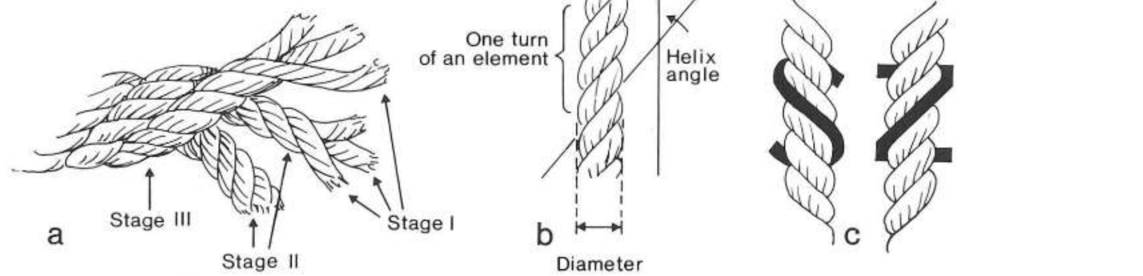


Fig 4 a. The different parts of a cord. b. The measuring of cord diameter and helix angle. c. S- and Z-direction of twist/ply.

I in such cordage are not even twisted. As is usual in studies concerned with twisted strands, the letters S and Z are used to indicate the direction of twist (fig 4c), the slant of the twist when the object is viewed from the side conforming to the central portion of the letter S or Z. Normally the twist in each successive stage is in the opposite direction from that in the foregoing stage (fig 4), giving the cord a twist equilibrium.

Since the term "twist" is here used for the first handling of the material in Stage I, it will not be applied to the handling of two or more construction elements together for the next stage. For this the term "ply" (usually used for the construction of yarns) will be preferred (Emery 1966, 10), and we shall speak of two-plied, three-plied structures, etc. Some types of cordage are plaited instead of being plied. The term "yarn" is not appropriate for the rough Stage I elements of the cordage made of unprocessed plant parts, but can be accepted for those made of processed tissues for which it has also been in popular use. The Stage II term "strand" is not applicable to most of the Bryggen cordage, whose construction is usually completed at this stage, and the term is not acceptable for a completed piece of cordage. The commonly-used term "rope" for cordage has been totally avoided, since in Dixon's system and also professionally it is used for the construction Stage III. Stage III constructions are relatively few at Bryggen and we have no finds of the Stage IV construction.

The Dixon system will thus with these alterations, read as follows:

Stage I: a single element or a bundle of raw material elements laid together and usually twisted or spun in S- or Z- direction to give continuity and/or flexibility.
Stage II: 2 or more Stage I elements (components) plied or plaited together.
Stage III: 2 or more Stage II elements plied or plaited together.
Stage IV: 2 or more Stage III elements plied or plaited together.

As well as the construction, the thickness of the cordage is of fundamental importance. Professionally the circumference of the structure would be measured, but for the actual cordage and similar products dealt with here, this is not practical and has not been employed. Nor is it used in popular tradition, where measurements such as "finger-thick" are customary. For our material, as with other published comparable cordage (eg Körber-Grohne 1977, 67), the diameter given in millimetres is better. Fig 4b shows how this measurement was taken. The diameter of the completed piece of cordage normally has a simple numerical relationship to the diameter of the Stage I element (fig 11), which means that the one diameter can be approximately deduced from the other, when the number of Stage I elements and the number of constructive stages in the complete structure are known. This is of interest for the evaluation of individual finds when they are in bad condition.

The degree of twist in the elements at the various stages has a functional consequence. The "degree of twist" is used to define the variation in twist firmness on a scale from soft to hard twist. This is sometimes called the tightness of the twist, an expression which points to one of the two usual ways of measuring it, namely by reckoning the turns in the spiral made by the twisted element along a given length of the structure (fig 4a,b); the other way is to measure the angle of the helix in the twisted element in relation to the long axis of the structure (fig 4b). The helix angle is the more practical measurement of the two, but it should be seen in connection with the corresponding diameter of the structure (Osborne 1954). It is obvious that even when the angle of helix is the same in two Stage I products of different thickness, the raw material in the thicker one will run in a wider spiral and consequently a slacker lay than in the thinner one. The diameter is denoted in the diagrams by the sign θ.

The energy transferred to the element during the twisting builds up an internal twisting energy in the opposite direction. This is reduced to an equilibrium when two or more elements with one twist direction are plied together in the opposite direction. Some of the twist in the lower stage element disappears during the plying, because each complete turn of one element around the other(s) will cause some of the original turn in the element to be untwisted.

The type of raw material has a natural influence on the helix angle. A steep angle, seemingly a slack twist, can be the firmest possible one for a stiff material, while being loose for a soft material. The degree of twist for a single find can thus be compared only with the twist in other finds made from the same type of raw material. General traits with regard to the twist for units of cordage made from the same material can, on the other hand, be compared with such traits in units from other types of material, thus indicating the inherent qualities of the different types of cordage.

The structure of the raw materials in old cordage may be rather compressed and distorted and thus difficult to identify, but the standard methods for plant anatomy studies have worked satisfactorily. Thin slices were cut by hand from the tissue in three distinctive structural directions: in two planes parallel to the tangential and radial tissues, when seen in relation to the axial direction of the plant structure, and in the transverse plane across the grain. By placing the slices between glass slides and observing them under a light-transmission microscope, the main structure of the plant tissue and the anatomical details relevant for diagnostic purposes can be studied. For the bast material it was often sufficient to study the tangential plane provided by the wide side of the thinly shredded bast layers. All the plant material could be assigned to a genus or a species, mostly of Nordic trees and shrubs.

THE CORDAGE CLASSES

1 The withes

The withes or withies (n = 112) are cordage-like items which differ from the rest of the cordage structures in that they are rather stiff bands used for tying, made by twisting young, flexible, straight, woody stems, usually sucker shoots.

In the twisting process the tissues of the stem necessarily split lengthwise, so that the stem becomes more pliable as a tying material. The end piece of the thickest part of the stem is normally kept untwisted. The single twisted stem can be used as it is, or be

bent double with the parts plied around each other and then often with a locking device at the thick end, with the untwisted piece acting as a pin. Between two and four stems can be plied together and the structure lengthened in different ways (Olofsson 1936, 142–43). In this way various types and combinations of bands were produced with a wide application for tying and lashing, thus satisfying such needs in a self-supporting economy. All details about their manufacture are well known (Høeg 1976a, b).

A Finding circumstances

Of the withe finds 106 have been dated. The number of finds from the different fire intervals can be seen from fig 3. The distribution in time of the withe finds can best be discussed in relation to the other cordage classes from Bryggen. The three curves seen in fig 5 show the distribution in time of the bast and twig cordage and the withes, each class being shown as a percentage of the total number of these groups in each time interval. Small classes of cordage like those made from moss, heather, grass and asbestos have not been taken into account in the diagram, nor the 13 finds of cordage found in the layers above the 1413 fire-layer. These are far too scattered as regards both type and location to give a reliable picture of the distribution in the upper levels. The diagram clearly shows that the withes decrease in frequency, especially as compared with the bast cordage and probably therefore also with regard to the activities at Bryggen, since withes otherwise, at least in rural areas, continued to be used right up to our own time.

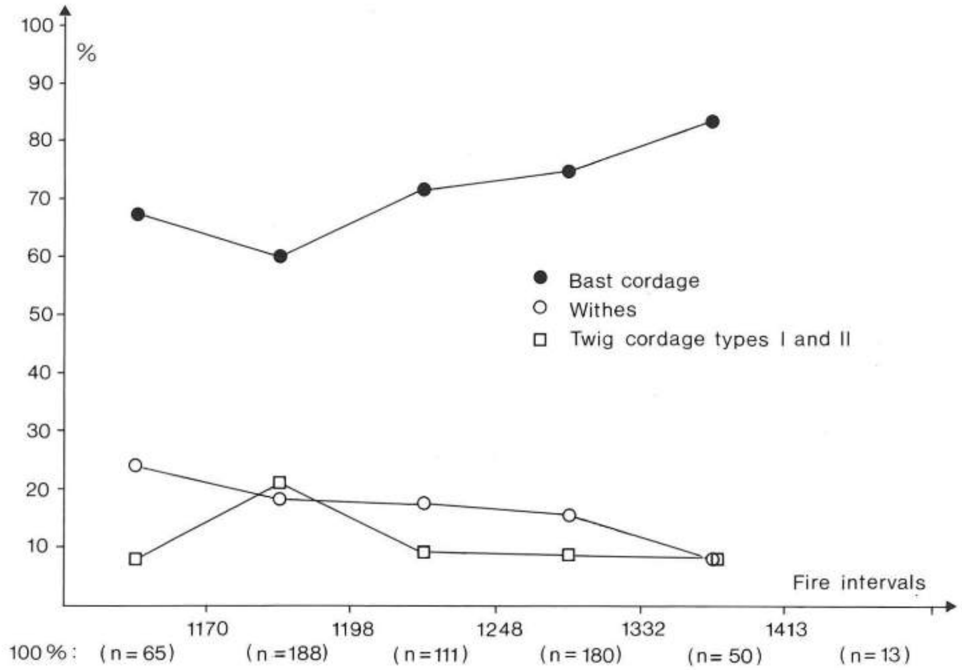


Fig 5 Relative distribution of bast cordage, withes and twig cordage type I and II (counted together) shown as a percentage within each fire interval. The few finds later than the 1413 fire (n = 13) have not been taken into account. The total number of finds in these three categories in each fire interval = 100%.

All the withes are stray finds, mostly from the deposits associated with the quay constructions. Nearly all of them are merely fragments. If they had been used for special purposes in connection with work along the quays, one would have expected to find at least some of the types with some significant form, but they seem mostly to have been thrown away as useless fragments. The finding circumstances do not give any indications to explain where and for what they were used.

B Raw material

The anatomical study of the withes revealed that 82 of them were made from birch *(Betula sp)*, 16 from willow *(Salix sp)*, and four each from juniper *(Juniperus communis)* and hazel *(Corylus avellana)*. The last six withes were made from four other wood types, namely two from beech *(Fagus silvatica)*, two from oak *(Quercus sp)*, and one each from ash *(Fraxinus excelsior)* and yew *(Taxus baccata)*. The stems were from a couple of years up to at least five years old when cut.

These can all be of local origin, even the pieces made of beech, which in reality is not a native of the west coast of Norway. There is, however, a beech forest north of Bergen, probably originally planted, but already established before AD 1000 (Fægri 1954, 230–49).

The frequency of the different species as raw material for the withes found at Bryggen reflects what has been noted about them in later traditions. Høeg (1976a, 43–62, b) says that the wood type preferred was birch. For some special purposes willow and spruce (in South-East Norway) were used. Juniper was also regarded as quite good, while occasionally people just took what was available. Willow seems to have been preferred as raw material in countries with less birch (Merriam-Webster 1958), and even the actual Norwegian terms used for withes and willow (*vidjer* and *vier*) are sometimes confused. Although the terms may have been distinct earlier, their meaning seems, in that case, to have been confused later.

Birch, willow, juniper and yew are all known to be flexible woods, (Wiesner 1928, II, 1337, 1321, 1308, 1283) with willow as the most flexible. Birch is known to be difficult to split, and since splitting is an essential part of withe manufacture, the preference for birch in our area can seem a little puzzling. But birch is also much tougher than willow, and the combination of a tough yet flexible wood which will seldom split too far may be the explanation for the preference. Beech is known as an inelastic wood, but easy to bend when wet. Hazel wood is hard, but elastic. Oak is considered a stiff material and is even contrasted with willow in an old Latin phrase describing an inflexible person: *"ortus a quercu, non a salice"* (raised from oak, not from willow). Yet it has been used occasionally, for instance at Haithabu (Körber-Grohne 1977, 83), and for wickerwork in Feddersen Wierde (Körber-Grohne 1967, 27).

For 56 of the withe finds it is possible to ascertain the approximate time of the year the stems were cut. Thirty-three of them were cut outside the growing season, while six were cut relatively late and 17 rather early in the growing season. It is not possible to find any difference in this trend for any of the raw materials. The dominant harvesting time was thus outside the growing season. Later traditions vary about what time of the year the withes should be collected. Most people were apparently of the opinion that the time between sowing and harvesting was best, though after the greatest sap rising, when they would have been too brittle (Høeg 1976a, 44–46, b). During summer the shoots should otherwise be left for a day or so after cutting before they were twisted, in order to lower the sap pressure (pers comm B Spangelo, Botanical Inst, Univ of Bergen), but they had to be twisted before the shoots dried out. Some people thought that the withes should be cut in late autumn (but not in frost), as they would then be stronger. A few people simply took them when they needed them. The different

cutting times probably had different advantages. The sapless winter-shoots would probably be tougher, while twisting them might be easier during summer.

C Construction

Even though the withe finds are very fragmentary, they represent many different methods of construction. The diameter of the single twisted stems in the finds varies between 2 mm and 15 mm, usually corresponding to the thinnest and thickest ends of the stems. The normal thickness of modern withes is about the same, though we know that much thicker ones could occasionally be made (Høeg 1976a, 44–46, b). The bark was always removed. Nearly all the fragments are more or less curved, which is quite natural because of their main use as objects for tying and lashing. In modern times withes have also been kept coiled when stored in order to secure the twist.

All the withe finds are twisted in the same direction with S-twist (fig 6, fig 7a). This is also the usual direction of twist in recent withes and is connected with the way the withe is handled by a right-handed person during the twisting process. The opposite twist direction (Z-twist) has been known as the "wrong" direction. The twisting was hard work and only a trained person could do it properly, especially where side shoots had been removed (fig 7a).

The angle between the slant of the twist and the lengthwise direction of the withe is seldom more than 10 to 15 degrees in the finds (fig 6, fig 7a), and this is also the normal twist in modern examples, a twist which is easily retained without overstraining the material.

Sixty-one of the withes were single twisted stem fragments, but a few of them show signs of having been parts of plied withes. Twenty-three finds are two-plied with Z-ply direction. Among these there are eight finds with a closed loop at one end, which shows that a single withe was bent double and the two parts then plied together. Twenty-four finds are three-plied and four finds are four-plied (fig 10a), one of which (no. 54910) strangely enough is S-plied and therfore probably formed part of a more complex object. This special type of construction will be further commented upon in connection with comparable finds in other cordage classes. None of the three- or four-plied withe-finds has closed loop ends, and most of them give the impression of having been plied from separate stems because of the relatively even thickness of the parts.

The traditionally untwisted part of the thick end of the shoot is intact on 20 of the finds. In six of them, all single-stem withes, the end is threaded as a locking pin through an open ring-like overhand knot. Four of these knots are complete structures in themselves, and the thinner ends of the stem had clearly also been cut (fig 6a). In the other two knots of this type the thinner end is broken, and the withe may therefore

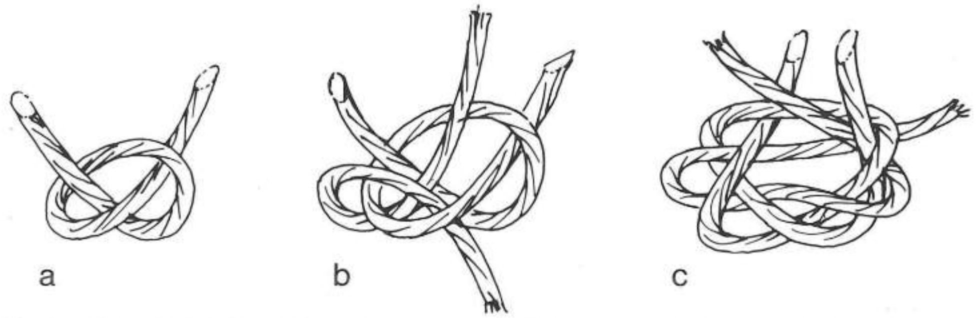


Fig 6 Schematic drawing of knotted withes. a. no. 28964. b. no. 12301. c. no. 30535.

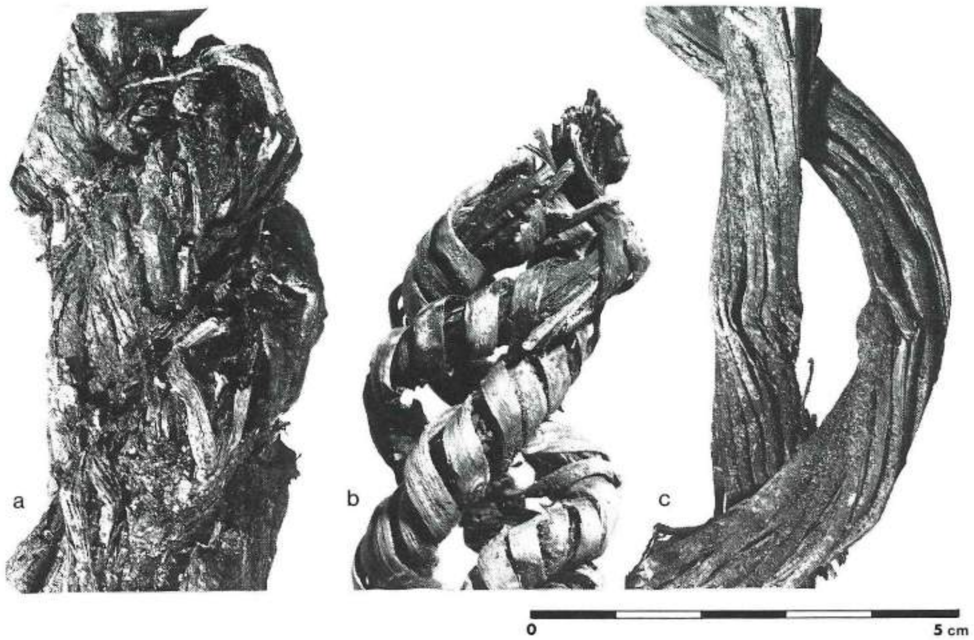


Fig 7 a. Detail of the twig material of a twig cord type I (willow, no. 77732). b. Detail of the twig material and the construction of a twig cord type II (willow, no. 12241). c. Detail of a withe, showing how the wood splits neatly at the point where a side-shoot has been removed (birch, no. 45405a).

have been longer. In three of the knots, extra withe pieces were hooked in, but whether they formed part of a chain cannot be ascertained (fig 6b, c). Four more finds also have simple knots, but not with the stiff end-piece threaded in. In three of these there are also up to three extra withe pieces hooked into the knot in different ways. The elegant withe-locking device known from later times (Høeg 1976b) is not represented at Bryggen. No difference in time distribution between the different construction types can be distinguished.

D Comparative finds and traditions

Withes are occasionally mentioned among the finds from archaeological excavations, but the wood is rarely identified. A few examples will be referred to here. J M Coles *et al* (1978) mentions ties of twisted withes wound round the vertical and horizontal members of the panels in the Neolithic trackway at Walton, where they helped to keep the structure together. From the Bronze Age a withe loop made from hazel and yew was found together with the Ferriby boat 3 (Wright & Churchill 1965, plate I), and a "two-stranded birch rope" was found holding together a repair in the Appleby logboat (McGrail 1979, plate 67). Willow withes from one of the first centuries AD were found at Feddersen Wierde (Haarnagel 1979, Tafel 45). From the excavations at Haithabu eight withes are described (Körber-Grohne 1977, 82). Some of these are single twisted stems, others are two- or three-plied. They are made from hazel, willow and oak. From the published illustrations it is evident that the Ferriby example, those from Feddersen Wierde and the Haithabu hazel ones are S-twisted with the typical slack angle of twist.

The two- and three-plied examples from Haithabu and Feddersen Wierde are Z-plied.

We know from more recent times that withes were produced in the fjord communities of Western Norway and sold to the inhabitants of the outer treeless coastal areas, even being sold in shops (Høeg 1976a, 49). The coastal areas were already treeless long before medieval times (Kaland 1971, 19). Withes were probably brought to Bergen from other places as long as there was a market for them there. As we have seen, this market seems to have diminished gradually already during the Middle Ages.

Well up into the present century every farmer could produce his own withes for all purposes (Høeg 1976a, 49, b), such as tethering animals, lashing together parts of waggons and other constructions, packing of various kinds, binding skis and snow-shoes to the feet, in the construction of fences and so on. They were also used in boats, for instance to keep the oars in place. They were used for animal traps and were ideal for fish traps, as the withe material does not absorb much water and therefore was light-weighted and easy to handle. Three-plied cordage-like withes were used for drawing sweep-nets in Norrbotten, Sweden (Olofsson 1936, 143), and strong chain-like constructions of withes could be used for hauling timber and other heavy objects (Hanssen & Lundestad 1932, 375, Ingstad 1961, 34). The plied cord-like withes can be seen as a form lying somewhere between ordinary withes and cordage made from twigs. Made from a cheap material which is found practically everywhere, withes have been in frequent and regular use right up to our own time, when metal wire and chains took their place.

2 Twig cordage Type I

All the finds belonging to this class (n = 35) are, as stated in the classification key, made from multiple twigs bundled together for the construction of the Stage I element. Additional twigs successively overlap one another, thus lengthening the bundle. This is always more or less twisted and always in the S- direction.

A Finding circumstances

Twenty-seven of the finds are well documented and dated; the rest are still undated. Most of the undated ones seem to belong to the oldest layers. Three finds are from the layers below the fire-layer of 1170, 15 were found in the fire interval 1170–1198, six in the fire interval 1198–1248, and three in the interval 1248–1332. No difference can be found in the vertical distribution between the cordage made from the two main types of material used, namely birch and willow. When compared with the chronological distribution of the withes and the bast cordage (fig 5), the twig cordage of both type I and type II seems to have been particularly popular at Bryggen in the fire interval 1170–1198: 55.6% of the dated finds of type I and 48% of the type II finds were from this period as against 29.4% of the bast cordage and 33% of the withes.

The twenty-seven dated cords were all found in back-fill deposits with no relation to their original function. Since most of the back-fill was in and around the quay constructions, the items of this class of cordage, like those of the other classes, were mostly found in the front part of the site. The 18 finds from layers older than the fire of 1198 (fig 3) were for some reason all found in the northern (Gullskoen) area of the excavation, but as the total number of finds in the class is relatively small, this is most probably due to chance. Other cordage types found in these same earlier levels were more scattered, as were the more recent finds of this class.

B Raw material

The raw material used for this type of cordage comes from three sources, juniper (n =

2), willow (n = 16), and birch (n = 17). The juniper twigs are mostly without bark, whereas the thinnest birch-twigs still often have dark brownish bark on them. The thinnest willow twigs usually have a shiny, now pale yellow-brown bark (fig 7b, c), sometimes with a slightly greenish tint, and are glabrous, thus excluding some willow species. From the frequency of the raw material types in the finds it seems as though this cordage class was made equally often from birch and willow twigs and only occasionally from juniper.

As mentioned in the discussion of the withes, the wood of most willow species is known to be exceptionally pliable, more so than wood from juniper, and even more so than birch (Wiesner 1928, II, 1320, 1308, 337), which is why it is always preferred for basket-making. Possibly these three materials were chosen for cordage intended for different purposes.

The birch cordage appears today often somewhat looser in its structure and more often disintegrated than that made from willow. The two juniper finds are still compact in their structure. A slight difference in the tendency for shrinkage in the three kinds of wood (Wiesner 1928, II, 1320, 1308, 1337) can only be partly responsible for this trait, although the tendency is greatest for birch and slightest for juniper. The loose structure is probably mostly due to the fact that birch twigs are the least pliable of the materials, so that from the beginning they were less closely arranged in the bundles of twigs. Moreover, they took less twist, as we shall see later, and this also made them less cohesive.

The twigs are rather variable in thickness in each bundle and for each type of material. Their diameter cannot, of course, be measured systematically, so the measurements given here have been estimated from what can be seen from the outside and ends of the cord fragments. Whole round twigs have diameters from 1.5 to 7 mm as they appear today. Many twigs with diameters up to 10 mm were also used, but then split into two. Even thicker twigs occur, but they were twisted like withes with S-twist before being mixed with the thinner ones. No difference can be found among the three raw materials in this respect and only some few of the thinnest cords were exclusively made from the thinnest twigs. The thin twigs usually still have bark on them (fig 7b), whereas the thicker twigs and especially the twisted ones seldom have bark left. The shiny bark of the finer willow twigs has usually shrunk together with the wood, while the dark bark of the birch twigs lies like a loose casing around the wood.

As can be expected from the variation in thickness of the twigs, their age also varies. The finer twigs usually have up to three annual growth rings, but some of the thick ones can have up to seven rings.

The harvesting season for the twigs could be established for 28 of the finds. In 14 cases they had been cut after a complete growing season. In five cases they had been taken late and in six cases early in the growing season. An examination of several twigs from an individual find showed different harvesting times for the components in three cases. In each example one of the twigs had been cut between growing seasons. This trait was not further investigated, the fact only noted as interesting. No difference in the frequence of the harvesting times between birch and willow could be seen. The twigs of the two juniper cords have been gathered early in the growing season. No general rule about when the twig material had to be collected could thus be found, although, like most of the withes, most of this material had been collected between growing seasons and presumably for the same reasons. They did not necessarily have to be fresh when used, since twigs cut at different seasons could be used in the same piece of cordage, but those gathered earlier probably had at least to be soaked before use.

C Construction

In connection with the various questions concerning the manufacture of this type of cordage, we would first point out that some of the two-plied ones may have been made in the same way as heather cordage was made in the Western Isles of Scotland right up to our own time (Fenton 1961, 208). This was made in one combined working operation, the two Stage I elements being built up simultaneously as they were twisted around each other to a complete two-plied cord. The Stage I elements themselves received very little twist during this procedure. Such a practice is difficult to prove for our finds, and the details in the construction of the Stage I elements will be described as though they had been constructed separately. To lengthen the element, more twigs were added, overlapping at random when necessary.

The basic feature of the Stage I elements is the diameter of the bundle of twigs (fig 8). Fourteen of the fifteen measurable willow cords have Stage I diameter from 8 to 25 mm, while the last one (no. 9982) is about 42 mm. Twelve of the thirteen measurable birch cords have diameters from 14 to 25 mm, while the last of these (no. "8902") is about 38 mm. The two juniper cords have Stage I diameters of 22 and 28 mm. Fig 8 demonstrates the difference between birch and willow cords in respect of the most frequent Stage I diameters used. The birch (and juniper) elements are usually at least 20 mm thick, while the willow elements are usually less than 20 mm thick. It would therefore seem that the more pliable willow twigs were utilized first and foremost for cordage of smaller dimensions, while the stiffer birch twigs were used more often for coarser cords. We can see from the figure that the Stage III constructions were clearly not based on particular Stage I diameters.

The degree of twist given to the Stage I twig bundles varied markedly. It could also often vary to some extent along the single element. The measurements given here may be the only possible measurement for some pieces, while for others it may be the mean of several measurements, depending on the condition of the finds. In spite of this variation in exactness, the measurements reveal interesting traits, which will therefore be discussed further.

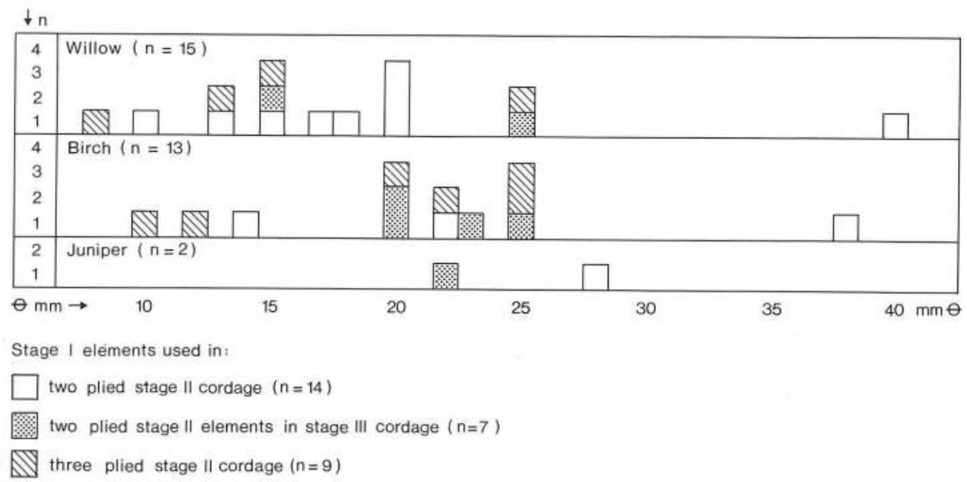


Fig 8 Twig cordage type I. Variation in the diameters of Stage I elements of identifiable constructions (n = 30). The figure also shows which element sizes have been used in the further constructions.

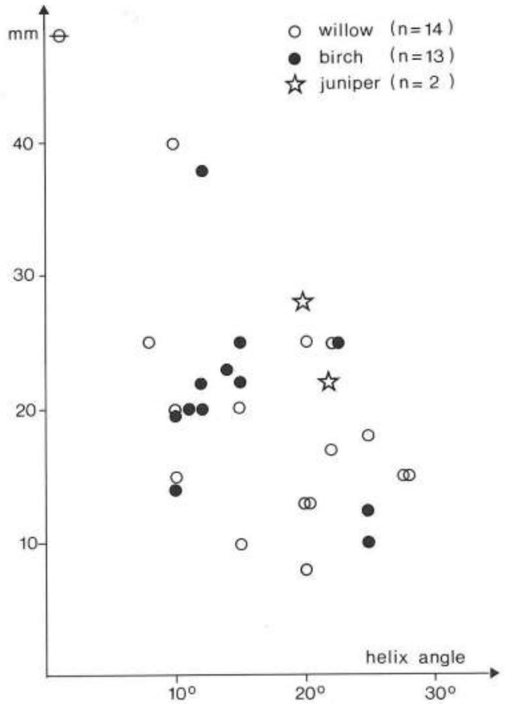


Fig 9 Twig cordage type I. Relationship between diameter and helix angle for the measurable Stage I elements (n=29) made from willow, birch and juniper.

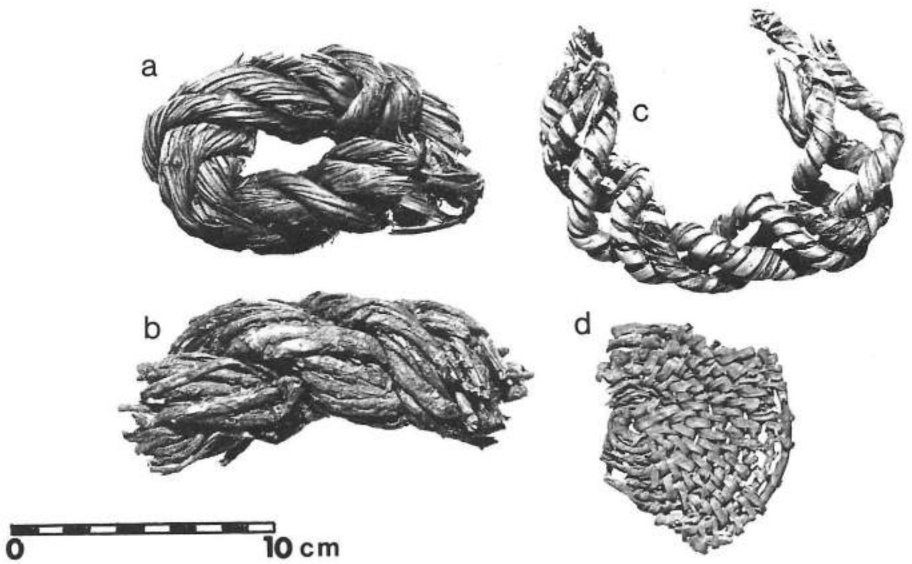


Fig 10 Different types of cordage and a piece of basketry made from whole plant parts. a. Withe (four-plied, birch, no. 12822). b. Twig cord type I (two-plied, willow, no. 77732). c. Twig cord type II (three-plied, willow, no. 12241). d. Piece of coiled basketry (willow, no. 38319).

The helix angle of the Stage I elements can be measured for 29 finds (fig 9). For the 14 cords made of willow twigs it varies from 10 degrees to 28 degrees (fig 7b, 10b), nine of them having angles of 20 degrees and upwards. For the 13 measurable birch elements the angle varies from 8 degrees to 25 degrees, but only three of them have angles greater than 15 degrees. The two juniper cords have angles of 20 degrees and 22 degrees. As these are parts of Stage II constructions, the element twist would have been slightly more accentuated before plying.

In fig 9 the points combine the diameter and the helix angle of the Stage I elements for the 29 measurable cords, further divided according to raw material. We can see that the normally thinner Stage I elements made from willow have a relatively stronger twist than is usual for the normally thicker birch elements. The picture is not entirely clear, but it seems to show that the diameter of the twig bundle is the main factor regulating the possible twist input. It seems at least fairly natural that the two thick elements at the top of the diagram (no. 9982 made of willow and "8902" made of birch) would resist a stronger twist, regardless of raw material type. On the other hand, one could also expect an extra resistance to the twisting for the thinnest elements, where the strain put on a single twig can be assumed to be more pronounced, but no such effect can be seen. It was not, moreover, possible to find any preference for certain degrees of twist on the elements used for the different cordage constructions.

The complete method of manufacture can be studied for 30 finds, of which 23 were completed as Stage II cordage and seven as Stage III cordage. Of the Stage II cordage finds 12 are two-plied. One of these is made from juniper, with a diameter of 42 mm and a twist angle of 20 degrees. Eight finds are made from willow with diameters varying from 15 to 65 mm and with twist angles from 10 degrees to 25 degrees, with the smallest angle on the thickest cord. Three finds are made from birch, with diameters varying from 20 mm to 55 mm, all with twist angles around 20 degrees. Thus the most common material for the two-plied constructions of this type from Bryggen is willow twigs. No preferred diameters can be detected.

Eleven Stage II cordage finds are three-plied. Five of these are made from willow, and have diameters from 18 mm to 50 mm and helix angles from 20 degrees to 30 degrees. Six cords are made from birch, with diameters from 22 mm to 50 mm and helix angles from 15 degrees to 25 degrees. The three-ply constructions of this type from Bryggen were therefore equally often made from these two materials. No diameter preference can be detected.

When the Stage I elements are plied together, the resulting diameter of the Stage II cordage will, of course, depend on the number of elements involved. The diameter seems to be relatively predictable according to a simple numerical relationship. Fig 11 demonstrates the relationship between the Stage I and Stage II diameters for 56 finds of two- and three-plied cordage for three classes of the cordage made from whole, unprocessed plant parts: twig cordage type I treated here, twig cordage type II, and heather cordage. All these are made from stiff materials and can *a priori* be expected to have the same qualities in this respect.

A two-plied piece of cordage is, according to fig 11, normally about 1.5 times as thick as the single element (a linear relationship of 3 : 2). A three-plied piece of cordage has normally twice the diameter of the single element (a linear relationship of 2 : 1). A three-plied Stage III piece of cordage can thus be expected to have twice the diameter of the two-plied Stage II. Only four of the seven Stage III finds in this class could be reliably measured, but they do roughly follow this rule. Fig 11 also shows the strikingly regular distribution of diameters, with no detectable clustering around certain thicknesses, which could have been expected from the asumption that certain types of cordage were needed for special purposes and so constructed according to certain standards.

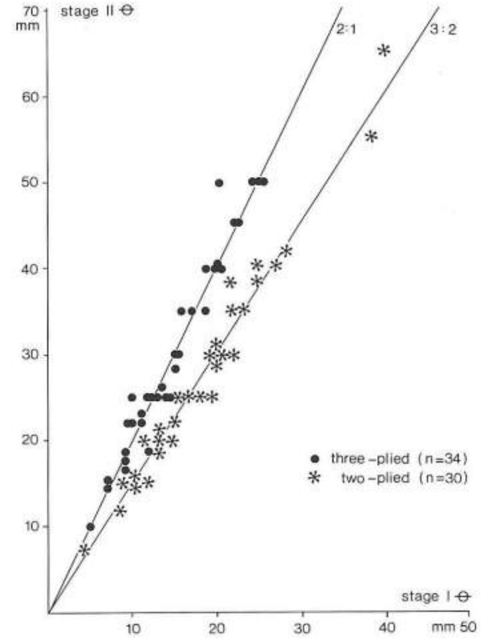


Fig 11 Twig cordage types I and II and heather cordage shown together: relationship between the diameters of Stages I and II.

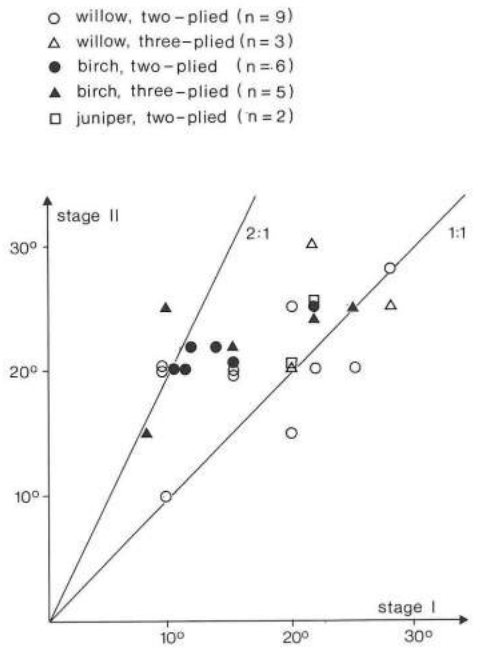


Fig 12 Twig cordage type I: relationship between the helix angles of Stages I and II for the different construction types and materials.

The helix angle for the Stage II construction can be expected to have a certain relationship with the helix angle and the associated energy of untwisting in the Stage I elements. In order to see whether any trends could be detected, all the measurable Stage II constructions in this class were brought together, including those used in three-plied cords, a total of 25 finds (fig 12). The separation of the two main materials is due to the already known fact that the Stage I willow elements usually have a greater helix angle than the birch ones. The helix angle of the corresponding willow Stage II constructions shows the expected results, in that the two angles are mostly about the same. The birch cordage, on the other hand, shows a general tendency for more twist in Stage II than in Stage I. The explanation for this trend may be that the greater resistance of the birch twig bundles to the twisting strain can generate a greater internal energy of untwisting and thereby give a more pronounced opposite lay to the Stage II cord. As a result, the Stage II constructions in this class probably have about the same lengthwise elasticity, regardless of the physical properties of the different raw materials.

The seven Stage III finds are all three-plied from two-plied Stage II elements, six of them in S-direction from the normal Z-plied Stage II elements and the seventh is Z-plied from S-plied Stage II elements. The latter (no. 78304, from the fire interval 1170–1198) is made from willow and must have been the thickest of all the finds in this cordage class, judging from the fragments (it is in poor condition). The Stage II elements of this find are about 38 mm in diameter, resulting in a diameter of about 76 mm for the complete three-plied cord, in accordance with the rule deduced in fig 11. The special lay (Osborne 1954, 1099) of Stage II here can be paralleled with the withe find no. 54910 from below the fire-layer of 1170. This withe was made from birch with four single S-twisted withes, which were then S-plied together; there were some indications that it had been a part of a more complex item. Both finds are possibly primitive examples of a constructional principle which is also found in a few of the later bast cords from Bryggen. This special lay accentuates the twist of the Stage I elements. According to Osborne (1954, 1099), it gives a smoother Stage III product with less tensile strength than those made with normal lay. Whether such a result could also be deduced from the coarse products here it is, of course, difficult to say.

Of the other Stage III finds one is made from juniper and has a diameter of 68 mm and a helix angle of 18 degrees, one is made from willow with a diameter of 42 mm and a helix angle of 22 degrees, and four are made from birch with diameters varying from 60 mm to 70 mm and helix angles close to 20 degrees. The juniper and birch specimens are therefore quite similar externally with respect to diameter, and they all have helix angles close to 20 degrees.

From all these details of the physical properties of the twig cordage type I constructions, it seems as though willow was preferred for the thinner Stage II cordage and birch for the thicker. Otherwise the most striking feature of this cordage class is the great variation with no discernible special sub-groups, with the possible exception of the Stage III cordage. It is difficult to tell whether the inherent qualities of the different raw materials lead to such different end-products that they were necessarily used for different, special purposes. Most of the facts point to an unspecified and possibly rather wide employment of this cordage type.

D Comparative finds and traditions

Cordage of this type seem to have been found at Haithabu. K-E Behre writes (1969, 16): "Neben diesen gedrehten Bastschnuren kamen mehrfach auch Schnure aus feinen gedrehten Weidenzweigen vor". Behre does not state whether they are made from bundles of twigs, but if the finds had been of the withe type, they would surely have been described as such. This is so far the only (eventual) parallel from other archaeological excavations known to the author.

With regard to later traditions concerning twig cordage we are not in a much better position. Only two notes are known to the author, one about birch and one about willow cordage. Both are from Norway and were collected by Hanssen & Lundestad (1932, 375). The note about birch cordage is a quotation from an unprinted manuscript from 1770, written by H M Seehus, a clergyman from Western Norway. He states that cordage twisted from bundles of birch twigs, (Norw *bjerkeriis*), was often used in salmon traps fastened to big stones, to keep the net in place. He also says that such a piece of cordage could not last for more than one summer. Nothing is mentioned about the construction of the cordage, but there is reason to believe that it was of the type discussed here, since birch, judging from the Bryggen finds, was not used for twig cordage of type II. Eastern Scandinavian and Finnish cordage made of birch is reported to be of the withe type (Nilsson 1961, 131).

With regard to willow cordage, a note from Jæren, in South-West Norway, says that it was used "because they have no lime *(Tilia)* there" (Hanssen & Lundestad 1932, 375). *Salix aurita* (Eared Sallow) is mentioned as the source of the twig material. This is probably not among the species used for the Bryggen finds, since the bark is somewhat different from the shiny, yellow-tinted and smooth bark of the twigs used here. The construction of the cordage is not described in this short note, but it is emphasized that the wood was used (ie the whole twig), not the separated bark or bast. Since the willow cordage in the note is compared to lime bast cordage, there is a possibility that it was of the type that will be described under twig cordage type II. This is usually better made than type I, and in one place at Bryggen it was used in the same way as bast cordage (as mooring ropes).

3 Twig cordage type II

This type of cordage is distinguished by the spiral wrapping or whipping of the twig bundles of the Stage I element. The finds (n = 56) have also other distinctive features in common. Willow is used as the only source of raw material both for the bundle of twigs and for the wrapping strips, which are made from thicker, straight-grained twigs split lengthwise. Only one find, no. 35255, a tiny cord, differs in that the bundles of willow twigs are wrapped with lime *(Tilia)* bast. The twig bundles are all twisted in the S-direction, though most often with a very low degree of twist, sometimes hardly visible. The wrapping also always follows this same S-direction, but with a much more pronounced helix angle (fig 7c, 10c). The Stage I elements were used in Stage II constructions, which are, whenever this can be traced, always Z-plied. Some of these are, in turn, used as parts of Stage III constructions. The end-product can be studied for 34 of the finds.

A Finding circumstances

Six of the finds belonging to this class are still undated, but at least three of these belong to the layers below the fire of 1248. Like the twig cordage of type I, and in contrast to withes and bast cordage, this class is especially well represented in the fire interval 1170–1198 (fig 3), with 24 finds (48% of the total finds of the class). The main form, the three-plied Stage II cordage, is found in all phases in about the same relative proportion to the other forms, which unfortunately are represented by too few examples to tell us anything about possible fluctuations, although taken together they give the same general picture as the three-plied ones.

Most of the cords were found in the waterfront deposits under circumstances irrel-

evant to their original usage. Of the 24 finds from the fire interval 1170–1198 only two were found to the rear of this area, both of them in deposits inside building no. 38. Eleven cords were found on the sea-bed in front of the quays, one of them (no. 18721a) as a mooring cord still connected to one of the posts of the quay and found together with loose Stage I elements of this same type (but with different dimensions) and other mooring cords made from lime bast. It was a three-plied Stage II construction, about 35 mm thick, the same dimension as for the parallel finds of lime bast at the same place.

B Raw material

The willow twigs are of the same type as those used in the twig type I cordage. They are thin with a smooth and often shiny yellowish-brown bark (fig 7c), but there is a pronounced measurable difference from type I in the dimensions of the twigs chosen. About half of the finds only have twigs with diameters below 3 mm, and those of the rest are rarely thicker than 5 mm. There was much more variation in type I. Split twigs are seldom found here, and only for making thin twigs even thinner, whereas in type I the splitting was done to make rather thick twigs usable. The only twisted twig found in the whole group was about 5 mm thick, whereas twisted twigs in type I were often more than 10 mm in diameter.

The wrapping strips vary only slightly in width and are now mostly about 5 mm wide. It seems that some of the Stage I elements had been completely covered by the strips. Judging from the gap between the strips in their present state, they could have shrunk about ⅓ in width. In most finds, however, it seems that the wrapping had never completely covered the twigs. The strips look as if they had been intentionally pressed or squeezed flat to form bands, and they are always without bark (fig 7c, 10c). The strips are today up to 2 mm thick along their central line. Their anatomy is very compressed; some of them appear to be the complete half of a twig while some are clearly only a segment. The outer curvature of the split twig always faces outwards. The strips do not appear to be anatomically different from the twigs, but they might be derived from a different species with longer and coarser twigs or shoots than the species used for the core. Schneider (1972, 233) states that it is difficult to split willow twigs into more than two parts, so it is possible that the pliable and thong-like wrapping strips were split after having been boiled, a method sporadically mentioned, for instance from Slovakia (Horváthová 1972, 88–89).

Depending on the diameter, the fine twigs usually have about two growth rings, the thicker ones seldom more than four. The wrapping strips representing a half twig show three to four rings. The cutting season can be seen in the samples taken from the twigs in 41 finds and from the wrapping strips in 34 finds. A cutting time between growing seasons is most common, seen in 22 twigs and 20 strips. Six twigs and three strips were cut very late in the growing season, or possibly after, and of the remaining finds, both twigs and strips, about half were cut early and the rest at some point in the middle of the season.

For 28 of the finds the cutting season can be determined for both twig and wrapping strip. In eight of the finds the seasons are different, but always with one material (twig or wrapping strip) cut between growing seasons. As with the materials used in the withes and the twig cordage of type I, there was no firm tradition for when the material had to be cut, though here too the time between growing seasons was preferred.

C Construction

The twig bundles of the Stage I elements have diameters varying from 3 mm to 27 mm for 45 of the 46 measurable finds, the final one (no. 22565b) having an element diameter of about 40 mm. The find with the thinnest bundles of all, only 3 mm (no. 35255), is the one whose elements are wrapped with lime bast. On the whole the Stage I twig bundles of this cordage class tend to be somewhat thinner than those of the willow twig cordage of type I. More than half of the measurable elements are thinner than 15 mm as opposed to about a quarter of the other type. On the other hand, the normal upper limit for the diameter of the bundle, excluding the few with diameters around 40 mm, seems to be the same for both types, somewhere around 25 mm. As mentioned above, the Stage I elements are always S-twisted.

The degree of twist of the Stage I elements is rather slack. For 37 of 38 measurable finds the twist of the twig bundle varies from nearly 0 to 15 degrees, with a twist around 10 degrees for 24 of them. The final one is the one with exceptionally thin twig bundles wrapped with lime bast. This is not well-preserved, but seems to have had a twist angle of 20 degrees. The connection between the amount of twist and the diameter of the twig bundle can be seen for all these finds. There is a slight suggestion that the two features are mutually interdependent, in that the eight finds with a twist angle below 8 degrees are all thicker than 11 mm, and four of the five finds with a twist angle above 12 degrees are thinner than 11 mm. The diameter of the elements with the medium twist of around 10 degrees varies over the whole diameter scale.

The elements of the willow cordage of type I had generally a much more pronounced twist, mostly 20 degrees or more, which gave the element an elastic tension important for the future construction. But here such a tension must be practically absent, also because the extra fine twig material in itself is more pliant than the coarser material used in type I. In the cordage type discussed here the fine twigs can often be seen bundled tightly and smoothly together, lying nearly fibre-like within the wrapping, apparently with no resistance to bundling (fig 7c).

The wrapping of the Stage I elements gives, when it is still intact, an outward appearance of tidiness to this type of cordage as compared to the twig cordage of type I. But the wrapping strips were clearly worn away quite easily, so that there are only traces left on many of the finds, protected in between the elements. Because of this, and the insufficient twist of the twig bundles, most of the finds are now loose in their composition and many are in a bad condition.

As mentioned above, the wrapping is always done in the S-direction and with a more pronounced helix angle than the twig core (fig 7c), varying from 25 to 60 degrees for 42 measurable finds, most of them with angles from 30 to 45 degrees. From two to four, but normally three, strips were laid parallel for the wrapping, the ends being placed alongside the core and covered by new strips. The flat (split) side of the wrapping strip faces the core. It is often impossible to see whether a gap had been left between the strips on purpose or whether an interjacent strip is lacking. Since the width of the strips is fairly even, also from one find to the next, the helix angle of the wrapping depends, on the one hand, on the number of strips, and, on the other, on the diameter of the core bundle. For 28 of the finds this dependence can be shecked. Fifteen of the 18 finds with a wrapping angle above 40 degrees have a diameter greater than 10 mm, while seven of the 10 finds with a wrapping angle below 40 degrees have diameters of less than 10 mm. Whether the number of wrapping strips varies with the bundle diameter and this trait eventually also influences the wrapping angle cannot be established for this material.

The complete construction can be studied for only 35 of the 52 finds. Twenty-nine were completed as Stage II cordage, all plied in the Z- direction. Only four of them are two-plied, including the tiny cord with components wrapped with lime bast and the one made from especially thick components (no. 22565b). Another of the two-plied finds (no. 55612) is bent double in a way that makes it appear possible that it was

intended as a two-ply Stage III construction. Twenty-three of the Stage II cordage finds are three-plied and two are four-plied.

Six finds are Stage III constructions, with the third stage plied in the S-direction from Z-plied Stage II components. Three of these are three-plied from three-plied components, one is four-plied from three-plied components, and two are four-plied from two-plied components.

The construction of the cordage in this class is somewhat variable, as we have seen, yet with a preference for the Stage II three-plied type. In type I the Stage II two-plied variant is the most common type, moreover only two-plied components were used for Stage III constructions in that cordage class.

The diameter of the complete cordage structures varies throughout the class, from 7 mm to about 100 mm. Twenty-seven of the 29 measurable Stage II cords have diameters from 10 mm to 45 mm, fairly evenly distributed between these limits. The other two are the two-plied extremes, the lime-bast-wrapped one with a diameter of only 7 mm and the one made from especially thick components, with a diameter of about 60 mm. The six Stage III cordage finds have diameters from 60 mm to 100 mm, based on Stage II elements varying from 20 mm to 45 mm in diameter. The Stage III construction is thus always used for making extra thick cordage. The only exception would be the possibly two-plied Stage III construction no. 55612 mentioned above, which would, if the interpretation is right, have a diameter of only about 22 mm.

The two- and three-plied cordage of Stage II as well as Stage III types have diameters rather close to what might be expected from the diameters of the lower stage elements, see fig 11. For Stage I elements this means the diameter of the core plus wrapping. The two Stage II and the three Stage III finds which are four-plied have diameters varying from 2.5 to 3.5 times the diameter of the lower stage elements, the normal apparently being less than 3 times. It has not been possible to find any preference for certain diameters for any of the forms.

The angle of twist of the Stage II cordage varies from 20 to 45 degrees, around 30 degrees being most common. The angle is thus for some inexplicable reason much more pronounced than for the respective Stage I elements. There seems to be no connection between the amount of twist of the complete structure and its diameter for any of the forms.

The Stage II elements used for the Stage III constructions also have a strong twist, varying from 20 to 45 degrees, and this may be expected to be of importance for the Stage III structure. Only four of the finds can be measured reliably, and they include three different forms. Yet the angle of the Stage II element is very similar to that of the complete structure, for which it varies between 33 and 45 degrees.

Nothing in the construction can give any direct information about the handling of the material during the making of the actual cordage. The Stage I elements must have been made separately, otherwise the wrapping with many strips would be too complicated. The composition of one single Stage I element points to work for more than two hands even at this stage. With regard to the twist of the bundles of twigs, it is reasonable to assume that it must have been applied to at least a part of the bundle before this part was wrapped. It may, of course, have been stronger at the start, possibly untwisting somewhat inside the wrapping when the firm grasp of the hands on the actual twig bundle was released during the wrapping process.

D Comparative finds and traditions

Cordage of this type does not seem to have been described in connection with other archaeological excavations, nor in later traditions, as far as the author knows. A note in Hanssen & Lundestad (1932, 374), referred to under twig cordage type I, may possibly point to this type. Otherwise this lack of information is probably due more to the sparseness of literature concerning cordage or to the lack of relevant waterfront excavations rather than to the fact that this type was restricted to medieval Bergen.

The idea of wrapping bundled core material with smoother, stronger or neater strips or fibres is otherwise known from other products, though not necessarily for the same reasons. Some of these products are mentioned here for comparison. The closest example is some of the bast cordage also from Bryggen, where the Stage I elements are spun with a particularly wide and smooth bast strip following in a tight spiral around the outside of the bast bundle. But according to the practice followed in more recent times with the same result, this wrapping was accomplished simply by a slight variation in the usual handling of the material during the spinning process (Hanssen & Lundestad 1932, 394), and the wrapping strip has nearly the same, though usually slightly greater, helix angle than the core material. Only one strip at a time was used for the purpose. This wrapping technique is thus clearly quite different from the necessarily more laborious one used for the twig cordage of this class. But the idea of wrapping the individual Stage I elements can be an influence from the bast spinning procedure. Or perhaps the influence went in the opposite direction or even has a different origin.

For lack of better examples it is tempting to compare the wrapping technique with the production of coiled basketry (Merriam-Webster 1958), known from many places all over the world, and in Scandinavia at least from the Early Iron Age onwards (Biørnstad 1964, Stigum 1964). The core bundle of more or less fibrous but never really soft material is here called foundation or warp, and the spiral wrapping material is called weft (Winick 1977, 124). The core is never twisted and normally only one weft strip is used at a time. Some or all the wrapping turns do also take the form of stitches going around or through the preceding coil of the basket. The construction of the core element and the wrapping and stitching with the weft are done simultaneously in one combined working operation. North American Indians (among many others) are known to have made this type of basketry, using as a foundation bundles of split willow twigs or else a few or even single whole willow twigs, then called three, two or single rod foundations (Schneider 1972, 288). These were wrapped with the split halves of willow twigs, with the split side facing the core in the same manner as for our cordage. In Scandinavia birch roots have mostly been used for this type of basketry (Biørnstad 1964, Stigum 1964), but a fragmentary find of coiled basketry from Bryggen (no. 39319, fig 10d) shows that willow was used for such products also here. The foundation core of this find is a single 3 to 5 mm thick quarter-split willow twig. Some kind of hardwood sliced lengthwise is used as the wrapping material. This material has decomposed somewhat but resembles alder *(Alnus)* more than other Nordic hardwoods. Apart from the common feature of the composition of the elements, the look of such baskets produces an immediate association with our twig cordage. There may perhaps have been a hybridization between the ideas behind coarse coiled basketry and the bast cordage with wrapped elements at some time and in some area where the demand for cordage was much greater than the availability of good native raw material. If so, our cordage may be a relatively late and local invention for satisfying the demands of a busy place like Bryggen. Only more excavated cordage material from other places and other periods can give the answer.

4 Heather cordage

A Finding circumstances

The heather cordage (n = 5) is relatively easy to recognize among the other cordage finds. It is made from strikingly thin wooden stems (fig 13b), all with dry brownish

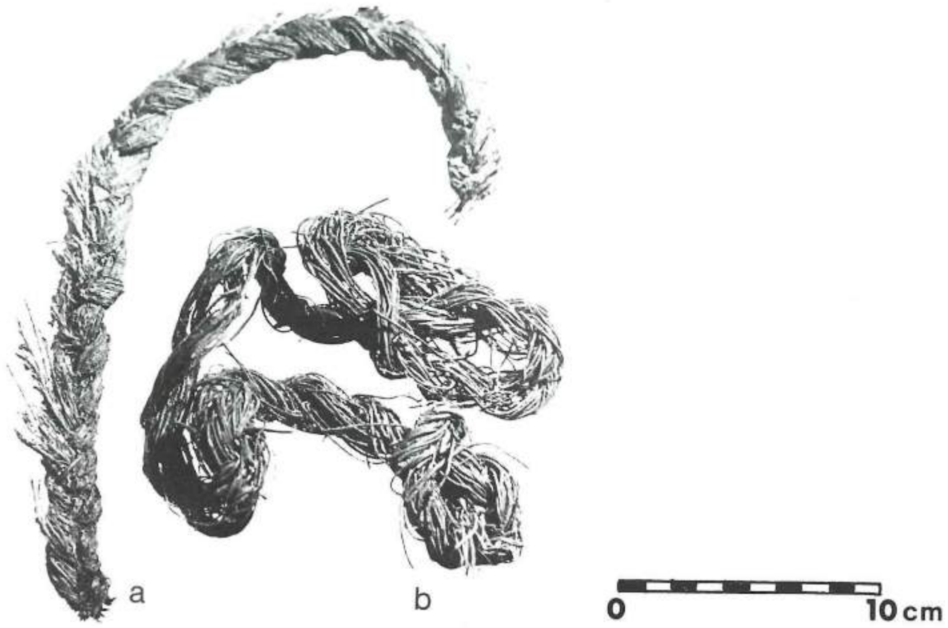


Fig 13 a. Moss cord (three-plaited, no. 55829). b. Heather cord (two-plied, no. 28714).

bark still attached. They were found in back-fill deposits in various parts of the site. One of them is still undated. Of the dated ones three were found in the fire interval 1248–1332 and one in the interval 1332–1413.

B Raw material

The raw material consists of long thin stems of ling or heather *(Calluna vulgaris)*. The wood is still rather tough and only insignificantly shrunk, so that the anatomy is easily studied. The diameter of the stems varies, in their present state, from 0.5 to 3 mm, with the majority between 1 and 2 mm. Thus only the finest shoots were used in the manufacture of the cordage. The stems of nos 4130a, "28714" and 29248 have clean sharp-cut ends showing that they were harvested with the aid of an edge tool. Along the west coast of Norway fine heather has been harvested for animal fodder with a scythe up to our own day (Høeg 1976a, 258–59). This was mostly done in the autumn, but also at other times when necessary. In find no. 40330 some of the stems have cut ends, the rest have not. In find no. 40188 no cut ends can be seen and they look as if they had been torn off. Thus different practices seem to have been followed for the harvesting. In later times coarse heather was torn off by hand when collected for fuel (Høeg 1976a, 257), but then the roots usually followed except in very cold weather (pers inf), but here there are no roots.

The samples for microscopic analysis show that the stems were up to five years old when cut, but usually younger. There was no fixed harvesting season for this raw material. The stems from two finds were taken early in the growing season, while those of the other three finds were taken late in or after the growing season. No connection between the different harvesting methods and the harvesting season can be seen.

C Construction
The five finds are very alike. The form is the same, namely a loose Stage II structure, two-plied in the Z-direction (fig 13b), with helix angles varying from 20 to 30 degrees, with the average possibly around 25 degrees. The Stage I elements are S-twisted where the twist is discernible, with a helix angle varying from 0 to 10 degrees, even within the same piece of cordage. The diameter of the constituent parts varies from 9 to 13 mm among the different finds, giving the completed Stage II cordage diameters from 13 to 20 mm respectively.

Overhand knots, now relatively open, which appear fairly regularly at the ends of the cordage (fig 13b) seem to have been made to prevent the loose ends from unravelling. This is the only cordage type in which such knots seem to have been necessary. No. 28714 (fig 13b) and no. 29248 have a knot at each end. The cords are about 30 and 37 cm long respectively between the knots, which shows that even such short pieces were taken care of for further use. No. 4130a has a knot at one end, while at the other it is tied with a knot (now loosely) to another piece of the same type of cordage, but without a knot at the far end. These two pieces together are 65 cm long, the extra length involved in the knots being disregarded. No. 40188, 26 cm long, has a knot at one end only and the 30 cm long piece no. 40330 has no knots.

D Comparative finds and traditions
Exactly the same type of cordage is known in northern Britain at least from 2500–2000 BC, occurring at Skara Brae in Orkney (Clarke 1976, 25), where it was found in two distinct thicknesses, yet both rather thin. However, there are "suggestions that thinner ropes may have been wound together to provide increased size" (op cit). A published photograph of one of the cords looks like one of our pieces, though it is somewhat thinner. From the photograph it can further be seen that the plying has about the same angle as on our finds, and the elements seem to be almost without any twist, also more or less like our finds.

This type of cordage cannot be traced in Norwegian tradition, but bundles of heather stems tied together have been used as pot-scrubbers and brushes and brooms in different parts of Norway right up to the present century (Høeg 1976a, 258). In the northern parts of the British Isles (Shetland, Orkney, Caithness and the Scottish Highland areas) heather cordage has been in use to our own day, mainly for roping thatch on the roofs of houses (Fenton 1961, 208), but on the Isle of Man also for mooring boats (Sayce 1939, 163). The term used for it in the former three areas corresponds to the old Norse term *"sima"*, meaning cord (Fenton 1961, 207, Fritzner 1886–96). This term seems in later times in Norway to have been used mostly for cordage and caulking cords made from hair (Aasen 1918, Nordland 1961, 126).

In the north British areas the material was picked when the young heather had finished growing. Fenton (1961, 207) describes how the cords were made, and our finds could very well be products of the same process. Making the two Stage I elements and plying them together was one combined operation. The material was held in the left hand and two bundles of stems formed by the right hand. One of the bundles was given a twist as it was turned under the other bundle, and so on. This technique can give the slight twist varying from 0 to 10 degrees found in the elements of our specimens. By gradually overlapping with fresh material, the piece of cordage could be made up to such a length that it was necessary to twist it around the body while continuing the work. Nothing is said about whether the material was used fresh, or moistened, or if this did not matter.

5 Hair moss cordage

Cordage made from hair moss *(Polytrichum commune)* (n=4) is different from most of the other cordage from Bryggen in that it is plaited instead of being plied (fig 13a). The only parallels found at Bryggen are a few plaited cords made from goat hair (Schjølberg 1984, 78). In addition a lot of loose tufts of hair moss were found. These tufts were usually more or less coiled and may have been raw material, or perhaps they had been used in this state for some unknown purpose. There is also one find of loosely plaited moss bundles (no. 80928), which are from 15 to 20 mm in diameter. The plait is about 35 mm thick near the top end of the moss stems but thinner further down. This plait can have been made to keep the moss stems tidy for later use, as a sort of dolly.

A Finding circumstances
The circumstances in which they were found show that the hair moss and its products were occasionally used at Bryggen from before the fire of 1170 and at least up to the fire of 1413.

B Raw material
The raw material used for this cordage was the longest available stems of hair moss with their leaves still attached at the top. *Polytrichum* is the most highly developed of all mosses and the stem is strong and characteristic. In the dolly find the length of the stems is easily measured: they are about 40 cm long. This is unusually long, as they rarely grow to more than 30 cm (Størmer 1945, 86). The setae or sporecase-stalks are never present. The stems are well under 1 mm in diameter and can be as thin as 0.25 mm. In their present state they are dark brown. The identification of the moss is easy from its general appearance and because the leaves still have some grooved marginal cells left along the lamellae on the underside (Lye 1968, 67).

C Construction
The four cords were all made by simply plaiting together three untwisted Stage I components, though they vary in thickness and firmness. Like other such braids they are somewhat flat rather than round. The Stage I elements are also flattish because they were flattened out on the surface of the structure during the plaiting process. This flattening of the components varies with the position in the turns of the braid and also with the relation between its width and thickness. The easiest measurement of the element for further comparisons is its width on the wide side of the plait.

Only the cord no. 55829 (fig 13a) is tight and made well enough to give reliable measurements for the different parts. The other three are much looser in their structure and seem to have been so also originally. No. 55829 was found partly in pieces as a bundle (not coiled) and its total length can be estimated at about 220 cm. It may have been a really strong cord, even though it is not specially thick. It is about 27 mm wide and 15 mm thick. Its elements vary in width from 10 to 15 mm on the flat side of the braid, and they are up to 8 mm thick. Their angle to the lengthwise direction of the structure on the wide side is about 45 degrees. The remaining three (nos 10311, 23494 and "80491") are 65 mm, 23 mm and about 36 mm wide respectively and 40 mm, 13 mm and about 19 mm thick. The helix angle is close to 35 degrees for them all. The Stage I elements in these three finds are about 25 mm, 10 mm, and 17 mm broad, and 17 mm, 8 mm, and 9 mm thick respectively. No. 10311 is 60 cm long, no. 23494 was found in four pieces, giving a total length of about 365 cm. No. "80491" was found bundled like no. 55829 and broken into many pieces, the longest of which is 45 cm, together at least 100 cm. None of these three can have been planned for a purpose which required strong tension or friction, whereas no. 55829 could have taken both.

There is another very striking trait in the construction of the four cords. The small tufts of material protruding along the cord, which mark where more moss stalks were added as the cord was lengthened, show that new material was not added here and there when needed, but systematically along each Stage I element in the plait at a certain turn of the element during the plaiting process (fig 13a). This clearly shows that the lengthening of the elements and the plaiting were simultaneously processes. It also shows that the stems were added to the elements with their root ends in the direction of the unfinished plait, while the apparently undesirable top ends, tightly set with small leaves, were left outside the braid. These protruding tufts are now partly broken off, but enough is left of them in all the four cords to show that they were not originally trimmed off. They protrude obliquely in a row along one of the wide sides of the cords, giving this edge a rather shaggy appearance (fig 13a). Even if it was not for some functional reason that the tufts were left attached, they do not at any rate appear to have interfered with the use of the cords, even for the well-made no. 55829.

D Comparative finds and traditions

No cordage like this was found at Haithabu, though Körber-Grohne (1977, 67) mentions hair moss as a likely material for making brushes. But parallel finds are reported from the thirteenth and fourteenth century layers of the waterfront site at Bristol, excavated as part of the Redcliffe Project. "Perhaps the most interesting material is the plaited moss (Polytrichum) rope which appears to have been used for caulking boats" (Ponsford 1983, 14). In the plaited cords from Bryggen it is clearly the tough and rather stiff stems of the moss which were preferred. Even those cords which are loose in structure seem much too stiff as caulking material and at least two of them would be too thick with their diameters of 36 and 65 mm. Caulking with softer mosses is otherwise well known, both for boats (Wright & Churchill 1965, 5) and for buildings. In the final paper by Ponsford (1985, 121) about the waterfront site at Bristol the theory concerning the use of the hair moss plaits as caulking material is mentioned only as a reference to the work of Wright & Churchill (1965).

A cord of hair moss was found in connection with caulking in the fragments of the Late Bronze Age boat no. 3 from North Ferriby, England (Wright & Churchill 1965, 5, plate I). From plate I in the Ferriby report we can see that the hair moss cord is a two-plied Stage II construction and thus different from the Bristol and Bryggen finds. The twist angle of the Stage I element seems to vary from about 20 to 35 degrees, which may be a relatively strong twist for this material, and the cord was probably not made by our "heather cordage method". The helix angle of the ply seems to be about 20 degrees. On the whole the cord would not seem to have been a soft structure. From plate VIII in the same paper it is evident that the cord is a little more than 10 mm thick. It does not appear pressed flat like the finds of used caulking cords found at Bryggen, made of wool and hair (Schjølberg 1984, 76). And its function is clearly somewhat different. It has been placed along "the vee of the grooved seam with wads of two different mosses (*Neckera complanata* and *Eurhynchium striata*) rammed in above it". According to the drawing in fig 6 in the paper, the two softer mosses are only rammed into the one side of the V-shaped groove; the other side is empty. The technical significance of the hair moss cord is not discussed by the authors nor does it need to be here, but it is tempting to see the hair moss cord as a sort of elastic filler in the groove, rather than just padding, at the same time acting as a stopper preventing the softer moss from entering the empty side of the groove. No such cord was found in connection with the caulking with the softer mosses in the two other Ferriby boats.

From Grue in the south-eastern part of Norway there is a tradition about the use of hair moss for caulking boats in the past, but no description exists of how it was used (Høeg 1976a, 164). Some of the people in this area originally came from Finland and perhaps an answer to these questions can be found in the eastern Baltic areas.

P Walton and A Hall have very kindly supplied information about cords similar to the type from Bryggen which have been found in early medieval layers in York. These finds will be published in P Walton "The Textiles from 16–22 Coppergate" in the series "The Archaeology of York". They also report that the type has recently been found in Germany.

A perfect parallel to our dolly is known from Lochlee Crannog (Ayrshire, Scotland), assigned to the first and second centuries AD. "It is a plait of three, two inches thick and 17 inches long, of *P commune*. The strands at one end are coarse, and the other end fine. This plait might well be a collection of moss waiting to be used in moss-fabric work, plaited to be kept tidy and manageable until used, as in modern practice in rafia-work, for instance" (Henshall 1950, 154).

We have no record about hair moss cordage in Norwegian tradition, but the material was frequently used for brushes and even brooms at different places throughout the country. The material is said to keep its elasticity well. It was even used as filling in mattresses, in which case leaves were first stripped off (Høeg 1976a, 164). A really exciting use of the material is reported from the excavation at Lochlee Crannog mentioned above (Henshall 1950, 154). Here textile-like fragments were found, the moss fabrics, made in the extremely old technique of cross-twisting, a forerunner of weaving, which did not require long lengths of "yarn" either for the warp or for the weft, and practically no equipment. It seems as though hair moss was a multi-purpose raw material in the past.

The shaggy appearance of our cordage is puzzling, at least if it was intended for a specific purpose. A special type of shaggy cord called nippering-sennit (Jensen 1924, 47) was and possibly still is used in sailing vessels for lashing around certain coarse cordage against which the sails are exposed so that they tend to fray, in order to prevent damage. This sennit is constructed in a very different way from our plaitings and is much more slender and pliable, but it may perhaps suggest a somewhat parallel function for the moss cordage.

6 Grass cordage

No. 23346 from the fire interval 1248–1332 is the only find representing this class of cordage. It is a three-plied piece in bad condition, collected as a sample from a disintegrated mass. It is loose in construction and this appears to be the original condition. It is 43 cm long, approximately 8 mm in diameter and has a twist degree of about 30. The elements are uneven, approximately 4 mm in diameter and with a slack twist of about 25 degrees.

It is twisted from grass stalks and blades, now in pieces, so it is not possible to determine either the diameter of the stalks or the widths of the blades of the grass, but it was clearly a relatively coarse material. No internodes are visible. The stomata and the epidermis are both of graminea type. The cells of the epidermis are many times longer than wide and they have markedly undulating long walls. Pairs of short cells are regularly present.

The cord looks like a rather causal construction. Grass cordage has not been regularly used in Norway in recent times.

7 Coir cordage

A Finding circumstances
No. 7211 is the only cord found at Bryggen which is made from an exotic plant raw material (fig 14d). It is a tiny cord made from strikingly fine-fibred material as compared with all the other cordage finds from Bryggen, even though from a modern point of view it is a somewhat coarse fibre. It was found between the fire-layer of 1332 and 1413 in the Bugården area of Bryggen.

B Raw material
Coir consists of the fibres obtained by a retting process from the husk of the coconut. The coconut palm *(Cocos nucifera)* grows only in tropical coastal areas. The fibres in the find are very well preserved and have today a pale yellowish-grey colour. They are round in section, with diameters ranging from less than 0.1 mm up to 0.3 mm and are thinner toward the ends. The different diameters of the fibres seen in the cord may simply be due to the variation between the middle and the end of the fibres.

The anatomy of the fibre is well preserved, consisting of a bundle of vascular tissue surrounded and strengthened by bast cells. The vascular tissue is always partly dissolved, making the fibre hollow. The samples taken for analysis showed an easily identifiable picture of the fibre, and there were still some characteristic longitudinal rows of lens-shaped cilicified cells along the outermost bast cells of the fibre.

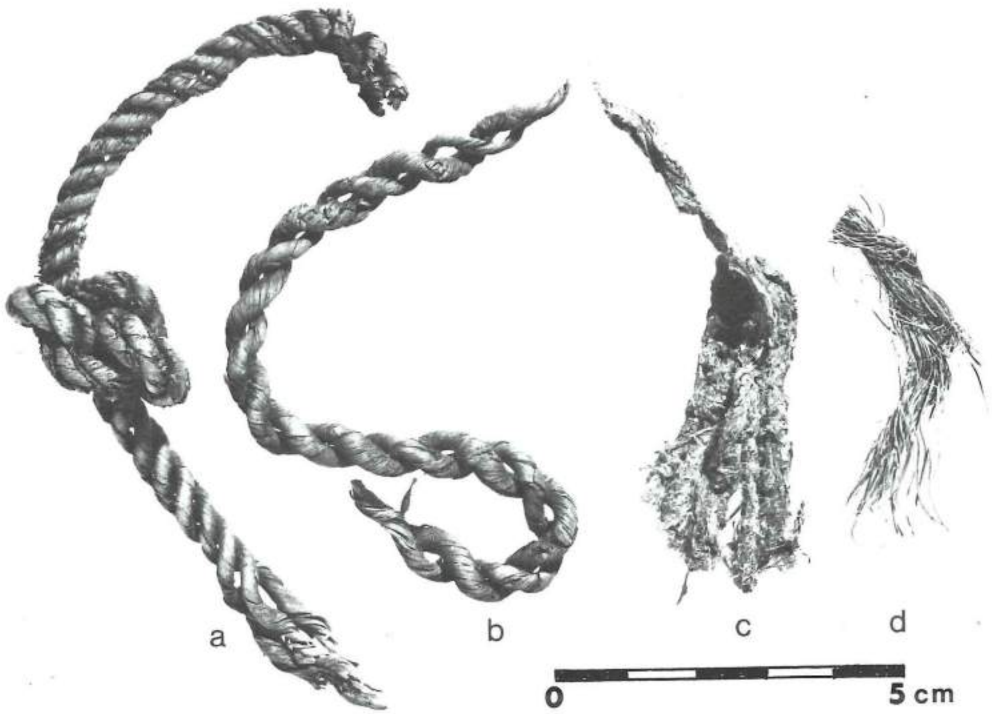


Fig 14 Three-plied pine wood cord (no. 11422). b. Two-plied spruce wood cord (no. 29750). c. Nine-plied asbestos cord (no. 3674). d. Two-plied coir cord (no. 7211).

Wiesner (1927, I, 654–57) states that the diameter of coconut fibres varies between 0.05 and 0.3 mm. Different crop types vary in fibre thickness, depending on the variety, size of the nut and degree of ripening. The fibres of the Bryggen cord seem thus to come from a variety with relatively coarse fibres. The light colour of the fibres (and the cord) might suggest that the material was retted in fresh water during the preparatory process, since this is said to give a light fibre. The saltier the water is, the darker the fibre will be. The original methods of processing the fibre used in the areas where the palms grow vary greatly, depending also on the intended use, so it is not possible to say anything definite about the origin of our find.

C Construction
The piece is a Stage II construction (fig 14d), about 6 mm in diameter, and plied in the S-direction from elements about 4 mm in diameter. These are without any visible twist. The ply angle is about 20 to 25 degrees. Since the find is only a few centimetres long, it is impossible to see whether it may originally have been part of a Stage III construction. If not, it must have been a rather weak cord. It seems unlikely that the Stage I components of this structure were made separately, because more twist would probably have been required to keep the element together. Perhaps it was made in a way more like the "heather cordage method", where the construction of the elements and the plying are done simultaneously.

D Comparative finds and traditions
There seem to be no reported finds of coir fibre cords contemporary with no. 7211 or earlier from comparative sites. There is one find from Oslo, dated some hundred years later, which has been identified by the author. There is no reason to expect that such finds represent a commonly known and used fibre product before relatively recent times. Processing of coconut products for the European market was started by settlers in Ceylon after the year 1740 (Esdorn 1961, 33), but it was not possible to extract it in an economical way before it could be processed mechanically and thus cheaply. It is most reasonable to regard the find as a chance import, for instance as part of the lashing around packages, if in fact the construction of the small piece is complete.

8 Cordage made from shredded wood

A Finding circumstances
Three finds of cordage from Bryggen are made from thin slivers of wood (fig 14a, b). They are well preserved and clearly well made. They are strikingly woody with a pale greyish-brown colour, and the wood appears fresh even today when cut. Two of them were found in deposits from the fire interval 1198–1248, no. 22063 made from pine *(Pinus silvestris)* and no. 29750 (fig 14b) from spruce *(Picea abies)*. No. 11422, which is made from pine (fig 14a), came from deposits dated to the fire interval 1248–1332.

B Raw material
The woody strips are thin and band-like, very much like thin strips of bast. The samples taken for analysis show that the slivers in the various finds were split from the stem in different lengthwise planes. For the spruce find and the pine find no. 22063, they were split more or less parallel to the rays, the radially running stem tissues, whereas for the pine find no. 11422, they were split parallel to the annual growth rings, ie transverse to the rays. The difference, however, is not visible to the eye. The pine sliver of no. 11422 taken for analysis shows only wide-celled spring wood. This find is rather worn and many of the outer strips are missing.

C Construction
The Stage I elements are strikingly round in cross-section. They have yielded little to one another, and in the spruce piece they have not caused the slightest impressions on one another (fig 14b). The elements of the spruce find and of the pine find no. 11422, have a core of uneven material, which was carefully and tightly covered with a fine, wide strip wound spirally edge to edge and sometimes slightly overlapping, in exactly the same way as that which can be seen on many bast cordage elements. Only one coating strip was used at a time. The technique of this spinning process (fig 15b) will be discussed in connection with the reference to more recent traditions. The Stage I elements of the pine find no. 22063 were spun without any special covering strip, but it appears just as even and well made as the others.

The helix angle of the coating strips is slightly greater than that of the core, the difference being hardly measurable. That the strips were guided separately during the spinning process can be seen because they do not follow the inner strips in their turns. The helix angle of the core is rather great, 40 degrees for the spruce find, 42 degrees for the pine find, no. 22063, and 45 degrees for the pine find, no. 11422. When compared with the helix angles of the elements in the classes of cordage made from unprocessed plant parts, this seems to be a very strong twist. This feature shows that although a wooden material, these thin slivers were much more pliable and easy to twist than the whole plant parts.

The coating strips vary from 4 to 8 mm in width on the pine find no. 11422 with an average of 5 mm, and they are slightly wider on the spruce piece, varying up to 10 mm. Their thickness varies from less than 0.3 mm up to 0.5 mm. The core material is, as mentioned above, more uneven, in both thickness and width. On the elements of no. 22063 the better parts of the strips were kept to the outside during spinning.

All three cords are Stage II constructions, the two pine finds three-plied and the spruce find two-plied in the Z-direction (fig 14a, b). The helix angle of the ply is about 28 degrees for the two-plied cord and about 40 degrees for the three-plied ones. The diameters of the cords are about what could be expected from the diameters of the components according to fig 8, with 5 mm for the two-plied one and 6–7 mm for the three-plied ones.

On the pine piece no. 11422, which is now broken into two, there are two knots 11 cm apart. One is a single overhand knot, the other is double, consisting of two simple knots (fig 14a), to make it larger. The length of cord between the knots, as well as the knots themselves, are rather worn, while end pieces beyond the knots are not. There are no signs implying that there had been any special side pressure against the knots, as would have been expected if they had been stopper knots of some sort.

D Comparative finds and traditions
No cordage finds like these have been reported from other archaeological excavations as far as the author knows. But the use of slivers of pine and spruce wood for cordage is known from more recent traditions especially in the eastern and northern districts of Sweden (Modéer 1928, 27–70, Olofsson 1936, 138–42), and from Østerdalen and a few places in Gudbrandsdalen in Eastern Norway (Hanssen 1934, 177–85, Ingstad 1961, 3–45). These are areas where lime does not grow. Even in these districts this cordage had a rather limited application, and lime bast was regarded as superior for most uses (Nilson 1961, 81).

It was important that the slivers were taken from stems with close, straight-grained, resin-free and clean wood from a slowly growing tree. It was especially difficult to find suitable spruce, and when it was found, the product was still considered inferior to pine cordage (Modéer 1928, 33). In Swedish Lappland similar cordage was also made

from pine and spruce root slivers, and these types were considered to be much stronger than those made from stem wood (Olofsson 1936, 135–38), no doubt because root wood is much closer in growth and with more tough tissue components in it. The wood of our finds do not seem to be particularly close and is presumably stem wood.

Wood stems of about 15 to 20 cm in diameter were preferred and only the outer 2.6 to 6 cm wide zone of the stem could be used, ie the elastic, living part of the stem. The wood was either used fresh or the cut pieces were heated to soften them before the slivers were made. The splitting was started by a cut with a knife, and then the rest of the sliver was pulled away by hand. According to Modéer, the slivers used for the coating could be up to 20 mm wide, but in our finds they never exceed 10 mm. Wider slivers were certainly used on thicker elements than those in our finds. The slivers were usually 0.25 to 0.65 mm thick, which is about the same as for our finds. On the Swedish island of Öland in the Baltic, pine wood was split parallel to the radially running rays (Modéer 1928, 40), as in our spruce find and the pine find no. 22063. The manufacturing process is considered to be a late influence on Öland from somewhere else.

In Norway it is reported that it was important to split the slivers parallel to the annual growth rings (Hanssen 1934, 179), as had been done for our pine find no. 11422. Also in northern Sweden the slivers were split parallel to the growth rings (Olofsson 1936, 119). In the latter area some features of the manufacturing process point to a long tradition for making cordage of this type (Granlund 1944, 167). Our finds show that the type of cordage and the two ways of splitting the slivers both go back at least to medieval times. The two directions of splitting also have parallels in the splitting of wood for basket-making (Hodges 1964, 146).

For spinning the Stage I elements a large version of a winch or reel seems to have been used everywhere (fig 15b, c). When fastened to a wall or some other solid support, it left both hands free for handling the material, a necessary requirement when spinning with a wrapping strip. A smaller reel held in the left hand during spinning (fig 15a) does not allow this possibility. The finished length was wound on to the reel. Only on Öland does the four-armed type seem to have been used for wood-strip spinning; elsewhere the two-armed type was used (Nilson 1961, 57). The process was otherwise the same and also the result, except for the fact that one could wind longer lengths of the finished components on to the larger, four-armed reel. When the central shaft of the reel was fastened, for example into a hole in the wall, the frame could rotate freely during the spinning process, helped by the hands. Only relatively thin Stage I elements

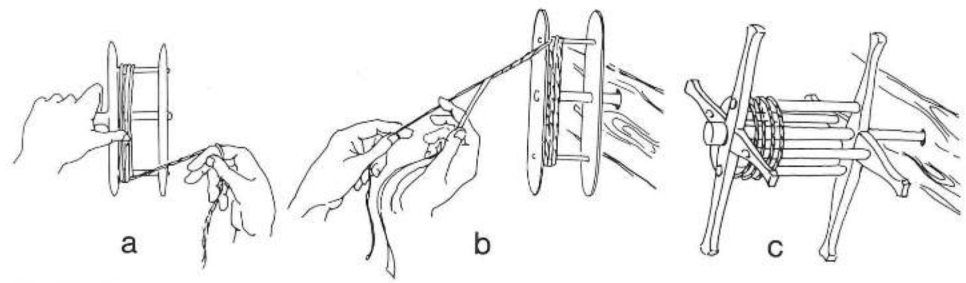


Fig 15 The most commonly used implements for spinning bast and wood strips into Stage I elements. a. The small two-armed reel or winch held in the hand. b. The larger two-armed reel or winch fastened to something solid, leaving both hands free for handling the material, thus making it possible to spin with a wrapping strip. c. The four-armed reel or winch with the same advantages as the larger two-armed one, plus a greater storing capacity. Modified from Modéer (1928).

made from wood strips are said to have been spun on the reel: the usual thickness was about 5.5 to 7 mm, and for thicker cordage 7.5 to 9 mm (Modéer 1928, 56). Our finds thus have unusually thin elements, only 3 mm in diameter.

The details of the spinning and plying procedure are well known (Modéer 1928, Hanssen 1934, Olofsson 1936, Nilson 1961), and only a few main features will be mentioned here. The technique is mostly the same as that used for the manufacture of bast cordage. If the spinning was done with a wrapping strip, as seems to have been the most common method, the core material was held in the left hand and the coating strip in the right hand at an angle of about 40–50 degrees to the lengthwise direction of the core material (fig 15b), so that the coating had this angle when wrapped spirally around the core. This is the same angle as that found on the specimens from Bryggen. We shall later see that this angle varies much more for the elements of the bast cordage made in this way. As the reel turned, the core was twisted and the coating strip wrapped spirally around it at the same time (fig 15b). That the helix angle of the coating sliver is slightly greater than the twist angle of the core of our finds can possibly also be explained by the fact that the strip has to turn around the outside of the core, whereas this is only twisting around its own centre. The wrapping strip therefore has to describe a greater perimeter for the same length of the element and the angle will as a result be somewhat greater. The spinning technique reported from more recent times seems so far to have been used also for the Bryggen finds.

When plying the components for the Stage II constructions, only two Stage I elements were plied together at first, even if the most usual final construction was three-plied. The third element was plied together with the two-plied structure afterwards, being forced in between the other two elements. The result seems always to have been perfectly even, so the method must have been practical. This method of plying could be done by one person and was in more recent times connected with small-scale cordage production, also with bast as the raw material. No Stage III constructions are mentioned in the traditions concerning the cordage made of this type of raw material.

This type of cordage was not used for agricultural purposes, since it could become rather brittle when dry. It was stronger when used in water and was very resistant to rotting (Nilson 1961, 81). Its main use was for fishing tackle (Olofsson 1936, 141), especially for hauling sweeps-nets. For this purpose the cord should have a diameter of about 16 to 18 mm. It had the great advantage that it floated on the water, even longer than modern coir cordage. The type was light in weight and easy to handle. The cords kept themselves straight and therefore did not get into a tangle, nor did they become entangled with the fishing gear. Spruce cordage was said to stretch too much and was not as resistant to friction as that made from pine. In Norway and some parts of Sweden this kind of cordage was also used for tying the timber-booms used during floatage. When not in use, it was kept dry and then moistened before use (Hanssen 1934, 177). Quite a lot of this type of cordage was made for sale, specially on Öland. As late as 1944 such cordage still had a market in Sweden (Granlund 1944, 167).

How far back in time wood-strip cordage can have been made it is difficult to say. That the splitting process has to be started with a sharp knife now seems to be quite a basic necessity, but there are traces of a more primitive way of doing the shredding. Without giving any references Hodges mentions this in his "Artifacts" (1964, 127): "In rarer cases the wood itself might be the source of fibres. Thus pine wood was occasionally soaked in hot water, followed by heating to separate the fibres". This means probably that fibrous parts of tissue were separated and the method must have been something like one used by forest Indians in North America for making thin splints for basketry and possibly also for cordage. They take a log of fresh or moistened hardwood without bark, preferably the Black Ash *(Fraxinuns nigra)*, and pound it vigorously with a

mallet until lengthwise strips parallel to the growth rings can be separated. Usually they loosen single growth layers (Schneider 1972, 251), and in this process the wide-celled spring wood is crushed. Our finds were clearly not made in such a primitive way, since the laboratory sample from a pine strip from no. 11422 shows only spring wood with no signs of crushing.

As we have seen, there are no traditions concerning wood-strip cordage from Western Norway. There is very little spruce in this part of the country and what little there is has become established relatively recently (Fægri 1950, 236–39). It is most reasonable to assume that the three finds have their origin in coniferous forest areas in Eastern Scandinavia and in the traditions connected with them.

9 Bast cordage

The term bast is here used for the fibrous layer on the inside of the bark of trees. Herbaceous bast is not included because it has not been found at Bryggen.

The bast cordage from some tree species is more suitable for use as a raw material than bast from others. Lime trees seem to have been the main source of bast for cordage wherever in the world some species of lime exists.

There are also indications showing that the bast of juniper and other wood was used in various regions, including Scandinavia, but we know relatively little about this. The earliest finds of items made from bast in Northern Europe are some pieces of bast cord nets dating back to the Maglemosian culture, the earliest Mesolithic culture in Northern Europe, "made of plant material such as willow bast or more usually of lime bast once the tree had established itself in the Post-glacial sequence" (Dimbleby 1967, 63). Chronologically closer to the Bryggen material is the large amount of bast cordage which was found at Haithabu. Some of this was made of lime bast, but most of the finds are made of oak bast (Körber-Grohne 1977, 73). Lime was possibly scarce there at that time. Bast cordage has occasionally been found in Norway, but it has not been systematically studied nor the raw material identified. The most famous find is from the ship burial at Oseberg, and this was probably made from lime bast (Høeg 1965). From medieval layers in Oslo there are finds of both lime and juniper bast cordage, which have been identified by the author.

The rich assemblage of bast cordage from Bryggen (n = 455) alone comprises more than half of the total find numbers of all types of cordage from here, and is certainly the most important of them all. The raw material is normally easy to distinguish from the other categories of raw material because it has a strikingly softer and much more pliable structure. Yet the bast material is very variable, firstly because it was taken from two different species of trees, namely lime *(Tilia cordata)* with 83.1% (n = 378) of the bast cordage finds and juniper *(Juniperus communis)*, secondly because of the varying treatment of the raw material before manufacture and finally, to some extent, because of different degrees of wear during use. Included with the bast cordage finds are also some finds of special constructions. These comprise one very short cord with elaborate loop constructions at both ends, three pieces constructed in the form of a cross and four fragments of net constructions.

A Finding circumstances

The bast cordage is well represented throughout the site, but like the other cordage it was mostly found as fragments in the deposits of the reclaimed area of the quays. Quite a number of the fragments of bast cordage were found lying in the silt in front of the old quays, apparently lost at the various artificial sea-bed levels, perhaps during loading and unloading. These finds are not representative of particular forms and it is impossible

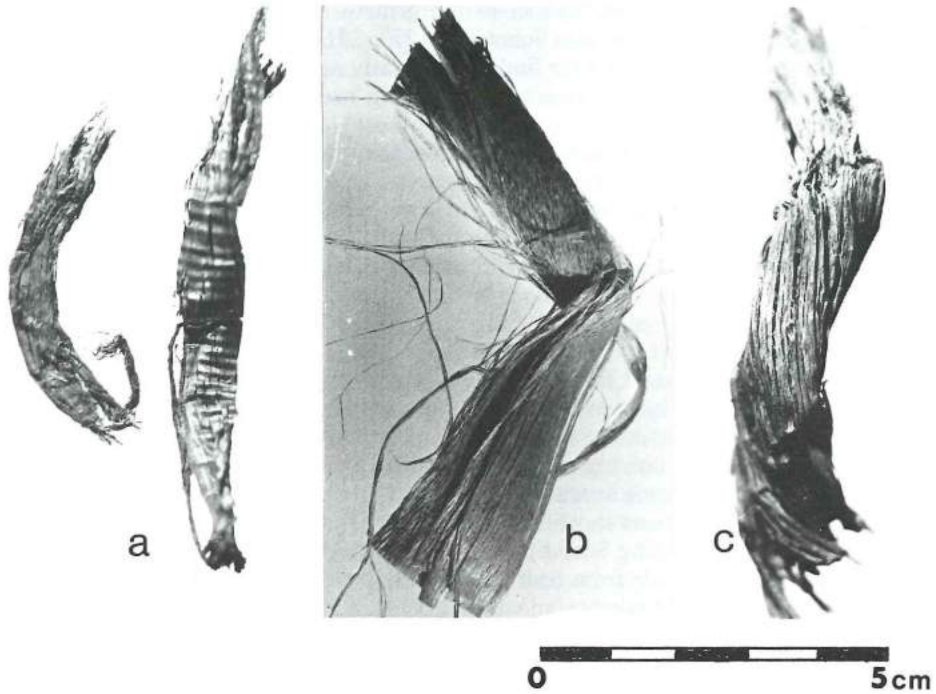


Fig 16 a. Juniper bast (from cord no. 14202) showing strips with and without transverse undulations. b. Recent example of retted lime bast showing the finely structured inner layers (below) and the coarsely structured outer layers (above). c. Lime bast (from cord no. 55038) showing a thick, unretted strip spun as a whole with unseparated bast layers.

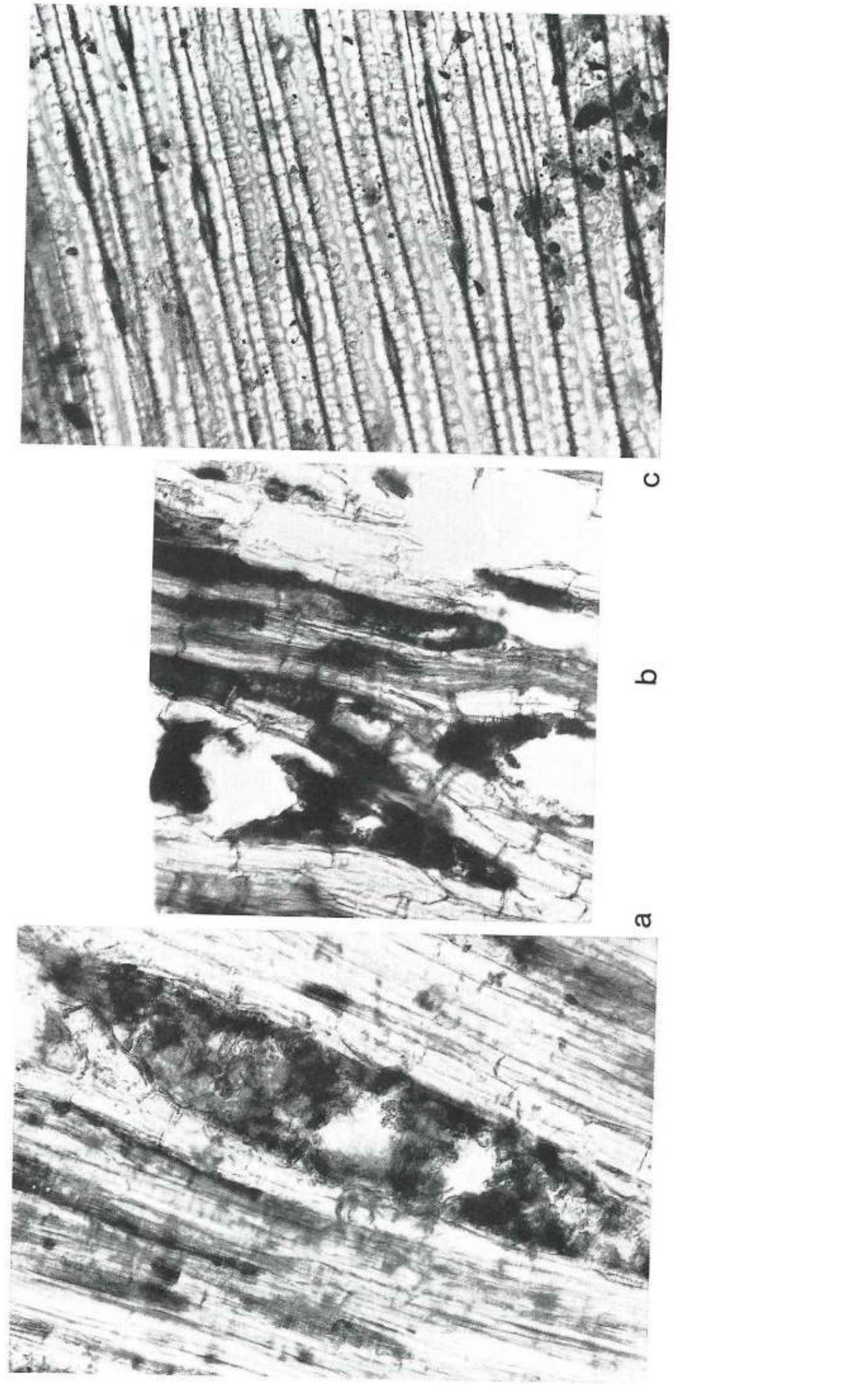
to connect them with specific functions. The only finds in the whole assemblage which give any indication about their function are a row of mooring cords found in front of the quay constructions from 1170, still attached to the front posts of the quay (fig 1b). These cords are Stage II and III three-plied structures with diameters from 25 to 50 mm. As mentioned above, one of these mooring cords was a twig cord of type II with a diameter of 30 mm.

From fig 5 we can see that bast cordage maintained its dominant position in the Bryggen context throughout the whole period, at least when compared to withes and twig cordage. This popular raw material was undoubtedly used as much as possible, as far as it was available.

B Raw material

The two types of bast are usually quite different in their general outward appearance (fig 16a, b). Lime bast is usually pale brown or a dark yellowish grey, whereas juniper bast often has a strikingly warm, deep brown colour. In addition lime bast is rather dull with a paper-like appearance, while juniper bast often has a silky sheen and

Fig 17 Microphotographs (ca 500 ×). a. Lime bast (from cord no. 10038). b. Lime bast (from cord no. 55521), with slightly blackened tissue details, probably due to original processing over an open fire. c. Juniper bast (from cord no. 10371a).



extremely thin bast layers with groups of tiny undulations here and there across the band of fibres. On lime bast the rays are often very distinct, whereas they are invisible on juniper bast, except under the microscope (fig 17a, b).

All the finds have been studied microscopically. The identification was based first and foremost on a comparison with a collection of recent bast, and also on the works of Holtheide (1951), Körber-Grohne (1977) and Wiesner (vol II, 1928). The best identification criteria for the juniper bast are the lack of bast parenchyma and the characteristic building of the fibre cell walls, with the fibres arranged perfectly parallel in the band (fig 17a). For lime bast the major characteristics are the form of the rays and the ray parenchyma cells, but first and foremost the size and form of the cells and the cell-walls in the bast parenchyma (which is always present in lime bast), together with the diameter of the fibres when visible and with its general appearance (fig 17b, c).

Bast grows successively in thin layers, more or less separated by softer tissues, between the wood and the bark, so that the most recent part of the bast layer with the smoothest structure lies nearest to the wood and the oldest and coarsest part nearest to the corky, dead bark. It grows to a thickness of several millimetres. Bast from young trees or branches or from slowly growing small trees is preferred, because this is finer and closer in structure and also tougher, and therefore more resistant to friction, as well as being more pliable, than the older, coarser, darker and more woody bast from older trees. For the same reason the younger, innermost part of a bast layer is preferred to the outermost layer (fig 16b). Juniper bast is finely structured through all the layers.

The bast has to be separated from the other tissues and split lengthwise into bands up to a few centimetres wide, which are then usually thinned down, sometimes to paper-thin strips. Different processes were used for separating the bast producing different qualities as a result. The easiest and simplest way is to separate the bast layer in early summer when it is full of sap and therefore easily removable. We have only one account about how juniper bast was traditionally obtained: it was assumed that it was taken fresh in early summer and used at once (Høeg 1976a, 398). Körber-Grohne (1977, 85), who experimented practically with many bast types, found juniper bast very difficult to remove at the beginning of May, but for some reason this may possibly have been too early that particular year.

About the lime bast we know that it was obtained in different ways, ranging from simply stripping a piece of bark from a smooth part of the tree trunk at the right time, to a systematic cultivation of lime trees over several years in order to be able to obtain repeatedly as much good bast as possible from each tree in the future.

If the bast was to be taken in early summer, the right time was said to be when the leaves had just grown to full size (Molaug 1936–37, 67). This time varies somewhat according to the area, but it normally happens a few weeks before midsummer. In unfavourable years it can occur quite late in summer.

The bark had first to be stripped from the wood. This could sometimes be done when the tree was still standing on its roots, at least if the bark from an old tree was to be harvested. The tree could revive even if one half side of the trunk was harvested, but usually young trees or branches were cut down and the bark then peeled off. A lime tree can tolerate drastic cutting, and for cultivation young trees would be cut down to about a man's height, after which they would grow long straight branches from the cutting point: these could then be cut when they had grown to about the thickness of an arm. Such trees can still be seen in many places in Norway. Whether this practice was already followed in medieval times we do not know.

At the same time it was also easy to separate the bast from the bark, to shred the bast into thin layers, and then to spin the Stage I elements and ply them together into

a cord at once. Freshly worked bast gave a hard, strong cord, pale yellowish in colour. However, it was usually difficult to fit the whole process in with all the other tasks at this busy time of the year. As the whole operation had to be done at once, production would necessary be limited.

Alternatively, the bark could be placed in water for a retting process which made the separating and thinning of the bast very easy later on. The bast tissue itself was partly delignified by this process and thereby softened, or in reality weakened, "until it was soft as hemp" (Hanssen & Lundestad 1932, 379). If this process was started at once, the warm summer water could do the job quickly, the process taking from a few weeks to some months depending on the summer weather.

It was important that the retting process should not go too far, because then the bast would be too weak. If fresh water was used, it should be running, but otherwise salt water was regarded (at least along the coast) as giving a better result. The bark was bundled and weighted down in a pit on the beach below the water-line, where the waves could wash over it. The retting process turns the bast yellowish-brown. The resulting quality would vary with the temperature and salinity of the water, with the thickness and coarseness of the bast, and with the ability to control the process. It would also vary with the time of the year, because it was just as common to do the retting during other seasons. Sometimes the bast was softened further by beating and rubbing.

The pieces of bark could also be dried and retted later. Sometimes even the peeling of the bark had to be dispensed with in the summer. For the farmers it was most convenient to cut the branches when they had time for such work and then soak whole bundles of brances for retting. It seems to have been usual to cut the branches early in spring and soak them, the process then being so slow that it was easier to avoid over-retting. However, the result would be more uneven. The branches could be kept in the water until late in autumn. They could even be cut in autumn and then soaked, and then the retting could take up to a year. When we consider that even this is not an exhaustive list of the various methods that could be used, it becomes quite clear that we could never expect to determine which particular processing method was used to produce the various qualities present among the Bryggen finds.

In some areas stronger unretted bast was preferred, but it was still desirable to soften it somewhat. One method used was later traditionally known only in Nordfjord in Western Norway, near the northern limit of the lime area (Hanssen & Lundestad 1932, 395), and from Scania in south-western Sweden (Granlund 1943, 169). In Nordfjord the branches were cut late in autumn and immediately placed on a framework over the fire in an old-fashioned chimneyless stove (Norw *røykovn*). In Scania a special bast-stove is mentioned, but they also used the bread-oven. This treatment of the branches took about 24 hours, and it was then easy to separate the bast and thin it. The thinning and the spinning processes had then to be done at once and there was no soaking. The method gave a bast of a yellow colour, rather hard to handle, but the result was a very strong cordage. The method has been described by J A Krogh, a priest living in Nordfjord in the last part of the eighteenth century (Hanssen & Lundestad 1932, 395). He also mentions that some of this cordage was sold in Bergen. Later traditions do only vaguely mention the method, which is assumed to have disappeared together with the old chimneyless stove. Heating of fresh woody materials in order to soften them has otherwise been used for many different purposes and is also known for the production of the wood-strip cordage described above.

In the finds from Bryggen it is possible to find good examples of the three main ways of treating the bast. A few finds are remarkably woody, being made from thin strips of fine and closely structured inner bast from lime, still pale yellowish in colour. The

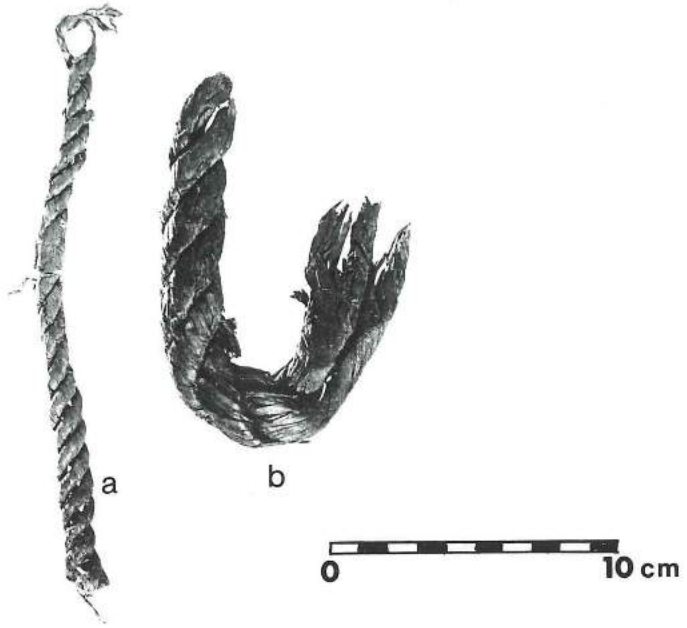


Fig 18 a. Lime bast cord made from unprocessed, rather woody bast (no. 6250). b. Lime bast cord made from well-retted and softly spun bast (no. 22984). Note the even outer surface.

bast does not show signs of any treatment, and these cords must be examples of the early summer production, when all the different stages in the manufacture were carried out at once before the fresh bast dried out (fig 18a). Next we have at least 30 lime bast finds of an often easily recognizable type of cordage made from a medium woody bast, with an occasional touch of a deep yellow colour. They usually also have a special, rather spicy smell, which was not noticed for any of the other types of cordage. The cords made from this bast are rather coarse, and the bast strips were not usually thinned down before use, as the whole thick bast layer is spun together (fig 16c). These cords most probably represent the late autumn cordage production from bast which was baked over an open fire. Is it possible that the smell after all these years can be attributed to the smoke? Some of the anatomical details in these finds, in particular the ray parenchyma cells, have a more blackish colour instead of the normal brown and even the walls of the bast parenchyma cells are sometimes blackened, so that the cell form appears clearer (fig 17c), again a feature which may be attributed to the smoke from the heating process. The type was found in layers from before the fire-layer of 1170 and up to the fire of 1413.

Most of the finds are made from retted bast, but in some cases it seems to have been insufficiently retted and is therefore slightly woody, while in other cases it would appear to have been over-retted, with extremely thin layers and a somewhat greyish colour. Most of the bast is of good quality. On the whole the bast of the finds from the deepest layers seems more often to be of a softer and more finely shredded bast than the material from more recent layers, even though, as mentioned above, we also find the coarse products of the heating method in the deep layers.

C Construction

Bast cordage has been produced in Scandinavia so recently that every detail in the technique of the construction has been studied, described, drawn and photographed (eg Granlund 1943, Hanssen & Lundestad 1932, Høeg 1976a, Modéer 1928, Nilsson 1927, Olofsson 1936). These works are fundamental to the understanding of the constructional details of the bast cordage found at Bryggen.

a The Stage I element constructions

The Stage I elements of the finds are usually evenly spun, with small variations in diameter along the individual element, which shows that the bast material must have been relatively easy to control during spinning. The spinning technique described in later traditions, as well as the implements used, are the same as those described above for the wood-strip cordage and seem to have been used also during medieval times (Nilson 1961, 74). As with the wood-strip spinning, the element was made either with a wrapping strip or without. The degree of spinning varied according to the desired quality of the cord.

The diameter of the Stage I elements can be measured on most of the finds. Measurements of the outer diameter have been taken to the nearest half mm, regardless of whether there was a wrapping strip or not, because the very thin wrapping strips seldom increase the diameter by as much as 1 mm. On fig 19 the variation in the diameters of the elements and the frequency of the different diameters are shown separately for the measurable specimens of lime bast cordage (n = 304) and juniper bast cordage (n = 62). The finds of single elements are also taken into account here, but not those whose helix angle cannot be measured as a result of the poor condition of the find. It appears from the diagram that the variation in diameter is much greater for the lime bast cordage (1.5–35 mm) than for the juniper bast cordage (2–15 mm). The diagram also shows a slight difference between the two bast categories in respect of the two most frequent element diameters. For lime bast this is about 5 mm, representing 25.7% (n = 78) of the finds, and about 7 mm for 35.5% (n = 22) of the juniper bast finds. When setting up separate diagrams for the different fire intervals (not shown here), this preference

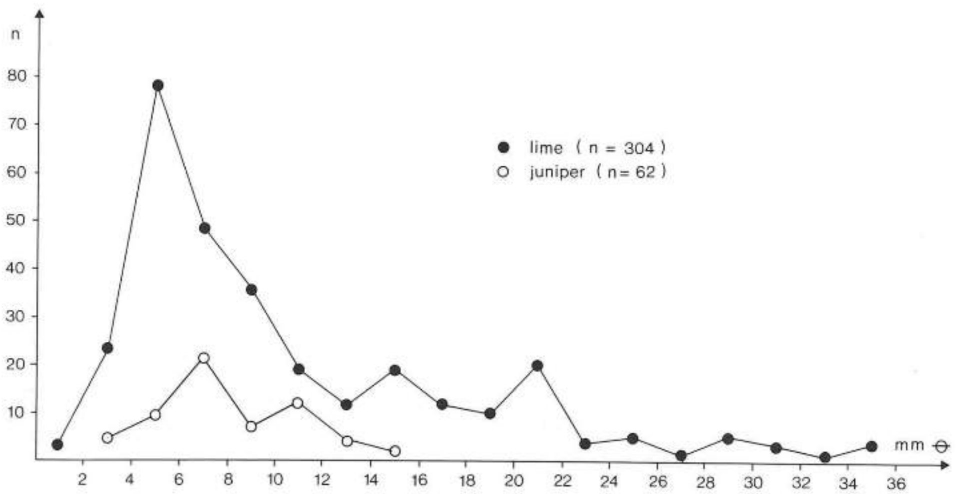


Fig 19 Distribution by diameter of Stage I elements of lime and juniper bast cordage with measurable helix angles.

emerges as a long-standing tradition. On the other hand, the other diameters which are accentuated in the diagram fig 19 more or less disappear in the separate diagrams, and it was therefore not possible to establish any other dominant traditional diameter for the elements. The mean diameter of the elements is 10 mm for the lime bast finds and 7.5 mm for the juniper bast finds. 8.6% (n=26) of the lime bast elements and 22.6% (n=14) of the juniper bast elements have diameters smaller than their respective most frequent diameter, while 65.8% (n=200) of the lime bast elements and 41.9% (n=26) of the juniper bast elements have diameters greater than their respective most frequent diameter. There is no variation worth mentioning in these values as regards the finds from the different fire intervals, and this emphasizes that there are no recordable changes in the traditions in respect of variation in the diameters of the elements over the course of time. However, the different types of bast cordage do show slightly different results in these respects.

The group of lime bast cordage which is assumed to have been manufactured by the heating process was, as mentioned above, found to have elements with greater dimensions, at least those spun from thick, unshredded bast strips, and these account for the majority. In the three lime bast finds made of woody bast, the elements have diameters from 5 to 6 mm. Some cords, which seem to have been treated with a resin-like coating (about 50 finds), mostly have element diameters from 2 to 10 mm, and only three of them have diameters from 10 to 15 mm. One doubtful find of this type has elements with a diameter of about 30 mm.

About the spinning of bast cordage Stage I elements we may, with regard to their diameters, conclude that the traditions were kept unchanged during the entire Bryggen period. For as much as ⅔ of the lime bast cordage there was an unlimited range of larger dimensions for the elements, whereas this range for some reason seems to have been much narrower for the juniper cordage. This difference can possibly be attributed to the fact that juniper bast is clearly softer than lime bast and therefore probably also less resistant to wear and friction. This can in fact be seen directly on the finds, as the outer layers of bast are usually missing on the juniper cords, only surviving between the elements, whereas this is rather rare for the lime cordage. The juniper bast was possibly not suited for coarser use. This may possibly explain why the most common diameter for the juniper elements was slightly greater than the most common one for the lime bast elements: when they were to be used for the same purposes, they had probably been given some extra layers at the start because these so easily wore off.

On 98.7% (n=449) of the bast cordage finds the spinning direction of the Stage I elements can be seen. Of these, 95.8% (n=430) have S-spun elements, the remainder (n=19) have Z-spun elements. Those with Z-spun elements include only one juniper cord. The percentage of Z-spun elements is thus well within the percentage of left-handed members of the population. The proportion given in various standard works of reference varies, but it is always well below 10%. It is therefore tempting to explain the Z-spun elements on this basis, because the handling of the material during the spinning process must necessarily be influenced by a left-handed spinner. Otherwise the Z-spun elements do not differ from the rest, nor does the resulting cordage made from them, except that this, of course, also has the opposite twist of normal cordage. These cords have therefore been treated together with the rest with regard to other qualities. For some reason they are more than normally abundant in the fire interval 1198–1248, with 12.5% of the finds occurring in that period.

For 80.4% (n=366) of the finds the helix angle of the material in the Stage I elements is measurable. As with the other classes of cordage, the measurements used in the descriptions are the mean values for each find. Fig 20 shows the variation in the helix angle for the two bast raw materials, lime (n=304) and juniper (n=62), as well as the

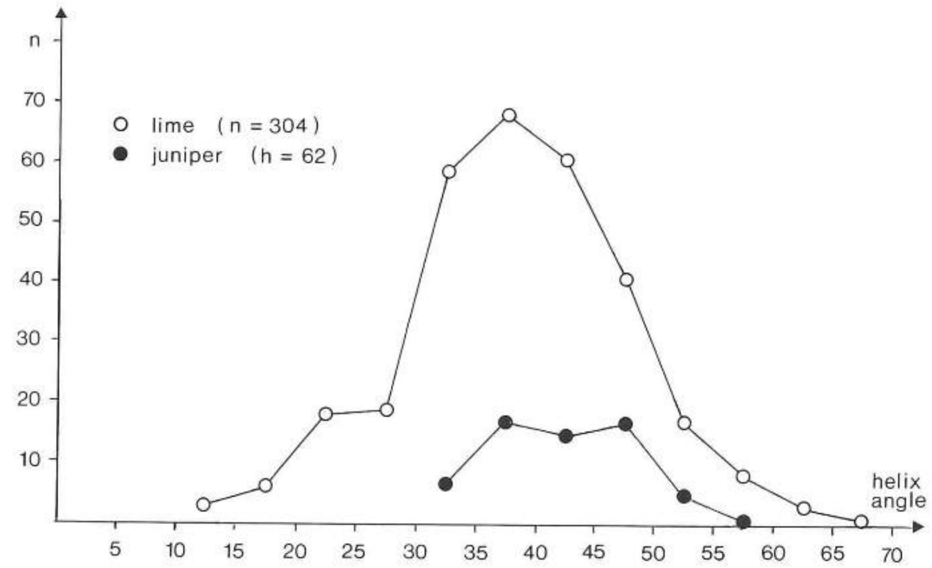


Fig 20 Distribution by helix angle of Stage I elements of lime and juniper bast cordage.

frequency of the different angles among the finds. We can see from the diagram that the range of angles is greater for the lime bast cordage (10 to 65 degree) than for the juniper cordage (30 to 55 degree). For some reason the lime bast finds below the fire of 1170 differ from the later finds in this respect, in that the helix angles of their elements vary from 30 to 65 degrees, whereas they otherwise vary from 10 to 55 degrees. There may be a connection between this greater degree of spinning and the tendency mentioned earlier for a finer and thus more pliable bast material in the oldest retted bast cordage from Bryggen.

It further appears from the diagram in fig 20 that the most frequent helix angles for both materials are from 30 to 50 degrees. 75.0% (n=228) of the lime and 92.0% (n=57) of the juniper bast elements were spun with these angles. The mean values for the two materials are 36.4 degrees for the lime and 40.4 degrees for the juniper bast elements. This slight difference is also visible in the diagram (fig 20). Such a small difference cannot be attributed to any intended difference for the two materials in manufacture, and is probably an automatic reaction to the softer and therefore more pliable juniper bast material; this is similar to the fact that the earliest lime bast cordage, which was generally made of somewhat softer bast than the later cordage, has a mean value of the helix angle as high as 41.6 degrees. Also some cords made from apparently over-retted lime bast have a relatively great helix angle.

None of the juniper bast elements have helix angles below 30 degrees, but 15.1% (n=46) of the lime elements have lesser angles, down to 10 degrees. Most of the lower values are found in the cores of elements spun with a wrapping strip. Helix angles above 50 degrees have been recorded on a total of 9.5% (n=29) of the lime bast and 9.7% (n=6) of those made from juniper bast. Diagrams, similar to fig 20, but for each separate fire interval (not reproduced here), have shown that the main tendencies seem to be mostly the same, except for the oldest lime bast finds, as we saw above.

During the study of the finds it appeared clearly that a great variation in the degree of spinning was intentional, in that some cords are made of strongly spun elements, making them more resistant to tension and possibly also to wear, whereas others are made from remarkably soft spun elements, giving the product a special softness and flexibility. It has not, however, been possible to trace identifiable groups of retted bast cordage with specific combinations of bast quality and helix angle of the Stage I elements. For most of the cordage the helix angle is therefore of interest only in the description of the individual find, but of little significance for classifying the finds.

The spinning of components with a wrapping strip has been mentioned several times, and the spinning technique is described in the chapter on wood-strip cordage. Similar implements were used. There are no examples of this spinning method among the juniper bast finds, but it can sometimes be difficult to determine the method from the find itself and the possibility must therefore be left open. On the other hand, juniper bast cords very easily lose the outer bast layers, as mentioned above, so there would probably be little purpose in a special wrapping strip.

Of the lime bast finds only 14.4% (n=54) are clearly made in this way. There are no such finds from after the fire of 1332, but then we have very few altogether. Only eleven finds of this type are from before the fire of 1198. They may be slightly more common, but have not been recognized because the wrapping strip can sometimes be difficult to discover, though in most of the finds it is easy to see that the bast was spun from one single strip (in the case of the thin element specimens), or as one strip bundle. Most of them look just as neat as the wrapped ones, because care was obviously taken – as it also was in later times – to keep the tough and finely structured inner-bast strips to the outside, so that they covered the element. This measure proved to be effective: it is astonishingly rare that the outer layer of lime bast cordage wore away.

The diameter of the elements spun with a wrapping strip varies from 9 mm to 35 mm for 49 finds, and there are one with a diameter of 5 mm, three with a diameter of 6 mm, and one of 8 mm. The mean diameter for all the wrapped elements, inclusive of the wrapping strip, is 16 mm, compared with a mean of 10 mm for the total number of finds, the reason being, of course, that the thinner elements were often made of only one bast strip at a time.

The core of the wrapped elements generally has a lesser helix angle than that of the unwrapped ones. In 42 finds the angle of twist in the core can be reliably measured; it varies from 10 degrees to 35 degrees for 40 of them, the other two having angles of 40 and 50 degrees. The mean angle for the wrapped elements is 27.4 degrees compared with 36.4 degrees for all lime bast elements. Regardless of the quality of the bast material in the core, the wrapping strip is always of top quality, up to 20 mm wide, and usually thinner than 0.5 mm. Where it is clear, the angle of the wrapped element varies from 25 to 65 degrees, with a mean value of 51 degrees. That it is always greater than the respective core angle was the criterion used to define this group of cords, and so it is built into the mean value. This value should possibly be somewhat less, as the difference in angles of core and wrapping strip may not be discernible for some finds, as mentioned above.

The most striking feature is the low angle of twist of the core in the wrapped elements. Nothing in the later traditions explains why this should be so. It was probably not even intended. In some way it must lower the quality of the cord, because of the lower resilience to stretch of these elements. The wrapping technique seems never to have been used on particularly softly spun elements: the wrapping in itself would possibly have added some rigidity. Maybe the technique in itself gave the cords a special quality which it is difficult to appreciate now.

The combination of the diameter of the Stage I element and the respective helix angle can be studied on 79.3% (n=361) of the finds, including finds of single elements. They were spun with a different degree of twist when intended for different purposes, but it has not been possible to find any standard types with a particular combination of raw material, element diameter and twist angle. The only "standard" combinations which have been found are those of the most frequent values of the two measurable features. About 40.4% of the finds have a combination of a diameter of between 4 and 9 mm, and a helix angle between 28 degrees and 46 degrees. The percentage is somewhat less for the lime bast cordage and slightly greater for the juniper bast cordage.

b The Stage II constructions

For most of the bast cordage (n=413) the complete construction can be ascertained. 88.9% (n=367) of these had been used as Stage II cordage. 1.7% (n=7) of the finds are special Stage II constructions which were not used as cords, and 9.4% (n=39) are Stage III cordage.

Of the Stage II cordage the three-plied construction is the dominating type, accounting for 80.9% (n=297) of the finds. It was found relatively more often with lime bast than juniper bast, with 85.1% (n=258) of the lime bast Stage II cordage having this construction compared with 60.9% (n=39) of the corresponding juniper bast finds. 18.0% (n=66) of the Stage II cordage is two-plied, and this construction was found relatively more often with juniper bast than with lime bast, 39.1% (n=25) of the juniper bast Stage II cordage being made in this way as opposed to only 13.5% (n=41) of the lime bast finds. The four finds which are four-plied are all made of lime bast.

Of the seven Stage II special constructions one is a short piece of cord made of juniper bast, with loops at either end, and three are cross-shaped constructions also of juniper bast. Finally there are three finds of coarse net fragments made of lime bast.

The normal direction of twist of the Stage II cordage is Z-twist, since the Stage I elements are usually S-spun. Only 15 finds are S-twisted from Z-spun elements and these are all three-plied cords made with lime bast, with one single exception.

The diameters of the Stage II cords are mostly in conformity with the "rules" shown in fig 11 for other classes of cordage. This means that the diameter of a two-plied cord is about 1.5 times the diameter of each of the individual elements, and a three-plied cord is about twice as thick as each of the individual elements. Four-plied cords seem to be approximately 2.2 times as thick as the individual elements. But cordage made from elements spun extremely softly does not follow these numerical ratios as closely as that made from elements with a stronger degree of twist. The soft Stage I elements are often pressed so closely together during the plying process that the resulting cord is thinner than expected. An example of this can be seen in fig 18b.

The measurable three-plied lime bast cordage (n=259) is made from elements of all diameters (see fig 19), resulting in cord diameters varying from 3 mm to 70 mm, with a mean of 20.6 mm. About half of them (49.0%, n=127) have diameters of between 8 and 16 mm, and among these the most frequent diameter is close to 9 mm (50 finds or 19.3% of the total). Seventeen finds have diameters of less than 8 mm and the rest (n=115) have diameters greater than 16 mm, with an evenly decreasing frequency up to 70 mm. The corresponding juniper cordage (n=38) has diameters varying from 4.5 mm up to only 30 mm, owing to the relatively limited variation of the juniper Stage I elements (see fig 19). The mean is 15.1 mm. More than half of them (55.3%, n=21) have diameters of between 8 mm and 16 mm, the most frequent diameter being close to 15 mm (for 15 finds, 39.5% of the total). Four finds have diameters less than 8 mm and the rest (n=13) have diameters greater than 16 mm, with an evenly decreasing frequency up to 30 mm.

For the measurable two-plied lime bast cordage (n=43) the thicker Stage I elements were not used, and the cord diameters vary from 3 to 30 mm, with a mean of 12.1 mm. Nearly half of them (48.8%, n=21) have diameters of from 8 mm to 16 mm, and among these the most frequent diameter is close to 9 mm (for eight finds, 18.6% of the total), which is the same as that found for the three-plied lime bast cordage. Twelve finds have diameters less than 8 mm and ten have diameters from 16 mm upwards, evenly distributed up to 30 mm. The corresponding juniper cordage (n = 23) has diameters of from 5 mm to 25 mm, with a mean of 11.8 mm. More than two-thirds (69.6%, n = 16) have diameters between 8 mm and 16 mm, the most frequent being close to 15 mm (for 8 finds, 34.8% of the total). This is the same as that found for the three-plied juniper bast cordage. Five finds have diameters less than 8 mm, one find has a diameter of 17 mm and one a diameter of 25 mm. The four four-plied finds have diameters ranging from 13 to 40 mm.

Disregarding all the three-plied lime bast cords of greater dimensions, the range of dimensions for the two- and three-plied cordage is remarkably similar. More recently, the two-plied construction was mostly used for thinner cords, in preference to a three-plied construction. As with the finds from Bryggen, however, three-plied constructions were nevertheless the most common, but usually produced in four different dimensions. Such groups of dimensions are not at all traceable in the Bryggen material. On the other hand, there is a clear difference between the most common diameters of the lime bast cordage and those of the juniper bast cordage. The most common diameter of the juniper bast cordage is somewhat greater than that of the lime bast, regardless of the number of Stage I elements.

The angle of twist of the two- and three-plied Stage II constructions is normally about the same or somewhat less than that of the respective Stage I element. Fig 21 shows this relationship between the two angles, using the measurable three-plied cordage from the fire interval 1248–1332 (n = 43) as an example. The picture is the same for all the three-plied cordage found above the fire-layer of 1198, but for the finds from the

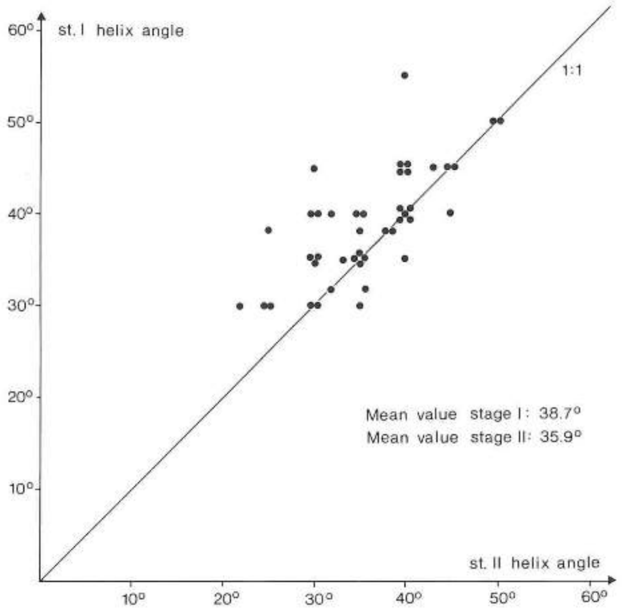


Fig 21 Relationship between the helix angles of Stage I elements spun without wrapping strip and those of the Stage II of three-plied lime bast cords, found in the fire interval 1248–1332 (n = 43).

deeper layers the variation is greater. The mean value for the angle of twist of the cords in fig 18 is 35.9 degrees as opposed to 38.7 degrees for the respective Stage I elements. The corresponding values for three-plied juniper bast cordage is 38.2 degrees for the Stage II construction and 41.8 degrees for the Stage I elements.

The picture is largely the same for the two-plied cordage, only more accentuated. The Stage II angles of twist here are remarkably lower than for the three-plied cordage, with a mean of only 29.3 degrees for the lime bast cordage and 31.5 degrees for the juniper bast cordage. This is due to the fact that a two-plied construction is always somewhat looser than a three-plied one. This is also one of the main reasons for making three-plied cordage, in that its closer construction gives it a smoother surface, and the tauter lay also gives it a better elasticity lengthwise. Moreover, a smoother surface can tolerate more friction than one which is less smooth.

For cordage made up of components spun with wrapping strips and consequently with a lower angle of twist in the core, the relationship between the measurements is different, in that the angle of twist in Stage II is much higher than the angle in the respective Stage I element core. With the assumed low untwisting energy of these elements, a corresponding low twist of the Stage II construction might have been expected, but for some reason this is not the case. Perhaps the wrapping strips add rigidity to the Stage I elements and thus give them a higher untwisting energy.

No cordage groups with any special combinations of diameter and angle of twist can be detected in the material, only a relatively broad range of "normal cordage" with relatively small dimensions and a relatively strong twist.

In the later traditions concerning bast cordage there seems to be no mention of Stage II cords being made of more than three Stage I elements. In the Bryggen finds, however, we have four cords which are four-plied (nos 18558, 25499, 30491, 55593). No. 18558 was found in the fire interval 1198–1248, the other three in the interval 1170–1198. They are all made from fine and well-retted lime bast. They have the following diameters and corresponding helix angles: no. 25499: 13 mm/30 degrees; no. 30491: 15 mm/40 degrees; no. 18558 30 mm/40 degrees; and no. 55593: 40 mm/30 degrees. In all cases the helix angles are about the same as those of the respective Stage I element. The elements of the two thickest cords are spun from thick bast strips, seemingly of a slightly woody type, and they had not been worked to make them thinner. No. 25499 is made from two Stage I elements, which were bent double before the four ends were plied together.

In modern four-plied constructions there is a central extra cord, a "heart", filling up a cavity in the middle of the construction, but for our soft bast cordage this was clearly not considered necessary, and would also seem quite alien to popular cordage production. According to Ashley (1966, 598), a four-plied cord without a heart used to be called "cant rope" or sometimes "four cant". It seems that Stage II cordage with more than four elements was never made with bast materials.

c Special Stage II constructions

When cordage was plied for small-scale production, or when only a limited length was needed, it was often, right up to recent times, made by doubling the individual Stage I elements, as described above for the four-plied no. 25499, usually with subsequent plying of the two parts to a two-ply construction. One end of the cord was therefore closed and could not fray. By using a special technique, the method was also used for three-plied constructions. One-third of the ready-spun Stage I element was bent back along itself, thus lying parallel with the middle third, with which it was then plied as a two-plied construction. The remaining third was then bent back along the two-plied cord and plied along it as its third element, being forced in between the two other parts. The result was a cord with two closed ends, each with the single loose end drawn through the little end loop and thus locked. How the method was actually performed in practice is especially well illustrated by Modéer (1928, figs 16–26) in his work about wood-strip cordage. The technique was the same for bast cordage.

Besides the four-plied examples with their closed ends, we have a further 10 cord finds from Bryggen which show that the method was used from before 1170 until after 1332. Four of these are two-plied cords: no. 45197 made from lime bast, and nos 10371a, 50609 and 80102a made from juniper bast. They are all about 15 mm in diameter. The remaining six finds are three-plied cords: nos 51892 and 80726, with diameters of 10 and 12 mm, are made of juniper bast and the other four, nos 4816, 45727, 46384b and 64378a are made from lime bast. These lime bast finds demonstrate that the closed end technique was used for cordage of all dimensions, in that two cords are about 13 mm thick, while no. 45727 has a diameter of 55 mm and no. 46384b a diameter of 70 mm. All of them have a rather good twist, from about 40 to about 50 degrees. The two thick ones are made of elements spun from thick un-thinned bast strips, no. 45727 of a rather woody bast.

There is also a curious little find from the fire interval 1170–1198, no. 43024, made from juniper bast in a two-ply cross-shaped construction, where the ends of the four arms are all closed. It is shown schematically in fig 22a. A small piece of a three-plaited juniper bast cord is fastened to one of the four arms. It is difficult to explain the purpose of this object, and it seems more like the result of an experiment rather than a useful implement. There are no signs of any stress in the appended plaited cord. The diameter of the cord is about 6 mm, and the length of the arms from 14 to 16 cm.

There are two more juniper bast finds fairly similar to no. 43024. No. 18645 is a cross-shaped construction with the middle part made in exactly the same way, but none of the arms has a closed end. The item looks as though it had been lost before it was finished, since the Stage I elements end in untwisted bast strips. On one arm the two bast strips are knotted together with a simple loose knot, possibly to prevent it from

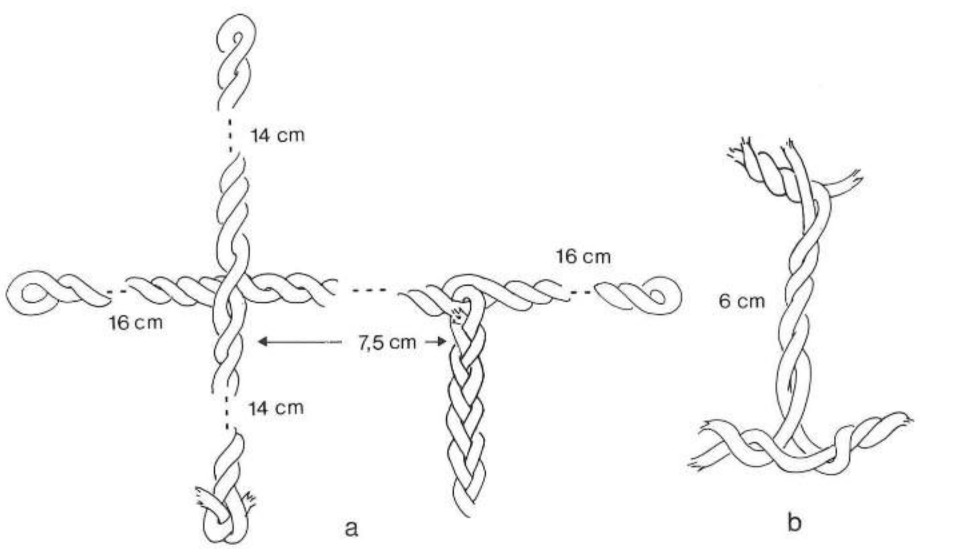


Fig 22 Schematic drawings of cross-point constructions. a. No. 43024 with four closed ends and appended triple plait. b. no. 71871.

unravelling. The plied pieces of the arms are from 12 to 14 cm long and the unplied ends of the elements are from 6 to 13 cm long. The diameter of the two-plied cord in this find is about 12 mm, so it is a coarser construction than no. 43024. The other find, no. 71871, is very fragmentary (see fig 22b). A two-plied cord 6 cm long has a cross-shaped construction at either end. One cross has three arms and the other possibly also had, but here only one arm is sufficiently preserved. The diameter of the central two-plied cord is about 7.5 mm.

There are also three finds with a specially constructed loop-end. One of them, no. 18097, made of lime bast, has a partially destroyed loop, which cannot be studied in detail, but it seems to resemble the others. These (nos 17886b and 31466) are three-plied cords made from juniper bast, as is a two-looped construction no. 24007. No. 31466 (fig. 23b) is an S-plied cord made from Z-spun Stage I elements. The loop end is constructed on the basis of the closed end of a two-plied construction. The closed end was then bent back along the plied cord and hooked around it at a distance suitable for the size of the loop (see smaller diagram fig 23b). A third element part was then plied along the cord up to the base of the loop, making the cord three-plied, and then plied around the loop, where it is now broken, the end probably having been somewhere further down the cord part of the construction. The diameter of the cord is 11 mm.

No. 17886b has a loop constructed on the basis of the open end of a two-plied cord. A suitable length of the plied end was bent back along the cord for making the loop, and one of the two Stage I elements was plied around the loop again as its third element (like fig 23b), and tucked away in between the elements to fasten it. The other element

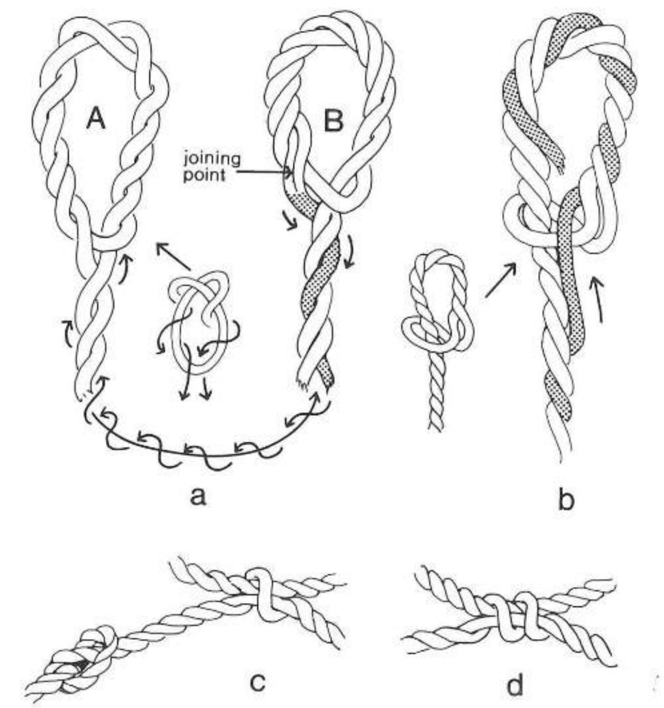


Fig 23 Schematic drawings of end loops of cords and crossing points of net fragments. a. no. 24007 with a loop at each end. b. no. 31466. c. no. 10284. d. no. 31695.

of the two-plied cord construction was then plied along the cord itself as its third element. The diameter of the cord is 12 mm.

No. 24007 is a 34 cm long cord with a loop construction at each end. Loop A (fig 23a), was the first part of the entire construction to be made, in that a closed loop or ring was formed about one-third of the way along a long element, and the two ends then twisted in either direction around the loop until they met, after which they were plied together to form a two-plied cord. The second loop B was then constructed in almost exactly the same way as the loop of find no. 17886b described above, but with one difference: when it was finished, the element which had been used as its third element was not cut and fastened, but twisted together with the second element to form a single strand, which was then plied back along the cord as its third element and around loop A before being fastened at the base of that loop. The detail where the two elements were twisted together into a single one would suggest that the spinning of the elements was at least partly carried out at the same time as the constructional work. The cord is 7.5 mm in diameter. The elements are about 3.5 mm thick and are spun from one single bast strip at a time. Such a thin element can easily have been twisted by hand, and this was most probably the case here, since it is difficult to imagine that any spinning implement could have been employed during the construction of this small but complex item. There are signs of wear at the distal ends of the two loops.

Similar loop constructions have been found among the cordage from the ship burial at Oseberg (Christensen 1974). These may have been made from lime bast (Høeg 1965).

Three finds of two-plied Stage II constructions have been interpreted as fragments of coarse nets (nos 10284, 30131 and 31695), even though no complete net mesh has survived. They are made from lime bast. They are very fragmentary, but the presence of the binding point constructions illustrated in fig 23c, d are quite characteristic, having also been found in bast nets from Haithabu (von Brandt 1970, 69–73, Körber-Grohne 1977, Abb 14). The Haithabu net fragments are in a much better condition than the Bryggen ones, and they provide the basis for understanding the fragments from Bryggen.

The binding points of these net constructions are different from the cross-shaped constructions described above in connection with some finds made of juniper bast. The nets were made in successive rows of meshes, with each new mesh attached to a mesh in the previous row by a special technique. The nets would seem to be made of two-ply cords, but this is not really the case. The work was done with two free Stage I elements, which were simply twisted around each other to form a short length of cord between one binding point and the next. At each binding point one of the elements is merely carried forward, while the second is twisted once or twice around the cord of the mesh in the previous row, before again being twisted together with the first element until the next binding point. The two elements alternate in by-passing and being locked to the previous row.

From published illustrations of the nets from Haithabu it can be seen that they are very regular. One of them is a strong three-plied construction, although the cord in the mesh is only 6 mm in diameter. In this one the binding element twists round the previous mesh three times (von Brandt 1970, 71). Two net finds are made from two-plied constructions, and here the binding element twists round the previous mesh twice (Körber-Grohne 1977, Abb 14, 81). The Haithabu nets are made from oak bast.

It is not possible to form any real impression of the Bryggen nets, but there seems to be less regularity in the binding points which have survived. In find no. 10284 from the fire interval 1198–1248, the binding element is twisted only once around the cord of the previous row (fig 23c). One of the free ends of a cord in this piece has a simple knot at a short distance from the binding point, which it ought not to have if it is a

fragment of a net. The piece may not have been finished, or perhaps it is after all a part of some other item. It is very coarse: the cord has a diameter of 20 mm. A binding point which seems to be rather like this one is illustrated by Granlund (1943, fig 7c, 181). This was used for a net construction for carrying hay.

Find no. 30131 from the fire interval 1170–1198 is even more fragmentary than the one just described, but a binding point is visible. Here the binding element of one cord has been twisted around the second cord at least once. The diameter of the cord is about 9 mm.

The last item, no. 31695, found below the fire-layer of 1170, has at least eight binding points preserved, but with almost no connections between them. One of the binding points is rather like the one found in no. 10284 (fig 23c), while the others are of the regular type found in the two-plied Haithabu nets (fig 23d), where the binding element is twisted twice around the cord of the previous row. The diameter of the cord in this find is about 6.5 mm, and the distance between two binding points is about 6 cm.

The diameter of the cord in the three-plied net from Haithabu is 6 mm, and the diagonal distance of the mesh measured between two binding points is given as about 9 cm (von Brandt 1970, 69). The two-plied net no. 251 from Haithabu has a cord whose diameter varies from 3 to 5 mm, according to the illustration (Körber-Grohne 1977, Abb 14, 81). The nets from Haithabu are thus made of considerably finer components than the Bryggen ones.

As we have seen, fragments of bast nets have been found in northern Europe from as early as the Early Mesolithic period. Von Brandt has studied the literature on nets found in all periods from all over the world, but could not find any description of binding points like those in the net fragments from Haithabu. This type was therefore described for the first time in his paper. Now, however, we have something very similar from Bryggen. Coarse bast nets of different constructions are otherwise well known, made for many purposes, also in the medieval period. Granlund has illustrated a number of different recent Swedish nets (Granlund 1943 pl 24). They were used for fishing gear, as hunting nets and for several minor purposes. Von Brandt has discussed the purpose of the net fragments found in the harbour at Haithabu and has suggested that they may have been used in the transport of goods. This could equally well explain their presence in the harbour at Bryggen.

From the west coast of Norway large net constructions made of lime bast are known to have been used for whaling, but they were possibly not constructed in the way described here. Whales were driven into a creek, which was then closed by the net, said in one instance to have been 50 metres long. The cord in the net had about the thickness of a finger and the mesh sides were about 30 cm. The practice is known from at least as early as 1520 (Stoltz 1957, 148).

d The Stage III constructions

Stage III constructions have only been found among the lime bast cordage, where they amount to only 10.1% (n = 39) of the finds. There may have been some more, because a few of the Stage II cordage finds show signs of possibly having been parts of larger constructions. Many of the finds are badly preserved, and for only 25 of them can the complete construction be discerned. Even for some of these it is difficult to obtain good measurements of all the details.

Thirty-three of the finds are dated. None was found in the layers below the fire of 1170, but this is probably due to chance, since the practice of making Stage III constructions is testified to among the ninth century Oseberg finds (Christensen 1974) and at Haithabu (Körber-Grohne 1977, 70).

The Stage III finds can be easily divided into two groups. One of these is called here the "traditional group" (n = 22) and the second the "untraditional group" (n = 17). These designations are used in order to avoid any suggestion of interpretation concerning the second group right from the start. The traditional group is so called because the finds are constructed in the normal way, where each stage is twisted in the opposite direction from the previous one. The untraditional group is constructed in a way which breaks with this principle. The Stage II components of the finds in this group have all been twisted in the same direction as the Stage I elements and the number of Stage I elements used for each Stage II element is usually higher than the number used in the traditional group. Stage III was then twisted in the opposite direction from Stage II (as normal).

Another striking difference between the two groups is that on the whole they belong to different periods. Only one find of the traditional group is later than the fire-layer of 1332, while only two of the untraditional ones are earlier than this fire-layer.

The traditional group will be described first. For eight of them the number of Stage I elements involved in the construction cannot be ascertained, but most of them seem to have been three-plied. One find is two-plied, and eleven finds are three-plied constructions. Two finds are eight-plied.

The variation in diameter is enormous. The two-plied find (25400a) is only 6 mm thick. The three-plied structures are from 10 to 120 mm thick and the two eight-plied ones have diameters of 39 and 160 mm. If the incomplete finds are interpreted as three-plied cords, their diameters can roughly be estimated to twice the diameter of the respective Stage II elements, which are all measurable, and these finds will then vary in thickness from 20 to 110 mm. Interpreted as two-plied they will vary from 15 to 90 mm. In both cases they are just as variable as the measurable cordage. There is an even distribution of the diameters of both the measurable and the estimated items, with no clustering around any particular sizes. Since the incomplete finds look like three-plied ones, we shall here assume them to be so, together with the others, in a attempt to ascertain any chronological variations. Seven finds (four measured and three estimated

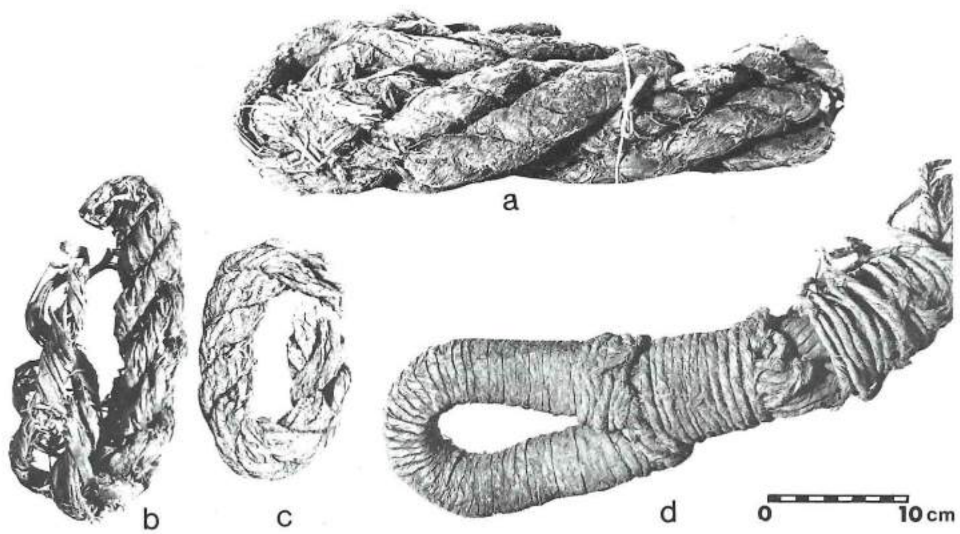


Fig 24 Traditional and "untraditional" lime bast cordage. a. Thick fragment in traditional construction (no. 22909). b. Traditional construction (no. 29666). c. "Untraditional" construction (no. 38472). d. Large whipped loop in "untraditional" construction (no. 7635). All the same scale.

ones) have diameters from 70 mm and upwards. Six of these belong to the fire interval 1170–1198 and the seventh to the interval 1198–1248. The finds with smaller dimensions are evenly spread in time up to 1332. After this date there is, as stated above, only one find from the whole group. It would seem that the large dimensions of the traditional Stage III bast cordage constructions were of little interest at Bryggen after 1198.

The helix angles of the constructions are 30 degrees or less for all the measurable finds except one. This one is the only late find of the whole group, no. 38951, from the fire interval 1413–1476. It is a three-plied 20 mm thick cord, made from exceptionally strongly twisted Stage I and Stage II elements, and has an helix angle of 50 degrees.

Disregarding the variation in diameter, the group is also very variable with regard to other details, for instance the number of Stage I elements used in Stage II elements. This can be ascertained for all the finds of the group. Seven are plied from two-plied Stage II elements. One of these is the 36 mm thick eight-plied Stage III construction, no. 61982, from the fire interval 1170–1198. Twelve finds are made from three-plied Stage II elements, including the other eight-plied Stage III construction, no. 22909, which is 160 mm thick and came from the same fire interval as the first one, 1170–1198 (fig 24a). It is in reality plied from four Stage II elements which were doubled over before the eight parts were plied together. No. 9363c from the fire interval 1248–1332 was plied from four-plied Stage II elements, and finally there is a very special find no. 25036 from the fire interval 1198–1248, a poorly preserved three-plied construction made from three fifteen-plied Stage II elements. The 45 Stage I elements thus involved in this piece of cordage are only 1.5 mm in diameter, Z-spun from a single thin bast strip. The successive stages are twisted in consecutive opposite directions as usual, so the completed construction is also Z-twisted, and it is only 28 mm in diameter despite the number of the components. The find is thus a very untraditional construction in nearly all details, except for the twist sequence, the feature which is the reason for placing the cord here in the traditional group.

Four of the traditional Stage III constructions are made from rather thick Stage I elements spun with a wrapping strip. Three finds are made from rather woody bast, spun in thick, unthinned strips, while the rest are made from retted bast of variable quality.

It is perfectly clear that this group of traditional Stage III cordage does not reflect any standard types, nor any common purpose. Many of them were, as we have seen, not even made for the purpose of producing specially thick cordage.

Stage III constructions are not directly mentioned among the later traditions, but Hanssen & Lundestad show a photo of a mooring cord of lime bast from Hardanger, which is clearly a three-plied S-twisted Stage III construction with two-plied Stage II elements (Hanssen & Lundestad 1932, fig 3, 385).

The 17 finds of the untraditional group of Stage III constructions give quite a strong impression of a common constructive idea, and they are not as variable in diameter as the traditional group. First and foremost they are all based on thin Stage I elements varying only from 3 to 7 mm among the various finds. They are all S-spun and all are without wrapping strips. The lime bast material for most of them is strikingly finely structured and well retted, never over-retted.

These thin elements were then plied together in the same direction as the spin direction, the S-direction, usually with many elements together (fig 24c, d). It is not easy to count them, because this can only be done where the Stage II element is broken, and here some of the Stage I elements may have disappeared. But it is clear that the number of Stage I elements involved varies without any preference for certain numbers. Seven finds have from three to five elements, seven finds from eight to twelve, one find has 20 and one has 25 Stage I elements in each Stage II element.

The principle of this special Stage II arrangment is new for the bast cordage, but there was one withe find (no. 54910) which was S-plied from two S-twisted single withes, and which seemed to have been part of a further construction. A thick twig cordage of type I made of willow, no. 78304 from the fire interval 1170–1198, was also constructed in this way. Osborne (1954, 1099) calls this arrangment a "hawser" construction, but other authors do not seem to restrict the term "hawser" to this special construction. It is said that the arrangement (the lay) enhances the twist of the Stage I elements, at the same time giving the resulting cord a good twist and a smoother surface and making it much more pliable, but with less tensile strength.

The Stage III construction of the untraditional group is usually three-plied from the Stage II bundles; only one find is two-plied and one find is six-plied. The resulting diameters vary from 17 to as much as 45 mm for the finds with up to 12 Stage I elements in each Stage II element. The find with 20 elements in each bundle, no "20864", has a diameter of 60 mm, and the one with 25 elements in each bundle, no. 7635, is 70 mm thick. The helix angle of the Stage III ply is around 40 degrees for most of the finds in this group, which is a much better twist than was found in the traditional group.

No. 7635 is quite exceptional, being a great eye or loop (fig 24d). The loop seems to have been the first part of the whole cord to be constructed: an untwisted bundle of about 38 Stage I elements was bent double, forming a bundle of twice the thickness. The looped end was kept open and tightly and neatly whipped or wrapped with a single Stage I element. The base of the loop was also tightly wrapped. The thick bundle of Stage I elements was then divided into three, each part S-twisted, and then the three parts Z-plied together. There is some oblique wear at the distal end of the loop (see fig 24d), which points to a function as a part of the shroud of a ship. The bast is perfectly finely structured, still band-like, well retted, and somewhat paler than usual. It may be a result of a special retting method, for instance in fresh water, which seems to give different types of retted materials a paler colour (for instance flax, and reputedly also coir). The process must, moreover, have been carefully controlled. Even though based on the same constructional idea as the other finds in the untraditional group, this find differs in a somewhat indefinable way. It would seem to be the work of a highly skilled professional craftsman from beginning to end, including the retting of the bast. We do not know if the *bastari* or cord makers also handled the raw material themselves, but it is more likely that they bought the material from the districts where it was produced and where the possibilities for retting were better than in a port. However, we know nothing about this.

This whole group of "untraditional" cordage was new at Bryggen just before 1332 and the constructional idea is foreign to Scandinavian popular bast cordage production. The group can be explained as possible imports and considering the period in which they are found, it may be tempting to see them as reflecting a contact with the east Baltic area, where lime bast products have been a speciality from medieval times up to the present. Unfortunately the author is unacquainted with the traditional cordage types in that area, and with the treatment of the bast material. The finds may, of course, represent casual waste from boats coming from the Baltic area with corn products. But they may also come from other places. According to Helle, "smaller quantities of articles like ... hemp and bast (partly as cordage) were imported from other countries" (Helle 1982, 321).

With regard to the quality of the bast, most of these pieces could be local products. They are all made of good bast, but only the bast in the whipped loop differs from that which is also found in the traditional cordage production. It is just as tempting to see most of the group as the production of a local craftsman. The *bastari* were known

in Bergen before 1276, when the Town Laws of King Magnus Lagabøter were passed. The term *bastari* clearly implies work with wood bast, as hemp was both known and named as such (Høeg 1961). This group of finds is not large, but among the lime bast cordage with identifiable constructions found above the fire-layer of 1332 (n = 44), there are 12 finds of this group, representing 29.5% of the total. The *bastari* would surely also have produced traditional types of cordage for traditional use.

One may therefore ask why the break with the traditions occurred at the time this group was produced. If it was made in Norway, it could for instance be explained as an answer to a demand from a market which possibly knew about lime bast cordage constructed in this way from other places. Or the production may reflect a competition from a growing market for quite a different type of cordage, for which the new lime bast construction were perhaps a substitue. From this point of view the "untraditional" cordage might be seen as indicating an increase in the use of hemp cordage. If so, this competition must have been felt to be urgent shortly before 1332, since there are few traces of the type in the rich cordage material found below this fire-layer. The constructional idea may be an attempt at giving bast cordage some of the qualities of hemp cordage.

D Comparative finds and traditions

As mentioned above, net fragments seem to be the oldest bast items found in northern Europe, occurring in the Maglemosian culture. Such constructions presuppose the knowledge of cordage making. Other ways of utilizing bast are reported from later periods in Switzerland (von Stokar 1938, 38). In the lake dwellings at Mondsee, lime bast was used for textile purposes at a time when flax was already being used in nearby areas. It is also found as "Überreste des schnur-keramischen Röckchens aus dem Frauengrab VI in Litzendorf-Weimar" *(ibid)*. Wood bast used for textile purposes is known from many cultures up to our own day, the best known being the North-West American Indians' use of cedar bast, described in most works about their culture. M Hald (1950, 126) mentions lime bast being used in connection with textile work in Bronze Age Denmark, as well as for sewing bark items. As a sewing material it is otherwise well known from many places at various times. With regard to periods later than the Early Bronze Age von Stokar (1938, 38) says: "Wir finden ihn von da ab nunmehr in technischer Verwendung, wie als Matte, als Packmaterial und – durch die ganze Vorzeit nicht abreissend – als Schnur und Schiffstau".

At Haithabu a great deal of bast cordage (n = 286) was excavated, and it has been studied and identified by Behre (1969, 16) and Körber-Grohne (1977). This is a very interesting group of material seen in relation to the finds from Bryggen. Most of the Haithabu finds are made of oak bast (n = 247), a raw material not found at Bryggen. Only 38 finds are made from lime bast and three from willow bast, which is also missing from the Bryggen assemblage. In construction they are, like the common types from Bryggen, based on S-spun Stage I elements and plied in the normal direction sequence. In the Bryggen material the three-plied Stage II construction is the dominating type, making up 73% of the total amount of identifiable bast cord constructions, whereas there is only 16.2% of two-plied Stage II cordage. In the Haithabu material there is nearly as much two-plied as three-plied cordage, and there were also two finds of four-plied cords. There are only two examples of Stage III constructions, which are traditional three-plied cords made of two-plied elements, like many of those from Bryggen. Finally, there is one Stage IV construction, two-plied from two Stage III components constructed in the same way as the Stage III cords.

The most frequent diameters found for the Haithabu Stage II cordage are from 13 to 19 mm. This is about the same as for the Bryggen Stage II juniper bast cordage, which is approximately 15 mm, whereas the most frequent diameter for the corresponding lime bast cordage is about 9 mm. Most of the Haithabu finds are thinner than 13 mm, and relatively few are up to 40 mm in diameter. The greater dimensions in the Haithabu material occur in the two Stage III constructions, both of which are 70 mm in diameter, and in the Stage IV construction, which is 100 mm thick. In the Bryggen material there are no finds with diameters exceeding 30 mm among the two-plied Stage II constructions, nor among the juniper bast three-plied cordage, but the lime bast three-plied Stage II cordage comprises many finds with greater dimensions, up to 70 mm in diameter. Also here the Stage III constructions provide the greater dimensions, especially in the deepest of the excavated layers. But, on the the other hand, many of the Stage III constructions are not at all thick. For these finds the particular construction must have been chosen in order to give the cord a smoother surface, which is more resistant to wear. It is obvious that the original intention of the Stage III construction must have been to make cordage with greater dimensions and with better surface qualities than could be obtained with coarse Stage II cordage. The coarse Stage II lime bast cordage from Bryggen might be seen as a possibly cheaper product than the coarse Stage III constructions.

In this connection the spinning implements are of some interest. The most common one used for bast (and wood strip) spinning in more recent times is the two-armed or four-armed winch or reel (Sayce 1939 uses the SW English dialect form "wink") (fig 15). Both of these implements, when fastened for instance in a wall, leave both hands free for the handling of the material during spinning, which is also a prerequisite when spinning Stage I elements with wrapping strips. Wrapped elements occur in the Bryggen cordage as early as among the finds from below the fire-layer of 1170. The simpler two-armed reel is the elder of the two. Nilson (1961, 74) has found indications which seem to show that also the later four-armed reel, which originated in the great lime bast producing areas east of the Baltic, was introduced to Scandinavia quite early in medieval times, for instance to the west coast of Norway. Nilson thinks that it was first taken into use where bast cordage was produced on a somewhat larger scale. Because of the greater circumference of the four-armed reel, it can hold greater lengths of spun element, which is wrapped on to it during spinning. This may have been especially important for spinning suitable lengths of the more voluminous Stage I elements. The finds of coarse Stage II lime bast cordage from Bryggen, based on exceptionally thick elements – a type not found at Haithabu – may thus have some connection with this effective implement. Moreover, this type of cordage was found in layers earlier than 1170. It is tempting to think that it was the professional craftsman, the *bastari*, who introduced the new and more rational implement and, with its aid, also produced a cheaper commercialized product, in this case already before 1170. The two-armed reel was later mostly used for spinning elements of smaller dimensions (Modéer 1928, 47–51).

We shall now examine more closely the problem of the striking difference between the most common diameters of the lime bast Stage II cordage from Bryggen (about 9 mm), on the one hand, and those of the juniper bast cordage (around 15 mm) and the Haithabu cordage dominated by oak bast (13 to 19 mm), on the other. Since lime bast has always been regarded as the superior wood bast, the other two types must have somewhat poorer qualities, for instance as regards strength. If their use can be seen as a substitute for lime bast, then it is possible that the most commonly used type of cordage in all three bast categories was produced to serve more or less the same purposes. The diameter of the most common type of lime bast cordage is only about 60% of that of the corresponding juniper bast cordage, and the relationship to the Haithabu oak bast finds seems to be rather similar. Perhaps this difference can be seen

as a direct expression of the difference in basic qualities, so that lime bast cords can be made that much thinner than the other types for the same purpose.

In the Haithabu cordage lime bast cords are found only in medium sizes, with diameters from 7 to 25 mm, whereas those made from oak bast were produced in all sizes, both thinner and thicker cords. This would seem to indicate that the lime bast was reserved for the cordage types which were in greatest demand. In the Bryggen material we do not find this trend, since lime bast was used here for all sizes and types, whereas juniper bast had a much more restricted production.

"Even up to recent times lime bast has been an important material, in spite of the fact that the lime trees are now much less abundant than they were in prehistoric times" (Dimbleby 1967, 46–47). In the east Baltic areas lime bast products have been manufactured on an industrial scale up to our own time, but in Scandinavia the production has been on a smaller scale. In southern Sweden the professional cordage makers still used lime bast for cordage production in the fifteenth century (Nilson 1961, 143). A small-scale non-professional production for sale at market places has been carried on until recent times in both Sweden and Norway, and lime bast cordage could be bought in Bergen in the present century. The last place known to have kept up the production was Gloppen in Nordfjord. Here a limited production was even taken up again during the Second World War, when it was difficult to get other raw materials.

Cordage has always been the predominant product made from bast, but many other kinds of practical items were, of course, made, including different kinds of nets, which were used to a much greater extent than the finds from Bryggen would seem to indicate. This is not really the place to go into detail, and only a few products will be mentioned in order to show the wide range of application of bast. It is interesting to note that in Hardanger lime bast yarn was sometimes used for the warp threads in *ryer*, coarse but decorative bedspreads (Hanssen & Lundestad 1932, 389). From other places it is said that it was used for cheap horse harness, in which case it was possibly plaited, and it has also been used like birch bark for plaited shoes.

The cordage was said to be made up in four thicknesses for sale. The actual dimensions are not given, but no clear groups have been found at Bryggen. It should also have specific lengths. But for special uses bast cordage could with the assistance of a sufficient number of people be made up to any length. The large net constructions mentioned above, which were used for whaling at the west coast of Norway, were stretched across a creek with the help of a great lime bast cord, fastened to either side of the creek, from which the net was suspended. The cord was owned in partnership. One of the partners in a large investment at Telavåg, south-west of Bergen, around 1520 was the liege lord at Bergenhus, Vincentz Lunge, who received a share of the catch in return for providing parts of the net and cordage, as well as a barrel of beer for each whale (Stoltz 1957, 148).

There is nothing in later traditions about the use of lime bast cordage in the rigging system of boats, and it would not seem to be strong enough for such a purpose, at least not for the running parts (Christensen 1969). But the large loop construction, find no. 7635 (fig 24d), can still best be explained as part of a standing rigging system.

10 Asbestos cordage

Only one cord from Bryggen is not made from organic material. No. 3674 (fig 14c) was found in deposits dating from the end of the fifteenth or the beginning of the sixteenth century. It is a soft and exceptionally fine-fibred little piece of cordage, only 7 cm long. It has a pale whitish colour.

Under the microscope the fibre material is shiny white. The fibre bands range in width from around 50 microns to much more, splitting up into very thin needle-like fibrillae, which are about 4 microns or less in diameter, and transparent, glossy and smooth. They are not combustible, only glowing when ignited. A sample was subjected to an X-ray diffraction examination at the Geological Institute, University of Oslo, by Rune Wendelbo, who states that at least 95% of the sample is chrysolite, a serpentine asbestos. The examination was performed according to Brown & Brindley (1980, 322–328). This result was expected, since amphibolic asbestos does not produce good fibres.

The piece of cordage is about 10 mm in diameter and has rather a cotton-like and disordered look. It is a kind of Stage III construction, but this stage has no twist today, merely consisting of a bundle of about 9 Stage II elements. These elements are two-plied in Z-direction with a ply angle from 10 to 20 degrees and diameters up to 3 mm. They are plied from Stage I elements which are slightly S-spun, with diameters from 1 to 2 mm.

The spinning of shredded asbestos fibres was well known already in classical times, and is mentioned in literature as a curiosity. A really exciting find is reported from northern Sweden: this can be dated back to the Neolithic (Linder-Rissén 1972, 48). A cord was found drawn through a hole in the rim of a potsherd, clearly part of a suspension cord for the pot. From the published illustrations, one can see that it looks very similar to the Bryggen find, and the description shows that it was constructed in much the same way. Linder-Rissén states that it is very like modern asbestos cords used until recently for caulking roof-structures.

11 Plaited band of wood strips

Find no. 12570 from the fire interval 1248–1332 is not a cord, but it is of interest in illustrating how wood materials were and still are used here and there (fig 25). It is a beautifully plaited ribbon made of seven obliquely interlaced thin wood strips, with the plaiting in 2/2 technique (two-over-two system). The band is between 11 and 15 mm wide and from 1 to 1.5 mm thick. The colour is pale brownish grey. The wood strips are from 2 to 4 mm wide and about 0.5 mm thick.

A microscopic examination showed that the strips are tangentially shredded from

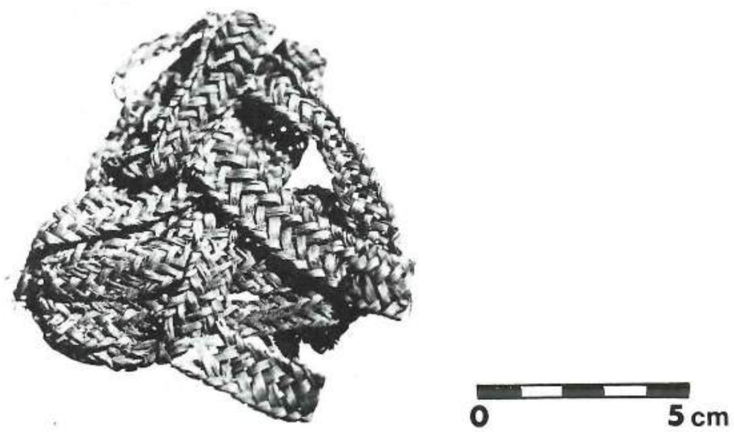


Fig 25 Plaited band of willow wood strips (no. 12570).

the wood of a willow *(Salix)* species. It is certainly none of the species which were used for any of the willow twig cordage found at Bryggen, because the ray cells are considerably longer radially than such cells in the local material. It is probably not a Norwegian product, because it must have been made from a specially tough willow wood, such as the Common Osier *(Salix viminalis)* or White Willow *(Salix alba)*, used in basketry. Neither of these two species are indigenous to Norway. White Willow has been cultivated in the south-eastern parts of the country for some hundred years as a material used for making plaited fishing implements, but not as early as when this band was lost at Bryggen. Willow-shoots are usually not easy to split into more than two (Schneider 1972, 233). The extremely fine splitting of the wood suggests that the material must first have been boiled, a practice known to have been used in some places for fine splitting, for instance in Slovakia (Horváthová, 1972, 88–89).

12 Plaited band of leather strips

The plaited leather band, find no. 86825, from the fire interval 1198–1248 is mentioned here mostly as the "exception to prove the rule" that we do not find leather cordage at Bryggen, despite the fact that the archaeological deposits have produced enormous number of leather items. The band was plaited from three sharply cut thongs, which are 6 to 8 mm wide and 2 to 3 mm thick. The band is 17 mm wide and 6 mm thick. The type of leather has not been identified.

In Norway, the term *reip* (Eng rope) seems to have been specially connected with leather cordage, which is known to have been used from very early times. Cords of walrus hide are said to have been used in connection with the rigging of ships in Norway, for those parts where extra strong cordage was required (Falk 1912, 60, Christensen 1969). It has also been used for the same purpose in traditional boats along the Norwegian coast right up to the last century (Brøgger & Shetelig 1950, 78, 1971, 76).

DISCUSSION

Most of the available published material concerning the manufacture of cordage relevant to the study of the cordage from Bryggen has been referred to in connection with the descriptions of the various classes of cordage and the different problems concerning the types as well as individual finds. In this section more general aspects about the collection of finds as a whole will be discussed. Questions concerning the different raw materials used in the manufacture of the finds and any lacunae in the materials due to poor preservation are regarded as essential to an understanding of the place of the Bryggen cordage in the history of the traditional craft of cordage manufacture, as well as of its role at Bryggen with regard to producers as well as customers.

The finds of cordage were interpreted as a coherent group of cordage already during the excavation, including the primitive withes made from single twisted shoots. Some of the withes are constructed in a very cord-like way (fig 10a) and were surely used for some of the same purposes as other types of cordage. They have therefore been regarded as obviously belonging to the group. The reason, on the other hand, for treating the cords made from hair together with other hair products instead of including them here, is that most of them are weak caulking cords, and the few stronger constructions consist mostly of braided cordage or sinnet, which was made at least partly for a decorative purpose (Schjølberg 1984, 78). Among the Bryggen finds there are no strong hair cords made for example with an admixture of pig bristles, like those known from more recent times (Nilson 1961, 93–94) and used in the same way as other strong cordage types in rural areas.

The conditions at Bryggen for the preservation of this group of finds were different in the various parts of the site, with the result that the general distribution pattern of the finds first and foremost reflects those places which were favourable for preservation. Thus the bulk of the cord fragments were found in the deeper levels of the voluminous wet and anaerobic deposits at the front of the site associated with the various quay constructions, where they probably ended up quite soon after being discarded. The places of the richest finds followed the successive quay fronts out into the harbour basin. The excavation was only in peripheral contact with the latest of the medieval waterfronts and their associated fillings, so that about 90% of the cordage finds belong to the levels from the middle of the twelfth century to the fire of 1332, and only 13 finds are later than the fire of 1413 (fig 3). It is thus clear that we are chiefly dealing with cordage finds from the time before the Hanse gained their dominant position at Bryggen. Even if Bergen during the whole period was a busy port based on international commerce and saw many foreign visitors, the environment at Bryggen itself was at this time dominated by Norwegians. Thus the finds from the deposits in front of the older quays are most probably dominated by the refuse deriving from the activities of the local people and their items, including the cordage which they had used.

No special tendencies in the horizontal distribution can now be discerned for the cordage finds from any of the fire intervals, but it is not impossible that some tendencies will be traced later, when the distribution pattern of comparative find groups has been established, in particular the textiles, which seem to have survived mainly under the same circumstances as the cordage finds. A clue to a better understanding of the distribution on the site can possibly be found in the various types of deposits, which were sometimes dominated by different materials such as mosses or wood-chips. Such materials must have come from different activities and different places, and can therefore also be expected to contain somewhat different types of refuse.

There was a considerable variation in the length of time which elapsed between the great fires at Bryggen, and there are also variations in how far the waterfront expanded outwards during the different rebuilding phases (Herteig 1985). Consequently there are also variations in the volume of deposits which accumulated between the different quay constructions. Added to this is the variation in content of the deposits. It is quite clear that the number of cord finds from the successive fire intervals cannot, when compared with one another, be seen as a measure of the variation in the importance of cordage at Bryggen in the respective periods. The importance was surely great the whole time and presumably constantly increasing.

The fire interval 1170–1198 has yielded the greatest number of finds (n = 187), especially considering its short duration. From the interval 1248–1332 we have the same number of finds (n = 188), but here they represent 84 years. As stated above, the actual number of cordage finds is of little interest in itself; it is the variation in frequency among the different types of cordage throughout time which is interesting, since these variations, when compared with one another, can be interpreted as variations relevant to the types of cordage used at Bryggen (cf fig 5). In order to remove irrelevant factors from the frequency analysis, the percentage of each type of cordage in relation to the total number of cordage finds in each fire interval (n = 100%) has been used for a relative comparison of the various types. Fig 5 shows the relative variations in frequency for the most numerous classes of cordage, for which this comparative method seems relatively reliable. These are the withes (n = 112), which show a general decrease in frequency, the two classes of twig cordage (n = 91), which have parallel variations in

frequency and which together show a noticeable maximum frequency in the fire interval 1170–1198, and the bast cordage (n = 455), with a relative maximum frequency in the fire interval 1248–1332. The actual numbers used for fig 5 appear from fig 3. They seem to suggest that the increase in frequency of the bast cordage, shown in fig 5 is a product of the relative nature of the curves, and is not supported by the actual numbers, even though an increase in the use of lime bast might well be possible, for example as a result of intensified production owing to the cultivation of lime trees, which is definitely attested at a later period (Høeg 1976a, 635–38), or as a result of import, or perhaps both factors. The import of bast and bast cordage mentioned by Helle (1982, 321) can therefore seem reasonable. On the other hand, Høeg (1965) refers to a source suggesting that bast cordage was exported from Norway to England in the pre-Hanseatic period. In reality there are no sources which indicate how much bast was available or how much was needed, whether there was enough of it or too little.

The utilization of the easily separated lime bast must in Norway as elsewhere be as old as the advent of the lime tree as the climate improved. In the literary evidence the use of it can be traced back to early medieval times: in the Eddic poem of Rigsþula the making of bast cordage is mentioned as slaves' work (the dating of Rigsþula is disputed, being placed variously between the Viking Age and the thirteenth century, Holtsmark 1969).

In some of the sagas too there are references to bast cordage, for example in Egil's Saga and Grettis Saga. The term *bastari* for the craftsman is known from 1276.

Lime bast cords predominate in every fire interval group of finds (fig 3). Of the total number of finds treated in this paper (n = 673), the lime bast cords (n = 378) account for 56.2%. But if the withes (n = 112), most of which cannot be seen as real cordage, are excluded, the percentage of lime bast finds in relation to the rest of the cordage is 67.3%. Juniper bast cordage (n = 77) can be seen as a supplement to lime bast cordage, and altogether the bast cordage finds make up 81% of the real cordage. This may be compared to the collection of cordage finds from Haithabu some hundred years earlier, where a total of 99% of the finds (withes included) were made from bast, mostly oak bast (Körber-Grohne 1977, 73, 82). This difference may mean either that we had too little good raw material here, or that the coarser and for some purposes stronger cordage types simply were more in demand for certain activities in the harbour of Bergen.

Nearly up to our own time, when hempen cordage has been used and produced in Norway for centuries, lime bast retained its popularity, especially in the fishing industry for the production of fishing equipment, for hauling trawl-nets and similar purposes, as well as in agriculture. Lime bast cordage was said to be especially strong when used in water, it was very soft to the hands, and it did not distort when dry. It was also light in weight and did not absorb much water. All these qualities have been emphasized in comparison to hempen cordage (Høeg 1976a, 633–640, Nilsson 1927), and explain why lime bast after all could compete with hemp cordage for such a long time.

We do not know to what degree the growing medieval fishing industry was dependent on lime bast cordage, but probably no less than in later periods. It is an open question what material was used for the lines of the extensive fisheries which were the foundation for the commerce and growth of Bergen. Also the question concerning the use of bast cordage for the tackle of the traditional Nordic boat types must be left unanswered (Christensen 1969). The purpose of the bast cordage found in the Oseberg ship burial from the Viking Age is not known. There is no evidence concerning the use of bast cordage in the traditions about the tackle of the old-fashioned types of boats that have been used for fishing along the west coast of Norway and for coastal trade well into our own time. Bast cordage could be possible for the standing parts of the rigging, but not for the running parts, since it is susceptible to fraying. The questions must be kept open because of the find of the whipped loop construction no. 7635 (fig 24d) from the fire interval 1332–1413, which certainly looks like a part of a standing rigging. But it is a unique find in every respect and not necessarily Norwegian. It could just as easily have been lost from a foreign ship and, if so, perhaps one from a region with an even stronger and somewhat different tradition concerning the manufacture of lime bast cordage, for example the eastern Baltic.

Juniper bast was used as the raw material for 17% of the bast cordage finds. This bast is clearly weaker than lime bast and must be seen as a poorer substitute for it. The use of juniper bast is referred to in later traditions, specially from Sunnfjord, but without any details and not emphasized any more than those vague indications that elm, willow and yew bast also was used (Hanssen & Lundestad 1932, 373–74, Hyltén-Cavallius 1868, II, 122, Høeg 1976a, 652, 573, 1981 63–67, Linné 1949, 61, Nilson 1961, 76, 81, Stigum 1939, 17–20, 130). No cordage made from the last-mentioned types of bast has been found at Bryggen, nor any made from oak bast, which was so important in Haithabu (Körber-Grohne 1977, 73). In view of the vague references to the use of different types of bast other than lime, it is surprising to find such a diligent use of juniper bast but of none of the others.

The bast strips of juniper are just as wide and even as those from lime bast and could hardly have been peeled from the usual type of shrubby juniper. It is tempting to surmise that it may have been a by-product from some other production, like the very strong poles made from straight-grown junipers, used for fences and similar structures, which were an export article. Also other products may have provided bast in addition to the main product. Rolf Meling of the Botanical Institute at the University of Bergen has personally informed me that his grandfather, living in the southernmost part of Norway, used to plait bow-nets from long straight shoots of juniper and before plaiting them he retted the shoots in water so that it was easier to peel off the bark. This was also, as we have seen above, a common method when peeling the bast layer from the bark of the lime tree twigs (Hanssen & Lundestad 1932, 380–88), also making the bast easier to handle.

For manufacture of withes and twig cordage the raw material was mainly taken from birch and willow with their straight-growing shoots, mostly birch shoots for the withes, and thin twigs for the other. Only willow was used for the production of the type II twig cordage. The rest of the cordage classes made from other materials (fig 2, 3) are rather poorly represented among the finds from Bryggen and clearly did not belong to the ordinary stock of cordage here. The main types were the withes, the twig cordage and first and foremost the bast cordage.

Altogether, the manufacture of the types of cordage found at Bryggen shows a great dependence on the resources provided by trees and shrubs native to the west coast of Norway, and it is possible that most of the raw materials and cordage were supplied from this area, together with the knowledge of how to treat these materials in order to make them usable in the production of cordage. The evidence from the Bryggen finds shows that, at least in the pre-Hanseatic phases, an extensive utilization of coarse materials producing correspondingly coarse types of cordage was found necessary and serviceable, in addition to a steady use of bast cordage. Pollen analysis has shown that the outer coastal islands and districts, including many of the districts close to Bergen, were rather treeless and barren due to human activities already long before the Middle Ages (Kaland 1971, 19), so that most of the supplies of cordage or of raw materials for cordage production must have been delivered from the inland districts and fjord areas. The lime tree, for instance, is today, and must also have been then, most abundant on the warmer lower mountain slopes along the fjords. Even simple items like withes

were still traded from the inland districts to the coastal areas in recent times (Høeg 1976a). It is possible that the knowledge about how to treat the different materials was mainly limited to the areas which provided the raw material. Moreover, many types had to be made from fresh raw material. Most of the cordage can therefore have been traded as finished products. On the other hand it is possible that the craftsman, the *bastari*, himself also liked to have control over the preparatory stages of the production, including the retting of the lime bast. About this we know nothing.

The total lack of hempen, flax and leather cordage among the Bryggen finds provokes the question whether the collection is fully representative of the cordage used at Bryggen and elsewhere in Norway in medieval times. Even the smallest fragments of leather refuse have survived well in the deposits at Bryggen and if such cordage had been commonly used there, we should certainly have found traces of it. Specially strong cordage from walrus hide was used for the hauling parts of the rigging of the traditional types of boats, just as they have been in traditional boats along the west coast nearly up to our own time (Brøgger & Shetelig 1950, 78, 1971, 76). The absence of leather cordage must mean that it was not commonly used in the activities at Bryggen itself, and the remains of boat-rigging were probably not thrown out along the front of the quays. The harbour regulations prohibited boats from staying at the quays longer than was required for loading and unloading and, when necessary, rigging must therefore have been repaired elsewhere.

In contrast to the good preservation conditions for wood and leather in the waterlogged deposits at Bryggen, it is quite clear that these same deposits were not suitable for the preservation of finer cellulose fibres like flax and hemp. Among the textiles there are, for instance, only a few minute pieces of charred linen fabric left. Hemp and hempen cordage were mentioned in literary sources form the Middle Ages, but we do not know for which purposes and to what degree this cordage was actually used. Nor is it known when the local manufacture of such cordage was started here. Hempen cordage was probably in the beginning regarded as a luxury. It is possible that it was used first of all for boat-tackle, for which the great strength of hempen cordage combined with its good flexibility must have been specially important. There are no indications in the early sources about this cordage being used for the early medieval types of Nordic boats. On the other hand, hempen cordage must have been of fundamental importance for the more complex tackle of the heavier vessels which were developed further south in the fourteenth century. Their introduction was somewhat delayed in Norway (Brøgger & Shetelig 1950, 284, 1971 238–39), and so possibly also any real need for hempen cordage.

It seems that the use of hemp as a raw material for cordage production became permanently established in Western Europe from about the fourteenth century, then mostly Russian hemp. In Scandinavia it made its appearance in about the fifteenth century, apparently coinciding with the introduction of the new boat types. It is probable that the Hanse controlled the import of hemp, as they did for the grain from the same regions (ie south-eastern Baltic), and that in the beginning it was imported in the form of finished products (Harris 1975, 32). The lack of hempen cordage among the finds from Bryggen cannot from these assumptions be regarded as a lacuna in the material, since this (and probably also leather cordage) would not normally be expected among the Bryggen finds. The conclusion must be that the types of cordage found at Bryggen are on the whole representative of what was used in that milieu in the pre-Hanseatic period.

Shortly before 1332 a new method for the construction of lime bast cordage, which here is called "untraditional", was introduced. It was used for cordage of greater dimensions, probably making it both more resistant to fraying and more flexible. At the same time the more primitive types of thick lime bast cordage disappeared from Bryggen. The introduction of the new method probably indicates a reaction to a growing competition from imported hempen cordage, even though traces of the latter have not been found at Bryggen. It is otherwise difficult to interpret the group of finds which were made in this new way. The quality of the bast and the spinning of the elements do not differ on the whole from the traditional types, with the possible exception of the whipped loop construction no. 7635 (fig 24d), which has a strikingly well-retted bast and unusually evenly spun elements. This find can best be interpreted as an import, both by reason of the quality and because it seems to be a part of a rigging system, and there is no traceable tradition for this in Norway. This new principle of construction may have been older in the homeland of lime bast production in the eastern Baltic, for example, and then was taken up and copied here. The whole group can, of course, be imported, but we should then have expected some parallel finds of thick lime bast cordage made in the traditional way. On the other hand, the "untraditional" constructions cannot be found in the later domestic production of Norway and Sweden, so for ordinary cordage production and use the type seems not to have been of interest.

Otherwise all the cordage types were made according to a simple but effective system known from the earliest records of the craft and still in use today. The strong dominance of S-twisting of the Stage I elements reflects the practical handling of the material for a right-handed person. This tradition was not broken when more effective working implements like the bigger reels or winches (fig 15b, c) were introduced, and the spinning direction probably became more optional, except when spinning with a wrapping strip, because this strip must be guided by the right hand (for a right-handed person). These reels seem to have been introduced from the eastern Baltic, initially for professional use (Nilson 1961, 74). They are a prerequisite for spinning elements with a wrapping strip (fig 15b), and from this feature they can be traced back at least to the middle of the twelfth century at Bryggen (the excavations have until now not been in contact with earlier levels). This feature can thus probably be interpreted as an indication of the presence of the craftsman, *bastari*, in the town from at least this time.

The mention of the *bastari* in Bergen in the Town Laws of 1276 is of a negative nature: he should *not* work in a special area. Otherwise the craft is not recorded. It is possible that the craft had a low status, since in the Eddic poem of Rigsþula it is mentioned as slaves' work. In later times the popular production of cordage seems mainly to have been associated with people with a low income from other sources. The craft did not require any great investment, in contrast to the much later hemp cordage industry.

Nothing is known about when the production of hempen cordage was started in Bergen. From later times we know that hemp fibres were considered difficult to handle for amateurs and preferably finished products were bought from the professionals. The small-scale production of the fibre in some rural areas seems mostly to have been used for textile purposes (Nilson 1961). There is no record of a real cordage industry in Bergen with ropewalks for spinning hemp with the great wheel until shortly before 1600 (Harris 1975, 33). This type of industry demanded great investments and was started by rich merchants with the aid of foreign craftsmen, mostly Dutch, because the Netherlands dominated the craft at this time. It seems that the industry soon assumed relatively great dimensions in Bergen, while there was apparently not a single ropewalk in Oslo, which must therefore have imported all the necessary cordage *(ibid)*. The number of great ropewalks varied, but in the middle of the eighteenth century there were at least seven such industries in the town at the same time, and in addition there

seems always to have been a small-scale production of hempen cordage outside the great industries *(ibid)*.

The finds do not throw much light on the customer's use of the different types of cordage found at Bryggen, nor on the way in which the trade was organized. The relatively high frequency of cordage made from coarse materials when compared with the finds from Haithabu may, as mentioned above, indicate a scarcity of better materials, or also a special need for strong cordage. Both the withes and the type I twig cordage can be seen as stronger than bast cordage. The twig cordage of type II, on the other hand, cannot have been as strong, in that the whole construction seems to be relatively weak. The wrapping strips of the Stage I elements seem here to have been worn away quite easily and the weak twist of the core material gave little cohesion. The find of one cord of this type used together with lime bast cords for mooring purposes may indicate a general similarity of use, and the type may therefore be interpreted as a poor substitute for lime bast cordage. The special construction can be seen as an attempt to imitate some of the qualities of lime bast cordage, as it makes it possible to use twigs for cordage of all the same thicknesses as bast cordage, and also renders the type more pliable than the type I twig cordage. The type is not described from other places or times, and the question whether this cordage was a local invention to meet a demand for cordage which was greater than the availability can only be answered through finds from other excavations at other places.

SUMMARY

Cordage fragments have been found in great numbers (n = 673) during the excavations at Bryggen, mostly in waterlogged deposits along the quay fronts and without any connection with their original use, except for some mooring cords. About 90% of the finds were found in the levels below the fire of 1332. The raw material has been identified for all the finds and a classification system has been worked out on the basis of raw material categories.

One find is made from asbestos and one from leather, all the rest from plant materials. All these are made from indigenous Nordic materials, mostly from trees and shrubs, with the single exception of a find made from coconut fibre, found in the fire interval 1332–1413. Cordage made from finer cellulose fibres like hemp has not been found.

There are six classes of cordage made from whole, unprocessed plant parts. The withes (n = 112) are mostly made from birch shoots. Twig cordage of type I (n = 35) is made from twisted bundles of willow or birch twigs, while twig cordage of type II (n = 56) is constructed from exceptionally fine willow twigs in bundles which have been spirally wrapped with split strips of coarser willow. There are five finds of heather cordage, four finds of plaited hair moss cordage, and only one tiny piece of grass cordage.

Then there are three classes of cordage made from special plant tissues. The coconut fibre cord belongs here, as well as three finds of cords made from finely split wood of pine and spruce, while the last class is the bast cordage (n = 455), 83% of which is made from lime bast, the rest from juniper bast. Oak bast or other types have not been found.

The description of the types of cordage is based on features of its construction, starting with the basic element, Stage I, and then the successive construction stages involving the plying together of the lower stage components. The different combinations

of raw material, the diameter of the elements of the different construction stages, and the amount of twist given to them have been subjected to a thorough study in order to understand the technical qualities of the finished cord and its possibilities for practical use. Such evaluations have also been compared with more recent traditions.

Bast cordage maintained a central position throughout all the phases at Bryggen, while the withes continually decreased in importance throughout the period. The twig cordage of both types seems, when compared with the other classes of cordage, to have met a special demand during the period 1170–1198, probably partly owing to a shortage of better raw materials. The twig cordage of type II was not a strong type of cordage, apparently constructed for flexibility rather than for strength, and it may possibly be seen as a substitute for lime bast cordage.

Shortly before 1332 we find the first examples of an innovation in the construction of lime bast cordage, which can be seen as a – for that time – modernized product in order to make the thicker lime bast constructions stronger and more flexible. Whether these finds were produced locally or represent imported products we cannot say, but if they are not part of a foreign tradition, then they may possibly be seen as invented in competition with another type of cordage, the stronger and more flexible hempen cordage.

This collection of finds is seen as representative of the cordage used at Bryggen in the pre-Hanseatic period. The main types were the withes, the twig cordage, and the bast cordage, the bast cordage being the most important. Most of the cordage types were probably brought to Bergen as finished products, though much bast cordage must have been made in Bergen by professional craftsmen. Hempen cordage may not have been taken into common use before the Hanseatic period, and then at first imported as finished products.

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Sound Tools and Music at Bryggen

BY KARI JOHNSEN

Sounds have always been part of the human environment – both natural sounds and sounds made by man himself. When trying to form an impression of our ancestors' life at Bryggen, this is an aspect we should not overlook.

But sound is a short-lived phenomenon. It exists at a moment in time and leaves no traces that can be studied at a later date. Retaining sound and preserving it for posterity has not been possible until our own century. Thus we cannot study the actual sounds of the past but have to draw our conclusions from other sources: finds of sound-producing objects, literary references, and iconographical evidence.

The Bryggen excavations have yielded a small group of finds that can be described as sound tools, ie objects made for the purpose of producing sounds. Some of them can be clearly defined as musical instruments, but there are also sound tools for other purposes than music. They are single finds, spread throughout the area, and their dates vary widely, from 1200 to 1700.

The group consists of the following objects:

I One jew's harp (mouth harp) (no. 56213)
II Seven fragments of ceramic horns (nos 87, 466, 510, 1325, 2165, 3408, 17393)
III One ceramic whistle in the shape of an animal (no. 95079)
IV One flute of vegetable material (no. 12778)
V Two bone flutes (nos 85768, 95075).

In addition to this, there are three artefacts which could be interpreted as tuning pegs (nos 17335, 55094 and 55628) and one possible bridge for a string instrument (no. 9171).

JEW'S HARP

The jew's harp from Bryggen (no. 56213) has a probable dating of about 1500. It is made of iron and has a rhomboid cross-section. Total length is 60 mm. The bow has a near-circular shape with an internal diameter of about 30 mm, thus taking up half the length of the instrument. The stang is missing but a remaining stub in the bow indicates its position. A slight unevenness in the length of the prongs is probably due to corrosion.

The jew's harps found so far in Norway are mainly from the last few hundred years, making the Bryggen specimen one of the oldest finds. The tradition is probably much older. A Danish collector of antiquities reported in 1643 that a jew's harp had been found in a burial urn near Mandal. The instrument has since been lost, but the circumstances of the find seem to show that it could have been buried before AD 1000.

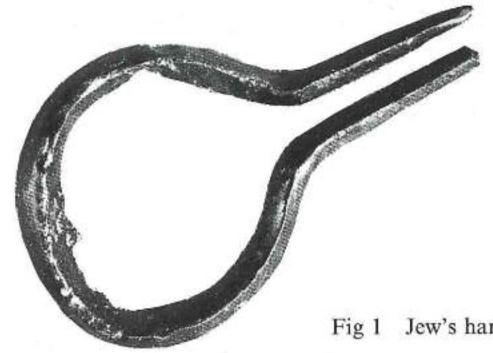

Fig 1 Jew's harp from c 1500. Length 60 mm.

However, as there are no other finds from such an early period, we do not know whether jew's harps were commonly known in Norway at the time (Sevåg 1973, 122).

Even if there are few medieval finds from our country, Swedish finds show that the instrument was well known in Scandinavia. About 60 medieval jew's harps have been found in Swedish towns, castles and monasteries (Reimers 1977, 1).

Medieval instruments usually had a relatively small bow and long prongs, judging from finds and pictorial evidence, but another type, more like the Bryggen instrument, emerges in Central Europe around 1500. It has a fairly big bow and short prongs. This seems to have become the most common European type and such instruments were produced in great numbers on the Continent.

A small group of these "Continental" jew's harps has been found in Norway. They are probably all imported. Local makers seem to have followed the medieval tradition of making instruments with small bows and long prongs (Sevåg 1973, 127).

CERAMIC HORNS

Seven fragments of ceramic horns have been found in various parts of the excavated area. Two of them (nos 510 and 466) found in Bugården Søndre could well be parts of the same instrument. They are made of pipe clay. Also from Bugården Søndre comes another fragment (no. 1325) of pipe clay. This fragment is interesting because it shows the mouthpiece of the instrument, whereas all the other finds are parts of tubes only.

A single pipe clay tube, with a part of another tube adhering to it (no. 17393), was found at some distance from the other pipe clay fragments but could be chronologically identical with them.

The three terra cotta fragments (nos 2165, 87 and 3408) are all smaller than the pipe clay fragments. Two of them are double tubes, one is part of a single tube.

The dating of the horn fragments is somewhat uncertain, but they are probably all within the period 1500–1600. Only one other Norwegian find is known: part of a horn found in Oslo. It is now in the Museum of National Antiquities (Universitetets Oldsaksamling). Its date is uncertain.

The ceramic horns were in all probability imported, most likely from the Rhine district. In literary sources these instruments are known as Aachen horns, pilgrims' horns or weather horns. All the terms refer directly to the use of the instruments. Pilgrims who flocked to holy shrines brought horns with them or bought them there,

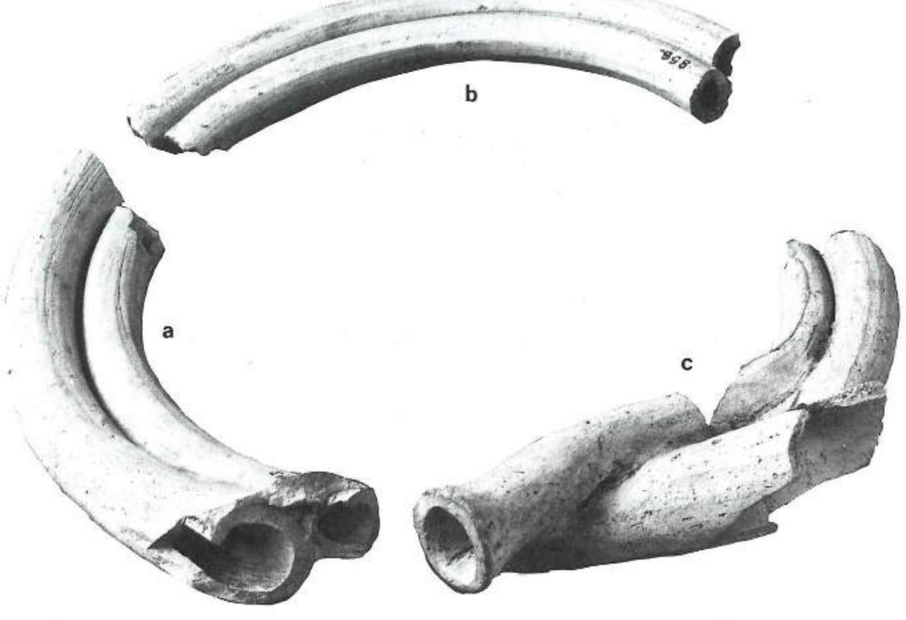

Fig 2 a–c. Fragments of ceramic horn of uncertain date – probably from between 1500–1600. a) 158 mm, b) 152 mm, c) 143 mm.

and these were sounded when the relics were taken out and shown to the crowd. In this way the pilgrims could express their joy and pay homage to the shrine. As this seems to have been especially common on pilgrimages to Aachen, the horns were sometimes known as Aachen horns. When used as "weather horns", the horns were sounded to frighten away demons who were thought to cause thunder (Svahnström 1984).

How the horns came to Bryggen is not known, but it seems likely that they were brought home by travellers, perhaps as "souvenirs" from pilgrimages in Europe.

CERAMIC WHISTLE

Another ceramic instrument is a little whistle shaped as a dog-like animal (no. 95079). Its original accession no. has been lost, but according to the find's list it was probably found in Bugården Søndre, in a context which may be associated with the building phase after the fire of 1476. The length is 95 mm, and it is covered with brownish-grey glazing. Three legs are broken off, leaving only the left foreleg. The whistle is sounded by blowing down the animal's tail which works as a duct-flute.

Whistles of this type have been common in Europe since the sixteenth century. Centres of production were the Rhine district and Silesia (Mårtensson 1970). The tail-blown instruments (with the amusing Danish name of *pib-i-røv-fløjter*) had no musical function. They were mainly used as toys.

Fig 3 Stone-ware whistle with brownish-grey glaze. From 17th century. Length 95 mm.

Could the Bryggen whistle have been a home-coming gift from a father who had been travelling abroad?

FLUTE OF VEGETABLE MATERIAL

Dating from not later than 1400 is a crudely made flute. The material is the stem of an umbelliferous plant, in all probability *Angelica sylvestris*. However, *Angelica archangelica* cannot be excluded (analysis made by K Krzywinski, Botanical Institute, The University of Bergen).

The flute (no. 12778) has a length of 230 mm. It has three holes near one end, two fingerholes on top, and a thumbhole at the back, placed between the two top holes. There is a fracture at the end of the thumbhole where the stem has been weakened by the cutting of the hole, but the pieces fit together perfectly.

It is not clear whether the find is the instrument in its original length, or if it has been broken or cut off and the end opposite to the fingerholes is missing. A joint in the stem near the middle may indicate that the original has been longer. When cutting a stem to get an open tube suitable for flute making, it would seem natural to cut between the joints, unless one wanted a longer tube than could be obtained this way. But on a plant of this kind it would not be unusual to have more than 230 mm between joints. It is also difficult to determine from the present state of the flute how the sound was actually produced. The explanation could be that part of the flute is missing.

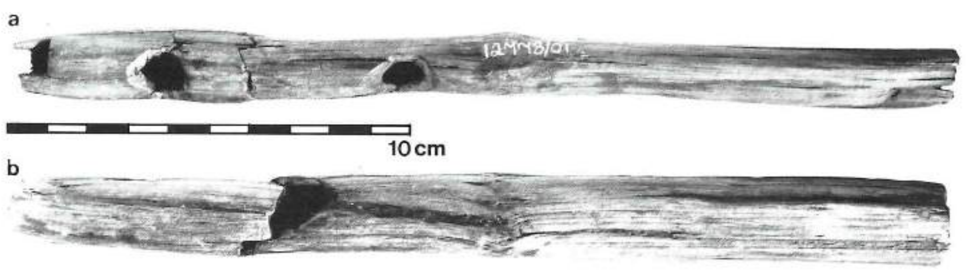

Fig 4 Flute of vegetable material probably from 14th century. Length 230 mm, a) from above, b) from beneath.

The making of flutes from plant stems has been a favourite summer pastime in many parts of the country up to the present day (Sevåg 1973, 73; Høeg 1976, 220). The primitive instruments were mostly made and used by children, more as toys than as musical instruments. The sound could be produced in various ways: the stems could be blown as trumpets, or as end-blown flutes, ie the air stream was blown across the end of the tube. The edge was usually bevelled to facilitate tone production. Block-and-duct flutes made from plant stems ar also known but do not seem to have been common. They were sometimes made when it was too late in the summer for making the more usual willow flutes (Sevåg 1973, 111). It is, however, rather tricky to fit a wooden block properly into a plant stem and would be particularly difficult for a child, but judging by the size of the fingerholes, the Bryggen flute must have been used by an adult.

Fingerholes are unusual on traditional plant-stem flutes but not unknown (Høeg 1976, 220). On the Bryggen specimen, the position of the three holes reminds one of the fingerholes on the medieval pipes played with the left hand while the player used his right hand to play an accompaniment on a tabor. Plant-stem flutes with fingerholes on the lower half of the tube are known from various parts of Eastern Europe, where they are still in use among shepherds (Emsheimer 1981). These flutes are played as tongue-and-duct flutes. As on block-and-duct flutes, the tone is produced by directing an air current against the lip of the flute through a narrow slit. On a tongue-and-duct flute, the slit is formed by the player, pushing his tongue into the opening at the end of the flute. If the Bryggen flute was originally played this way or as a block-and-duct flute, part of it must be missing.

BONE FLUTES

Two bone flutes are the oldest of the finds. The smaller one (no. 8768) dates from before 1250. It is made from the left tibia of a bird of the duck family, Anseriformes (analysis made by A K Hufthammer, Zoological Museum, The University of Bergen). The length is 91 mm. It has been played as a block-and-duct flute, the same principle as on our present-day recorders. The block is missing, which is the case on nearly all finds of this kind, as the block was made of a more perishable material than the flute itself: wood, wax or resin. The window, in the shape of a half-moon, is carved 15 mm from the widest end of the bone.

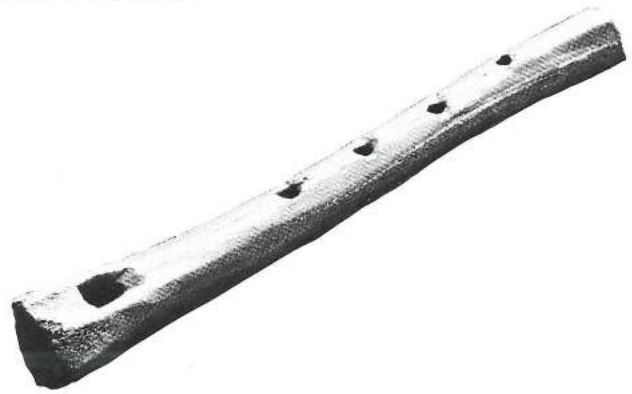

Fig 5 Bone flute from the first half of the 13th century. Length 91 mm.

The instrument has no fingerholes and will give only one note. Thus it can hardly be described as a musical instrument, but rather as a whistle, and it was probably used as a hunting-call. In Norwegian folk tradition, the use of bone whistles for this purpose is well known. The sound of the whistle was an imitation of bird or animal sounds, which were used to attract the animals when hunting.

From a musical point of view, the bone flute found under Bugården Nordre in 1957 is clearly the most interesting of the finds (no. 95075). It dates from the beginning of the fourteenth century and was found in an amazingly good state of preservation. Even the wooden block was intact and the flute was in playable condition, making it the oldest playable musical instrument found in this country.

The flute is 170 mm long, made from the tibia of a sheep or goat. The window is half-moon-shaped, and the flute has four fingerholes at approximately even intervals down the front. Holes 1 and 2 seem to be drilled out and then carved around the edges. Hole 3 is carved, but hole 4 is drilled and placed slightly to the left. A thumbhole is placed directly underneath the second fingerhole and seems to have been drilled in the same operation.

Shortly after the flute was found in 1957, it was taken to Reidar Sevåg at Norsk Folkemuseum, who examined it and explored its musical possibilities. As it has some cracks down the side, which opened up when the flute dried out, it had to be kept in water and played when still thoroughly wet.

Sevåg found an approximate C# to be the fundamental note of the instrument. Starting with all the holes covered and opening one by one, he got the following series of notes: C# – D – E – F# – A. By using cross-fingerings and overblowing, another six or seven notes could be produced.

To demonstrate the possibilities of the flute, Sevåg recorded two "medieval-sounding" tunes on a record (RCA-FEP 20) i the series Norsk Folkemusikk.

In connection with a recording of early music for the organisation "Håkonshallens Venner" in 1982, I was offered the opportunity to play the flute, which by that time had been varnished for conservation. The block had unfortunately been lost, and a newly made replacement had been put in. The instrument leaked rather badly from little cracks and holes. The worst of these were provisionally sealed but the flute was still rather hard-blown.

When trying out its tonal range, I found that D seemed to be the best sounding fundamental note. Opening the holes one by one gave the following: D – D# – F – G – A#, i e the same intervals as Sevåg's from 1957 but a semi-tone higher. The reason for this could be differences in our way of playing, or it could be due to changes in the flute's condition, necessitating a higher air-pressure.

By trying out the possibilities of more complex fingerings, I got the results shown below, compared with Sevåg's fingerings.

In the diagram, the holes are numbered 1–4 from the top. The thumbhole is designated with an 0. The sign means that a hole is opened, a number indicate a covered hole. A number with a line through it means that the hole is partly covered.

	Sevåg	Johnsen
C#	01234	
D	0123–	01234
D#	012~~3~~–	0123–
E	012—	012~~3~~–
F	01–34	012—
F#	01——	–1234

	Sevåg	Johnsen
G	0–23–	01——
G#	0–2—	–1——
A	0——	0–2—
A#		0——
B	01234 (overblown)	———
C		0–234 (overblown)
C#	0123–	0–23– (overblown)
D		0123– (overblown)
D#	012—	

The thumbhole is a puzzling feature of the flute. It does not seem to give added possibilities in the tonal range of the instrument. Sevåg found that nothing could be gained by using it that could not just as easily be managed by using the other holes. In my fingerings, I used it where the tone quality and pitch of a given note seemed to be improved by its use, compared with alternative fingerings.

Thumbholes are known on other European bone flutes finds, but far from all the flutes have them. In this classification system for block-and-duct flutes, Moeck (1969, 18) uses the position of the thumbhole as one of the classification criteria. His three categories are:

I Hochständig:	thumbhole above the first front fingerhole
II Gleichständig:	thumbhole behind the first front fingerhole
III Tiefständig:	thumbhole between the first and second front fingerhole.

With the thumbhole directly behind the second front fingerhole, the Bryggen flute does not fit into any of these categories. A possible explanation of the position of the hole could perhaps be that the maker of the flute copied some other instrument with a thumbhole, without knowing for which function it was intended. Another possibility could be a drilling "accident" in connection with the drilling of front hole 2, as this hole and the thumbhole seem to have been drilled in the same operation.

What remains is the qeustion of how the flute was actually used. In what circumstances was it played and what was its music? The flute itself provides us with some clues. It is a fairly primitive, home-made instrument with roughly made holes and it is not polished or decorated in any way. It is clearly not an instrument of a "professional" minstrel who travelled about and earned his living by playing in castles and courts. What we have here is the kind of flute that shepherds throughout the ages have made and played to pass the time while tending their flocks. Such flutes could also have been used at festive occasions, for entertainment and in providing music for dancing. For this purpose, it may have been used as a one-hand flute to the accompaniment of a drum. Bone flutes were sometimes played in this manner. Frederick Crane (1972, 29) notes that the majority of bone flutes found in Europe are playable with one hand and mural paintings from Swedish and Danish churches give evidence of flutes being used in this way in Scandinavia (M Müller 1974, 682). In the paintings the players, who are dressed as jesters, hold and play the flute with the left hand while beating a drum with the right. On the Bryggen flute, the bottom fingerhole (hole 4) is placed slightly to the left. Sevåg remarks in his notes that this position of the hole would suit the little finger of the left hand and could indicate that one-hand playing was intended. If the flute was really played this way, with the left hand only, the thumbhole could not have been used and the fingerings would have to be kept simple. Otherwise it would be impossible to hold and play the flute with one hand. But even if both hands were used, the Bryggen flute was probably an instrument used for playing simple tunes, perhaps made up by the player himself according to the tonal possibilities he found in his instrument.

The finds of musical instruments are too few to give us anything near a real picture of the musical side of life at Bryggen. It is also an unfortunate fact that the most important of all musical instruments, the human voice, is beyond the reach of music archaeology. We must therefore turn to other sources in trying to get a clearer picture of the role of music and minstrels over the centuries.

According to a sixteenth-century legend, music played its part in the life of the Bryggen area even before the town of Bergen came into existence. The following story of the town's foundation is told in Bergens Fundas, written about 1560. Some shepherds were tending sheep and goats near the bay of Vågen, when suddenly, among strange mumbling sounds, they heard all kinds of string and flute playing. They were very surprised and when they came home in the evening, they told their master what had happened. Upon hearing this, the master immediately prophesied that within a few years a mighty city would be built near Vågen. Some years later, in AD 1070, when great shoals of herring came into the harbour, the town was founded by King Olaf Kyrri ("the Quiet").

A busy trade centre, a residence for kings – medieval Bergen was a town that also provided opportunities for entertainers. Among the many travellers who came to the town were minstrels (ON *leikarar*) who were entertainers in a broad sense of the word: their acts could be a combination of music, juggling, story-telling, acrobatics, card tricks, etc. These kinds of travelling entertainers were known all over Europe under various names, such as minstrels, jongleurs or bufones.

According to the collection of Kings' sagas known as *Morkinskinna*, King Sigurd Haraldsson was entertained by minstrels when he was in Bergen about 1150 (*Morkinskinna* 1932, 446–47). King Sverri's Saga reports that in 1184 there was a quarrel between two minstrels and a skald who belonged to the court of Magnus Erlingson (Sverri's saga 1920, 91). The skald gave a description of them, mentioning the instruments they played: fiddle (*gigja*), flute (*pipa*) and a trumpet-type instrument (*trumba*).

The minstrels could be travellers, but there is also evidence of local minstresls connected with the courts. In *Konungs skuggsiá* (Speculum regale – King's mirror), which describes court life in Norway in the thirteenth century, minstrels are mentioned among the king's men. They were not constantly in the king's entourage but were among the men with special skills who could be called upon when the king needed them. In return, they were under his protection like other members of the court (*Konungs skuggsiá* 1983, 41).

Also in *Konungs skuggsiá* we find a description of table music during a meal at the seat of wisdom: "At my table one can hear stringed instruments with a sweet and lovely tone, there is poetry and songs one seldom hears, and there is all happiness and no sorrow" (*Konungs skuggsiá* 1983, 99). Evidently music played an important part in creating a happy atmosphere during an ideal meal. The description could be a reflection of such happy meals at the court of King Håkon Håkonsson, during whose reign *Konungs skuggsiá* was probably written. King Håkon, who reigned from 1217 to 1263, had close connections with England and the Continent and had translations made of French romances. Among these is a collection of French lais, short narrative poems which were recited at the courts of kings and other patrons in Western Europe, usually accompanied by string instruments. The lais were translated into Norse prose, but the translator knew the meaning of the word lai and informs his audience that "This book — may be called "Book of lais" *(Lioðabok)* because poets in Brittany – which is in France – composed lais (lioðsonga) from the stories told in this book (*Strengleikar* 1979, 4). He also gives a list of instruments commonly used for accompanying the lais. Among them are harps, fiddles, organs, psalteries "and all other kinds of string instruments that men make for their own and others's amusement in this life" (*Strengleikar* 1979, 4–6). The translation of the lais may have been carried out in or near Bergen (*Strengleikar* 1979, XXVI).

The early literary sources give us some glimpses of music connected with kings and courts, but there has certainly also been music-making and entertainment in the town itself, among town dwellers and visiting merchants. Travelling minstrels showed their acts wherever they found a market for their services.

The minstrels had a low social status in medieval society. Many of them were social outcasts. But their performances were enjoyed by high and low alike, and a town like Bergen must have presented many opportunities for them. For festivities, minstrels were hired: we hear that when King Håkon V was in Bergen in 1314 he banned the German fashions which were becoming popular. But for special occasions, for instance if a man was knighted or his wedding was celebrated, he could wear garments in the German fashion, but only if he gave them to the minstrels after the celebrations (D A Seip 1965, 463).

Other travelling musical performers were so-called goliards or vagantes. They were students and young men belonging to minor ecclesiastical orders who roamed all over Europe, singing Latin songs about love, spring, drinking and related subjects, moral and immoral.

There were no doubt also local performers, whose opportunities grew as the town expanded. Jan Ling says: "In connection with the growth of the Nordic towns, and especially the towns within the Hanseatic cultural sphere, the conditions for musicians changed in the Late Middle Ages. Social gatherings, weddings and other festivities gave these musicians the possibility of a regular income (J Ling 1967, 27).

As the music of minstrels and other medieval musicians was learned and played by ear, we know very little of the actual music played and sung. One local piece of music has survived: a song written in Latin for the royal wedding of Margaret of Scotland and King Eirik Magnusson, celebrated in King Håkon's Hall in 1281. The song is the oldest piece of Norwegian secular music to survive in manuscript form. It must have been written by a member of the clergy, who would be the only kind of person to have the necessary education both in Latin and in music. Musical notation was used within the church, and liturgical music from Bergen has been found. But it is not known whether the surviving manuscript of the wedding song was written in Bergen or perhaps in the Orkneys. There is, however, reason to believe that it has belonged to Arne Sigurdsson, bishop of Bergen 1305–14 (Kolsrud & Reiss 1913, 33).

A piece of wood with runic inscriptions found in the Gullskoen tenement and dating from about 1300 also gives a glimpse of medieval music making. The inscriptions contain fragments of two love songs which are also known from a thirteenth-century manuscript from the monastery at Benedictbeuern in Bavaria, containing the collection of goliard songs which was published in 1847 under the title "Carmina Burana". The verses must have been carved by somebody who was familiar with both the Latin language and Nordic runes. We know that several young clerics from Bergen studied in England and France during the period (Liestøl 1980, 8), and as such songs were well known in academic circles in both countries, they may have been brought home by somebody who had studied abroad.

The Hanseatic community had its own rules and rites. In early summer, the so-called "games" were played: inauguration ceremonies for young merchant apprentices coming from Hanseatic towns to work at Bryggen. The season of the games was also a season of festivities. Before the actual games started, there were excursions into the woods, accompanied by pipes and drums, to collect greenery for decorations and branches for the flogging which was a common feature of the games. A festive meal followed, with plenty of food and drink for everybody. The apprentices were then led in a procession to where the games were to take place, again accompanied by pipes and drums (Edvardsen 1951, 403). The drums used for these occasions belonged to each tenement: they were among the joint property kept in the master's chest (Koren-Wiberg 1899, 32).

We are told that during the flogging, trumpets and drums were played to drown the victims' pitiful wailing and screaming. The chronicler remarks that this resulted in a lively kind of music "which must surely be very pleasing to the devil" (Edvardsen, 1951, 403).

The games were regarded as a kind of entertainment, and visitors were taken to see them. Perhaps the most prominent spectator was King Christian IV who was thus entertained on his visit to Bergen in 1599, according to the diary of his travelling companion Sivert Grubbe (Rørdam 1873).

A more "civilized" kind of entertainment were the theatre performances given occasionally by merchants and apprentices. Both comedies and tragedies were played. They were rehearsed during the winter, when trade was slack. Musicians from the town were hired to assist at the performances (Koren-Wiberg 1939, 42).

Musicians were also called in for other festive occasions (Koren-Wiberg 1939, 30). There were celebrations at Christmas, New Year and Twelfth Night, at Shrovetide and Martinmas. Merchants and their assistants gave parties on special occasions: when they were promoted, for visitors from abroad, and there were farewell parties for those who left the community at Bryggen. Apart from this, the young apprentices and assistants were allowed to have two dances every winter with expenses paid by their masters.

Music was always part of the festivities: singing, dancing and playing of instruments. And this has been the true role of music at Bryggen: to enhance the joyful occasions, to create pleasant diversions from the toil of everyday routine, thereby enriching the lives of all those who lived and worked there throughout the centuries.

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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.

In this volume Knut Krzywinski and Eli-Christine Soltvedt demonstrate the existence of a medieval brewery at Bryggen on the basis of grain recovered from successive fire layers on the same property. Proof of brewing has also been shown by the presence of various plants used for flavouring. Ellen Schjølberg's study on cordage products and production processes is an extensive investigation into a group of finds which has seldom found a place in archaeological literature. While Krzywinski's and Schjølberg's articles illustrate major occupations, Kari Johnsen's is an important contribution to our otherwise limited acquaintance with the musical instruments of the Medieval period.

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