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On the dating and function of the Comb Ceramics from Maarinkunnas

Abstract

This article deals with the relationships of two Neolithic pottery styles, Typical Comb Ware (Ka II) and Late Comb Ware (Ka III), from the 1997 excavation of the Vantaa Maarinkunnas site, southern Finland, with a special focus on the chronological, typological, and functional aspects of the pottery. In addition to analyses of typology and horizontal and vertical stratigraphy, radiocarbon dates of the organic crust and birch bark pitch on certain vessels are used to study the chronology of Comb Ceramics at Maarinkunnas. Lipid analyses of the crust, which is usually assumed to consist of ancient food remains, provide new information about possible uses of Comb Ceramic pottery.

1. Introduction and Research History

The 1997 excavation at the Maarinkunnas site in Vantaa yielded a large amount (c. 180 kg/ 115 857 sherds) of Comb Ceramic pottery that can be coarsely divided into two typological categories, Typical Comb Ware and Late Comb Ware. In addition, some Late Stone Age Asbestos Ware, some Corded Ware, and a few sherds that may possibly be classified as Early Comb Ware were included in the assemblage.

Comb Ceramics have been studied or touched on in various contexts by several Finnish archaeologists, only a few of whom will be mentioned here. The first scholar to write about the Stone Age and about Comb Ware was Julius Ailio. His two-volume book from 1909, *Die steinzeitlichen Wohnplatzfunde in Finland I–II*, provides a review of the Stone Age pottery finds known at the time. Sakari Pälsi's doctoral dissertation, *Riukjärven ja Piiskunsalmen kivikautiset asuinpaikat Kaukolassa* (1920), deals with a pair of occupation sites in Karelia and examines the decoration styles of the pottery. The most significant Comb Ware scholar, however, was Aarne Äyräpää (Europaeus). His 1930 publication *Die relative Chronologie der steinzeitlichen Keramik in Finnland I & II*, in particular, has become a cornerstone of pottery research. It introduces a style division and an outline of the style characteristics of Comb Ware, the main features of which are still valid today, and presents a relative Comb Ware chronology based on the elevations of occupation sites above sea level. In his later study, *Den yngre stenålderns kronologi i Finland och Sverige* (1956), Äyräpää expanded his pottery chronology.

Three master's theses dealing with Comb Ware typology also bear mention. In his 1978 study *Kymin Niskasuon keramiikkalöydöt*, Jyri Kokkonen used numerical

taxonomy to classify the Typical and Late Comb Ware of the Niskasuo occupation site in Kymi. Anne Vikkula's thesis *Vantaan Maarinkunnas-Stenkulla – tutkimuksia Uskela-keramiikan alalta* (1981) focuses particularly on Late Comb Ware. The most recent treatise of the subject is probably Minna Hautio's *Kampakeraamisen ilmaisun sosiaaliantropologinen tulkinta* (1998a). It concentrates on the relationship between the Jäkärlä group and the rest of Comb Ceramics. The problems concerning the Jäkärlä group have previously been extensively discussed by Torsten Edgren (1966) and Henrik Asplund (1995, 1998).

Other studies include Torsten Edgren's 1982 paper *Formgivning och funktion – en kamkeramisk studie*, which discusses the shape, decoration, and manufacture of Comb Ceramic vessels. Pottery manufacture, function, and chronology were also examined by Milton Nuñez in his 1990 paper *On Subneolithic Pottery and its adoption in late Mesolithic Finland*. C. F. Meinander discussed the dating of Typical Comb Ware in the Lake Saimaa region in his 1948 paper *Vehmersalmen Roikanmäen kivikautinen asuinpaikka*. His paper *Radiokarbondateringar till Finlands stenålder* (1971) also addressed questions pertaining to the chronology of Stone Age pottery. Oili Räihälä's paper *A Comb Ware House in Outokumpu Sätös – Some remarks on the application of ceramic typologies* deals, among other things, with problems of Comb Ceramic dating and typology. Comb Ceramic chronology is also discussed in the studies of shore displacement chronology by Ari Siiriäinen (*e.g.*, 1974, 1978, 1982) and Milton Nuñez (1978), among others.

Former research, especially, used to regard styles of pottery decoration as distinct chronological units (*e.g.*, Europaeus-Äyräpää 1930 and Äyräpää 1956; Luho 1948 and 1955; Meinander 1948 and 1971; Rauhala 1977; Huurre 1979). For example, the Typical Comb Ware style phase Ka II:1 was considered older than style phase Ka II:2. The assumption was that Comb Ceramics formed an evolutionary sequence. The Early Comb Ware phase was seen as a period of familiarization with pottery manufacture and learning to master it. It was followed by an upward trend that climaxed in the so-called Apex Style of Typical Comb Ware. Subsequently, the skill was for some reason lost, and a period of decline ensued, represented by the shift from Ka II:2 to the Late Comb Ware style phase Ka III:1 (*i.e.*, Uskela Ware), which has even been called the degenerate style. As far as I am aware, no-one has to date come up with a concrete reason for the "rusting" of pottery manufacturing skills. It has merely been generally supposed that the arrival of the Corded Ware Culture caused a steep decline in the Comb Ceramic Culture (Edgren 1984: 87; also Salo 1997: 45–46).

More recent research questions the *distinct* chronological division between the Comb Ceramic styles. As regards the Jäkärlä group, its contemporaneity with Typical Comb Ware was noted already by Äyräpää (Europaeus-Äyräpää 1930: 178–179). Jyri Kokkonen found in his studies of the Kymi Niskasuo pottery (1978: 75) that no consistent chronological difference could be established at least between the Typical Comb Ware subgroups Ka II:1 and Ka II:2. According to Oili Räihälä (1996: 116), at Outokumpu Sätös the pottery styles Ka II:2 and Ka III are practically contemporaneous. The Typical Comb Ware subgroups Ka II:1 and Ka II:2 have often been treated as a single style in studies concerned with Comb Ceramic chronology (*e.g.*, Siiriäinen 1974; Nuñez 1978). Recent radiocarbon dates

of pottery from Maarinkunnas indicate some chronological distinction between Typical and Late Comb Ware, but at the same time a few of the Late Comb Ware dates (Table 5) appear to be slightly older than the Ka II dates. What could be the meaning of these dates?

Answers to this question can be sought in the problems encountered in pottery classification. The style division of Äyräpää may no longer be totally relevant or precise enough, since its traditional classification system, which is based on pilot type examples, leads to averaging out the features and feature combinations characteristic of a certain class (Kokkonen 1982: 8–9; Hautio 1998a: 25). This results in difficulties in – if not even the impossibility of – classification: a particular sherd may be assignable to two or even more classes. Thus, pieces of pottery may be given "wrong" style designations, and the error is repeated in chronological studies.

On the other hand, it is possible that the different ceramic styles really were contemporaneous. If that is the case, the answer to the question may lie, for example, in the social and/or cultural environment of the pottery manufacturers and users, and a variety of explanations are possible. Situations like this have often led to contemplating the ties between pottery styles and ethnicity (*e.g.*, Edgren 1966; Asplund 1995 and 1998) or explaining the existence of ceramic subtypes from the point of view of group identity (*e.g.*, Hautio 1998a). Variations in decoration can also be seen to display subgroup identity – for example, it is possible that a certain type of decoration is the "property" of an individual or a family in the community. According to C. F. Meinander, the pottery assemblage from Vehmersalmi Roikanmäki includes two distinct groups of sherds belonging to the same general Ka II:1 style, suggesting the existence of two households, each with a slightly different pottery decoration design (Meinander 1948: 30–31). In addition to the socio- and ideotechnic functions, pottery also has its technomic, or practical, function (Binford 1962; see also Hautio 1998b: 12). It is possible that contemporary vessels of different styles have served different functions. Some kinds of vessels may, for example, have been better suited for food storage, while others may have served better in the preparation of foods or beverages.

The aim of this paper is to examine the Maarinkunnas pottery, especially the relationship between its typology and the radiocarbon dates from the crust and birch bark pitch adhering to the pot sherds, and to examine the possible practical functions, both of pottery in general and of particular pottery styles. The study also makes use of lipid analyses of the crust.

2. The stone age occupation site at Maarinkunnas and its comb ceramic assemblage

2.1 The location and topography of the site

The Maarinkunnas site lies on a gentle westward slope on the eastern shore of the Keravanjoki River, in the suburb of Hakkila, eastern Vantaa (Fig. 1). The site area continues north of Tikkurilantie (former Kuriiritie) road, where it is called Stenkul-

Fig. 1. View across the River Keravanjoki towards Maarinkunnas. The occupation site lies in the middle of the picture; the 1997 excavation areas were located behind the woods. *Photo: National Board of Antiquities/ Sirpa Leskinen 1997.*

la. The area formerly formed a part of the fields and gardens of Stenkulla manor and has been under cultivation for a long time. The slopes and terraces of former coastlines have consequently been obliterated. The lower elevation limit of the occupation site is c. 21 m, while the upper limit is around 25–26 m above sea level (Fig. 2). Due to various building projects, archaeological excavations have been carried out in the area by the National Board of Antiquities in 1976 and 1979 (Lea Väkeväinen), 1996 (Kaarlo Katiskoski), and 1997 (Sirpa Leskinen).

In 1997 an extensive excavation was carried out at Maarinkunnas because of a plan to build apartment houses in the area[1]. The affected lot covered an area of 4412 m^2, 570 m^2 of which were excavated. A thick layer of garden soil covered the excavation area, but under the soil a cultural layer was discovered, ranging in thickness from a few centimetres to 50–100 cm. Few features were present: in addition to some pits with stained and sooty sand, only a small hearth was uncovered in the upper part of the site. A radiocarbon date (Hela-238 5110±75 BP, uncalib.) places the hearth within the time of Typical Comb Ware (Table 5).

The excavation yielded a large collection of finds[2] that includes clay idols and their fragments, amber pendants and buttons, flint, quartz and slate implements (adzes, claw-edged "adzes", whetstones, scrapers, arrowheads, line sinkers, etc.),

[1] The excavation report is kept in the archive of the National Board of Antiquities, Department of Archaeology.

[2] The finds have been catalogued under the main number NM 30464; only the sub-numbers will be used in the text below.

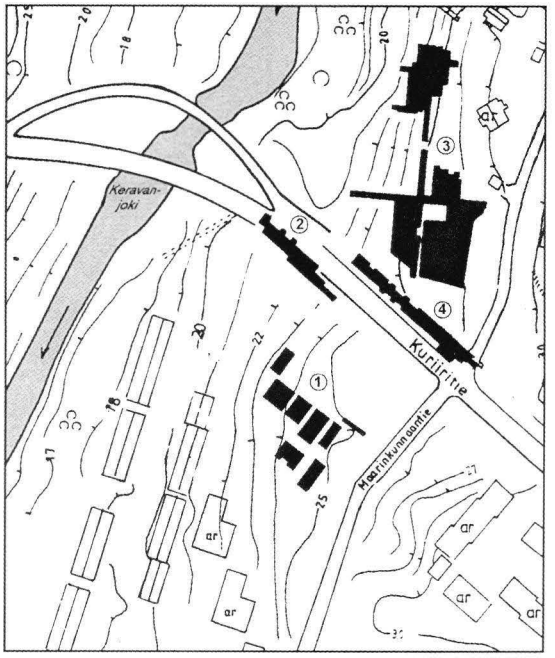

Fig. 2. General map of Maarinkunnas-Stenkulla area. Excavations: 1) Maarinkunnas 1997, 2) Maarinkunnas 1976, 3) Stenkulla 1996, 4) Stenkulla 1979. Excavation areas in 1997 covered about 13% of the area that was to be destroyed by building activities.

burnt bone, including a few bone implements, and charred nut shells. The majority of the assemblage, however, consists of pottery, which comprises 82% of the finds by numbers, and 79% by weight.

2.2 Classification of the material

The pottery discovered in the earlier excavations of Maarinkunnas – excluding the Corded Ware and the Asbestos Ware – has been identified as Typical Comb Ware and Uskela Ware by Vikkula (1981). In the present study the pottery has been classified according to Aarne Äyräpää's (1930) system complemented by subsequent research results (Kokkonen 1978; Vikkula 1981; Hautio 1998a, among others). The decoration elements and their combinations on the pot sherds have been used to designate the sherds as Äyräpää's styles Ka II:1, Ka II:2 and Ka III:1, even though Äyräpää's imprecise and descriptive system based on pilot type examples has sometimes been difficult to follow (*cf.* Räihälä 1996: 99, 103–104).

The 1997 assemblage from Maarinkunnas includes a total of 115 930 pot sherds. This study excludes, in addition to the Corded Ware and the Asbestos Ware, the undecorated body sherds of Comb Ceramic vessels[3], leaving 26 069 sherds as the primary research material. It has been customary in pottery studies to include only

[3] A few sherds (:913, :8465) resemble Early Comb Ware and have also been excluded from the analysis.

decorated rim sherds (Kokkonen 1978: 26–29; Vikkula 1981: 12), and occasionally also large decorated body sherds that can be assigned to the same vessels as one or several of the rim sherds (Rauhala 1977: 21). To ensure the representativeness of the material, the present study includes all decorated body sherds – in spite of the fact that a large number of these were unclassifiable due to the small size of the fragments.

A total of 14 152 pot sherds, or 54.3% of the primary material, have been given style designations (Table 1), leaving slightly less than half unclassified due to small size and/or lack of decoration elements (unidentified). Among the identified pot sherds, 1732 (12.2%) are from the vessel rim, while 12 408 (87.7%) are body sherds, and 14 (0.1%) are base sherds.

2.2.1 The Comb Ceramics from Maarinkunnas

Pottery decoration consists of three levels: the decoration elements, the motifs, and the composition (*e.g.*, Hautio 1998a: 19–20; Kokkonen 1978: 35). The clearest example of a decoration element is the presence or absence of a comb imprint. According to Anne Vikkula's definition, the presence of a comb imprint defines a sherd as Typical Comb Ware, whereas Late Comb Ware lacks comb imprints altogether (Vikkula 1981: 2 and 47). The presence of a pit, on the other hand, is not necessarily sufficient for classification (*cf.* Hautio 1998a: 29) – at least if the sherd is very small. The classification of larger sherds is more reliable, since they often retain at least part of the composition of the decoration. Classifying small sherds of Ka III is problematic, while the decoration elements of Ka II:1 are often so close together that even small sherds contain fragments of comb imprints. This may lead to an overrepresentation of Typical Comb Ware in the classified collection. In the Maarinkunnas assemblage, 9942 sherds have been classified as Typical Comb Ware, and 3847 as Late Comb Ware (Table 1.)

The most common and, indeed, practically exclusive, decoration elements on sherds classified as Typical Comb Ware are comb imprints and pits. In Ka II:1 vessels, in particular, comb imprints form horizontal bands where the imprints slant towards the right. The comb imprint motifs usually alternate with horizontal chains of round pits of equal size (Europaeus-Äyräpää 1930: 179–183). The Ka II:1 style is fairly easy to recognize, while Ka II:2 is more difficult. The most diagnostic feature of the latter are lozenge shaped, usually unbordered patterns composed of comb imprints, which occur as part of a sparse decoration (*cf.* Edgren 1984: 36). In addition, the comb imprints are usually more narrow and shallow than in style Ka II:1 (Europaeus-Äyräpää 1930: 183). The pits in Ka II:2 are either round, slightly elongated, or rectangular – sometimes they even resemble key holes (Ailio 1909, T18, f.1 and 4; Edgren 1984: 36). The rim of Typical Comb Ware vessels is usually thickened and the edge slopes inwards (Europaeus-Äyräpää 1930: 179). The top of the rim is decorated with comb imprints (*ibid.*), or occasionally with drawn lines.

In Uskela Ware, the most common decoration elements are pits and small shallow depressions, while comb imprints are completely absent (Rauhala 1977: 39;

Table 1. The Comb Ware styles in Maarinkunnas.

Style	*Temper*			*Total*	*%*
	sand/crushed stone	*organic*	**) other*		*(of identified potsherds)*
Ka II:1	304	41	6	351	2,5
Ka II:2	284	768	6	1058	7,5
Ka II undefined	6927	1477	129	8533	60,3
Ka II total	7515	2286	141	9942	70,3
Ka II/III	333	30	0	363	2,5
Ka III:1	991	2803	53	3847	27,2
identified total	8839	5119	194	14152	100,0
unidentified	8168	3359	390	11917	
Comb Ware total	17007	8478	584	26069	

*) includes unidentified temper and non-tempered ceramics

Vikkula 1981: 47). Pits occur in different sizes, and usually form bands that constitute decoration motifs. Vessel decoration may consist of pits exclusively, or the pits may be augmented by other decoration elements, the most common of which are arc shaped imprints or finger nail imprints (Europaeus 1915: 3; Europaeus-Äyräpää 1930: 186–187). Rows of finger nail imprints and arc shaped imprints often form bands that alternate with the pit motifs. Occasionally, the imprints form diagonal rows along the vessel surface. In most cases, the rims of KA III vessels are straight, with the rim edge flat or rounded. A couple of sherds from Maarinkunnas (:9534, :9714, both from the same vessel) display a rim that expands outwards.

No attempt has been made to distinguish potential sherds of style Ka III:2 (the Sipilänhaka style) among the pottery from Maarinkunnas because this style is conceptually unclear (*cf.* Vikkula 1981: 1). Since its diagnostic features have not been clearly defined in any publication dealing with pottery, classifying pot sherds as Ka III:2 is practically impossible[4]. A few of the Late Comb Ware sherds from Maarinkunnas (*e.g.*, :10184, :13807, :14025, :16160), however, might represent Sipilänhaka Ware, since their decoration consists exclusively of small pits and shallow depressions.

[4] The literature states briefly that large pits no longer exist in Ka III:2, and that the decoration consists of small round or oval, often dot-like pits (Europaeus-Äyräpää 1930: 187). The vessels are also said to be smaller than before (Edgren 1984: 36).

It is common in the study of pottery styles to encounter sherds that cannot be unequivocally assigned to any known and defined category. Sherds falling in the middle ground between the defined Typical Comb Ware and Uskela Ware, for example, have been called "contact period style," or "ad-style" (Vikkula 1981: 49–51; Hautio 1998a: 21). These terms imply a chronological continuum – the styles are assumed to form a typological series. In principle, however, the differences between styles may as well be functional or geographical, not chronological, and pottery combining elements from two coexisting, contemporaneous styles may exist. Sherds that combine features from both Typical Comb Ware and Late Comb Ware have here been labelled Ka II/III. The dominant decoration element in these sherds is the pit, but they also display groups of line or finger nail imprints that form horizontal bands the same way as comb imprints in Ka II do, or diagonal bands across the vessel surface. Another element is a comb imprint-like imprint consisting of individual short lines in a row. Occasionally, there is a horizontal groove below the rim, with pits impressed into it[5]. The rim is often thickened, with line decoration on top.

The great majority (60,3%) of the classified sherds have only been identified to the major style level as Ka II (Table 1, undefined). Only 2.5% (351 sherds) have been identified as Ka II:1 and 7.5% (1058 sherds) as Ka II:2. Uskela Ware forms 27.2% (3847 sherds) of the identified pottery. According to Pirjo Rauhala, in Liljendal Kvarnbacken the percentage of pottery identified as Uskela Ware was smaller than the true share of the style, because its typically sparse decoration made the classification of small sherds difficult or impossible. Rauhala thought that much of the unclassified pottery from Kvarnbacken was probably Uskela Ware. (Rauhala 1977:39.). The same may be true of Maarinkunnas. There are 363 sherds classified as Ka II/III in Maarinkunnas, equivalent to 2.5% of the whole identified pottery assemblage (Table 1).

2.2.2 Pottery temper

Both Äyräpää and several subsequent researchers (*e.g.*, Kokkonen 1978; Lavento 1992) have considered temper one of the style attributes when classifying pottery. Here, however, the classification is based strictly on features of decoration. This is due to the fact that preliminary investigation did not suggest a systematic tie between decoration style and kinds of temper. A number of other studies (*e.g.*, Rauhala 1977: 40; Vikkula 1981: 64–65; Pesonen 1996: 31; Hautio 1998a: 102–104) have also concluded that temper may have been a technical feature or a local phenomenon rather than an attribute characteristic to a particular pottery style. For an examination of the relationships between pottery styles and tempers to be possible, it is necessary to exclude temper from the style criteria.

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[5] A line of pits pressed in a horizontal groove next to the rim is sometimes considered a Ka III:1 feature (Europaeus-Äyräpää 1930: 185, Abb. 64; Edgren 1966: 74), although it also exists in Ka II:2 (Europaeus-Äyräpää 1930: 183–184; Kokkonen 1978: 8). Anne Vikkula considers this feature typical of the contact period style ad-Uskela (Vikkula 1981: 49).

The tempers of the pot sherds have been registered along with the examination of the decoration style. Three kinds of temper have been distinguished: 1) sand or crushed stone temper, 2) organic temper, and 3) other (untempered pottery or unidentified temper, among others). Pottery with organic temper is porous, since the organic material has usually dissolved, leaving only the voids where the plant fragments or calcareous material (limestone, bone, sea shell) used to be. The degree of dissolution varies even between the sherds of one vessel. This may be due to variations in the matrix in which the pottery has been deposited, in particular the amount of calcareous material within it (Hautio 1998a: 41 with ref.). The organic temper in the pottery from Maarinkunnas is probably burnt and crushed bone (Vikkula 1981: 15), which can still be seen in some sherds. The assemblage includes 17 007 potsherds tempered with sand or crushed stone, which constitute 65.7% of the whole material (Table 1). Organic temper is more scarce: it has been observed in 8478 sherds, comprising 32.5% of all of the Comb Ceramics from the site.

The clay fabric of Late Comb Ware has been described as porous (*e.g.*, Europaeus-Äyräpää 1930: 183; Edgren 1984: 36). Nevertheless, the Uskela Ware from, *e.g.*, Liljendal Kvarnbacken is usually tempered with sand or feldspar (Rauhala 1977: 40). Anne Vikkula (1981: 48) has made the same observation concerning the Uskela Ware from Maarinkunnas and Stenkulla. According to Pirjo Rauhala, the clay fabric is probably not a significant style criterion (Rauhala 1977: 40).

The assemblage studied here, nevertheless, shows some positive correlation between pottery styles and tempers (Table 2). The Maarinkunnas Typical Comb Ware is usually tempered with crushed stone or sand (75.6%), while the temper in Late Comb Ware is more commonly organic (72.9%). About a quarter of the Typical Comb Ware sherds, however, display evidence of organic temper, and a similar proportion of the Late Comb Ware sherds have been tempered with sand or crushed stone. There is a clear distinction between styles Ka II:1 and Ka II:2: the former is tempered predominantly with sand or crushed stone (86.6%), while the latter usually has an organic temper (72.6%). The pottery designated Ka II/III is most commonly tempered with sand or crushed stone (91.8%).

Anne Vikkula (1981: 64–65) considered temper and the consequent clay fabric technical features that cannot be regarded as, *e.g.*, style criteria. She also stated that local variation that depends on regional conditions occurs in the middle ground between the defined pottery styles. In other words, the choice of temper may have been influenced simply by the availability of materials. The choice is in some measure also tradition bound (Hautio 1998a: 103 with references). Although there is a degree of coincidence between the distinct pottery styles and temper materials in the Maarinkunnas assemblage, temper *cannot* be considered a style criterion, since up to $^{1}/_{4}$ of the sherds of a particular style depart from the norm. Possible reasons for the variation in tempers within pottery styles will not be examined further here. Temper, nevertheless, may have been significant, *e.g.*, for the functions of the vessels.

Table 2. The percentage of different tempers in Comb Ware styles.

Style	*Amount of potsherds*	*Temper %*			*Total %*
		sand/crushed stone	*organic*	**) other*	
Ka II:1	351	86,6	11,7	1,7	100,0
Ka II:2	1058	26,8	72,6	0,6	100,0
Ka total	9942	75,6	23,0	1,4	100,0
Ka II/III	363	91,8	8,2	0,0	100,0
Ka III:1	3847	25,7	72,9	1,4	100,0
Comb Ware total	26069	65,2	32,5	2,3	100,0

*) includes unidentified temper and non-tempered ceramics

3. Intra-site pottery distributions

Intra-site pottery distributions may sometimes give clues to the chronology of ceramic styles – provided that clear spatial trends can be observed in the various styles of pottery. The differences in the distributions of the different styles may be horizontal, with the older material in the section of the site that is at a higher elevation above sea level and the younger material lower. The interpretation of these kinds of distributions is based on the assumption that the settlement has been bound to the shoreline. It is also possible to study the distributions on the basis of the basic rule of vertical stratification, according to which older material should be found towards the bottom and younger material towards the top, if the stratification has not been disturbed.

3.1 Horizontal distributions

A preliminary analysis, presented in the excavation report, showed a slight tendency of the two main pottery styles, Typical Comb Ware and Late Comb Ware, to concentrate in different excavation areas and, thus, on different elevations within the site. The distribution plans in the report included the finds from the garden soil, which were not in their original positions or even close to them. A more reliable picture emerges when the garden soil is excluded and only the distributions from spit 1 down are examined.

The distribution plans in Figure 3 and Figure 4 show Typical Comb Ware and Late Comb Ware in the same areas, *i.e.*, their occurrences seem to be fairly mixed at the Maarinkunnas site. No distinct differences can be detected between the distributions of the Typical Comb Ware styles Ka II:1 and Ka II:2, or, for that

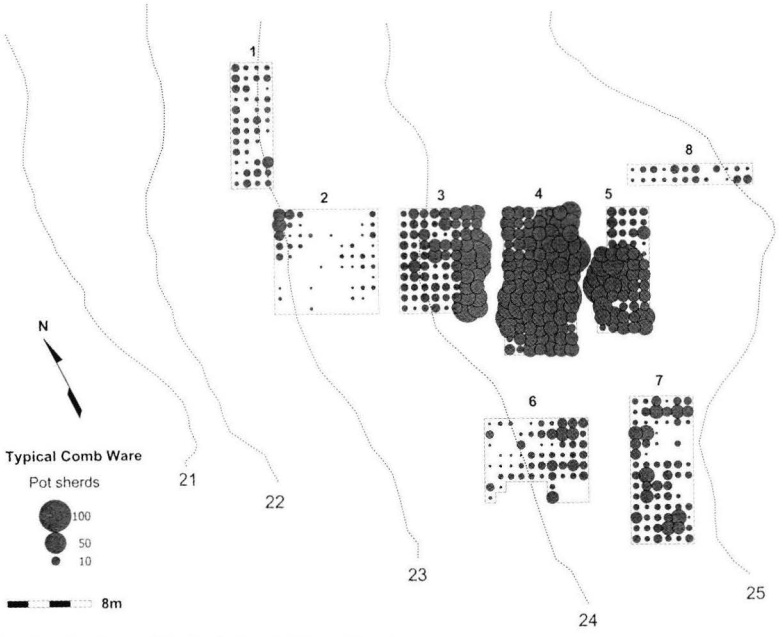

Fig. 3. The distribution of Typical Comb Ware (Ka II). *Map: Petro Pesonen.*

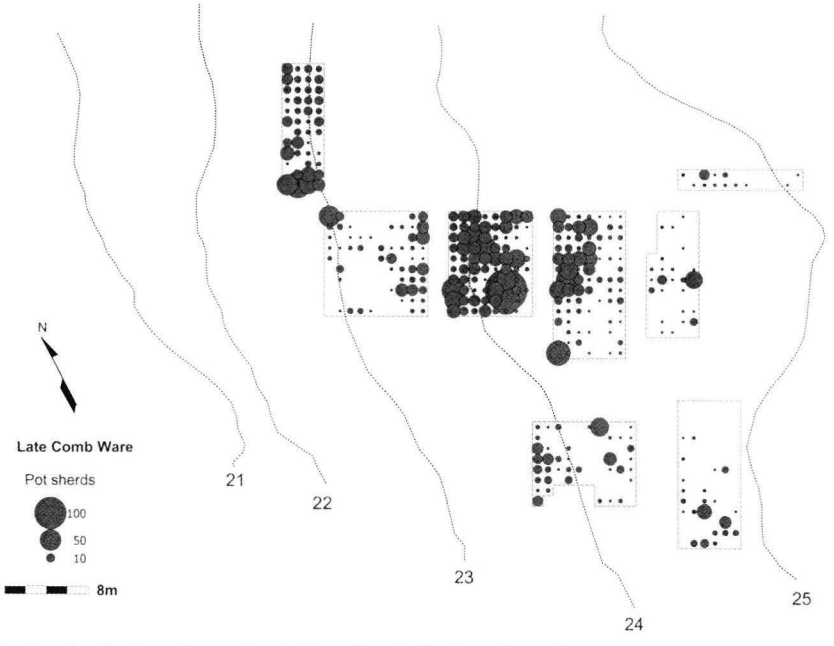

Fig. 4. The distribution of Late Comb Ware (Ka III:1). *Map: Petro Pesonen.*

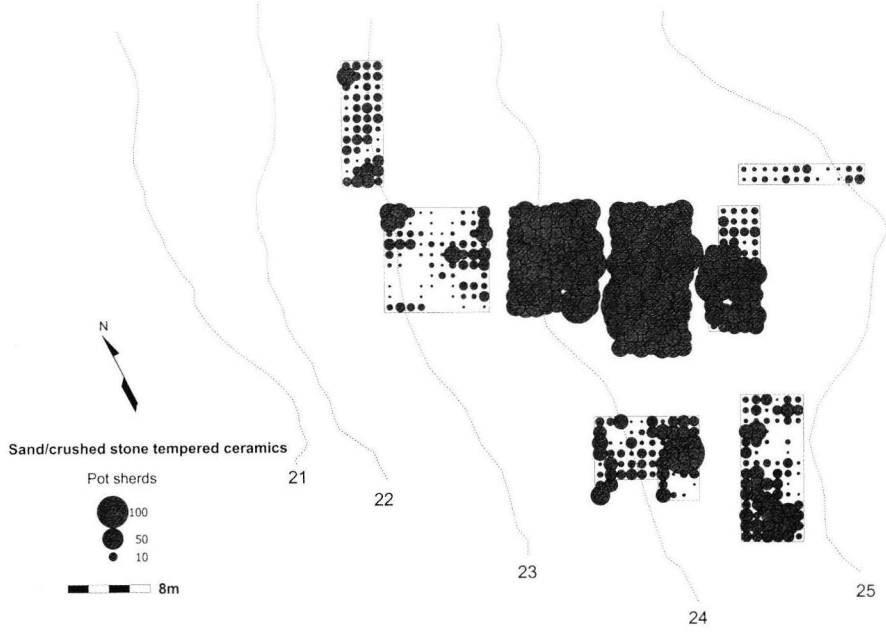

Fig. 5. The distribution of sand or crushed stone tempered pottery. *Map: Petro Pesonen.*

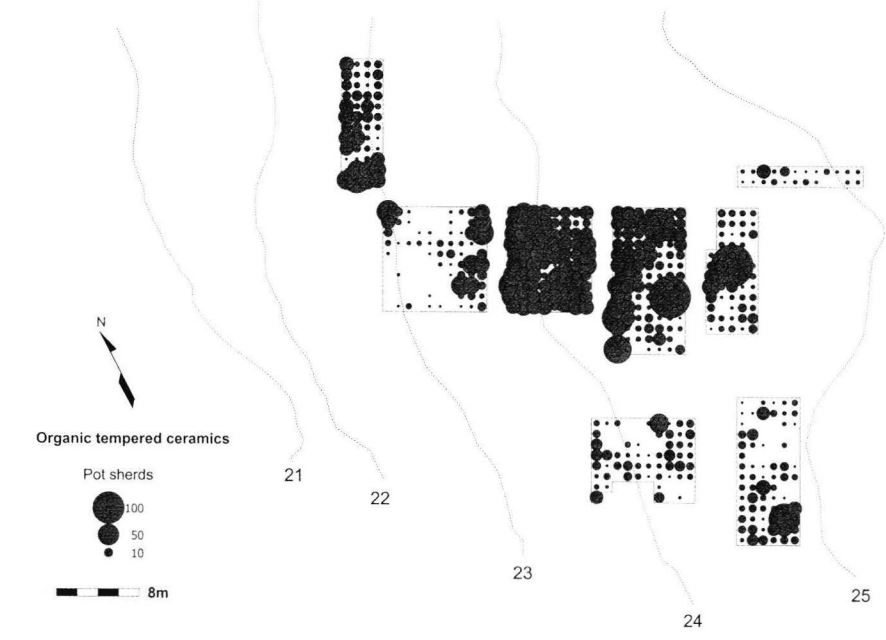

Fig. 6. The distribution of organic tempered pottery. *Map: Petro Pesonen.*

matter, between sherds with different temper materials (Fig. 5 and Fig. 6). The focus of both organic temper and sand or crushed stone temper is in the same region in the central part of the site, in excavation areas 3, 4, and 5.

Although there is a slight concentration of Typical Comb Ware in excavation areas 4 and 5 (Fig. 3), and a corresponding one of Late Comb Ware in excavation areas 1, 3, and 4 (Fig. 4), both styles centre on a relatively small area close to the 24 m above sea level contour. It seems, therefore, that the horizontal distributions of the finds cannot be employed for drawing chronological conclusions. The same phenomenon was observed at the Kvarnbacken site in Liljendal, where styles Ka II and Ka III:1 where found mainly in the same areas (Rauhala 1977: 88–89). In a recent article about shore displacement in the Helsinki area, Hannu Hyvärinen has also noted that Late Comb Ware in the area is concentrated on practically the same shore elevations as Typical Comb Ware (Hyvärinen 1999: 83).

3.2 Observations about vertical stratigraphy

The vertical stratigraphy of the pottery styles must be explored through quantitative methods, since no separate strata of different ages can be distinguished in the Maarinkunnas culture bearing deposits. According to Anne Vikkula, the occupation of the lower parts of the Maarinkunnas and Stenkulla sites has been too short for the development of a stratigraphy (Vikkula 1981: 121). However, even if no clearly distinguishable stratigraphic layers are visible during the excavation, the potential for a vertical stratigraphy of artifacts, for example pot sherds of various styles, can be studied through quantitative methods (*cf.* Rankama 1997). Experimental archaeology has also been used to demonstrate the existence of vertical stratigraphy (*e.g.*, Rankama & Kankaanpää 1999: 61).

The quantitative investigation involves area by area comparisons of the number of vessels of the various pottery styles with the total of ceramics in each excavation spit. The aim is to find out if, for example, the proportion of the supposedly younger Uskela Ware is higher towards the top of the cultural layer than that of the supposedly older Typical Comb Ware, and *vice versa*.

In excavation areas 1, 2, 6, 7, and 8 the proportions of pot sherds of different styles are fairly equal in each spit. In area 5 Late Comb Ware focuses slightly higher in the cultural layer than style Ka II:2 (Fig. 7). On the other hand, the number of unsubdivided Typical Comb Ware (Ka II) sherds is manyfold compared with Uskela Ware in every spit. Style Ka II:1 is divided practically equally between the spits. In areas 3 and 4 the situation is the opposite: the distribution of Uskela Ware continues deeper in the cultural layer than either of the Ka II styles (Fig. 8 and Fig. 9). The quantitative analyses of the pottery distributions in Maarinkunnas do not, thus, reveal any explicit trends of pottery style concentrations in different excavation spits. On the contrary, in most excavation areas all of the styles are found throughout the depth of the cultural layer. Consequently, the examination of vertical stratigraphy does not provide clear solutions to the problem of the pottery style chronology.

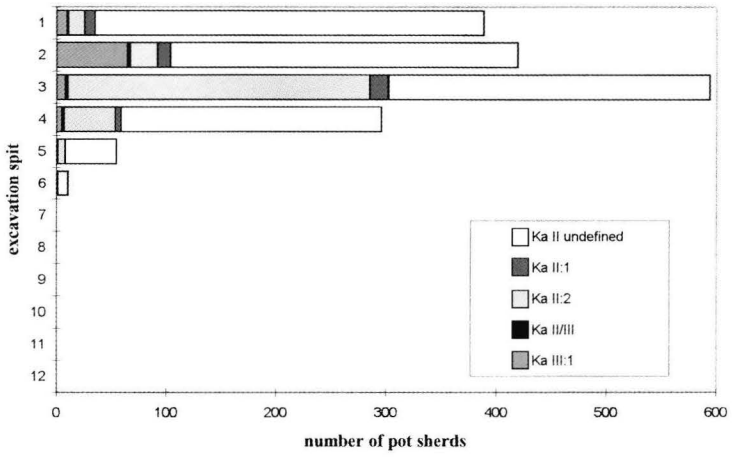

Fig. 7. The vertical distribution of different pottery styles in each 10 cm thick excavation spit in excavation area 5.

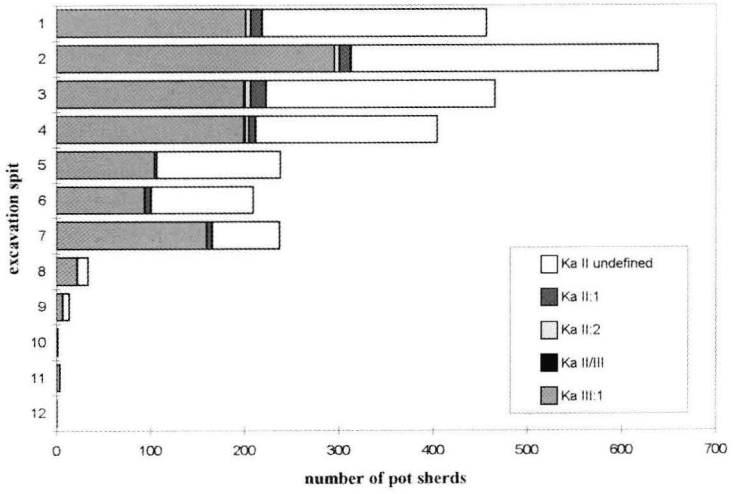

Fig. 8. The vertical distribution of different pottery styles in each 5–10 cm thick excavation spit in excavation area 3.

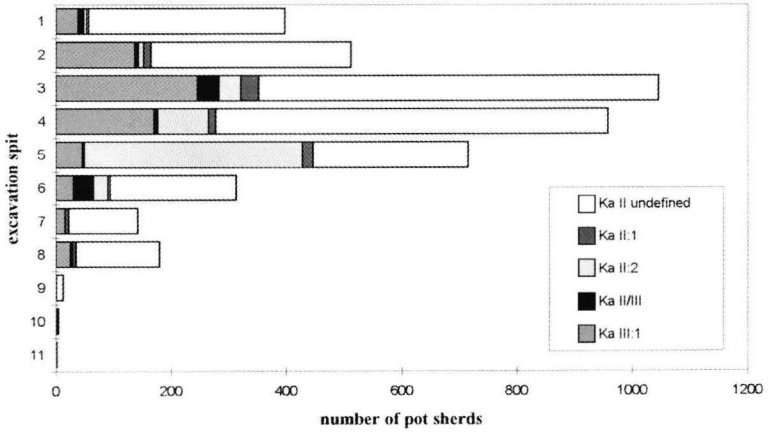

Fig. 9. The vertical distribution of different pottery styles in each 5–10 cm thick excavation spit in excavation area 4.

4. Radiocarbon dating the pottery

4.1 Birch bark pitch and organic crust as sources of radiocarbon dates

The Comb Ceramics from Maarinkunnas contain deposits of organic material suitable for radiocarbon analysis, *viz.*, organic crust and birch bark pitch. Accelerator mass spectrometry (AMS) radiocarbon dating of birch bark pitch, chewing resin, and organic crust adhering to pottery has become more and more common in Finland in the 1990's, and the results of the analyses are very promising (*e.g.*, Edgren 1997; Halinen 1997; Halinen & *al.* 1998; Jungner 1998; Karjalainen 1998; Koivisto 1998; Pesonen 1999). The sample size required for AMS analysis is very small, about one milligram of organic residue (Jungner 1998:84), which makes it possible to date occupation sites even in the absence of charcoal, or when the amount of charcoal in the cultural layer is too small for conventional radiocarbon analysis. The small sample size also makes it possible to date valuable objects that would be damaged by procuring a conventional sample (*ibid.*). Apart from dating occupation sites, dates from birch bark pitch and organic crust can be used to study pottery chronology (Lindér 1966; Andersen & Malmros 1985; Segerberg & *al.* 1991; Hallgren & Possnert 1997; Carpelan 1999; Persson 1999; Pesonen 1999).

Chemical analyses have shown that the material known as chewing resin consist of so-called birch bark pitch (Reunanen & *al.* 1993; Edgren 1997; Pesonen 1999), which has been prepared from birch bark through dry distillation (Pesonen 1994; Nykänen & Seppä 1997). During the Stone Age, birch bark pitch was used to repair pottery vessels (Kokkonen 1978: 34; Pesonen 1994) and, at least in Northern and Central Europe, also for hafting tools and weapons (Pesonen 1999: 191 with references). Finnish examples of birch bark pitch stuck to the bases of stone or quartz implements are known at least from Närpiö Rainesåsen (Meinander 1954: 39) and Rääkkylä Pörrinmökki (Pesonen 1999: 191). During the Iron Age, birch bark pitch was used to caulk the seams of wooden vessels (*e.g.*, Reunanen & *al.* 1993: Edgren 1997). The organic crust adhering to the surface of ceramic vessels, on the other hand, is quite obviously food residue (*e.g.*, Andersen & Malmros 1985; Arrhenius 1985 and 1987; Hallgren & Possnert 1997: 124, 126).

Birch bark pitch and organic crust are excellently suited for radiocarbon dating. A sample of birch bark pitch may have a maximum intrinsic age of ten years, since the pitch derives from the outer surface of the tree (Pesonen 1999: 192), while food residue can hardly be very old, assuming the vessels have only been used for a few, or, at the very most, a few dozen years. The margin of error in the results of the dating is, thus, considerably smaller than in charcoal samples that may derive from dry wood that was already hundreds of years old when it was burned. The only charcoal date from a hearth in Maarinkunnas (Hela-238: 5110±75 BP) is the oldest of the nine radiocarbon dates from the site (Table 5), and also the oldest from the whole Maarinkunnas-Stenkulla-Jokiniemi settlement area. It is 70 radiocarbon years older than the oldest pottery date (Hela-356: 5040±60 BP) even though the calibrated dates overlap. It is common to find that charcoal dates turn out to be older than birch bark pitch or organic crust dates from the same site (*e.g.*, Pesonen 1999:195).

There are some 100–150 pot sherds from Finland that have been AMS dated through samples of birch bark pitch or organic crust[6]. About 40–50 of the dates are of Typical Comb Ware; the published ones (30) are listed in Petro Pesonen's paper *Radiocarbon Dating of Birch Bark Pitches in Typical Comb Ware in Finland*. Only three of the dates derive from organic crust, the remaining 27 are birch bark pitch dates (Pesonen 1999: Appendix 2). The Early in the North Project, on the other hand, has financed the dating of 75 organic crust samples from pot sherds (Edgren 1999: 281), but detailed information about the pottery styles involved has not so far been published. Pottery dates in Sweden probably all derive from organic crust, and as far as is known, birch bark pitch dates for Stone Age pot sherds have so far been obtained only in Finland (P. Pesonen, pers. comm. 6.12.1999).

Only three sherds of the pottery from Maarinkunnas display signs of repairing with birch bark pitch. Two of these have been dated: one (:11862) seems to be stylistically related to Typical Comb Ware, while the other (:10801) bears features of Uskela Ware. The style of the third sherd (:7600) is unidentified. All previously dated pot sherds repaired with birch bark pitch have been Typical Comb Ware, although occasional examples of birch bark pitch repair are known from other pottery styles (Ka III, Pöljä), as well (P. Pesonen, pers. comm. 6.6.1999).

A total of 829 occurrences of black organic crust have been recorded among the pottery from Maarinkunnas[7], making up only 3% of the studied assemblage. Crust occurs most commonly on the inner surface of the vessels (593 cases), but also on the rim edge (153 cases) and on the outer surface (83 cases; Table 3). The crust is pitch black and has a flaky consistency with a cracked surface (Fig. 11). It often occurs as a fairly thick layer, which makes detaching it from the vessel surface relatively easy. The crust on the Funnel Beaker Pottery from the occupation site Skogsmossen in Sweden seems to be very similar (Hallgren & Possnert 1997: 124). The same applies to the crust on the Ertebølle Culture vessels from the Tybrind Vig site in Denmark: it consists of black, clinker-like residue baked onto the vessel surface (Andersen & Malmros 1985: 83).

4.2 The relationship between dates and styles

The eight radiocarbon dates of the Maarinkunnas Comb Ware pottery are presented in table 5 and figure 10. Four of the dated sherds have been classified as Typical Comb Ware. Sherds :7520 and :11228 belong to style Ka II:1 and have crushed stone temper (Fig. 12, a–b). The radiocarbon sample of both sherds consists of organic crust. The calibrated[8] dates are 3950–3780 BC and 3900–3640 BC, respec-

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[6] The exact number is difficult to estimate, since many of the dates are so far unpublished.

[7] Since every occurrence of crust has been recorded individually, and one sherd may contain up to three occurrences (inner surface, outer surface, rim edge), this figure does not indicate the number of sherds with crust, which is smaller (759; Table 3).

[8] The dates have been calibrated with OxCal version 2.18 (Stuiver & Kra 1986). The results are expressed with a probability of 1 s (68.2%).

Table 3. The occurence of crust in different pottery styles by number and percentage, as well as the position of crust in different parts of the vessels.

Ceramic style	*Total number of crusted pot sherds*	*% Crusted pot sherds of the total amount of sherds in each style*	*Total number of cases*	*Position*		
				inside	*outside*	*top of rim*
Ka II:1	22	6,3	22	21	1	0
Ka II:2	41	3,9	47	39	2	6
Ka II undefined	167	2,0	185	123	6	56
Ka II total	230	2,3	254	183	9	62
Ka II/III	27	7,4	32	20	3	9
Ka III:1	281	7,3	305	208	56	41
unidentified	221	1,9	238	182	15	41
Comb Ware total	759	2,9	829	593	83	153

tively. These dates are the oldest ones from Maarinkunnas, except for the charcoal date, the calibrated range of which is 4000–3790 BC.

Sherd :12889 is tempered with organic material and the decoration would seem to place it within style Ka II:2 (Fig. 12, c). The date of its organic crust is 3780–3540 BC. Sherd :11862 also represents style Ka II:2 (Fig. 12, d), but is tempered with crushed stone. The birch bark pitch date of this sherd is 3640–3380 BC. These dates clearly suggest that style Ka II:2 is younger than style Ka II:1.

The last four of the dated sherds can be classified as Late Comb Ware. Sherd :10801 (Fig. 13, a) is tempered with organic material. The birch bark pitch date of this sherd, 3620–3360 BC, is the youngest in the series, but, like two of the other dates, falls mostly within the range of the style Ka II:2 dates. The date of sherd :13811 (Fig. 13, b), which has a coarse temper, is 3620–3370 BC – the second youngest in the series – while sherd :9427 (Fig. 13, c), tempered with organic material, produced the date 3770–3520 BC. Both of these dates derive from organic crust. The organic crust date of sherd :1249, which is tempered with organic material (3900–3640 BC; Fig. 13, d), on the other hand, does not seem to fit any traditional chronological scheme. It is the second oldest date in the entire pottery date series, and falls in exactly the same range as the date of the style Ka II:1 sherd :11228.

The calibrated radiocarbon dates of the Comb Ceramics from Maarinkunnas fall within a 590 year period between 3950 and 3360 BC. The oldest dates derive from

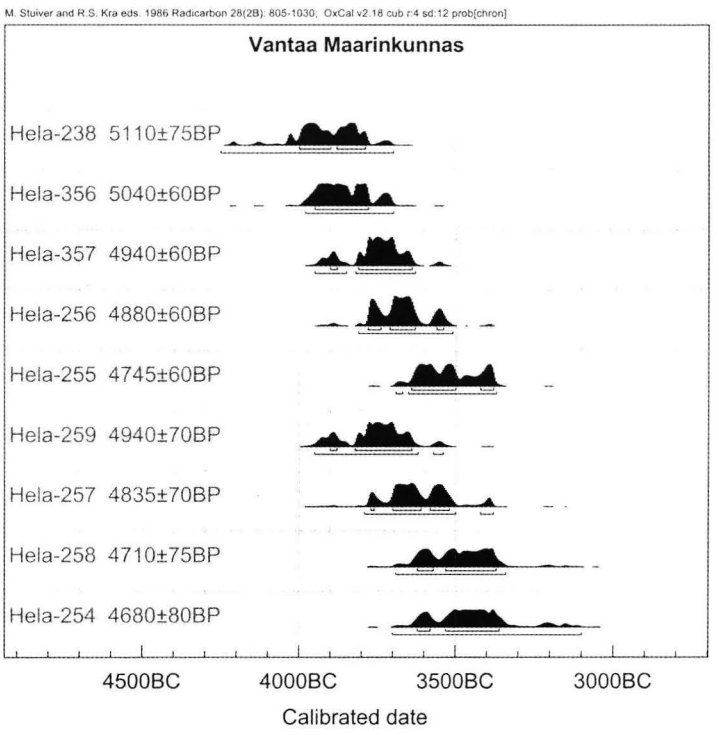

Fig. 10. Calibrated radiocarbon dates from Maarinkunnas in chronological order.

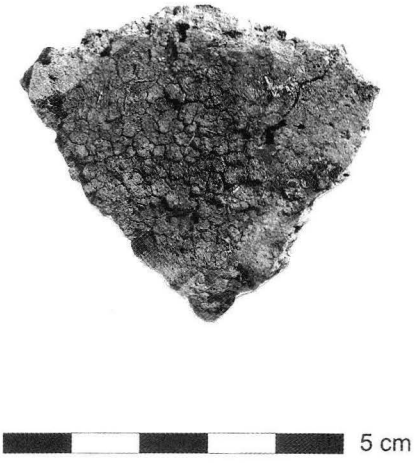

Fig. 11. Black, clinker-like, cracked, and charred organic remains (crust) on the inner surface of a pot sherd.

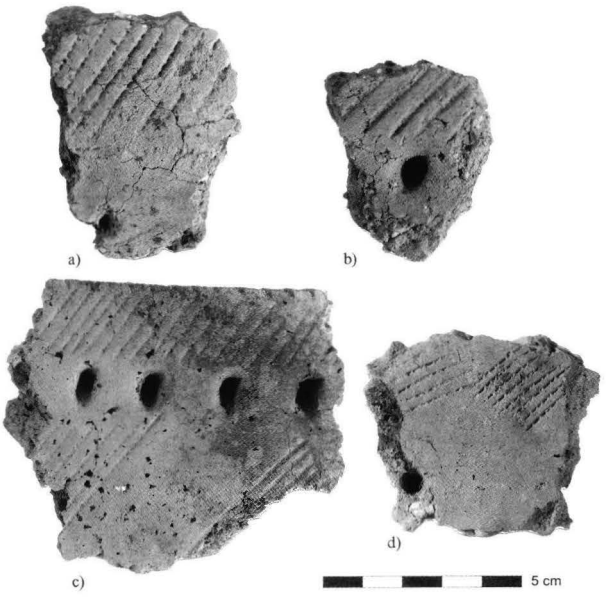

Fig. 12. Radiocarbon dated pot sherds, Typical Comb Ware: a) NM 30464:7520, style Ka II:1, b) NM 30464:11228, style Ka II:1 c) NM 30464:12889, style Ka II:2 d) NM 30464:11862, style Ka II:2. *Photo: National Board of Antiquities/ Markku Haverinen 2000.*

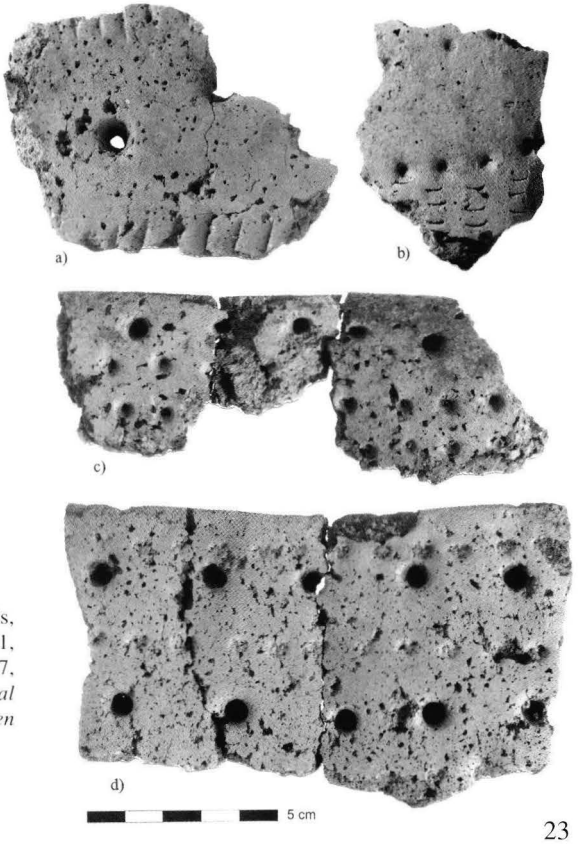

Fig. 13. Radiocarbon dated pot sherds, Late Comb Ware: a) NM 30464:10801, b) NM 30464:13811, c) NM 30464:9427, d) NM 30464:1249. *Photo: National Board of Antiquities/ Markku Haverinen 2000.*

style Ka II:1. Their maximum range is 3950–3640 BC, and they fit within the Typical Comb Ware calibrated age range 4000–3600 BC presented by Carpelan (1999: 256). The dates of style Ka II:2, the maximum age range of which is 3780–3380 BC, seem too young for the Typical Comb Ware age range above, but it may be noted that the scheme presented by Christian Carpelan has Typical Comb Ware ending 100–200 years earlier than other published schemes (Salo 1997: 9; Huurre 1998: 14; Pesonen 1999: 195). Torsten Edgren has suggested that the time period 3600–3200 BC "missing" from Carpelan's scheme might cover the range of the younger phase of Typical Comb Ware (style Ka II:2; Edgren 1999:289), an adjustment that would match the Maarinkunnas style Ka II:2 dates very well.

According to Carpelan, the date c. 3600 BC marks the beginning of the period of Late Comb Ware (the Uskela and Pyheensilta phases), which lasts until c. 2800 BC (Carpelan 1999:259). Two of the three youngest style Ka III:1 dates from Maarinkunnas (with the maximum age range of 3620–3360 BC) agree well with this scheme, and the third does not deviate from it significantly. The maximum range of these three dates (3770–3370 BC) agrees even better with the scheme presented by Matti Huurre, in which Uskela Ware falls between 3700 and 3300 BC (Huurre 1998: 14; also Salo 1997: 9).

The three youngest Ka III:1 dates from Maarinkunnas suggest that Uskela Ware and style Ka II:2 fall within exactly the same time range. The oldest style Ka III:1 date (3900–3640 BC), on the other hand, seems "too old" by far in comparison with the published chronological schemes. The reason for this cannot be found in the so-called reservoir effect that sometimes causes anomalous radiocarbon dates (*e.g.*, Persson 1999: 28–29), since the $\delta^{13}C$ value of the sample does not differ from the $\delta^{13}C$ values of the other samples from Maarinkunnas (Table 5).

If Typical Comb Ware were not subdivided into styles Ka II:1 and Ka II:2, its maximum date range would be 3950–3380 BC, which would mean that all three decoration styles – Ka II:1, Ka II:2, and Ka III:1 – would be totally contemporaneous. However, the differences in decoration support the division of Typical Comb Ware into styles Ka II:1 and Ka II:2 (*cf.* Kokkonen 1982: 3), and a chronological difference is also suggested by the radiocarbon dates. One of the radiocarbon dates from Maarinkunnas implies that Uskela Ware could be as old as Typical Comb Ware – even as old as its older style phase – but since it is a part of a relatively small series of dates, it cannot be given too much weight. The calibration puts the emphasis on the range 3820–3649 BC, which means that the sherd in question might represent the very first Uskela Ware vessels which, nevertheless, would be slightly younger than style Ka II:1. A larger series of radiocarbon dates would, of course, increase the reliability of the chronology, but even that might not give definitive answers to chronological questions[9].

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[9] In Sweden, the reliability of radiocarbon dates derived from organic crust on Funnel Beaker vessels has been tested, *e.g.*, by submitting two samples from each of three vessels to be dated. The minimum difference between the dates from one vessel was 15 years, while the maximum was 35 years plus the margin of error (Hallgren & Possnert 1997, Table 2). Since the dates from one vessel can vary, the same kind of variation undoubtedly occurs also between dates of different vessels of the same decoration style.

In any case the pottery assemblage from Maarinkunnas suggests that Ka II:1 is the earliest style, while style Ka II:2 and Uskela Ware appear somewhat later and are mainly found side by side throughout the period. The partial contemporaneity of Typical Comb Ware and Uskela Ware was suggested also by Anne Vikkula, who based her conclusions on the decoration of the vessels and on the distribution of the pottery styles at the Maarinkunnas site (Vikkula 1981: 129). Unto Salo (1997: 9) and Matti Huurre (1998: 14) also consider Typical Comb Ware and Late Comb Ware contemporaneous in part.

5. The function of the vessels

5.1 Style and function

The radiocarbon dates, thus, do not indicate significant chronological differences between the vessels of the various pottery styles in Maarinkunnas – a fact that can be explained in part by the wide time ranges of the dates resulting from calibration. Similar results have been obtained concerning the Swedish Funnel Beaker Culture (TRB): radiocarbon dates of organic crust show that typological variation does not necessarily imply chronological differences. Rather, the coexistence of separate, but contemporary pottery traditions is suggested (Hallgren & Possnert 1997: 120). In the Skogsmossen site three Neolithic occupation phases have been distinguished on the basis of a series of dates derived from the organic crust on pottery. The vessels, however, show no well-defined variation in decoration, composition, or vessel shape. In other words, the series of dates indicates stability and continuity in pottery decoration through a period of some 400 years. Based on this observation, it has been suggested that the decoration style of pottery depends more on social than on chronological factors (*ibid.*: 128–133).

The variations (styles) of pottery decoration have often been regarded as symbols and have been explained with reference to, for example, the social identity of the pottery manufacturer (*e.g.*, Räihälä 1996: 116). Adherence to a specific decoration style has been considered to be the result of a set of strict cultural norms within a society, which have dictated the decoration style of the vessels (Hallgren & Possnert 1997: 133 with references). In Finland, the Typical Comb Ware Cultural Group, for example, is considered to have been formed either by an immigrant population, or by a local population under strong cultural influence from abroad, while the Jäkärlä Group is seen as a descendant of the former Early Comb Ware tradition, continuing its existence side by side with Typical Comb Ware (Edgren 1966; Asplund 1995; Asplund 1998: 93).

In a similar way, Uskela Ware might have been the cultural "property" of a particular population that coexisted with a population that manufactured and used Typical Comb Ware (*cf.* Räihälä 1996: 116). The two populations can hardly have occupied the same settlement site at exactly the same time, however. Coexistence in the same region may have been made possible by differences in subsistence systems or in the resources exploited from one season to another (annual rounds) (*cf.* Edgren 1966: 148–149). The different styles of pottery might have been tied to

the differences in subsistence systems, and at the same time the styles might have played a role in strengthening group identity. On the other hand, it is possible that settlement sites might have been occupied by the various populations in turn for a longer period, perhaps even decades at a time, or that Uskela Ware and Typical Comb Ware were manufactured and used by the same population for different functions. A definitive answer to why various styles of pottery existed at the same time is very difficult to find (see Hautio 1998a: 113).

The primary functions of pottery vessels from occupation sites can be divided in four categories: storage vessels, cooking vessels, drinking vessels, and special vessels (Hulthén 1982). Various authors have suggested a number of uses for Stone Age vessels, including food storage, food or beverage preparation, water heating, and rendering train oil from blubber (*e.g.*, Salo 1989; Pesonen 1996; Huurre 1998; Ihalainen & Jussila 1998). According to Torsten Edgren (1982: 43) the shape, size, and function of Comb Ceramic vessels are closely tied together, and the function reflects the subsistence system and economy of the Comb Ceramic Culture. It has been suggested that the large Comb Ceramic vessels have served as storage containers for solid animal produce, required for managing the yield of seasonal mass hunts (Edgren 1982: 50–51; Salo 1989: 8; Nuñez 1999: 135).

Although pottery decoration has not usually been considered significant for the practical functions of the vessels (Asplund 1998: 89), there are some phenomena that might suggest different uses for different pottery styles. The style of decoration alone cannot, naturally, signify different functions for the vessels, but vessels of the various styles have, for example, features of temper and size that are significant for use (*cf.* Skibo & *al.* 1989). Oili Räihälä has suggested that the Ka II:1 style vessels at Outokumpu Sätös might have been cooking vessels, since they have been found mostly outside the house structure, where, it is often assumed, cooking has taken place. On the other hand the majority of the style Ka II:2 vessels have been found inside the house, which suggests a storage use for them (Räihälä 1996: 116).

I concur with Räihälä in that it is possible that vessels of different styles have served different functions, but I would invert the interpretation of those functions. Firstly, the fact that style Ka II:1 vessels are usually larger[10] than style Ka II:2 vessels implies that the former would have been better suited for storage. It was practical to manufacture the large pots on the spot and not transport them from one site to another (Edgren 1982: 44). The size of the vessels studied here has not been measured, but Late Comb Ware vessels are usually described as being smaller than Typical Comb Ware vessels (Vikkula 1981: 24–25). At the same time, style Ka II:2 vessels are considered thinner-walled and smaller than style Ka II:1 (Europaeus-Äyräpää 1930: 183). According to Jyri Kokkonen most of the Late Comb Ware vessels from Kymi Niskasuo can be classified as medium-sized[11] (Kokkonen 1978: 69). Medium-sized vessels, also, were easier to transport form one site to another than large ones (Edgren 1982: 55).

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[10] The large vessels (rim diameter >30 cm) described by Torsten Edgren (1982), for example, seem to be definitely classifiable as style Ka II:1, apart from, perhaps, the vessel from Orimattila Pennala, which displays features of style Ka II:2 (*cf.* Meinander 1971: 6).

[11] Kokkonen (1978: 31) classifies vessels with rim diameters of 10–20 cm as medium-sized, while Edgren (1982: 55) uses the measurements 20–30 cm.

In addition, repair holes[12] and/or birch bark pitch patching have usually been found only on sherds of style Ka II:1, which suggests that it has been possible to use them for storage even after breakage and repair. This use has not made them as susceptible to renewed breakage as, for example, heating over fire, or transport from place to place. Large vessels were also worth repairing, both because of their long use life and because of the fact that it was labourious and time consuming to manufacture them (Nuñez 1990: 50).

A third factor that supports the interpretation of the large style Ka II:1 pots as storage containers is their high gravitation and capillary porosity, observed in the porosity studies carried out by Pekka Ihalainen and Timo Jussila (Ihalainen & Jussila 1998: 33). Since the vessels are permeable by air, they are well suited for storage and tolerate well even extreme changes in weather. The sherds studied by Ihalainen and Jussila (*ibid.*) were thick-walled, tempered with crushed stone, and can best be classified as style Ka II:1. Porous vessels fit well for the storage of dry or dried goods, since they keep moisture out while allowing the air to circulate, which prevents the development of mould (Gustavsson 1997: 94). Birgit Arrhenius considers the early Scandinavian pottery styles, Ertebølle and Funnel Beaker pottery, perfectly suited for storage containers, specifically because the material is porous and has good insulative qualities: vessels of this kind may have been used for drying seeds or grain over a low heat, for example on top of embers or in an ember pit (Arrhenius 1987: 115). German archaeologists report finds of Neolithic food ("baked lumps of seed") that had been stored in pottery vessels, but had been spilled from the containers, still retaining the shape of the vessels (Rottländer & Schlichtherle 1978: 261). Torsten Edgren has pointed out that during excavations large Comb Ceramic pots are not usually found adjacent to hearths, a fact that he takes as further support for the idea that they are not cooking or food preparation vessels (Edgren 1982; 54). This idea is neither supported nor refuted by the Maarinkunnas material: only one small simple hearth was found in the excavation, and it could hardly have supported vessels of any considerable size. On the other hand, the largest pottery concentration in the Pieksämäki Naarajärvi site, for example, was located inside the house structure, next to the fireplace (Matiskainen & Jussila 1984: 30).

The smaller sizes of vessels of styles Ka II:2 and Ka III:1 probably made them better for food preparation. Vessels with organic temper (such as 75% of the Ka II:2 and Ka III:1 pottery from Maarinkunnas) are also lighter to transport, and less susceptible to breakage than vessels tempered with mineral matter (Skibo & *al.* 1989: 138 with references). In the Maarinkunnas assemblage, sherds of these styles have somewhat more organic crust adhering to their surfaces than style Ka II:1 (below). Even their exterior is occasionally dark (sooty), which might imply that the pots have been held above a fire. On the other hand a sooty exterior or the existence of organic crust do not necessarily indicate cooking: results from Swedish research demonstrate that the primary method of food preparation in Neolithic

[12] In the Maarinkunnas assemblage repair holes are found in at least two sherds, :14661 and :14083. The latter can be classified as Ka II:1, while the former is unclassifiable.

vessels was fermentation (Arrhenius & Slytå 1981; Arrhenius 1984, 1985, 1987; Arrhenius & Lidén 1988; Hallgren & Possnert 1997).

5.2 Organic crust on pottery

The occurrence of organic crust on the pot sherds from Maarinkunnas is not restricted to any particular pottery style. There are a total of 759 sherds with organic crust (Table 3). Two hundred and thirty of them can be classified as Typical Comb Ware and 281 as Late Comb Ware. Since Typical Comb Ware is more than twice as common in the material as Late Comb Ware (Table 1), a more reliable view is provided by the percentages of the sherds with organic crust within each pottery style. This kind of an examination shows that 2.3% of the Typical Comb Ware sherds have organic crust, while the percentage with Late Comb Ware is somewhat higher, *i.e.* 7.3% (Table 3).

The fact that sherds of Late Comb Ware are more difficult to identify than sherds of Typical Comb Ware means that there is probably more Late Comb Ware among the unidentified sherds. Consequently, restricting the examination to the rim sherds provides an even more accurate view of the proportion of organic crust occurrence within each style, even though the small number of sherds then reduces the reliability of the result. Among the rim sherds of Typical Comb Ware, 13.5% have organic crust deposits, while the percentage among Late Comb Ware is 19.4 (Table 4). Thus, the difference between these styles is not very big. On the other hand it is notable that style Ka II:1 has very few rim sherds with deposits of organic crust (8.3%), while the occurrence of organic crust on rim sherds of style Ka II:2 is as high as 31.6%. Even the rim sherds classified as Ka II/III often display this feature (27.9%). The occurrence of organic crust, thus, seems to allow the cautious conclusion that vessels of styles Ka II:2 and Ka II/III, and even Ka III:1, might have been used, among other things, in food preparation.

The organic crust usually occurs on the interior surface of the sherds (71.5%) and is less common on the exterior (10%) or the rim edge (18.5%). In Typical Comb Ware the crust occurs almost exclusively on the interior surface (72%) and only seldom on the exterior (3.6%). In Uskela Ware it occurs on the interior surface (68.2%), but fairly often also on the exterior (18.4%). Organic crust occurrences on the exterior surface have sometimes been interpreted as indications that a soup-like concoction has boiled over the rim of the vessels (Andersen & Malmros 1985: 91). On the other hand, it has been suggested that the Ertebølle vessels from Tybrind Vig in Denmark have been used over an open fire or in the middle of a thick layer of ash or embers – not among the stones of a hearth. The absence of organic crust on the exterior of the bottom part of the pots has been explained by suggesting that any food remains have been destroyed by the fire or the embers (*ibid.*: 95).

According to Birgit Arrhenius, however, there is no evidence of the use of Ertebølle vessels as cooking utensils. Chemical analyses of the vessels from Tybrind Vig showed that the crust derives from food prepared by fermentation (Arrhenius 1987: 115; also Arrhenius & Lidén 1988: 9.). A few of the samples of crust

Table 4. The occurence of crust on rim sherds by number and percentage.

Style	*Amount of rim pieces*	*Crusted rim pieces (number)*	*Crusted rim pieces (% of rim pieces in each style)*
Ka II:1	60	5	8,3
Ka II:2	57	18	31,6
Ka II undefined	750	94	12,5
Ka II total	867	117	13,5
Ka II/III	68	19	27,9
Ka III:1	797	155	19,4
Unidentified	1105	94	8,5
All ceramics	2837	385	13,6

Table 5. The radiocarbon dates from Maarinkunnas in chronological order.

Lab. no	*Material*	*Catalogue number*	*Pottery style*	*$\delta^{13}C$ ‰ vs VPDB*	*^{14}C age BP*	*cal BC* 1σ*	*2σ*
Hela-238	charcoal/ hearth	-	-	-26.9	5110±75	4000(0.55)3900 3880(0.45)3790	4250(1.00)3700
Hela-356	crust	:7520	Ka II:1	-23.2	5040±60	3950(1.00)3780	3980(1.00)3700
Hela-357	crust	:11228	Ka II:1	-22.5	4940±60	3900(0.05)3880 3810(0.95)3640	3950(0.16)3850 3820(0.84)3630
Hela-259	crust	:1249	Ka III:1	-22.3	4940±70	3900(0.07)3880 3820(0.93)3640	3950(0.97)3620 3570(0.03)3540
Hela-256	crust	:12889	Ka II:2	-21.4	4880±60	3780(0.25)3740 3710(0.67)3630 3560(0.08)3540	3810(1.00)3510
Hela-257	crust	:9427	Ka III:1	-24.1	4835±70	3770(0.04)3760 3700(0.60)3610 3580(0.36)3520	3790(0.95)3500 3420(0.05)3380
Hela-255	birch bark pitch	:11862	Ka II:2	-27.3	4745±60	3640(0.78)3500 3420(0.22)3380	3690(0.01)3670 3650(0.99)3370
Hela-258	crust	:13811	Ka III:1	-22.9	4710±75	3620(0.23)3570 3530(0.77)3370	3690(1.00)3340
Hela-254	birch bark pitch	:10801	Ka III:1	-28.3	4680±80	3620(0.15)3580 3530(0.85)3360	3700(1.00)3100

*** Calibration program OxCal v. 2.18 (Stuiver & Kra 1986). The figures in brackets represent the probability** for 1σ and 2σ subintervals, respectively.

from Neolithic vessels from the Auve site in Norway included, in addition to organic matter, some inorganic substance derived from the vessel itself. This was interpreted as evidence of mechanical activity, such as stirring the food in the pot, and taken to suggest that the food prepared could have been, for example, soup, stew, or porridge (Østmo & *al.* 1996: 38). A few of the samples provided evidence of heating the food, which led to the suggestion that the fermented dish may have been heated up before being consumed. Ethnographic evidence of this practice exists from Sweden (Østmo & *al.* 1996: 38–39 with references). In Germany, several Neolithic occupation sites have yielded vessels with interior crust deposits that have been interpreted as evidence of boiling, frying, or roasting meat and vegetable dishes (Rottländer & Schlichtherle 1978: 261). In any case Neolithic pottery has been used for food preparation in addition to storage, regardless of whether the method has been cooking or fermentation.

Several studies have concluded that the organic crust deposits on pottery derive from fermented food, since they are not actually charred, but only scorched. The foodstuff has accumulated on the vessel surface during fermentation (Arrhenius 1987: 116). Chemical analyses designed to detect particular trace elements, lipids, and proteins have shown that the organic crust on some Swedish Bronze Age vessels (Hallunda), as well as some Swedish and Norwegian Neolithic vessels (Löddesborg, Auve), derives from blood porridge or cake. The samples had high iron content (blood) together with vegetable lipids that are particularly abundant in cereals. These two together form the ingredients of blood cake (Arrhenius & Slytå 1981: 107; Arrhenius 1985: 342–344; Østmo & *al.* 1996: 34–39). Studies have shown that prehistoric gruel consisted of ground hazelnut and cereal mixed with whisked blood (Arrhenius 1987: 117). Gruel of this kind was consumed as late as the Viking Age (*ibid*). Experimental foodstuff studies resulted in visually and chemically similar food residues as those observed on Stone Age vessels (Arrhenius 1985: 343; 1987: 116). Fermentation is an ancient method of food preparation, originating in the Lower Palaeolithic (Arrhenius 1987: 116 with references). It is known to enhance the nutritional value of the food (Arrhenius & Slytå 1981: 108), as well as to improve preservation and to attain the special taste (Østmo & *al.* 1996: 38).

5.3 Lipid analysis of the organic crust

A lipid analysis was carried out on the organic crust adhering to the pottery from Maarinkunnas, based on the assumption that the crust was derived from foodstuff. To detect variation, crust samples were collected from vessels representing several decoration styles (Fig. 14–15). A total of 11 samples were analysed, one representing style Ka II:1, four representing style Ka II:2, four representing style Ka III:1, and two that can only be classified as Typical Comb Ware (Ka II) (Table 6). The samples were analysed by head laboratory technician Markku Reunanen at the Åbo Akademi Laboratory of Forest Products Chemistry; the results have been interpreted by docent Anu Hopia, Ph. D., of the University of Helsinki Department of Applied Chemistry and Microbiology (see Hopia & *al.*, Appendix).

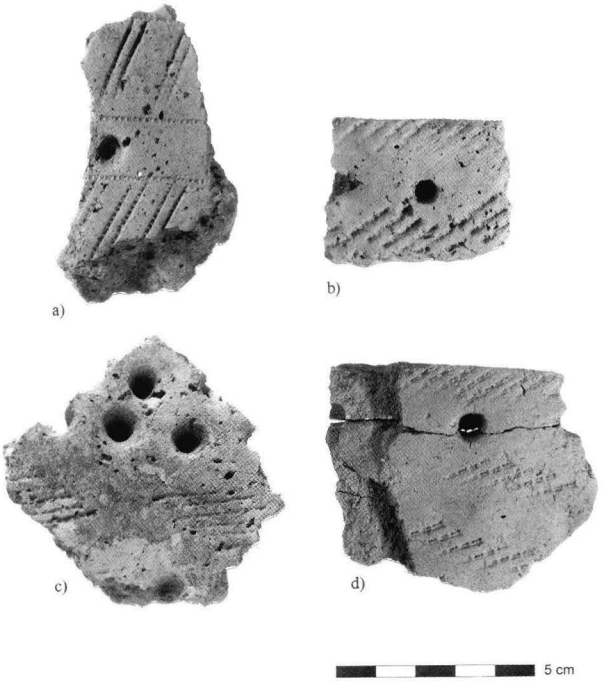

Fig. 14. Typical Comb Ware sherds with analysed crust: a) NM 30464:12554, style Ka II:1, b) NM 30464:13178, style Ka II:2, c) NM 30464:13300, style Ka II:2, d) NM 30464:16650, style Ka II:2. *Photo: National Board of Antiquities/ Markku Haverinen 2000.*

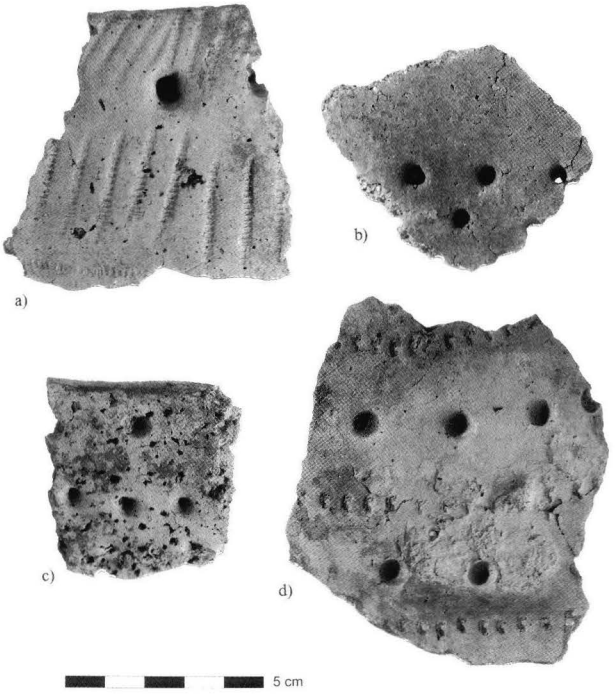

Fig. 15. Typical and Late Comb Ware sherds with analysed crust: a) NM 3046412606, style Ka II, b) NM 30464:5694, style Ka III:1, c) NM 30464:12833, style Ka III:1, d) NM 30464:14065, style Ka III:1. *Photo: National Board of Antiquities/ Markku Haverinen 2000.*

Table 6. The analysed samples of crust in Comb Ceramic pot sherds from Maarinkunnas.

Sample n:o	*Catalogue number*	*Pottery style*	*Temper*	*Minor components*
1	:12554	Ka II:1	sand	cholesterol, phytanic acid
2	:14065	Ka III:1	sand	cholesterol, phytanic acid
3	:12601	Ka II	sand	phytanic acid
4	:1249	Ka III:1	organic	cholesterol, phytanic acid
5	:12606	Ka II	sand	phytanic acid
6	:12833	Ka III:1	organic	cholesterol, phytanic acid
7	:12889	Ka II:2	organic	benzoic acid (high value)
8	:13300	Ka II:2	sand	phytanic acid
9	:16650	Ka II:2	sand	
10	:5694	Ka III:1	crushed stone	
11	:13178	Ka II:2	organic	phytanic acid

The samples were analysed for traces of fat, proteins, and carbohydrates, but the two latter were not detected. Traces of lipids[13], such as cholesterol, and their decomposition products, on the other hand, were found in all of the samples. In addition, some samples contained minor components, such as benzoic acid (see Appendix).

The majority of the fatty acids consisted of the two saturated fatty acids palmitic and stearic acid, which are common among the fats of all kinds of food. The ratio of stearic acid to palmitic acid (18:0/16:0), which varies from 0.2 to 0.4 in the studied samples, suggests that the fats derive from marine animals. The same applies to the ratio between the unsaturated fatty acids palmitoleic and oleic acid (16:1/18:1), which varied from 0.3 to 0.6 (*cf.* Hansson & Isaksson 1994; Isaksson 1996a and 1997b).

Eight of the samples also contained phytanic acid, which derives from chlorophyll. It was particularly abundant in the crust from sherd :12554. Phytanic acid occurs in animals that have consumed food rich in chlorophyll. It is, thus, found in the fats of marine and terrestrial herbivores; particularly high concentrations occur in some fish oils. (Appendix)

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[13] Lipids or fatty acids are the major substances studied in food crust analyses because of their preservation characteristics and their classification potential (Østmo & *al.* 1996: 24 with references). They remain unchanged in temperatures up to 300°C (Rottländer & Schlichtherle 1978: 263–264). In addition, they are excellent biomarkers, since all living organisms produce them for, *e.g.*, energy storage (Isaksson 1997a: 243–244). Carbohydrates and proteins, on the other hand, are water soluble and decompose more easily than lipids (Hansson & Isaksson 1994: 25).

In addition to lipids, fats and oils contain several other components, such as sterols. The only sterol present in the studied samples was cholesterol. It was found in four samples, especially in the crust from sherd :12554, which also contained phytanic acid. Cholesterol is an indication of animal tissue, since it is not found in plant matter. (Appendix)

Marine animals suggest fish, but especially seals, the oil and meat of which can be the source of the cholesterol, as well. This view is supported by the bone analysis from Maarinkunnas, which is dominated by seal bones, although fish bones, especially pike, are also present. The analysis results from the organic crust adhering to a pot sherd from Kökar Otterböte suggest that it derives from marine animals: the high lipid content indicates seal products (Gustavsson 1997: 95). Train oil from seals works very well in the long-term storage of berries, roots, meat, and fish (*ibid.*: 93). It has even been suggested that the reason for the adoption of pottery could be found in the systematic exchange economy that commenced and grew in the Comb Ceramic Period, in which one of the exchange goods was train oil stored in pottery vessels (Siiriäinen 1981; Nuñez 1990).

All of the samples contained benzoic acid. It is found naturally in the cowberry (*Vaccinium vitis-idaea*) and cranberry (*Vaccinium oxycoccos/ microcarpum*), and the modern food industry uses it as a preservative (E210). Since benzoic acid was present in all of the samples, however, rigorous source criticism must be applied, especially because benzoic acid has been found to be released in chemical forest industry as the result of some as yet undetermined process (Markku Reunanen, pers. comm. 11.1.2000). Benzoic acid has not been mentioned in, for example, the Swedish crust analyses, and further research is required before any definitive conclusions can be drawn.

It is, nevertheless, possible that the cowberry and cranberry have been part of the diet; they may have been used in food storage to prevent moulding or fermentation, and also eaten. If the cowberry and/or cranberry have been part of the diet, we are probably dealing with autumn fare, or at least food prepared or stored during the fall. The blubber layer of seals is at its thickest in the autumn, and late fall is a profitable period for netting seals close to the shoreline (Ylimaunu 1999: 130; also Ylimaunu & *al.* 1999: 140; 148). The Maarinkunnas bone assemblage includes seal bones from all parts of the carcass, which suggests that the processing of the catch took place at the site.

Since mashed cowberries keep through the winter, it is possible to use them as a nutritional supplement for several months. According to German research results the prehistoric diet has included a variety of berries, in addition to nuts and grain (Rottländer & Schlichtherle 1978: 263). It is also common knowledge that some Native Americans have habitually prepared a readily preserved high energy travel fare that consists of dried and ground bison meat, fat, and berries, such as wild cherries or mountain ash berries (Birket-Smith 1951: 103; s.v. 'pemmican,' The Columbia Encyclopedia 1993; Pemmican and...; A Recipe for...). It is, thus, not impossible that meat and berries have been combined into a single dish during the Comb Ceramic Period, as well. Among some Pacific Coast Indians the meat in the pemmican has been replaced with fish (s.v. 'pemmican,' The Columbia Encyclopedia 1993). Furthermore, Eskimos are known to make a kind of ice cream (*Akutuq*)

from seal oil or caribou fat, by first warming the oil and then whipping in air by hand, as the oil slowly cools into a foam. *Akutuq* is usually flavoured with cowberries (*Vaccinium vitis-idaea*). Other berries are also used to add taste. (Jones 1983: 89, 127.)

Three of the four crust samples that contained a fair amount of fatty acids (:12833, :1249, :14065) derive from pot sherds classified as style Ka III:1 and one (:12554) from a sherd representing style Ka II:1. Their high cholesterol content strongly suggests that food derived from the animal kingdom was stored or prepared in the vessels (see Appendix). The analysis results do not indicate any variation in food preparation or storage between the pottery styles, however: benzoic acid, for example, was present in all of the samples. The amounts of lipid residues in the samples, on the whole, are relatively modest, and some fatty acids have completely decomposed. Negative evidence, thus, cannot be used to draw conclusions.

The results of the crust analyses from Maarinkunnas differ from those from the neighbouring countries. In contrast to the samples analysed here, analyses of Swedish and Danish samples often show a total absence, or very small amounts, of cholesterol, whereas proteins and sometimes carbohydrates are present (Arrhenius 1984, 1985; Arrhenius & Lidén 1988). The results often suggest a diet derived from vegetable matter, which is natural, since agriculture and animal husbandry were already practised in southern Scandinavia in the 5th century BC, whereas in Finland tangible evidence of agriculture at this time is absent, at least as yet (Nuñez 1999: 135–136). During the Comb Ceramic Period the economy of Finland was still based on hunting, fishing, sealing, and gathering. It is also noteworthy that benzoic acid is apparently not present in the Swedish crust samples.

In addition to lipid analysis, inferences about prehistoric diet can be drawn on the basis of the value of the stable carbon isotope ^{13}C, which is routinely measured in connection with radiocarbon analysis. It can give clues, for example, as to whether the food residues in the crust are of marine or terrestrial origin. Contrary to the radiocarbon isotope (^{14}C), the stable carbon isotope (^{13}C) does not decline, but disintegrates through physical, geological, and biological processes. As a result, the composition of the isotope changes. The fractionation of the isotope is different in marine and terrestrial organisms (Eriksson 1996: 24 with references), and the degree of fractionation in animals, for example, is influenced not only by their diet but also by their position in the food chain (Tauber 1981: 332). A diet that is 100% marine produces a diagnostic $\delta^{13}C$ value, which is used as an ultimate reference value for marine animals. This $\delta^{13}C$ value is less negative than the terrestrial ultimate reference value (Eriksson 1996: 24–25). In other words, values between -18 and -30‰ suggest terrestrial origin, while values between 0 and -18‰ suggest marine origin (*e.g.*, Tauber 1981; Andersen & Malmros 1985: 86; Segerberg & *al.* 1991: 90; Hallgren & Possnert 1998: 126). In addition to food crust, ^{13}C values can be measured from human bone and hair (Tauber 1981; Eriksson 1996; Lidén 1996; Lidén & *al.* 1996).

The origin of the food crust in the vessels from the Tybrind Vig site, for example, has been examined with the help of carbon isotope ^{13}C. Preliminary analysis results suggested a primarily terrestrial origin for the crust (Andersen &

Malmros 1985), and subsequent studies did not change this interpretation (Arrhenius & Lidén 1988). Nevertheless, the crust was interpreted by Claus Malmros and Søren H. Andersen as the remains of fish soup with vegetables. This was based on microscopic studies that suggested the presence of fish remains, such as bones and fin rays, within the crust, and also on the presence of crust on the exterior of the pot (Andersen & Malmros 1985: 95). This interpretation has been subsequently refuted through microscopic and chemical analyses of the crust: the Tybrind Vig crust is the residue of a porridge that has been prepared by fermentation, but through some other method than the use of blood (Arrhenius & Lidén 1988: 9, 15). It has not been possible to ascertain whether the food crust consists of the remains of one meal or several (Andersen & Malmros 1985: 95).

An examination of the ^{13}C isotope values determined in connection with the radiocarbon dating of the Maarinkunnas samples (Table 5) shows that the $\delta^{13}C$ values for charcoal and birch bark pitch (-26.9 – -28.3‰) are more negative than the $\delta^{13}C$ values for food crust. As can be expected, they strongly suggest a terrestrial origin. The values measured from food crust (-21.4 – -24.1‰) do not indicate a clear marine origin, either, although they are less negative than the $\delta^{13}C$ values of the food crust from, *e.g.*, Skogsmossen or Tybrind Vig (*cf.* Hallgren & Possnert 1997; Andersen & Malmros 1985). On the other hand the food crusts of the Western Pitted Ware vessels from the Säter and Fagervik sites, which are regarded as terrestrial food residues, display similar $\delta^{13}C$ values as the Maarinkunnas material (Segerberg & *al.* 1991: 90). This seems, to a degree, to contradict the results of the Maarinkunnas lipid analysis, which suggest a marine origin for the residues. The effect that a combination of, *e.g.*, cowberry and marine animal matter may have on the $\delta^{13}C$ value has not so far been studied.

6. Vessels for different purposes?

It has occasionally been suggested that Comb Ceramic vessels were not used for food preparation at all. Unto Salo, for example, has suggested that pots were not needed for food preparation during the Stone Age, because meat and fish could be fried or consumed some other way. Consequently, he regards Comb Ceramic pots as exclusively storage containers, or vessels in which beverages could be prepared (Salo 1989: 8). The results of the crust analyses from Maarinkunnas show that food has been either prepared or stored in the Comb Ceramic vessels, but there is no evidence of actual cooking. The presence of several proteins (amino acids) and lipids usually suggests fairly low temperatures, since amino acids dissolve at 200°C and lipids at 300°C (Gustavsson 1997: 95; Rottländer & Schlichtherle 1978: 263–264). Fermentation, however, does not destroy amino acids or lipids (Gustavsson 1997: 95). No protein residues were found in the Maarinkunnas samples, a fact that might support the idea of cooking.

If no cooking was done in the vessels, how can the crust have been formed? As far as I understand, crust formation can take place in two ways: either as the food is baked onto the vessel surface in connection with cooking, or as a natural result of slow accumulation and oxidation, when part of the food that is prepared or kept in

the vessel remains on the surface because cleaning the vessels properly is probably difficult, and perhaps even unnecessary. In any case distinguishing between a food storage function and a food preparation function is difficult, especially if we are dealing with fermentation methods, since they involve both functions in the same process.

Even though vessels of styles Ka II and Ka III have not been considered functionally different, *e.g.*, due to their size, and both are said to be suitable for storage as well as other uses (Vikkula 1981: 25), it is still possible that differences in functions between the ceramic styles have existed, albeit not necessarily in a systematic and established way. The large size of Ka II:1 vessels means that they would work well as storage containers, or maybe for preparing beverages – although there is no direct evidence of this kind of use. It is possible to store liquids in vessels tempered with sand and crushed stone (Hulthén 1997: 151), although skin bags are better than pottery for water transport and keeping it from freezing during the winter (Gustavsson 1997: 93).

Experimental research shows that water heating efficacy is higher in vessels tempered with mineral matter than in vessels tempered with organic material (Skibo & *al.* 1989: 131). Ceramic vessels as a whole are well suited for water storage, because their porous structure keeps the water cool (Gustavsson 1997: 93). Heating the water with rocks has probably been possible (*e.g.*, Alakärppä 1999: 56), although evidence of it is absent. On the other hand, pottery is not so good, *e.g.*, for storing train oil, since the oil tends to seep through the vessel walls (Gustavsson 1997: 92). The fragility of pottery vessels makes them less ideal for transporting train oil than, for example, wooden containers or skin bags, but they may well have been used as *temporary* storage and fermentation containers (Ylimaunu & *al.* 1999: 146 with references). On the other hand, the pots with organic temper (Ka II:2 and Ka III:1) that today look very porous because the temper has dissolved, have not been any more fragile and susceptible to breakage during their use life than pots with sand or crushed stone temper (Hautio 1998a: 57). Quite the contrary, pots with organic temper may even have better shock-resistance (Skibo & *al.* 1989: 139). Their durability and smaller size suggest that they might function better in both transport and some sort of food preparation. It is even possible to heat, but not to boil water in them (*ibid.*: 131).

It is, of course, possible that pots of one ceramic style have served more than one function and been used for the storage or preparation of different kinds of food. In the Otterböte material, for example, lipid analyses of two identical pots show very different contents: one sample implies marine origin, while the other suggests the presence of vegetable matter, in particular barley – barley corn imprints have been observed on the surfaces of the Otterböte pots (Gustavsson 1997: 95; Isaksson 1997b: 173). In the archaeological context it is often impossible to distinguish between cooking vessels and storage containers, not to mention between cooking vessels of different kinds (Gustavsson 1997: 93). In addition, it is always possible that pots of one type have been used for several purposes (*ibid.*), and a single pot may have served a variety of functions. The results of crust analyses probably relate only to the last episode of use. On the other hand, the analysed crust may contain residues from previous foodstuffs, and the resulting

view may represent a kind of melange, an average of the different substances stored or prepared in the vessel. This might explain the curious combinations, such as the presence of benzoic acid and cholesterol in a single sample.

On the basis of the crust analyses carried out so far, it is not possible to single out any particular pottery style as cooking or storage vessels, since all analysed samples indicate this kind of use. Many more crust analyses are required before any firm linkages between ceramic styles and functions can be established. The problem of the function of ceramic vessels is complicated by the fact that our knowledge of potential vessels of other materials (such as wood, birch bark, and skin) is practically nil (Gustavsson 1997: 92). Even if the various styles were found to have served distinct functions, the question of whether the different pots have been manufactured by one population or several is still left open.

7. Summary

The Maarinkunnas pottery assemblage includes a number of pottery styles described by Aarne Äyräpää as early as 1930, *viz.* the Typical Comb Ware styles Ka II:1 and Ka II:2 and Uskela Ware Ka III:1. In addition, there are sherds that combine characteristics from both Typical Comb Ware and Uskela Ware. Both organic temper and stone and mineral temper occur: style Ka II:1 pottery is tempered primarily with sand or crushed stone, while styles Ka II:2 and Ka III:1 usually have organic temper. However, the tempering material probably cannot be considered a style criterion.

Radiocarbon dates from birch bark pitch and organic crust adhering to the pottery suggest that style Ka II:1 is somewhat older than styles Ka II:2 and Ka III:1, which are contemporaneous. One of the dates even implies that Ka III:1 might be older than Ka II:2. The reliability of the dates would, of course, be heightened by a longer series of samples. As regards the occurrence of crust on pottery of the various styles, Ka II:2 and Ka III:1 tend to display crust deposits slightly more often than Ka II:1. The presence of crust may be a clue to the use of the vessel: it may be assumed that potsherds with crust derive from vessels that have been used for food storage or preparation. The crust deposits and the smaller sizes of the pots of styles Ka II:2 and Ka III:1, as well as their organic temper, are features that might be cited as evidence for the use of these vessels for food preparation more often than vessels of style Ka II:1, which serve better as storage containers for, *e.g.*, foodstuff or water. It should be remembered, however, that the majority of the sherds of all kinds of pottery are devoid of crust, and, therefore, other functions have certainly existed. It is also possible that even a single pot may have served several functions; crust analysis allows conclusions chiefly about the final episode of use.

The formation of crust may have taken place through the burning of food prepared in the vessel, or as a result of a process of fermentation, as demonstrated by several Swedish studies. In any case the crust and the analysis results indicate some kind of food preparation or storage in the vessels. Since the results here do not suggest the kind of fermentation method indicated by the Swedish studies,