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Site formation processes and vertical stratigraphy in Finland

Abstract

The absence of vertical stratigraphy from the majority of Finnish Stone Age sites has been a given through most of our research history. The only generally acknowledged stratigraphic dimension has been "horizontal stratigraphy", or the gradual chronological change following the elevations of the sites above the present sea level. The accepted model of the formation of thick cultural layers has been the penetration of the material deeper and deeper into the soil through trampling during long-term or recurrent occupation. This paper attempts to show through examples drawn from experimental archaeology and from the analyses of the Ala-Jalve site in Utsjoki that there is a maximum limit to the penetration achieved through trampling, and that the formation of cultural layers exceeding the maximum trampling thickness requires other explanations. Understanding the formation processes of cultural layers is essential for accurate site analyses. The Ala-Jalve results show that the possibility of vertical stratigraphy is worth taking into account even on sites where no distinct layers are visible in the section.

Introduction

Most Finnish archaeologists would probably agree that vertical stratigraphy is extremely rare on Finnish open-air Stone Age or Early Metal Age sites. Although notable exceptions exist on riverside settlements, such as Kemijärvi Neitilä (Kehusmaa 1972) and Rovaniemi Kärräniemi (Siiriäinen 1986), where distinct flood deposits have been discovered above and between cultural layers, the general model of site formation involves simply the trampling of the cultural material deeper and deeper into the ground during long-term or recurrent episodes of occupation. This model is employed even on sites where the thickness of the cultural layer reaches up to 50–100 cm, especially if these lie on the coast.

The only stratigraphic dimension generally discussed has been the so-called horizontal stratigraphy. This is based on postglacial isostatic recovery and the assumption that Stone Age settlement has always been located as close to the shoreline as possible. According to this model, chronological variation within a site can best be distinguished by following the contours of the site topography and the elevations of the concentrations of finds above sea level. Since the optimal site location has been next to the water limit, the occupation has followed the receding shore line, and consequently, the lower the elevation of the finds, the younger they can be assumed to be.

This method of building relative chronologies through shore displacement was successfully employed already in the 1920's when the chronological division of the Stone Age pottery in Finland was developed (Europaeus 1922; Europaeus-Äyräpää 1930). After adjustments prompted by the emergence of radiocarbon dating (Siiriäinen 1974), it is still a valid rule of thumb on coastal sites. Its connection with geological dating is what enabled the Finnish Stone Age chronology even in pre-radiocarbon times to be closer to reality as we know it today than, e.g., the Central European chronologies that were dependent on assumed correlations with historical events in the Mediterranean sphere or, indeed, the Scandinavian ones based on them. Consequently, the "radiocarbon revolution" of the 1960's and 1970's was less of a revolution in Finland than it was in the rest of Europe.

The success of horizontal stratigraphy as a chronological device has had its drawbacks, however. Combined with the virtual absence of sites with visible stratigraphic layering it has meant that the absence of vertical stratigraphy in Finland has been taken for granted to such a degree that it has not been questioned or, in fact, much discussed in literature. The threshold for beginning a search for vertical stratigraphy has been high, especially as the perception of site formation in general has been fairly vague. The most commonly used methods of excavation and recording have not easily lent themselves to the study of vertical stratigraphy, either – a 10 cm excavation spit is simply too thick for distinguishing finer stratigraphic differences.

Suggestions of the presence of vertical stratigraphy have been countered by pointing out that since coastal occupation sites follow the rules of horizontal stratigraphy, vertical stratigraphy will automatically be absent. This assumption is void, since the existence of the one by no means excludes the possibility of the other. In the presence of horizontal stratigraphy the formation of vertical stratigraphy depends on the rate of accumulation of the matrix, and in certain conditions the accumulation can undoubtedly be sufficient for the development of vertical stratigraphy even if the focus of the occupation has gradually moved with the receding shoreline. Indeed, one of the points of this paper is that by studying vertical stratigraphy it may be possible to distinguish finer chronological differences within the archaeological material than is possible simply by relying on the kind of variation that becomes apparent within the chronological frame distinguishable through horizontal stratigraphy – in other words, that the chronological resolution of vertical stratigraphy will in all probability exceed that of horizontal stratigraphy, and that diversity within the material that has not been distinguishable with customary methods of analysis may well be found.

Studying site formation processes is essential before any other analyses of the excavated material can be attempted. It is necessary to understand how the cultural layer was formed: what kinds of episodes are responsible for the accumulation of the cultural material, what kind of buildup of matrix has occurred on the site before, during and after the occupation, and what processes may have altered the site after its prehistoric formation (cf. Schiffer 1987; Wood & Johnson 1978). If this understanding is not achieved – if, for example, the signs of vertical stratigraphy or of the mixing of the deposits through frost (e.g., Schweger 1985) or rodent activity (e.g. Bocek 1986; Bocek 1992; Rankama & Kaikusalo 1990) are not recognized – the danger of dealing with mixed deposits is very real. Mixed deposits will inevitably lead to mixed results, which are ultimately worthless. Worse, if the mixing of the materials is never recognized, the results may cause confusion in the general interpretation of chronology and culture history for years to come.

The purpose of this paper is to question the conventional model of site formation in Finland and to show first, that the formation of the cultural layer on open-air Stone Age/Early Metal Age sites may not be quite as simple as has been assumed, and second, that studying site formation processes is both possible and profitable even in Finnish conditions. The examples are drawn from experimental archaeology as well as from the analyses of the assemblage of the Ala-Jalve site in Utsjoki (see Rankama 1997). It must be emphasized that the cases discussed here involve strictly open-air sites without any structures, apart from fireplaces, dug into the ground or assembled on the surface by people. The discussion, thus, has only limited relevance to sites with, for example, semi-subterranean building remains or garbage pits – limited, that is, to areas of the sites outside the prehistoric earth-moving activity.

Soil formation and archaeological deposits

Figure 1 shows a strongly discolored prehistoric cultural layer at Ala-Jalve and will serve as a reminder of the kinds of factors that are relevant when analyzing the formation of archaeological sites. First, it is essential to recognize the podsol profile and the fact that there is a substantial deposition of wind-blown sand layers on top of the podsolized part of the section. Between the podsol and the aeolian layers there is a dark stripe that represents the buried ground surface at the end of the prehistoric occupation. This turf layer that is now buried was essential for the stabilization of the matrix and the onset of podsolization in the first place. Even the wind-blown sand is layered and seems to have been deposited in several episodes.

Underneath the distinct horizons of the podsol in Figure 1 there is a thick horizon of dark stained sand, the color of which is probably derived mostly from charcoal particles. The wavy shape of the lower edge of the stained sand suggests the possibility of gelifluction, or the gradual sliding of the matrix down the slope, caused by freeze-thaw cycles (cf. Schweger 1985; Washburn 1980). Since the analyzed excavation areas at Ala-Jalve lie on the terrace and not on the slope, the effect of gelifluction on the studied artefact distributions has not, however, been noticeable. The length of the scale rod in the picture is 50 cm. The lower limit of the stained layer is in places as much as 40 cm below the buried turf.

Figure 2 shows the generalized vertical artefact distribution in Excavation Area 2 that lies next to the section in Figure 1 (see Rankama 1997, Fig. 2). The actual excavation spits have here been combined to form three 10 cm levels. When the distribution is compared with the section photograph it becomes apparent that the majority of the finds derive from the podsolized upper part of the soil profile. The finds layer ends c. 25 cm below the original ground surface, while the soiled horizon extends some 15 cm further down. The relationship between the stained sand and the finds is, thus, not quite simple.

Fig. 1. Section of Excavation Area 4 at the Ala-Jalve site in Utsjoki. Photograph by Aki Arponen, © National Board of Antiquities 1985. Published with the permission of the National Board of Antiquities, Finland.

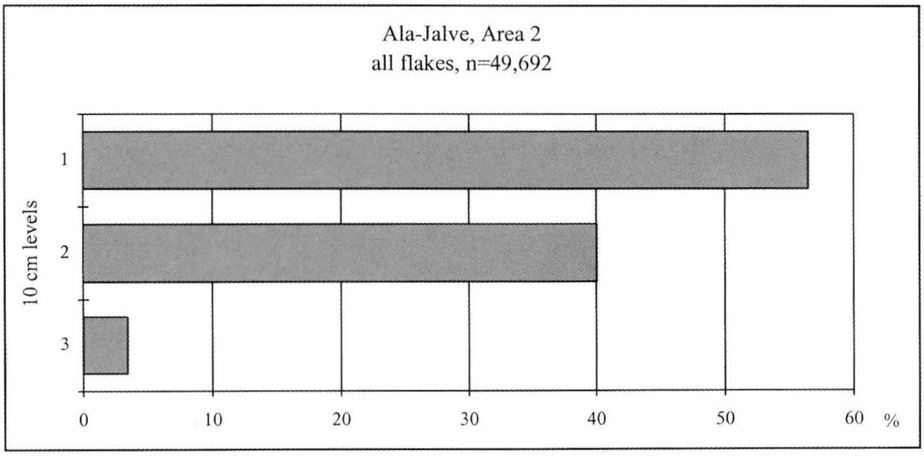

Fig. 2. Vertical distribution of quartz and quartzite flakes in Excavation Area 2 at Ala-Jalve, in combined 10 cm spits.

Soil formation has apparently removed the signs of cultural coloration in the upper part of the profile where the podsol horizons are distinct: the leaching caused by rain water has affected not only the iron oxides, bases, and humus in the sand (cf. Strahler 1969:309), but also the charcoal particles and other stains effected by human occupation. These staining agents have found their way below their original position, and even below the visible B-horizon of the podsol profile. This does not mean, however, that the upper profile has become culturally sterile: the artefacts will not be moved by rain water, and are still present.

These processes are obviously not unique to the Ala-Jalve site. What is important to note here, then, is first, that the soil terms "leached horizon" and "illuviation horizon" obviously do not refer to artefact distributions, and second, that the thickness of the stained "cultural layer", as it is seen today, may be much exaggerated compared to the original prehistoric situation. Even the shape of the stains may have been affected by soil formation or other disturbance processes. The truth of the matter can be found only through a survey of the finds distributions and through a thorough consideration of disturbance factors that may have affected the formation of the deposits during or after the prehistoric occupation.

The formation of such thick cultural layers as the one above has implicitly – and sometimes even explicitly (Vikkula 1981:121) – been assumed to have taken place during long-term or recurrent occupation, so that with time more and more artefacts and refuse have been mixed with the site matrix and buried gradually deeper and deeper into it. This model is necessarily based on the assumption that occupation always took place on bare beach sand not covered by vegetation or turf. As seen, for example, in the substantial stratigraphy of the Onion Portage site in Alaska (Anderson 1988), artefacts do not penetrate a turf layer. Bare sand, on the other hand, moves readily under the foot and is easily mixed. The model also assumes an infinite ability of the artefacts to penetrate deeper into the matrix. The question now is, how strong can the mixing actually be and how deep does it penetrate? In other words, can it really be assumed that a 25–30 cm cultural layer, not to mention the ones approaching a meter that have been discovered (e.g., Vikkula 1981:114), could be the result of simply trampling the archaeological remains?

Trampling experiments

The effects of trampling on archaeological materials have been studied in several experiments around the world, each focusing on different aspects of the question, depending on the particular research problems that prompted the study. The most relevant in the present context are the studies by Stockton (1973), Villa & Courtin (1983), and Gifford-Gonzalez & al. (1985), which focused on studying the behavior of lithic debitage buried in the sand. A trampling experiment designed specifically to simulate Finnish Stone Age conditions and to explain better the vertical artefact distributions at Ala-Jalve has also been carried out (Rankama & Kankaanpää 1994, 1999) and will be discussed below.

The results of all of the experiments mentioned above were similar in one respect: the artefacts were found to move around in the sand, but the maximum depth of vertical distribution was never more than 16 cm, and usually well below ten. Stockton's (1973) experiments were designed to throw light on the mechanisms of artefact mixing and sorting by size at a rock shelter site in Australia. To study the observed phenomenon that the average size of recovered artefacts decreased with depth and to test the hypothesis that this was caused by trampling, a collection of some 250 red glass fragments was placed on the surface of loose sand next to the archaeological excavations and then covered with 5 cm of more sand. The area was trampled for a day during the course of normal excavation activities.

The subsequent excavation of the experiment area revealed that the fragments had been distributed into a layer of 16 cm beginning at the surface. The trampling had, thus, not only caused some of the glass fragments to penetrate deeper into the underlying sand, but also lifted others above their original layer of deposition. A degree of size sorting had also occurred but, contrary to the author's assertion (Stockton 1973:116), the mean weights did not unequivocally descend with depth. Instead, they formed a curve, where the heaviest fragments were in spits 3 and 4, somewhat smaller ones were in spits 1 and 2 and the smallest and fewest fragments were in spits 5 and 6 (Fig. 3)[1]. In other words, it was true that the fragments in the lowest spits were the smallest ones, but also that the lifting caused by the trampling had affected slightly smaller fragments more than the largest ones.

Gifford-Gonzalez and her associates performed their experiments in California on two different types of matrix. In the first experiment a collection of 1000 replicated obsidian artefacts was placed on compact sandy silt, or "loam", and walked over for two hours by two persons. The site was then excavated and the locations of all of the individual artefacts were recorded three-dimensionally. The results showed that only 10 pieces had penetrated more than 4 cm into the matrix. In general the vertical penetration did not exceed 2 cm, and 94% of the artefacts had remained within 1 cm of their original level of deposition (Fig. 4). The authors

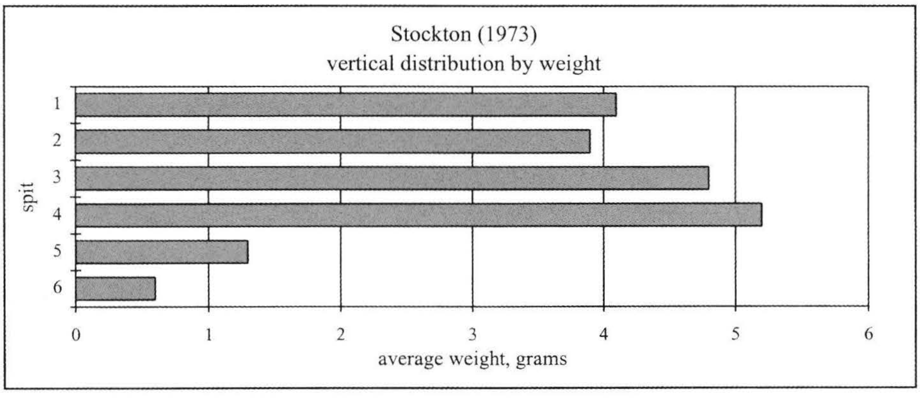

Fig. 3. The vertical distribution of artefacts by average weight after trampling in the experiment by Stockton (1973).

[1] Stockton's table of flake weights by spit (Stockton 1973:116) has a miscalculation in spit 1: 57 flakes weighing a total of 233 grams give an average weight of 4.1 grams, not 5.1.

attributed this result to the compact nature of the matrix (Gifford-Gonzalez & al. 1985).

The other experiment by the same group was performed on unconsolidated "medium-fine" dune sand (Gifford-Gonzalez & al. 1985:805). More detailed information on the character of the matrix is not available, since no grain size analysis was published. The procedure was similar to the previous one, with a similar collection of obsidian flakes deposited on the matrix. The results, however, were dramatically different: the vertical dispersal of the artefacts exceeded 10 cm (Fig. 5). The distribution approached a normal curve: c. 40% of the flakes were encoun-

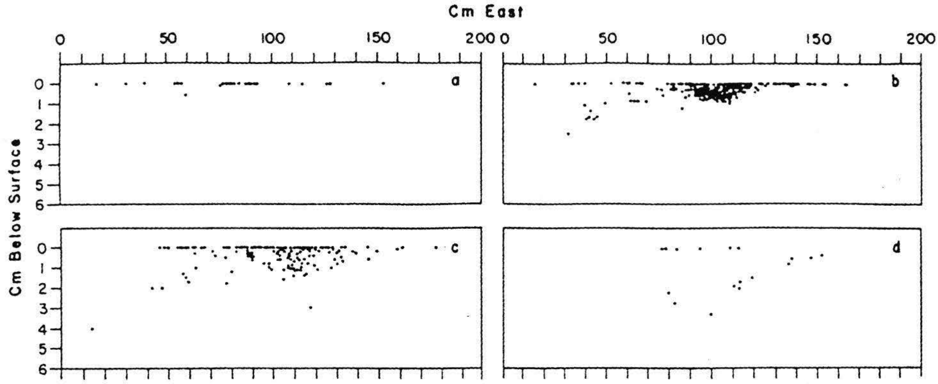

Fig. 4. Section view of the vertical distribution of artefacts after trampling on the compact loam site in the experiments of Gifford-Gonzalez & al. (1985).

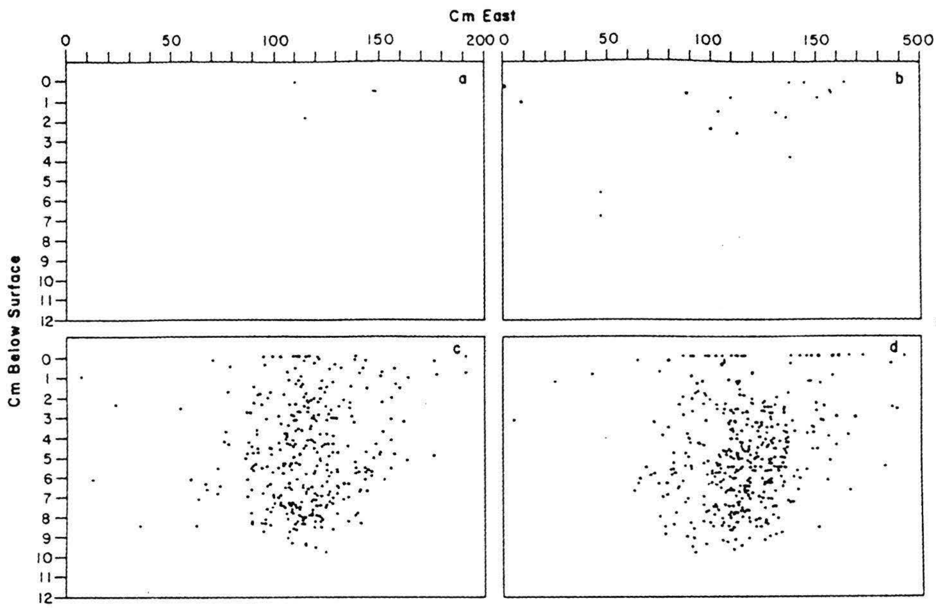

Fig. 5. Section view of the vertical distribution of artefacts after trampling on the loose dune sand site in the experiments of Gifford-Gonzalez & al. (1985).

tered at 3–8 cm below surface, with frequencies falling on both sides of this peak (Fig. 6; Gifford-Gonzalez & al. 1985:810, Table 1b). This seems to be the usual pattern for experimental vertical artefact scatters trampled on sandy matrices (Gifford-Gonzalez & al. 1985:810, 815–816, Fig. 8; Stockton 1973; Villa & Courtin 1983). Since all other conditions except the matrix were the same as in the previous experiment, the deep dispersal of the artefacts was attributed to the looseness of the sand on which the trampling occurred (Gifford-Gonzalez & al. 1985:805–807).

In the experiment carried out by Villa and Courtin (1983) 300 replicated artefacts were placed on an area outside a cave excavation in France that was repeatedly trampled during the normal course of excavation activities. The matrix was a "dry, loose, well-sorted silty sand (Villa & Courtin 1983:273)" – again, no grain size data are available. The area was divided in 1x1 m squares that were trampled for a minimum of 16 and a maximum of 36 days. This was, thus, the longest lasting and, perhaps, also the most realistic of the experiments discussed here. Part of the objective of the experiment was to study the mixing of deposits separated by a few centimeters of sterile sand. In one experimental square, therefore, two separate layers of artefacts were placed. The lower layer of artefacts was trampled for 20 days before it was covered with 3 cm of sand and a new layer of artefacts. The latter were then trampled for an additional 16 days.

The excavation of the experiment area revealed that in spite of the long duration of the trampling the artefacts had not penetrated more than 7–8 cm into the matrix (Fig. 7; Villa & Courtin 1983:273). It seems, thus, that there is a maximum vertical distance that artefacts will in general move under the foot. After the maximum depth has been reached the duration of the trampling is no more significant: no

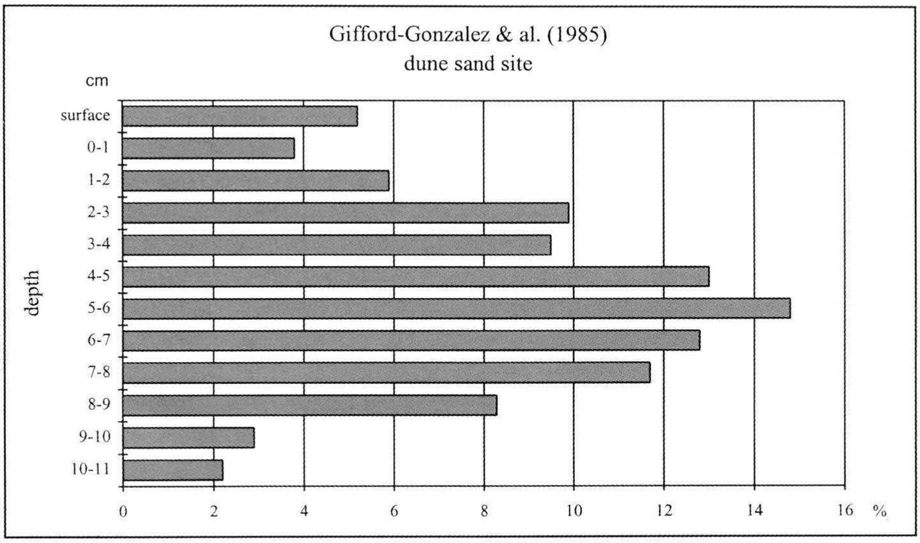

Fig. 6. Bar diagram of the vertical distribution of artefacts after trampling on the loose dune sand site in the experiments of Gifford-Gonzalez & al. (1985).

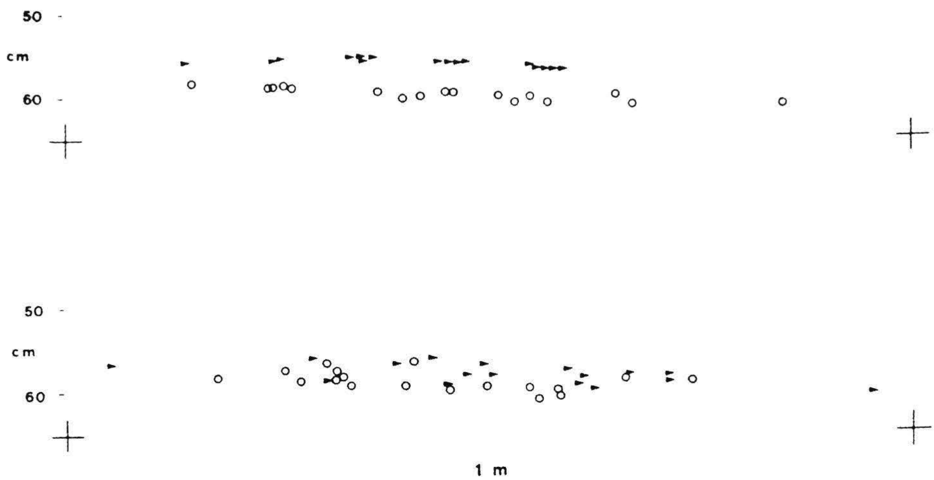

Fig. 7. Section view of the vertical distribution of artefacts separated by a 3 cm sterile layer before and after trampling in the experiments of Villa & Courtin (1983).

length of treadage will push them any deeper, assuming the top level of the matrix remains constant.

Figure 7 shows also that the trampling did manage to mix the artefacts in the two separate layers despite the 3 cm of sand that was placed between them. Although it is still possible to see a difference in the vertical trend between the upper and the lower level artefacts, it is obvious that a 3 cm sterile layer of sand between occupation episodes on a site with a loose matrix is not sufficient to keep their artefacts totally separate if any length of trampling occurs. On the other hand it may be assumed that there is a threshold in the thickness of deposited matrix after which mixing of artefacts will no longer occur. This threshold is probably at most somewhere around the 15–16 cm maximum trampling penetration and, depending on circumstances, may be much less.

The fourth trampling experiment was carried out at Brown University's Haffenreffer Museum of Anthropology over the winter of 1992–1993 (Rankama & Kankaanpää 1994, 1999). It was designed to address questions pertinent to Finnish Stone Age open-air site conditions, and specifically ones that had been found requiring investigation during the analyses of Ala-Jalve. These questions included:

1. How much vertical and horizontal movement does continued trampling produce in a lithic artefact scatter that has originally been laid on an even surface?
2. What are the shapes of vertical distribution curves produced through trampling, and how do they compare with curves from archaeological sites?
3. Does trampling have different effects on artefacts of different size groups?
4. Does trampling have different effects on artefacts of different shapes?
5. What kind of damage does a lithic assemblage suffer during trampling in a

fairly even-grained sandy matrix? Can this be distinguished from use damage?

6. Can the traces of a sterile layer between occupation phases be obscured by trampling? and if so,

7. Can the traces of the separate occupation layers still be discerned in vertical frequency diagrams?

A 2x2 m box was built of pressure-treated boards, with the height of the walls approximately 38 cm. The sand used in the box was mostly of medium coarseness, ranging from silt to gravel, and clearly coarser than dune sand (Fig. 8). Three different raw materials – obsidian, hard chert, and quartz – were used to produce collections of flakes, "tools", and cores of different shapes and hardnesses. These were spray painted with bright colors to ensure recovery after the trampling and to make observing possible fractures caused by the trampling easier. The flakes were divided into two size groups following the Ala-Jalve example: 2.2–6.3 mm and >6.3 mm. The samples used in the experiment consisted of 150 pieces of each size group of each raw material. In addition, ten obsidian "tools" and six quartz cores were included in the sample, making a total of 916 artefacts (Rankama & Kankaanpää 1994, 1999).

In the first part of the experiment, 20 cm of sand was shoveled into the box and lightly trampled to get an even, fairly solid surface. The obsidian and quartz artefacts were spread on this layer, which was then trampled for a total of four person-hours. Subsequently, another 8 cm of sand was shoveled into the box. The chert artefacts were spread on top of it in two concentrations, one containing size group 2.2–6.3 mm and the other containing size group >6.3 mm. The purpose of the two concentrations here was to study the horizontal displacement of the arte-

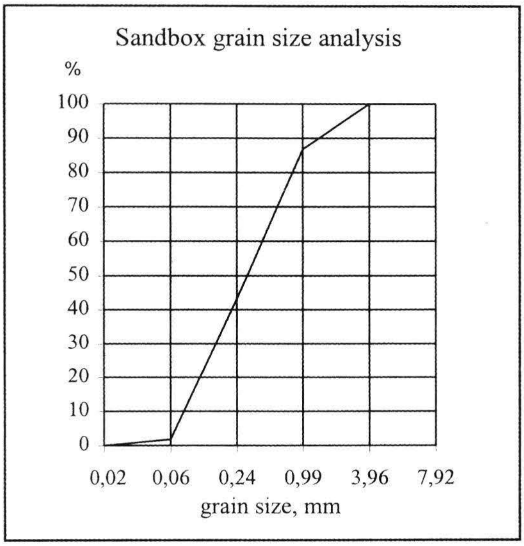

Fig. 8. Matrix grain size graph for the sandbox experiment.

facts, and also to get a better view of the vertical behavior of artefacts of different sizes (Rankama & Kankaanpää 1994, 1999).

The sandbox was then covered and left to rest over the winter. The second layer of artefacts was trampled after the sand had thawed the following spring. Again, four person-hours were spent walking over it. The box was then excavated with trowels and the locations of the artefacts were recorded three-dimensionally with a WILD TCU 1000 Total Electronic Station (Rankama & Kankaanpää 1994, 1999).

In the present context, the most significant results of the experiment concern the vertical displacement of the artefacts. These indicate that the maximum vertical displacement through trampling was no more than 5–6 cm and that part of even this movement was probably due to the compacting of the matrix. There was no mixing of the artefacts in the upper and lower scatters. In this matrix the 8 cm sterile layer between them had been sufficient to keep them separate, especially since the artefacts of the lower scatter had been trampled down from the surface by the time the second sand layer was deposited (Fig. 9; Rankama & Kankaanpää 1994, 1999).

Vertical displacement among the chert artefacts (top scatter) was more pronounced than among the obsidian and quartz (bottom scatter) – a phenomenon, for which an explanation is yet to be found. Both of the raw materials in the bottom scatter produced very similar vertical distribution curves, approaching a narrow normal curve (Rankama & Kankaanpää 1994, 1999). The curve for the chert was wider and even more "normal" (Fig. 10), which corroborates the results of the earlier trampling experiments (Gifford-Gonzalez & al. 1985:810, 815–816, Fig. 8; Stockton 1973; Villa & Courtin 1983). No evidence was found to support the suggestion that the shapes of the artefacts might play a role in their behavior during trampling (Rankama & Kankaanpää 1994, 1999).

The fact that in each raw material the trend of the distributions was for the flakes in the smaller size fraction to be slightly higher in the matrix than the larger size group (see Fig. 9) indicates that winter frost was not a deciding factor in the vertical displacement of the artefacts. The expected effect of frost would be for the smaller flakes to end up deeper in the matrix since they can more easily fall in the cracks created by the freezing and thawing water in the sand. The results of the experiment can therefore not be refuted by referring to the possible adverse effects of frost.

All of the experiments summarized above demonstrate that the formation of thick cultural layers can only be explained through trampling up to a depth of a maximum of 15 cm. The maximum penetration of trampled objects obviously depends on the kind of matrix present at the site. Compact silts and clays allow less penetration, while at the other end of the scale are dry, loose dune sands that are the most easily moved under the foot. Since the matrix of the majority of Finnish Stone Age sites probably lies between these extremes, the effect of trampling as a site forming mechanism may be assumed to be below the 15 cm maximum. Consequently, when the thickness of a cultural layer exceeds this, other explanations for its development than trampling need to be explored.

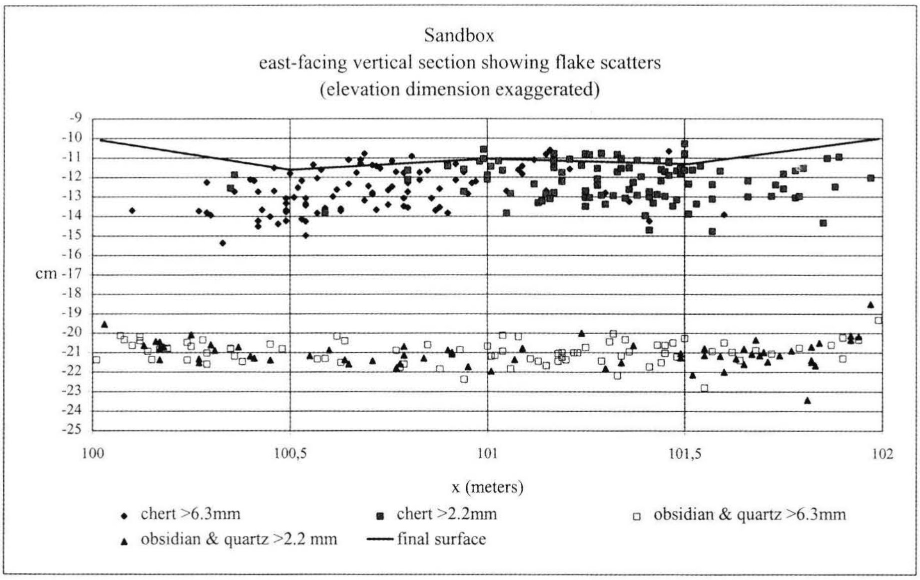

Fig. 9. East facing section view of the vertical distribution of artefacts along a 1 m wide transect through the centre of the sandbox after trampling.

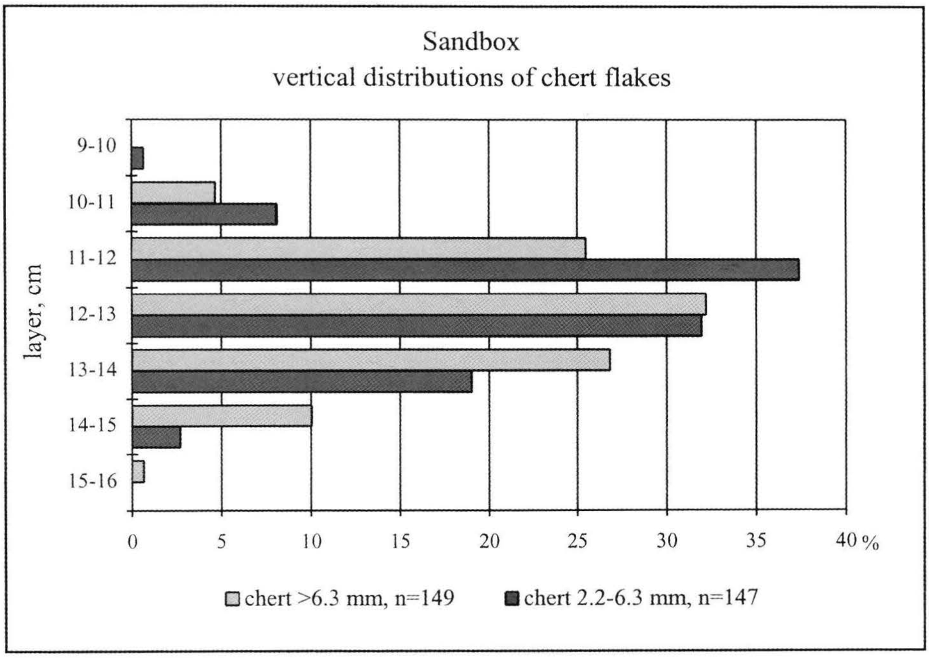

Fig. 10. Bar diagram of the vertical distributions of the chert flakes in the sandbox after trampling.

The Ala-Jalve analyses

The analyses of the cultural layer of the Stone Age/Early Metal Age site in Utsjoki Ala-Jalve (Rankama 1995, 1997) have provided an opportunity to contemplate other mechanisms of site formation. The first impression of the site's enormous finds assemblage is one of homogeneity. It is dominated overwhelmingly by lithic waste, 98% of which is quartzite and seems to be derived from the manufacture of bifacial straight-based arrowheads. This industry, together with the asbestos-tempered Group L Sär 2 pottery and the Sunderøy type slate arrowheads that are associated with it, can be dated with a fair amount of accuracy to between 1800 bc and 700 bc[2] (Rankama 1996:607–669; Rankama 1997).

The radiocarbon dates from Ala-Jalve, together with some characteristics of the distribution of the finds, however, suggest that the occupation of the site is not quite so simple to explain. There are indications of at least two earlier occupation phases. In Excavation Area 1, toward the edge of the main finds concentration (see Rankama 1997: Fig. 2), radiocarbon dates from reliable contexts concentrate between 2300 and 2000 bc, which is clearly too old for the Sär 2–Sunderøy–straight-based arrowhead complex. In addition, a long series of dates from a large hearth in the central area of the site suggests activity at 4200–4300 bc, around the Mesolithic/Neolithic boundary (Rankama 1997: Appendix 1).

Although none of the finds recovered from the site so far can be tied to the Late Mesolithic/Early Neolithic dates, some characteristics of the assemblage from Area 1 differ from the main assemblage and may be linked with the dates around 2200 bc. The lithic raw material composition here is reversed: 57% of the flakes are quartz and 43% are quartzite (Rankama 1997: Fig. 11). Those quartzite flakes that exist are different from the ones in the more centrally located Excavation Areas 2 and 13: larger flakes dominate clearly over the small ones that elsewhere form more than half of the assemblage (Fig. 11).

These suggestions of more than one period of occupation led to the search of more signs of the earlier use of the site. It was clear that if an understanding of what had taken place at the site during its use was to be achieved, it was necessary first to find out which elements of the assemblage actually belonged together. Otherwise any behavioral analysis would be compromised by the possibility that the data on which it was based represented separate episodes of activity, were therefore incompatible, and produced misleading results.

One of the hypotheses formulated in the beginning of the research was that although quartz as such could probably not be considered exclusive to the older occupation episodes of the site, it might be possible to see chronological variation reflected in the proportions of the raw materials. In other words, a greater proportion of quartz in the assemblage might be an indication of a period prior to the introduction of the intensive quartzite industry. The hypothesis was based on the fact that quartz is the dominant raw material throughout the Stone Age in Lapland and that most – but not all – of the quartzite at Ala-Jalve obviously derived from

[2] Uncalibrated radiocarbon years are used in this paper. For calibrated values of the Ala-Jalve dates, see Rankama 1997, Appendix 1.

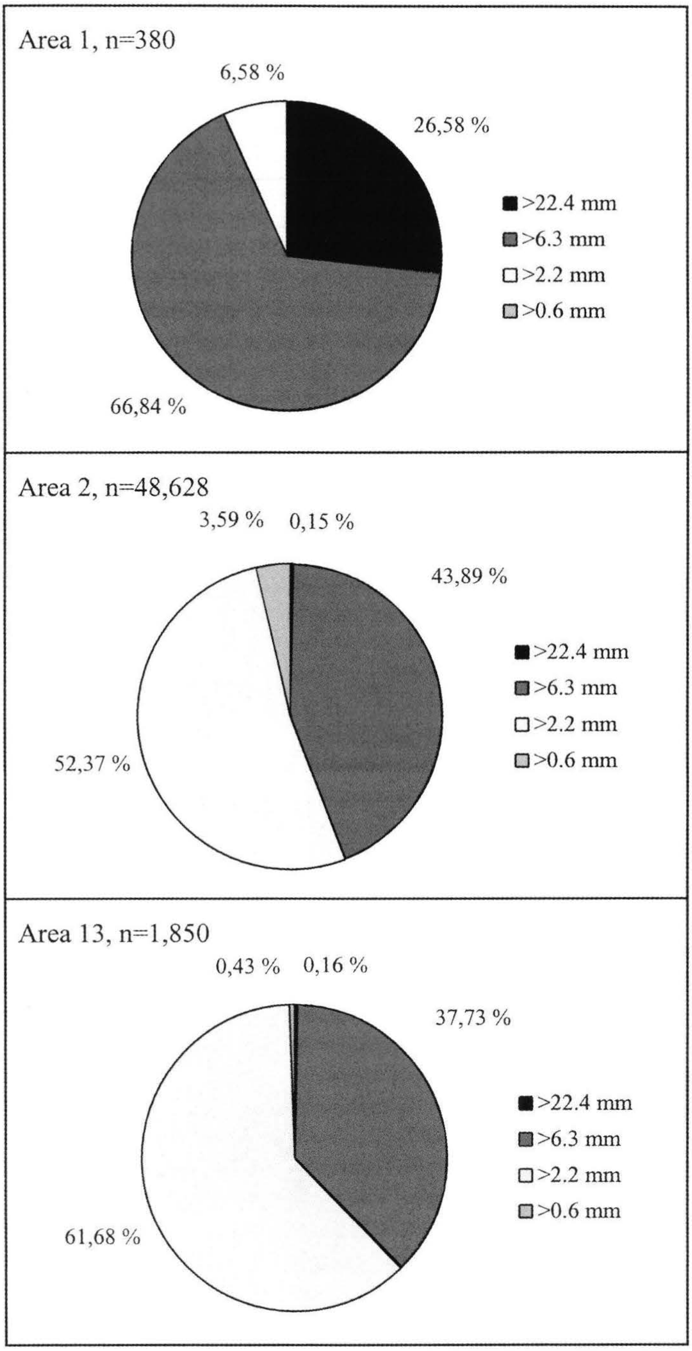

Fig. 11. Flake size distributions in Excavation Areas 1, 2, and 13 at Ala-Jalve.

bifacial reduction and was, therefore, tied to the manufacture of the chronologically diagnostic straight-based arrowheads that belonged to the Early Metal Age (Rankama 1997:18). It was also supported by the combination of early radiocarbon dates and quartz dominance in Excavation Area 1.

Another hypothesis was that there might be a period in the use of quartzite at the site where the raw material had been introduced but the bifacial manufacture had not yet begun. This would be visible as a greater proportion of flakes derived from platform core reduction. Since platform core flakes are often larger and thicker than bifacial flakes, the pattern of the size distribution of flakes in Area 1 might be seen as a suggestion of the possibility of earlier occupation here – or, perhaps, of distinct activity areas within the site. Since these hypotheses found support in the situation in Excavation Area 1, their testing could be continued in the subsequent analyses of the cultural layer at Ala-Jalve.

The fact that the density of finds at the site had made it necessary to excavate it in 2.5 cm spits and record the finds in 25x25 cm quadrats made it possible to carry out detailed distribution studies both horizontally and vertically. The vertical distribution studies revealed a bimodal distribution of quartz and quartzite flakes in Excavation Area 13: there was a strong peak in the curves at spit 1, but also another one in spit 6 (Fig. 12). The lower peak was more pronounced among the

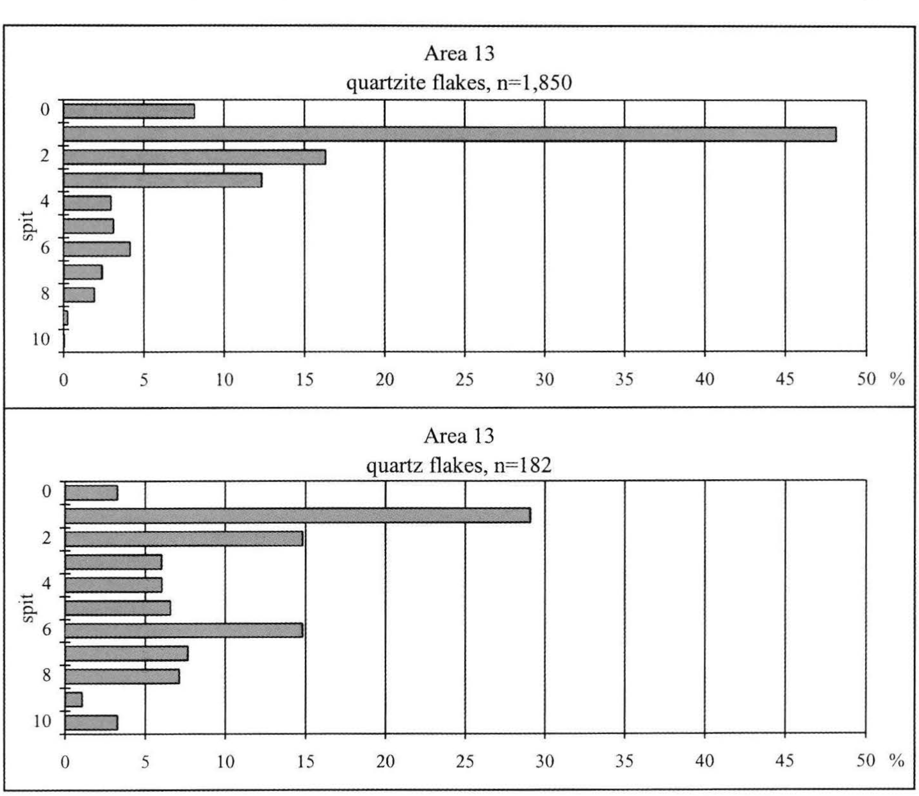

Fig. 12. The vertical distributions of quartzite and quartz flakes in Excavation Area 13 at Ala-Jalve.

quartz flakes. These were also on the whole more evenly distributed in the cultural layer than the quartzite flakes, whose emphasis was clearly in the upper part of the deposit.

This pattern suggests that the cultural layer, which seems quite homogeneous in the section (Fig. 1), nevertheless derives from at least two distinct occupation phases or episodes, and that after the first occupation, a layer of sand has been deposited on the cultural layer – otherwise the artefacts would have been mixed with each other. In other words, vertical stratigraphy seems to be indicated. The deposit of sand has been thick enough to keep later trampling from obscuring the differences between the archaeological deposits. The quartz–quartzite proportions are different in the upper and lower parts of the cultural layer: in spits 0–3 only 6% of the flakes are quartz and 94% are quartzite, while in spits 4–10 the figures are 23.5% of quartz and 76.5% of quartzite. This supports the hypothesis of the development of raw material use at the site.

In the other studied excavation areas the vertical distributions of flakes are not quite so clearly bimodal as in Area 13, at least not when looking at the raw material distributions one by one. In Excavation Area 2, however, the peaks of the vertical distribution curves of quartz and quartzite flakes are at different depths (Fig. 13): the quartzite curve peaks in spits 2–3, while the peak of the quartz curve is in spits 4–6. A similar trend, though not quite so clear, can be seen also in Area 1 (Rankama 1997: Fig. 15). This, again, supports the hypothesis that the predomi-

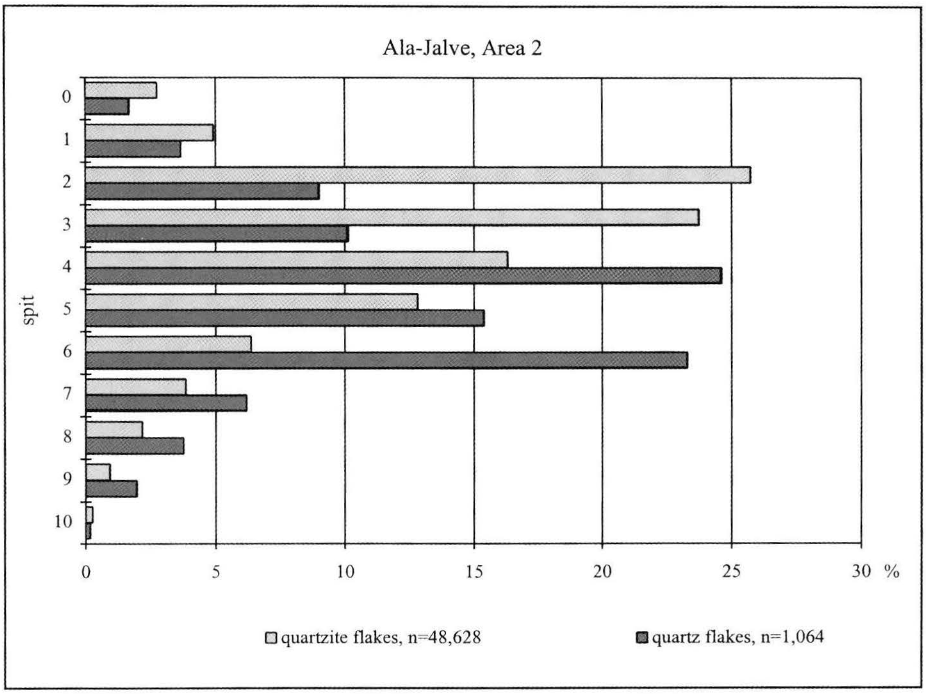

Fig. 13. The vertical distributions of quartzite and quartz flakes in Excavation Area 2 at Ala-Jalve.

nance of quartz is an early feature at Ala-Jalve. It also adds weight to the suggestion that the cultural layer contains vertical stratigraphy.

The fact that the curve in Area 2 is not strictly bimodal suggests that the deposition of sand on top of the earlier cultural layer has not throughout the site been sufficient to keep the occupations completely separate from each other. Some mixing has taken place, but not enough to obscure the vertical trends of the individual raw materials. Part of the mixing has probably been caused by post-occupation disturbance factors, such as frost and burrowing animals, of which there is evidence below the cultural layer (Rankama & Kaikusalo 1990)[3]. These factors, and the amplitude of quartzite as a whole, explain the high number of quartzite flakes even in the bottom part of the cultural layer. Nevertheless, they have not managed to change the general trend that the quartz flakes concentrate deeper than the quartzite – a trend that can not be explained through any known disturbance factor.

An analysis of lithic reduction techniques among the quartzite flakes, and the distributions of the techniques in different parts of the Ala-Jalve site revealed that the platform core flakes both in Area 1 and in Area 13 concentrate deeper in the cultural layer than the bifacial flakes (Fig. 14–15). Although the differences in the distributions are not great, they are sufficient to support the chronological differentiation between the techniques and to emphasize the differentiation between the upper and lower part of the cultural layer. The age difference between platform core and bifacial reduction is also supported by the horizontal distributions of the flaking techniques: in Area 1 platform core flakes form 55% and bifacial flakes only 39% of the quartzite flake assemblage, while in the other analyzed areas the clear majority of the quartzite flakes derive from bifacial reduction (Fig. 16; Rankama 1997:78–79). The vertical distribution differences in bifacial and platform core flakes in other excavation areas suggest that the pattern in Area 1 is, indeed, due to chronology and not to differences in activity areas within the site.

The analyses of the cultural layer at Ala-Jalve, thus, offer clear indications of vertical stratigraphy at the site. The results emphasize the value of detailed distribution studies in the analysis of Stone Age/Early Metal Age occupations even when distinct stratigraphic layers are not visible in the site section.

The mechanism of matrix deposition

The discovery of the bimodal vertical distribution of finds made it necessary to examine possible mechanisms that might have caused the deposition of sand on top of the cultural layer between the occupation phases at Ala-Jalve. During its occupation the site was too high from the river surface for floods to have reached it and flood deposition was out of the question. Other alternatives included landslides caused either by rainwater running down the slope from the upper terrace, or by freeze–thaw cycles. Since these mechanisms could be expected to have caused

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[3] See Rankama 1997 for a discussion of the effects of various disturbance factors on the cultural layer.

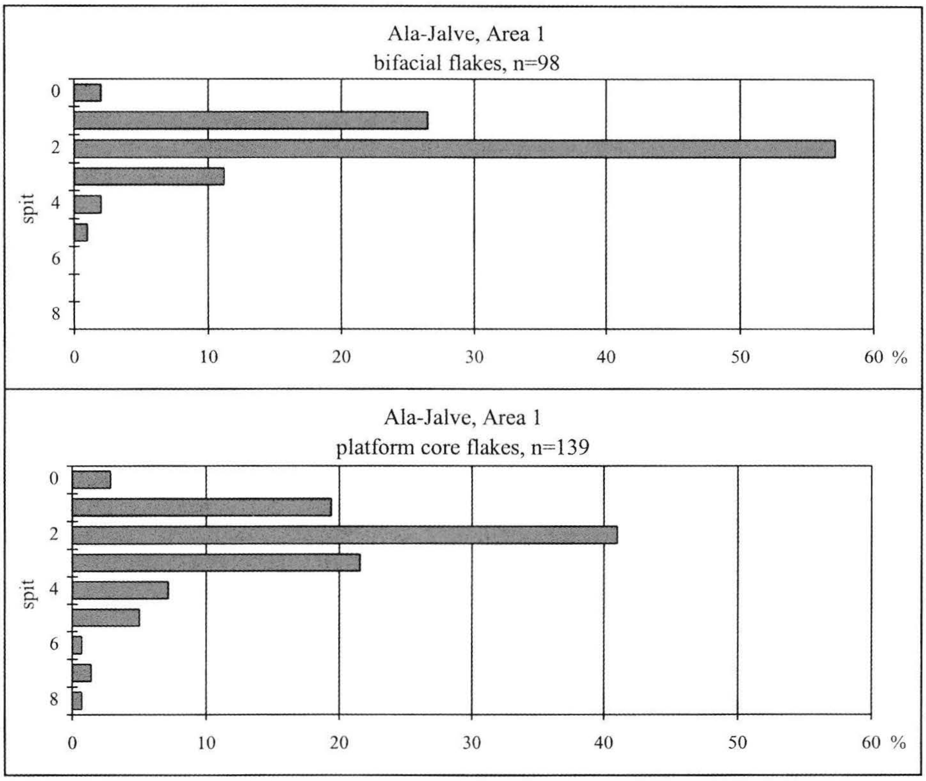

Fig. 14. The vertical distributions of bifacial and platform core quartzite flakes in Excavation Area 1 at Ala-Jalve.

more severe erosion than there was evidence for, they were also considered unlikely. The only remaining option was wind. The presence of evidence for later aeolian activity at the site (see Fig. 1) lent support to this possibility.

To evaluate the hypothesis that at least part of the sand on the site was, or could be, deposited by wind, a grain-size analysis of the matrix was carried out. The soil section showed that the bottom sand was of glaciofluvial origin. The grain-size analysis was designed to determine which of the other horizons could have been aeolian. With luck, it might be possible to distinguish the wind-deposited layers at the top of the cultural layer from the coarser sand at the bottom, into which the oldest cultural layer of the site had formed.

The grain-size analysis (Fig. 17) shows that the whole matrix is fine enough to allow wind transportation and that there is little difference between the six studied horizons. This is disappointing in the sense that apart from the clearly untouched glacial sand, no part of the matrix can unequivocally be shown to be *in situ*. On the other hand the results support the hypothesis of wind as the mechanism behind the added deposition of sand on the site. In fact, it now seems probable that wind deposition has taken place at the site throughout its prehistoric occupation: as long

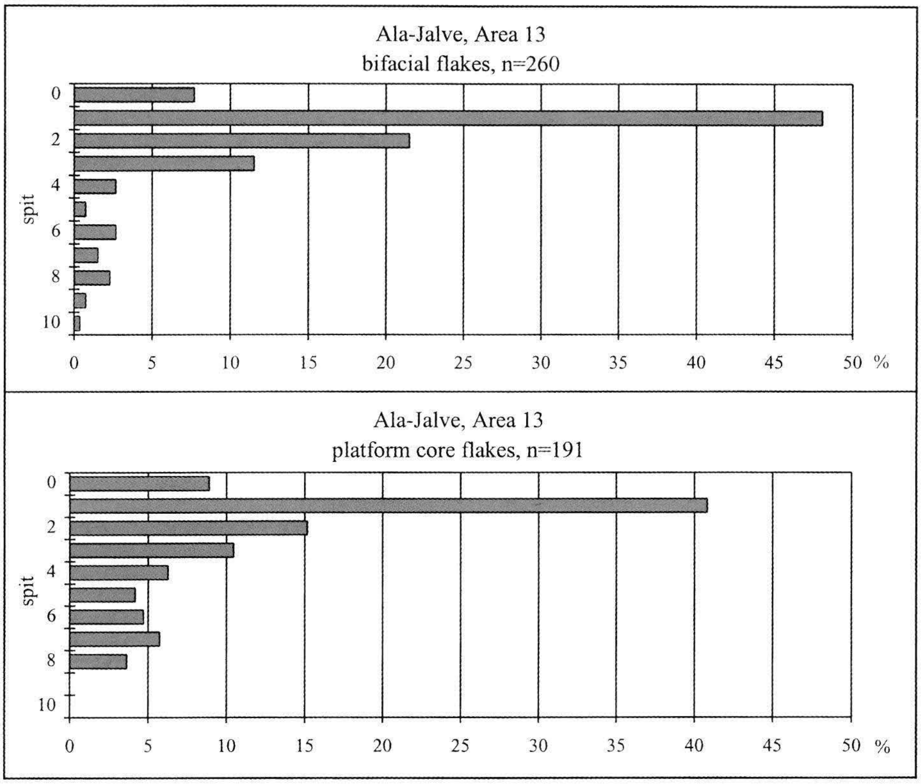

Fig. 15. The vertical distributions of bifacial and platform core quartzite flakes in Excavation Area 13 at Ala-Jalve.

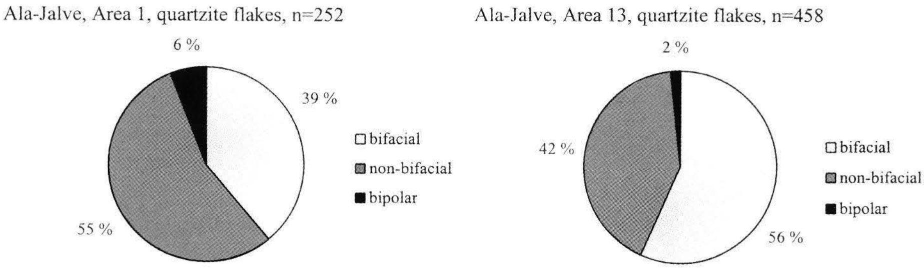

Fig. 16. The distributions of bifacial, platform core, and bipolar quartzite flakes in Excavation Areas 1 and 13 at Ala-Jalve.

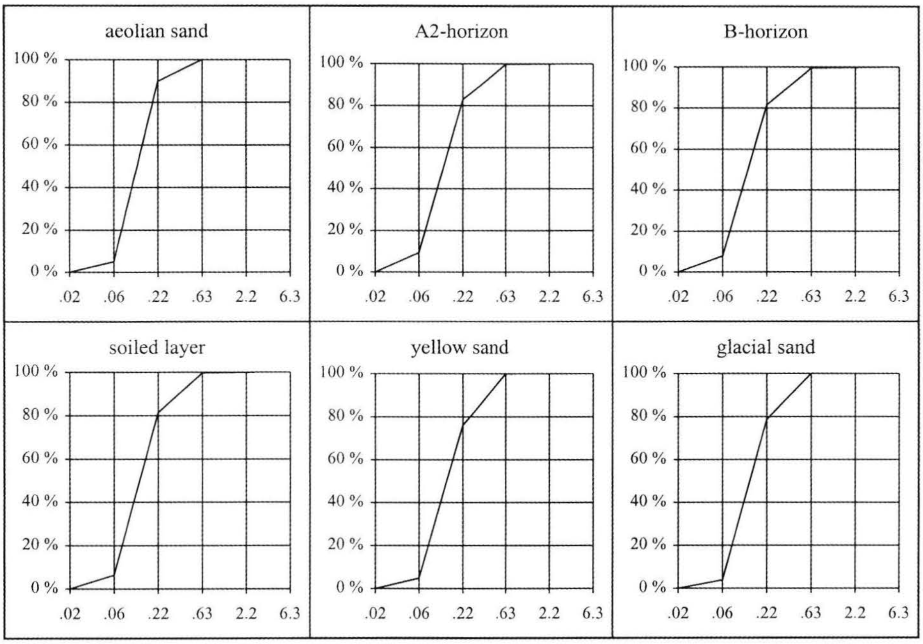

Fig. 17. Matrix grain size graphs for the samples from Ala-Jalve.

as an uninterrupted vegetation cover was absent, the sand flew every time the wind was strong enough – a phenomenon experienced more than once also by the excavation team. The source of the wind-blown sand is also close at hand: the local glacial sand qualifies nicely.

The fact that no clear wind-blown sand layers are seen in the soil section apart from the latest, recent, episodes of aeolian deposition can be explained through several phenomena:

1. During the time of the formation of the cultural layer the site was free of vegetation cover. There was, therefore, no turf layer that could have been covered by aeolian deposits and preserved in the section as a layer visible today;
2. The bare fine-grained sand matrix allowed the inevitable trampling during the occupation episodes to mix at least the thinner aeolian deposits with the rest of the cultural layer;
3. The podsolization that took place after the prehistoric occupation destroyed any signs of wind-blown layers that might still have been visible.

Although the top of the cultural layer was usually mixed with the wind-blown deposits and the cultural remains of the next occupation episode, the gradual accumulation of sand during centuries led to thicker and thicker deposits on top of the earliest archaeological material and the growth of a thicker cultural layer. It is the vertical stratigraphy developed through this process that can today be detected in the artefact distributions with the use of sufficiently accurate methods of recovery and analysis.

To summarize: In the case of Ala-Jalve, the thickness of the cultural layer, which exceeded 15 cm, indicated that the deposits at the site could not have been formed simply through trampling during long-term or recurrent occupation. The subsequent analyses of finds distributions revealed several signs of vertical stratigraphy, i.e., that the archaeological material on the site had between or during occupation episodes been covered with deposits of sand that had gradually caused the older material to be buried by a thick layer of matrix. The sand had been deposited on the site by wind. The fact that the vertical stratigraphy was not visible in the soil section did not prevent detecting it through a detailed analysis of the archaeological material.

Discussion

The examples outlined above indicate that the formation of cultural layers on open-air Stone Age/Early Metal Age sites is not simple and merits a close scrutiny. As soon as the thickness of a cultural layer exceeds 15 cm mechanisms of the deposition of matrix on top of the site during or between occupation episodes must be surveyed. In these situations the existence of vertical stratigraphy is likely, regardless of whether the site lies on the former sea shore or not.

The detection of vertical stratigraphy has the potential of providing us with finer chronological resolution than has been possible with traditional methods of dating based on horizontal stratigraphy. This is due to the fact that the deposition of matrix on a site can take place very rapidly: on a seasonally occupied site a new layer of sand may be deposited after every occupation episode. Since shore displacement has not been so fast as to cause the moving of the focus of the occupation every year or even every decade, noticeable growth of the cultural layer is possible within one location even on coastal sites. Consequently, fine-grained analyses of vertical artefact distributions may be able to detect development within previously distinguished chronological phases, not only between phases separated by different elevations above sea level.

At Ala-Jalve, vertical stratigraphy allowed the division of the quartzite utilization at the site into two distinct phases: one in which the emphasis in lithic technology was on platform core reduction and a later one in which bifacial reduction was the dominant technique employed. This had the wider implication that the introduction of the use of quartzite in Finnish Lapland could no longer be tied to the introduction of the chronologically diagnostic straight-based bifacial arrowhead and, consequently, that the presence of quartzite on archaeological sites could not be considered a chronological indicator (Rankama 1997).

Vertical stratigraphy at Ala-Jalve also suggested the possibility that the use of Group L Sär 2 pottery might go further back in time than the introduction of the straight-based arrowhead (Rankama 1997). In a similar way, the innovative analysis of vertical finds distributions at other sites might lead to detecting chronological differences between artefact groups that have previously been regarded as contemporaneous or that have not been considered chronologically diagnostic. It might even provide clues to finer divisions within pottery types that have gone undetected or unexplained before.

Even if no dramatic reorganization of artefact categories or chronology is forthcoming in every analysis, the scrutiny of vertical finds distributions allows the detection of site formation and disturbance processes, the understanding of which is essential to our ability to interpret the occupations and cultural processes we are studying. The key to gaining this understanding are the methods of excavation and recording that are employed. A finer resolution in analysis results can only be achieved through finer data collection methods, including thinner excavation spits and smaller units of recovery, or even the individual recording of every item. Although the use of a 10 cm spit may be sufficient for the level of analysis that relies on the interpretive potential of horizontal stratigraphy, it has impeded the detection of vertical stratigraphy in all but the most obvious cases, and consequently has deprived archaeologists of a potentially powerful analytical tool and even concealed its potential existence. The fact that vertical stratigraphy has so far been virtually unknown at Finnish Stone Age sites does not mean that it does not exist, only that it has not been looked for.

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