MESOLITHIC INTERFACES

VARIABILITY IN LITHIC TECHNOLOGIES IN EASTERN FENNOSCANDIA

EDITED BY TUIJA RANKAMA

THE ARCHAEOLOGICAL SOCIETY OF FINLAND

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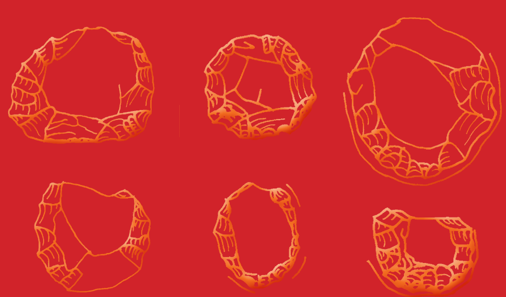

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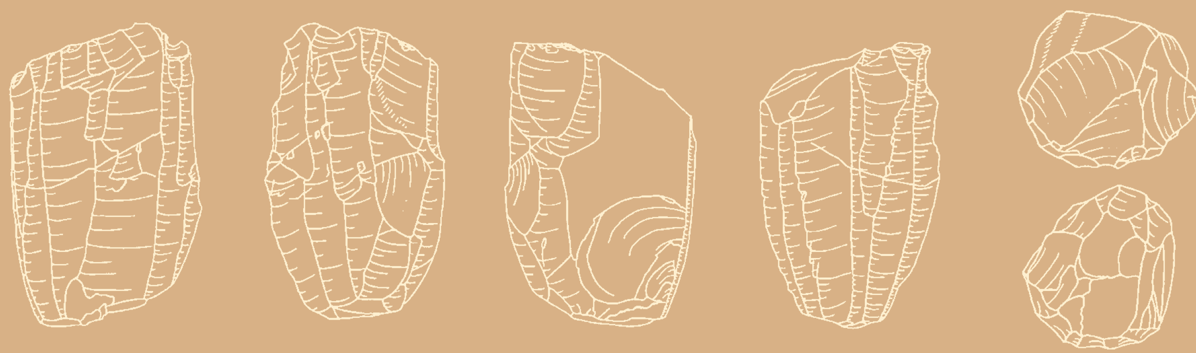
Contents



Foreword

Tuija Rankama

This book brings together results of the *Interfaces in the Mesolithic Stone Age of Eastern Fennoscandia* project. The project took shape in 2003 in discussions about the specific interests of the core members of the Lithic Studies Group at the University of Helsinki: Esa Hertell, Mikael A. Manninen, Tuija Rankama, and Miikka Tallavaara. It became clear that much of the research in progress or on the planning board had to do with different kinds of interfaces during the Mesolithic: geographical, geological, chronological, and cultural borders, as well as, importantly, the interface between technology and society. The group felt that for a number of reasons these could best be studied through lithic artefacts, which became the foci of the original research plan and remain the key element of this final publication.

Lithic artefacts have the advantage of being an abundant find category in Stone Age sites. Stone tools and waste are also virtually indestructible and therefore easy to recover in archaeological excavations. From a technological point of view, the most important characteristic of lithic assemblages is the fact that they derive from a reductive process: instead of building an artefact from smaller constituents, stone tools are manufactured by removing material from a blank. Due to its indestructibility, the removed material is preserved at the manufacturing site, which allows the archaeologist to reconstruct the manufacturing process. As human behaviour, this is influenced by its social context. A study of lithic technology is, thus, by definition, a study of human society. This book reflects that fact throughout its papers.

Not all of the research carried out by the *Interfaces* project is included in this publication. Some of it has been published separately, for example the results of our quartz knapping experiments (Tallavaara & al. 2010). As often happens in scientific projects, the

research has also branched out and formed new projects. A notable example of this is the Lapland Pioneers project currently funded by the Academy of Finland. It grew from the discovery of the Sujala site in 2002, and my part of the early research of the site was funded by the *Interfaces* project. As the research expanded and additional funding was obtained, the project became independent and began to publish on its own. Some of the results of the research have been included in this volume; more will be published as the work continues.

The contents of this book will be discussed briefly in the introductory chapter. What remains now is to thank those who have helped us complete this research and book project. Since so many people have been involved in the various research endeavours, each paper has its own set of acknowledgements. For the part of the whole *Interfaces* project, we first wish to thank the Finnish Cultural Foundation, who had enough faith in us to sponsor us for three consecutive years. We hope that this book proves that their faith was not totally ill-founded.

Throughout its existence, the *Interfaces* project has benefited from the help and support of the project advisory group: professor Douglas D. Anderson (Brown University), professor Sheila Coulson (University of Oslo), professor emeritus Richard A. Gould (Brown University) and professor Kjel Knutsson (Uppsala University). We sincerely thank them for everything they have done to help us along.

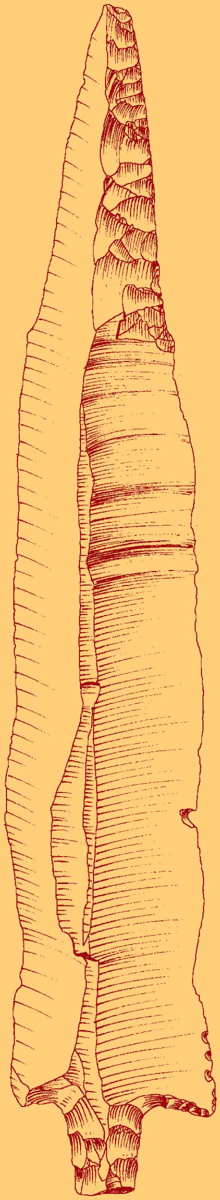
To ensure the scientific value of the papers in this book, each of them was reviewed by two esteemed referees. We are extremely grateful for the trouble they took in helping us make the book better. Our sincere thanks go to (in alphabetical order) Jan Apel, Hein Bjartmann Bjerck, Christian Carpelan, Sheila Coulson, Killian Driscoll, Berit Valentin Eriksen, Richard A. Gould, Ole Grøn, Petri Halinen, Bryan Hood, Jarmo Kankaanpää, Helena Knutsson, Heikki Matiskainen, Felix Riede, Mikkel Sørensen, and Mikhail Zhilin. It should be noted that, although the above list includes a few authors or spouses of authors, they, of course, did not review papers by close relations. In addition to the outside readers, the members of the *Interfaces* project have been each other's harshest critics – but also firmest supporters.

Some of the research included would not have been possible without the participation of scholars outside the core of the *Interfaces* project. We are very grateful to Jarmo Kankaanpää, Kjel Knutsson, and Aivar Kriiska for their indispensable contributions.

The wonderful layout and graphic design of the book (and some quirky illustrations) are the work of graphic designer-turned archaeologist Mikael Nyholm, who joined the book project fairly early and whose help and suggestions were invaluable for the end product. We thank him most sincerely! We also want to thank the Finnish Archaeological Society for agreeing to include the book in their publication programme and letting us design it the way we wanted.

Finally, as the leader of the *Interfaces* project and the Lithic Studies Group I want to thank the other members for the thirteen years we have worked and studied together. It has been a remarkable journey and a wonderful privilege to follow the development of talented students into full-fledged archaeologists and excellent researchers. Thank you, guys!

Veikkola, on the verge of spring, AD 2011
Tuija Rankama



Introduction

Esa Hertell & Mikael A. Manninen

The project *Interfaces in the Mesolithic Stone Age of Eastern Fennoscandia* was designed to study Mesolithic stone tool technologies in eastern Fennoscandia. As simple and straightforward a goal as that may sound at first, some words about the history of the project, the original and fulfilled goals, and the evolution of ideas may be a good starting point for this book. We hope that this helps in placing the book in its context as a part of Fennoscandian archaeology.

The foundation of the project was laid when Tuija Rankama started a volunteer study group on lithic technology at the University of Helsinki in the late 1990s. At that time, the discipline of archaeology as taught at the University of Helsinki provided relatively little formal training on the methods of analysing archaeological materials. Courses on prehistoric archaeology included mainly information on artefact typology, e.g., on ground stone tool types and pottery styles, and on the spatio-temporal distribution of types, rather than on the technological processes of manufacture and on the way this information could be utilised to draw inferences about the past. Due to the small number of working archaeologists and the nature of chipped quartz assemblages in Finland, local stone tool studies had concentrated on ground stone tools while the potential of chipped lithics was somewhat undervalued in comparison to other artefact classes. Students were acquainted with chipped lithics and basic flaking methods through passing references during courses on local and world archaeology, when basic types of stone artefacts, e.g., blades, handaxes, and Levallois cores, were briefly touched upon.

The newly formed group concentrated on lithic technology and on the study of chipped quartz, the main lithic raw material in Stone Age Finland. The course also provided new insights into archaeological materials in general, as concrete artefacts were incorporated into the larger theory/ies of hunter-gatherer archaeology. We suspect that this was soon realised by many of those later-to-become-archaeologists who took part in the study group. The issues discussed were new to us and the way things were approached and dealt with was also somewhat different from other courses. The lithic studies group had a continuity that was not available in other university courses that typically lasted only for a short semester. The group also provided a contact network where it was possible to discuss archaeological questions on a shared platform.

This was also the platform on which a project to study the Mesolithic was later launched. We decided to work with the Mesolithic, as the products of stone tool technology formed the major part of the artefact record of the period. Furthermore, interest in the Mesolithic had been growing since the late 1980s among Finnish researchers, but research on the material was, and still is, greatly underrepresented as compared with other periods. At the same time, we were already working with the Mesolithic in other connections. A common project thus provided a means to combine all the existing efforts. An application was written to the Finnish Cultural Foundation, and the Foundation showed a green light.

The original goal of the project was to study Mesolithic stone tool technology in spatially discrete case areas. What was aimed at was a relatively long band of individual research areas reaching from Estonia to northernmost Finland. This is a rather large area: the distance from southernmost to northernmost Finland alone exceeds 1000 kilometres. The idea was to collect information about technological variation and the possible causes of the variation in the different case areas. We hoped that this would form a framework of models that could be tested and/or built upon in later studies – a sort of backbone for future research. The original idea was partly maintained in the subsequent work and some chapters of the book discuss the original case areas.

The spatial dimension was the result of our earlier work and interests. Before the project was launched, we were already working in different areas. Tuija Rankama had been working in Lapland, i.e., in northern Finland, since the eighties, and Mikael A. Manninen was also working in the same area. Mikael and Esa Hertell had been involved in studies in Estonia with Aivar Kriiska. Results of research in these areas are available in this book. Further case areas in southern Finland and the northern Satakunta–southern Ostrobothnia region were included in the original project design and work in the area was carried out, but this research did not reach the current book.

As the name of the project indicates, another central theme in the original plan was to study *interfaces*. An *interface* was understood as a border zone, whether it be geographical, geological, chronological, cultural, or other. The idea was to study how these interfaces may have affected lithic technology. For example, the geological zone where sedimentary rocks and crystalline bedrock meet, i.e., the flint to quartz interface, as well as border zones between established archaeological cultures, were areas of interest to the project.

During the course of the research, the project goals shifted somewhat from the original area and interface-specific research to include questions addressing other problems, as well as general variation in stone tool technologies. It would be unwise to argue that a situa-

tion where project goals are drifting is ideal. Nevertheless, we feel that this freedom of a wandering mind gave us an opportunity to enhance our thinking and made us elaborate our research. We like to believe that changing goals in the course of the work helped us to accomplish research that would not have been possible in the beginning, or with the original plan.

A major part of contemporary research on stone tool technologies revolves around the question of how to extract information about the life of past societies by studying processes and patterns behind the lithic artefacts. When dealing with hunter-gatherers, as we are in this book, we want to know how stone tools and their manufacturing waste mirror the whole spectrum of past lifeways. What we are studying through the analyses of lithic materials are the spatial, temporal, and structural aspects of past societies, such as social contacts and organisation, land use and settlement systems, hunter-gatherer mobility, and the mechanisms behind the spread of ideas and innovations. Taken together, this means the anthropology of past people, that is, the sort of archaeology that generally has been and still is seen as the goal of archaeology as a discipline since the 1960s. In one way or another, this is the main orientation of most contemporary archaeologists, and the one we have adopted in this book.

Despite the general trend, there is today a great deal of variation in the way archaeologists conduct their research and in the questions they address. This book makes no exception. The questions that are asked, the theoretical and methodological approaches, and the philosophical orientation of the individual papers vary greatly. For this reason, it was soon decided that a holistic approach to the study of stone tools was the best option for the project to proceed. By *holistic* we mean the spectrum of questions, interests, and approaches, as well as the range of varying analytical methods in the analysis of the lithic record. The authors were free to choose the topics of greatest interest to them for the eight articles that are included in this book.

In the first paper, Hertell and Tallavaara study hunter-gatherer mobility and the spread of exotic lithics to southern Finland during the Early Mesolithic in a behavioural ecological framework. They find that exotic lithics were exchanged between hunter-gatherer groups, and provide an explanation for the diachronic patterning in archaeological data that emphasises the evolutionary dimension of human life in low population density conditions.

Kankaanpää and Rankama adopt a site-based view and conduct an intra-site spatial analysis to study hunter-gatherer lithic technology and spatial organisation at the Early Mesolithic Sujala site. They demonstrate the presence of four different clusters of finds representing distinct combinations of technologically diagnostic artefacts at the site, and discuss how these individual features can be related to past structures and indoor and outdoor activities.

The paper by Kriiska and co-workers presents and discusses lithic raw material economy, using a set of site assemblages from the Pärnu region in Estonia. They explore the methods of primary production at Mesolithic and Neolithic sites and suggest that many technological features can be linked to small raw material package size. They also show that when the availability of raw material changed, technological processes were adapted accordingly.

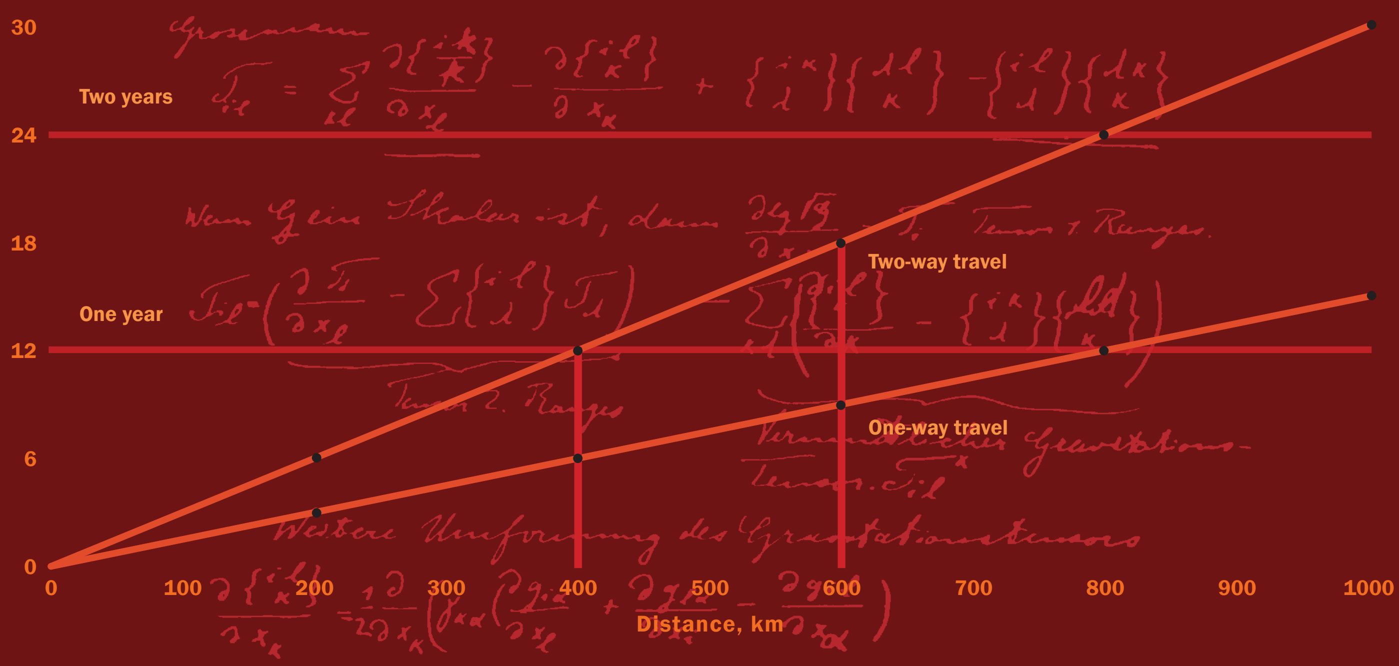
Manninen and Hertell provide a survey of flint and chert blades and blade related finds from Finland and discuss the spatial and temporal position of the artefacts in the archaeological record. They show that blade artefacts are found all over the country although they concentrate in specific areas. Most of the finds in the database can be dated to Mesolithic, but younger artefacts are also present.

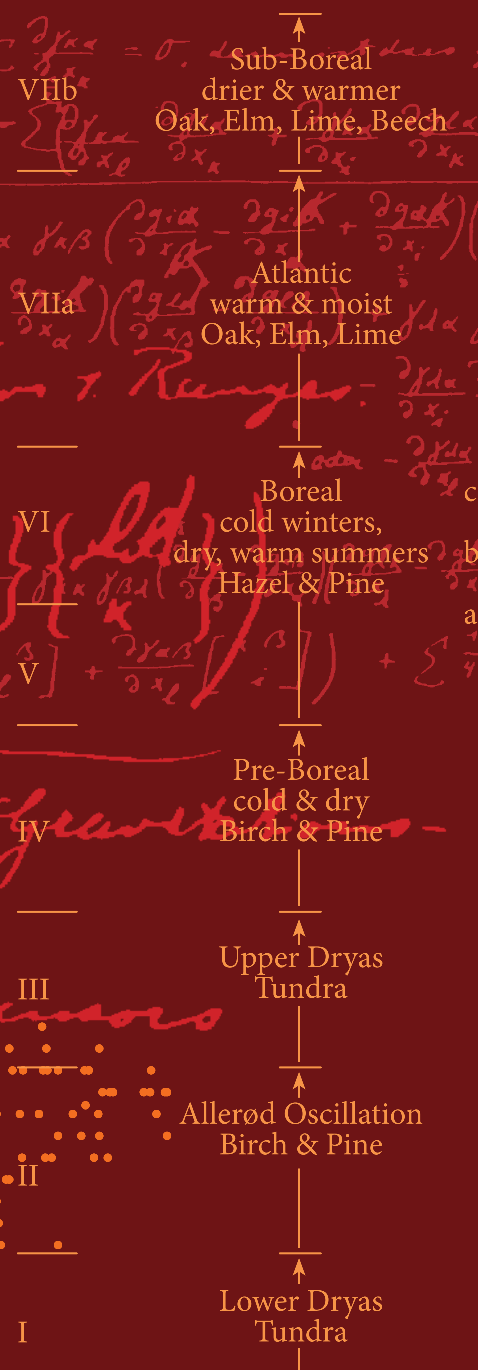
In their second paper, Hertell and Tallavaara explore the organisation of Mesolithic core technology in north-eastern Europe. They discuss how the variation in core technology can be linked with hunter-gatherer mobility, and conclude that specific core technologies correlate with indicators of mobility and site use. They also suggest that long term changes in the organisation of hunter-gatherer mobility led to the restructuring of lithic technologies over time.

In two papers, Manninen, with Knutsson and Tallavaara, respectively, studies and discusses unifying factors and variability in Mesolithic margin-retouched arrowheads in Finland as well as other parts of northern Europe. Manninen and Knutsson provide a survey of inland sites with oblique points in northern Finland, Norway and Sweden. They conclude that the inland sites with oblique points date from the Late Mesolithic, and suggest that these points are part of a single technological tradition that spread over the whole of northern Fennoscandia. Manninen and Tallavaara elaborate on this result and compare technological details in two populations of margin-retouched points from different parts of Finland using the theoretical framework of cultural evolution. They find differences between the two point populations, as well as in within-population variability, and conclude that these differences are related to the mechanical properties of the different raw materials used to produce the points. They also show that, in the light of the current data, the oblique point tradition appears to have spread from the north to the south in Finland, and suggest that cultural change in this case was triggered by major environmental changes.

Rankama and Kankaanpää utilise the *chaîne opératoire* concept to conduct a detailed analysis of the Late Mesolithic quartz technology at the Kaaraneskoski site in southern Finnish Lapland. The study includes technological, use-wear, and spatial analyses that are supplemented with artefact-typological and fracture analyses. The results enable, among other things, a discussion of cultural affiliation and contacts, Late Mesolithic mobility patterns, and site structure.

These articles contribute to the study of the early postglacial colonisation of northern Europe, hunter-gatherer mobility, technological variability in lithic technologies, the impact of raw material properties and availability on hunter-gatherer technological organisation, and the archaeological cultures of eastern Fennoscandia in general. In line with the original plan of the project, the book also provides new data, i.e., technological details, metric data, chronometric dates, and evidence of site structures and intra and inter-site spatial patterns. We hope that the articles will be useful to scholars interested in similar questions, and that the book will stimulate new questions and serve as a reference source for future studies. Hopefully it will be of use not only to those of us working with the Mesolithic or the Stone Age, but to all archaeologists and also to the general public.


Two years
One year
Two-way travel
One-way travel
30
24
18
12
6
0
0
100
200
300
400
500
600
700
800
900
1000
Distance, km


VIIb
Sub-Boreal
drier & warmer
Oak, Elm, Lime, Beech
VIIa
Atlantic
warm & moist
Oak, Elm, Lime
VI
Boreal
cold winters,
dry, warm summers
Hazel & Pine
c
b
a
V
IV
Pre-Boreal
cold & dry
Birch & Pine
III
Upper Dryas
Tundra
II
Allerød Oscillation
Birch & Pine
I
Lower Dryas
Tundra

1

High Mobility or Gift Exchange – Early Mesolithic Exotic Chipped Lithics in Southern Finland

Esa Hertell & Miikka Tallavaara

ABSTRACT Lithic materials have been distributed over considerable distances in many low-population-density demographic situations throughout the world. It has been suggested that this reflects either mobility or exchange, which have been explained by various mechanisms. In this paper, we discuss suggestions that have been put forth to explain the presence of exotic chipped lithics in southern Finland in the Early Mesolithic, and their subsequent disappearance from the archaeological record. Archaeologists have connected these exotic lithic materials to either high mobility, i.e., mainly migration, or exchange related to the colonisation process. Much of the discussion has been implicit. In this paper, we make these arguments explicit and formulate them as testable hypotheses with archaeological implications. We explore and discuss hunter-gatherer mobility, land use, and lithics use to understand the formation of the archaeological record and reveal the assumptions behind the high mobility argument. We further analyse the available data regarding exotic chipped lithic assemblages from southern Finland and show that different variations of mobility do not explain it well. Instead, we suggest that gift exchange is a better explanation for the observed patterns. On the basis of this observation, we formulate an evolutionary ecological model that explores hunter-gatherer mating behaviour during low-population-density dispersal. This mechanism explains the changes in the exchange network and, therefore, the presence and disappearance of the exotics from the archaeological record. To operationalise the abstract theoretical model, we present its archaeological implications and suggest some ways to test it. This paper helps archaeologists plan new research foci, generate a common language, and allow the collection of suitable datasets for testing mobility and exchange hypotheses in the future.

KEYWORDS
Colonisation, hunter-gatherers, mobility, mating, exotic lithics, Early Mesolithic, Europe.

Introduction

In this paper, we shall study the mechanism through which exotic chipped lithics arrived in Finland within the context of the Early Mesolithic.[1] No flint is naturally available in Finland, and quartz was the dominant lithic material during the Stone Age. In eastern Fennoscandia, the first occurrence of exotic lithics in the archaeological record is associated with the earliest post-glacial sites and, therefore, with the post-glacial expansion of hunter-gatherers to the area. The existence of Mesolithic flint has not been recognised for very long. This has implications for the work that has been carried out concerning the issue. It is reasonable to say that, so far, there have been very few attempts to explain the Mesolithic exotic chipped lithics found in southern Finland. In the following, we shall review the detailed research history of the subject.

[1] Part of this work was originally presented as a poster at the 7th International Conference on the Mesolithic in Europe in Belfast in 2005. Here, we elaborate and present the ideas in full.

In general, there are two alternative explanations with regards to how flint arrived in Finland during the Stone Age. It was either brought to the area by individuals who could personally procure it from natural sources, or it was procured and used by different individuals and thereby distributed through exchange networks. These two forms of distribution can be expected to leave slightly different signatures on the archaeological record. Consequently, it ought to be possible to differentiate these signatures and determine the distribution mechanisms through which the lithics ended up in Finland. In this paper, we explore this issue. We discuss mobility, land use, and lithic assemblage formation and proceed to analyse available data from southern Finland. On this basis, we then formulate an explanation of the archaeological record.

To contextualise and understand mobility and land use in the Early Mesolithic, we explore different varieties of forager mobility from an ecological perspective. The terminology used in the discussion concerning dispersal mechanisms and ways to move about the landscape, i.e., mobility, is variable in Finland. In this paper, we adopt the concepts common in New World archaeological literature, i.e., residential, logistic, and long-term mobility, and migration (Binford 1980; 2002; Kelly 1983; 1992; 1995). These different modes of mobility all have implications with regard to the archaeological record, e.g., in the form of exotic lithic assemblages, but also with respect to radiocarbon dates, refuse faunas, etc. In the mobility section, we discuss the different varieties of mobility in high-latitude environments and their implications. Throughout the discussion, we use ethnographic hunter-gatherer data to illustrate our points.[2]

To understand the effects of formation processes in the archaeological stone tool record, we explore the nature of chipped lithics and the way they are produced, used, and abandoned. We also discuss lithic reduction and curation, as they form the backbone for understanding Finnish lithic archaeological collections. Currently, the largest published dataset of exotic Early Mesolithic lithic materials in southern Finland comes from the Ristola site in Lahti (Takala 2004). We analyse this dataset and show that hunter-gatherer mobility accounts for it poorly and discuss why exchange explains the observed phenomena better.

To elaborate on exchange, we explore the issue of mate acquisition and suggest a mechanism that explains why and how flint arrived in Finland. We suggest that these archaeological exotics are physical remains of transactions between individuals who lived in conditions of low population density. The system of exchange was embedded in social relations that functioned to assist in mate search and acquisition, and therefore, the major driving force of this gift exchange was ultimately an attempt to maximise evolutionary success. We discuss the prerequisites of this mechanism and, subsequently, its implications for the archaeological record. This discussion should help archaeologists in planning new research and make it possible to collect suitable data for testing models in the future.

In Finland, the spread of exotics has been only a minor part of the discussion concerning the post-glacial colonisation of eastern Fennoscandia. Before the 1980s, the colonisation model involved Late Palaeolithic–Early Mesolithic reindeer hunters who followed the retreating ice and tundra zone northward (Luho 1957:129–133). Since the 1980s, Mesolithic colonisation has been seen as the result of the gradual dispersal of hunter-gatherers northwards in the birch-pine forest during the Boreal period (Siiriäinen 1981a; Nuñez 1987:6–7; Matiskainen 1989:67; Rankama 2003). This model has slight variations. Siiriäinen (1981a:25–26) suggested sealing opportunities as a pull mechanism into the area of present-day Finland. In his discussion of the Late Paleolithic–Early Mesolithic adaptive processes, Matiskainen (1989:67–68) also saw the adaptation to sealing as important in the Baltic Basin. Rankama (2003), discussing northern Lapland, stressed adaptation to inland environments and emphasised the difficulties related to adaptive changes when moving from one environment to another. Recent data from the 1990s and 2000s about the timing of the initial colonisation have pushed the earliest dates farther back in time, to the Preboreal (Jussila & Matiskainen 2003). It is now evident that the earliest sites associated with colonisation are found in a variety of environments. These range from birch-pine forest to the northern almost treeless subarctic zone. Consequently, refuse faunas vary from inland European elk, i.e., moose,

[2] There is a lot of variation in the estimates of different variables in the datasets as concerns e.g., the Nunamiut case, see Binford 2001: Table 5.01, Kelly 1983: Table 1, Kelly 1995: Table 4-1.

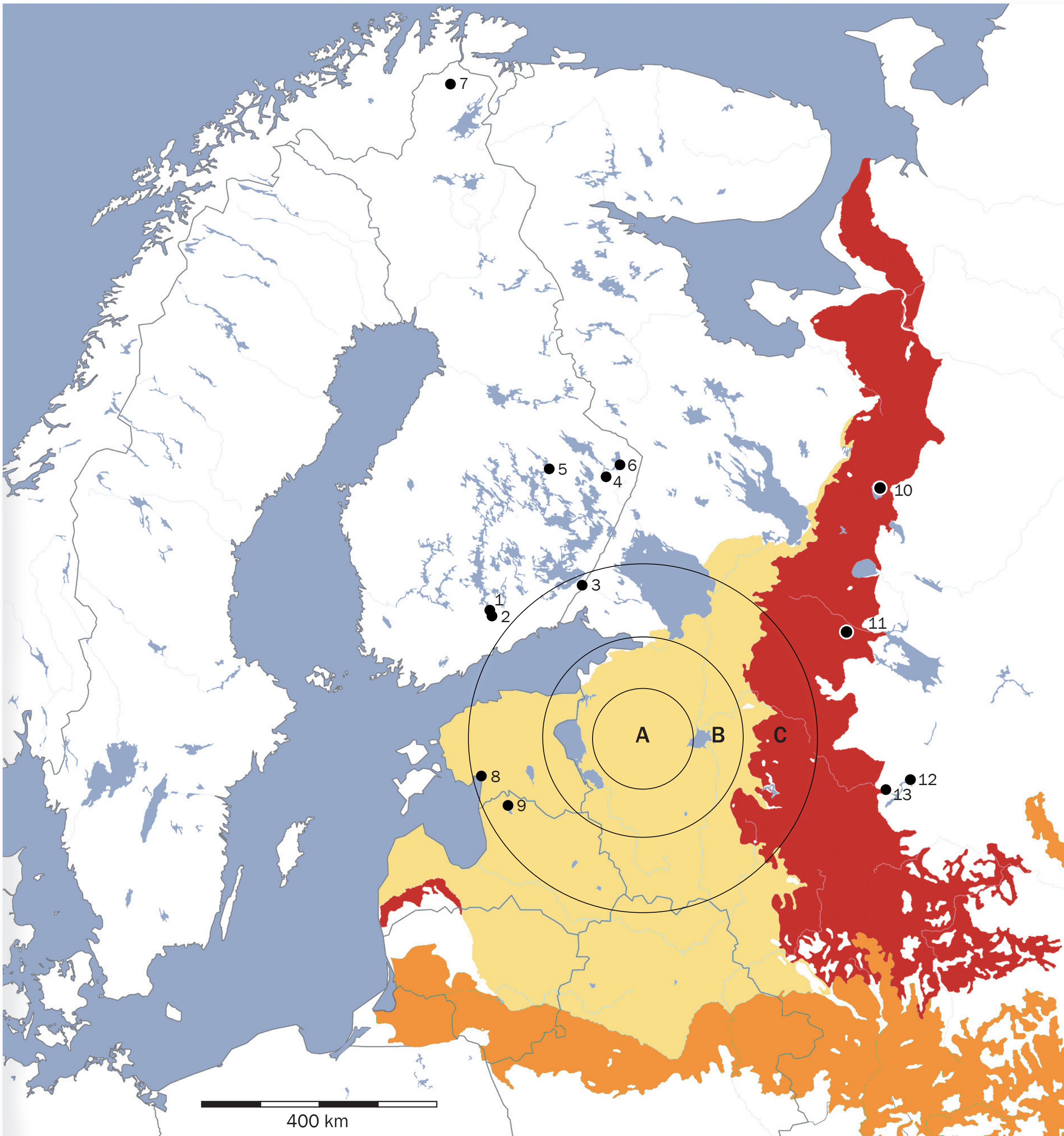


Figure 1. Map of the research area. Red = Carboniferous, orange = Cretaceous, yellow = Paleozoic (Devonian, Silurian & Ordovician) formations. **Key:** A) 25,000 km², B) 100,000 km², C) 300,000 km². **Sites:** 1. Ristola; 2. Myllykoski; 3. Kuurmanpohja/Saarenoja 2; 4. Rahakangas 1; 5. Helvetinhaudanpuro; 6. Syväys; 7. Sujala; 8. Pulli; 9. Zvejnieki; 10. Veretye I; 11. Kurevaniha; 12. Pekunovo , Prislon 1, Zaborovje 2; 13. Sukontsevo 3. Geological data from Persits *et al.,* 1997; Site locations from Latvia: Zagorska 1993, from Russia: Zhilin 2003; Koltsov & Zhilin 1999; Oshibkina 1997.

and beaver -dominated fauna in the south to reindeer-dominated fauna in the north. In a similar fashion, the use of other resources is diverse, e.g., lithic materials and technologies vary widely (e.g., Jussila *et al.* 2007; Rankama & Kankaanpää 2008; Takala 2004; Veski *et al.* 2005). To us, this demonstrates the adaptive flexibility of the Early Mesolithic foragers who spread into the north. We suggest that the explanation of the driving mechanism should be grounded in evolutionary theory and discuss the processes related to human dispersal explicitly from an evolutionary ecological perspective (Smith & Winterhalder 1992).

Geological settings and availability of flint

Modern-day Finland and the neighbouring region in north-western Russia form a part of the Fennoscandian Shield. The eastern part of the Fennoscandian Shield is largely devoid of flint and other high-quality raw materials for chipped lithic production. Because of this, other raw materials, mainly quartz, were used for chipped lithics in the area. However, there are a few small-scale occurrences of raw materials with better knapping qualities in Finland and in north-western Russia. In northern Finland, small sources of jasperoid are known (Kinnunen *et al.* 1985), and some pebble flint and silicified shales are found in the Kola Peninsula (Gurina 1987; Shumkin n.d.). To the south, east and north, the Fennoscandian Shield is surrounded by areas of sedimentary rocks where flint is locally present.

The distribution of sedimentary formations south and east of Finland is shown in **Figure 1**. Two main varieties of flint, Cretaceous and Carboniferous, are typically recognised in Finnish archaeological literature and are found in archaeological sites (Kinnunen *et al.* 1985). Geological formations bearing these varieties of flint extend from Lithuania to Belorussia and from Central Russia to the White Sea, respectively (Baltrūnas *et al.* 2006a; Persits *et al.* 1997; Zhilin 1997; Galibin & Timofeev 1993). Flint is also found in older Devonian and Silurian formations (henceforth, Paleozoic), e.g., in Estonia and Latvia, and was locally available and used in these areas during the Mesolithic (e.g., Baltrūnas *et al.* 2006b; Jaanits 1981:Fig.1; Jussila *et al.* 2006; 2007; Kriiska *et al. this volume*; Zagorska 1993:102). Paleozoic limestone is also found in the Baltic basin, for instance, in the bottom of the Gulf of Bothnia (Winterhalter 1972:30–33), but to what degree flint is present there and to what degree it has found its way to terrestrial till deposits remains to be demonstrated. Due to geology, therefore, it is reasonable to generalise that all flints found in the archaeological contexts of southern Finland must have been brought into the area by man one way or another.

From the perspective of a lithic user, the issue of flint availability is more complex, as the raw material availability and package size varies from one area to another. For example, in Estonia, the nodule size of Paleozoic flint materials is known to be relatively small (Kriiska *et al. this volume*). In the uppermost part of the River Volga, in Central Russia, the primary flint beds can be several hundred metres long with nodules of substantial size, whereas the quantity of flint in the secondary deposit decreases downstream (Zhilin 1997).

Research history and archaeological data

The Mesolithic period in Finland was long thought to have been devoid of exotic chipped lithics, i.e., flint (Vuorinen 1982:54). Although flint was occasionally found at Mesolithic sites, it was assigned to later intrusions or to younger phases of the same sites (Vuorinen 1982:38–39). However, since the 1960s, some flint artefacts have been attributed to the Mesolithic period. In 1964, Meinander (1964) reported tanged arrowheads that he dated on typological grounds to the Mesolithic and to the following Subneolithic period. In the middle of the 1980s, the flint finds from Lahti Ristola were dated to the Early Mesolithic (Edgren 1984; Kinnunen *et al.* 1985) and the presence of Mesolithic flint in Finland became widely acknowledged (see Hertell & Manninen 2006). Since the mid-1980s, Early Mesolithic flint has been mentioned in several publications (e.g., Matiskainen 1989; 1996; Schulz 1996).

The number of reported Mesolithic flint finds has grown in the 1990s and 2000s. New excavations in Lahti Ristola have yielded more flint (Takala 2003; 2004), and fieldwork in eastern and south-eastern Finland has also produced a number of new Mesolithic sites, some of which have also yielded new flint finds (Jussila *et al.* 2006; 2007; Jussila & Matiskainen 2003; Pesonen 2005:8). Most of the finds have been connected in the literature to the post-glacial colonisation phase of Finland (Edgren 1984; Jussila & Matiskainen 2003; Matiskainen 1996; Schulz 1996; Takala 2004).

Thus far, Lahti Ristola is the only Mesolithic site with a relatively large collection of exotic flint for which lithic data have been published (Takala 2004). Recent excavations at the Early Mesolithic Lappeenranta Saarenoja 2 site have also yielded a sizeable collection of exotics, but no published data exist as of yet.

So far, only small collections of Mesolithic flint are known from other sites, many of which are undated stray finds (Hertell & Manninen *this volume*). Nevertheless, these findings suggest an emerging pattern: early sites contain exotic lithic materials, and this requires systematic explanative work. Outside Finland, exotic lithic materials are also known from Early Mesolithic sites, e.g., in Pulli, Estonia, Zvejnieki, Latvia, and Veshevo 2 / Tarhojenranta in Russia near the Finnish border (Jussila *et al.* 2007:157; Jaanits 1981; 1990; Takala 2004:156; Zagorska 1993:102).

Ristola flint derives from Carboniferous and Cretaceous sedimentary formations (Edgren 1984; Kinnunen *et al.* 1985; Takala 2004). These sources of flint lie *c.* 400–600 km as the crow flies to the east and south, respectively (**Fig. 1**). Recent excavations at Helvetinhaudanpuro in eastern Finland produced a piece of black Cretaceous flint that has extended the linear distance from the source to 900 km (Jussila *et al.* 2007:157). Along the land route across the Karelian Isthmus, flint originating from the Cretaceous sediment area may have been carried *c.* 1000 km to Ristola.

These distances are considerable but not without parallels. In Finland, the same raw material types, especially Carboniferous flint, are generally found in Mid-Holocene assemblages (Kinnunen *et al.* 1985; Manninen *et al.* 2003; Vuorinen 1982) but in a completely different demographic and socioeconomic context. The long-distance spread of flint is also known from many other areas, especially in the context of Late Pleistocene and Early Holocene human dispersal and other situations characterised by low population density. In the European Upper Palaeolithic, exotic materials were spread over hundreds of kilometres, matching the distances involved in the present case (Rensink *et al.* 1991; Sulgostowska 2002:13–15). In North America, late Pleistocene foragers distributed lithic materials over extremely long distances that sometimes exceeded two thousand kilometres (Hofman 1991; Tankersley 1991). Arguments in favour of mobility – either migration or mobility inside a territory – or exchange have been presented in these and other cases (e.g., Gould & Saggers 1985; Janetski 2002; MacDonald 1998). The mechanisms to explain exchange networks often build on the idea that maintaining social contacts helps to reduce various forms of future risks, e.g., by facilitating access to other groups' territories (Gould 1980). What makes the situation archaeologically complex is that both mobility and exchange have operated simultaneously, at various levels, as exemplified, for example, by discussions on lithic and mollusc shell spread in Europe (Eriksen 2002; Rensink *et al.* 1991). These cases suggest that a single mechanism is unlikely to explain all of the distribution of exotic materials in northern Europe either. Instead, the cases need to be solved one by one or raw material by raw material, i.e., on a contextual basis. The present case study explores the spread of exotic lithics that correlates with population dispersal to uninhabited land and, therefore, studies the evolutionary strategies of hunter-gatherers who lived in conditions of low population density.

Existing explanations in Finland – mobility and exchange

Despite the growing awareness over the past two decades of the existence of Mesolithic flint in Finland, there have been very few efforts to explain the presence of these exotics. So far, two general propositions have been put forth to explain the situation. These parallel the explanations cited above. The first model suggests that migrating pioneers brought flint artefacts with them, and the second suggests distribution through exchange. These models are partly contradictory, and in many cases, they have not been expressed explicitly or elaborated upon.

The presence of exotic lithic material at Lahti Ristola has commonly been explained through the first model. According to this proposition, flint was brought to the site by foragers who migrated to the area from the south with their flint artefacts. Edgren (1984:22) originally suggested that the tools were the personal equipment of someone who immigrated from the south, i.e., Estonia.

More recently, it has been suggested that individuals who migrated to the site from the south, i.e., from the area of the Kunda culture, "*brought with them raw material for artefacts, such as flint cores and half-finished blades, and possibly also complete flint artefacts*." (Takala 2004:170; 2009:36). That the flint was brought to Ristola by pioneers was also emphasised by Zhilin (2003:692), who suggested that the pioneers were "*not familiar with local resources and had to carry necessary amount of flint over long distances*". We interpret this to imply that the pioneers came from areas where such flint was naturally available.

We shall call this the *high mobility* hypothesis. It states that flint was brought to Finland by individuals who carried the raw material, blanks, and tools with them. Although not stated explicitly in all of the cases, central to our new formulation of the hypothesis is that the raw material was procured, transported, used, and discarded by the same individuals. In other words, they came to southern Finland from areas where the flint was locally available. This was not originally argued by Edgren (1984) or Takala (2004); they only suggested that Estonia was the origin of the migrating individuals but did not really explain how the flint ended up there. The new formulation also widens the model to include different ways to move around the landscape and is not restricted to migration only.

Although the arguments on migrating or mobile individuals bringing flint material with them are scarce, these are still explicit. The suggestions of exchange are less clear and open to interpretation. Following Edgren's (1984) work, Matiskainen (1989:V,73) wrote that the exotic lithics in Ristola "*indicate a migration of settlers*" but then continued that "*once the former ties and contacts of this population were severed quartz became the sole material used in retouched artefacts*". For us, this seems to imply that two mechanisms were functioning behind the spread of exotics into Finland. In the first phase, individuals brought the flint with them, and later, it was distributed through exchange until these contacts were finally severed. Why such contacts were maintained and why they ended was not discussed.

Zhilin (2003) discussed the Early Mesolithic lithics in north-western Russia, the East Baltic countries, and Finland. He suggested two patterns: in Finland and the East Baltic, flint was carried along as a raw material supply as quoted above. The other pattern was that the single artefacts, tools, and blades of exotic materials found at sites in Estonia and Central Russia were either distributed by highly mobile people who carried their tools with them or exchanged between groups. The mechanism that produced both patterns was a *communication network* that was formed to create stable exogamic links because of low population densities among people with similar cultural traditions from the Early Mesolithic onwards (Zhilin 2003:692). Following Zhilin (2003), Takala (2004:169–170, 177; 2009:36) also noted the possibility of exchange or trade but did not elaborate on this.

Following the original work behind this paper, Hertell & Manninen (2006:45) stated that the Mesolithic flint collections in Finland consist of heterogeneous sets of artefacts whose character can best be explained through exchange rather than direct migration from flint source areas, but they did not clarify their argument. Jussila and associates (Jussila *et al.* 2007:159) also suggest exchange by remarking that "*through the help of direct and indirect contacts exotic raw material could drift hundreds of kilometres without major migrations*" but do not elaborate on the concepts or discuss the mechanism further.

To summarise the short review above, it can be said that most of the published works on the Early Mesolithic exotics in the study area operate on a very general level. Many of the remarks on the issue are implicit, and argumentation about the processes and the distribution mechanisms is largely absent. Furthermore, there has been little attempt to analyse the mechanisms through the lithic data.

How mobile were Mesolithic hunter-gatherers in northern Europe?

Following Binford (1980; 2002) and Kelly (1983; 1992; 1995), we divide hunter-gatherer land use and mobility into four models of moving around the landscape (residential, logistical, long-term, and migration). These types of mobility can be predicted to affect the lithic archaeological record differently, at least in part. Residential mobility refers to campsite shifts that the whole occupational unit carries out together. In logistical mobility, single individuals or groups operate from their residential sites. These trips can be mounted for the purposes of hunting, gathering, collecting firewood, or searching for spouses, etc. It is also possible to break migration down into residential moves. For foragers migrating from their original areas, the migration is necessarily the result of a number of consecutive residential moves. Long-term mobility means change in the size and location of the home range habitually used by foragers over long times, e.g., the lifetime of an individual. Other ways and reasons to move around the landscape have also been proposed. The landscape learning process is seen to be important in the colonisation process, and s*couting* of new areas can provide information and enhance learning (e.g., Kelly 2003, Rockman 2003).

Hunter-gatherers can also make *pilgrimages* or *journeys*, e.g., to visit other groups (Zedeno & Stoffle 2003, Whallon 2006). Boas (1964:166–7) for example, reports the Central Eskimo making journeys that may have lasted for a year or more.

For the sake of clarity, we shall discuss the different mobility patterns one by one. Mobility, by definition, always has a spatial dimension. Individuals move around in a landscape, not in random fashion and everywhere, but within a certain region. We shall consider this area, the home range, first, as this gives us a good starting point for the discussion of the scale of hunter-gatherer land use and, therefore, the scale of mobility required to cover the territory in an Early Mesolithic context.

Region	Size sq km
Finland	338,424
North Karelia	21,584
Estonia	45,228
Latvia	64,589
Russia	
Leningrad region	84,500
Pskov region	55,300
Republic of Karelia	180,500
Estonia, Latvia & Pskov	165,117
Estonia, Latvia, Pskov & Leningrad	249,617

Figure 2. Sizes of selected northern European states and regions. Data from
http://fi.wikipedia.org/wiki/Suomi
http://www.maanmittauslaitos.fi
https://www.cia.gov/library/publications/the-world-factbook/
http://en.wikipedia.org/wiki/Leningrad_Oblast
http://en.wikipedia.org/wiki/Pskov_Oblast
http://www.gov.karelia.ru/

Land use and home range

Reported hunter-gatherer land use can have extensive spatial coverage. Binford (2002:115), for example, reports that the lifetime travels of a Nunamiut male can cover an area of more than 300,000 sq km in size. This comes close to the size of modern-day Finland (see **Fig. 2**). In a similar fashion, E. Leacock's (1969:6–8) Montagnais informant was able to produce a map covering a large area of the southern Labrador, suggesting he had personal experience of it all. Lovis and co-workers (2005:674) estimate this area to be *c.* 240,000 sq km in size. Our estimate is somewhat smaller and is *c.* 200,000 sq km. The Central Eskimo knowledge of land is also known to be extensive. They produced maps that covered the southern part of Baffin Island (Boas 1964:236–239). Kelly (2003:45) estimates these to have covered 650,000 sq km in size. This estimate seems too large, given the size of the whole island. Our estimate is considerably smaller, *c.* 230,000 sq km. Despite the deviation in the estimates, the examples make it clear that some northern hunter-gatherers may have travelled over large areas during their lifetime.

It is possible that some Early Mesolithic hunter-gatherers in northern Europe traversed areas as large as the Montagnais or Nunamiut during their lifetime. These figures make it clear that the archaeological record produced by a single Early Mesolithic individual extends over large areas and can be found over wide regions in Finland and neighbouring regions. Furthermore, these figures help to explain how knowledge and technological information, e.g., about lithics, pottery, housing, agriculture, and rituals, can spread over vast areas in the northern hemisphere in a short time on an archaeological time scale. Although impressive in size, these figures are of little use in explaining exotics in southern Finland, as hunter-gatherers did not cover areas of this size over short periods, although they may have gained the knowledge over a lifetime.

Instead of long-term mobility and the area covered in a lifetime, the home range, i.e., the area habitually used by an individual, is a more useful concept for the current analysis. In general, the home range size of a foraging animal is a function of the animal´s size and diet. The larger the size of the forager and the higher the trophic level, the larger the exploited area must be (Harestad & Bunnell 1979). Because this is a consequence of the structure of our ecosystem, it can be expected to hold true for all foragers, including humans past and present. This can be shown to be the case for ethnographically documented hunter-gatherers (Kelly 1983; 1995).

On a global scale, hunter-gatherer diet is known to be systemically related to the environment. Available plant foods decrease towards the poles and the hunter-gatherer use of plant food diminishes accordingly (Binford 1990; Kelly 1995). On the basis of contemporary hunter-gatherer datasets (Binford 2001), the amount of gathered food, which can be used as a rough proxy for plant food, for the boreal zone can be calculated to be generally below 30% of the diet (see **Fig. 3**). The rest of the food intake consists of foods hunted in either terrestrial or in aquatic environments. The ratio is not constant but situational, and foraging models predict

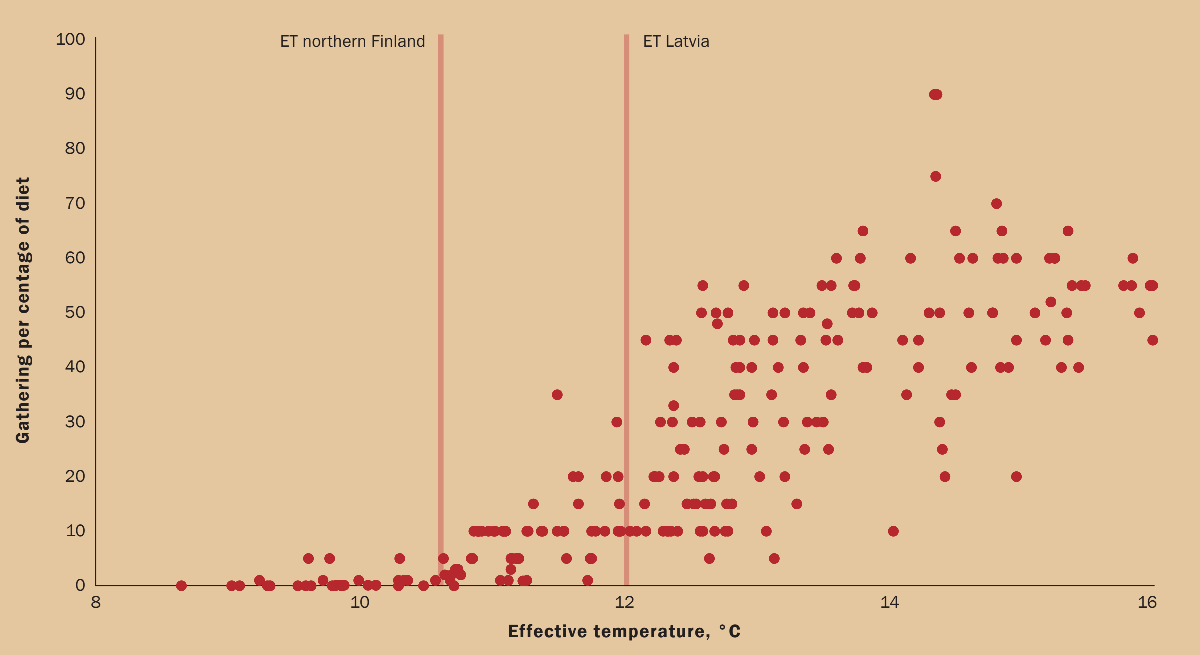


Figure 3. The relationship between effective temperature and gathered foods in the diet of ethnographic hunter-gatherers. Each red dot represents an ethnographic group. ET 8 = the poles, ET 10.6 = northern Finland, ET 12 = Latvia. Southern Finland is c. ET 11.9. Ethnographic data from Binford 2001: table 5.01; temperature data from Drebs *et al.* 2002.

diet composition change in relation to various factors, for example, resource availability (Kaplan & Hill 1992).

Early Mesolithic hunter-gatherers in northeastern Europe subsisted heavily on large- and medium-sized terrestrial mammals. In the forested zone, European elk and beaver were the main prey species, and in the treeless zone in the north, reindeer were targeted (e.g., Jussila *et al.* 2007; Rankama & Kankaanpää 2008; Veski *et al.* 2005; Zagorska 1993; Koltsov & Zhilin 1999; Oshibkina 1997). The composition of terrestrial diets changed during the Mesolithic in the study area: the percentage of elk decreased in the refuse faunas, and the percentage of smaller mammals increased after the Early Mesolithic (**Fig. 4**). This implies that later foragers targeted elk less often and had a wider diet breadth than their predecessors in northern Europe. We suggest that this process was related to population growth in northern Europe (Hertell 2009; Tallavaara *et al.* 2010). Population growth reduced the amount of available habitats, restricted options for mobility and, therefore, generally diminished the size of the home ranges. Since large animals provide higher rates of return than smaller ones (Kelly 1995:Table 3–3; Ugan 2005), targeting elk in the Early Mesolithic, thus, probably provided higher average hunting returns from a terrestrial environment than did the fauna hunted in the later Mesolithic.

As illustrated in **Figure 3**, the average amount of gathered foods was *c.* 10% for the hunter-gatherers who lived in the areas that equal the area between northern Finland and Latvia. It is reasonable to assume that the percentage of plant food was also equal in the Early Mesolithic. If we assume that the non-plant food fraction of the diet was based on hunted terrestrial foods, we can then explore the size of the home range required by Early Mesolithic foragers.

The hunter-gatherer space requirement can be first illustrated by the Nunamiut case. With an estimated 90% terrestrial meat diet, the Mesolithic foragers' percentage of hunted foods approximates ethnographic estimates of the diet of the Nunamiut, who consume *c.* 87–89% terrestrially hunted foods (see Binford 2001: Table 5.01, Kelly 1995:Table 3–1). At first, it seems reasonable to note that the Nunamiut example is rather extreme when considering northern European Mesolithic foragers. This is suggested by the difference in the environment in which the Nunamiut and Early Mesolithic hunters lived. The late Preboreal environment in northern Europe was clearly more productive than that of northern Alaska. For example, the effective temperature values that approximate environmental produc-

Elk percentage			
	Meso 1	Meso 2	Meso 3
Russia, Ivanovskoje 7			
IF %	38	16	17
MNI %	10	6	5
Latvia			
IF %	92	77	21
Finland, coastal			
IF %	16	14	2

Figure 4. The percentage of elk bones in Mesolithic refuse faunas from Finland (burnt bone fragments), Latvia and Russia. The periodization is relative and as in original publications. IF = identified fragments, MNI = minimum number of individuals. Data from Zhilin *et al*. 2002; Zagorska 1993; Ukkonen 2001.

tivity fall below 10 for the Nunamiut home area (Binford 2001:Table 4.01). According to Heikkilä & Seppä (2003), the Early Mesolithic annual mean temperature in southern Finland was around 1° C, which translates to ET value of 11.1 (see Hertell 2009). This implies that survival by foraging required less space in northern Europe than in northern Alaska. The percentage of large terrestrial game in the diet of the Mesolithic hunters was probably smaller, as indicated by the refuse faunas in which beaver and other small mammal bones are common. This implies that there was less emphasis on large land mammals in northern Europe than among the Nunamiut. Despite this, the Nunamiut case provides an idea of the space that hunter-gatherers need and use.

According to Binford (2002:110), a Nunamiut group of five families resides on an area of approximately 5000 square kilometres during one year. Trips are made outside this residential core area, and the area exploited may total up to 25,000 square kilometres during one year. If we compare the size of this range to different areas of northern Europe, it can be seen that during one year a single Nunamiut band could have subsisted in and around the area of North Karelia in Finland **(cf. Fig. 2)**. Two such bands might have lived in Estonia and another two in Latvia, etc. A hypothetical Nunamiut group living in southern Finland, or in any other nearby area, then, would not have encountered Carboniferous or Cretaceous lithic sources during their annual trips.

To move beyond a single example, foragers' need for space can be studied through comparative animal ecology and ethnography. On the basis of the known correlation between animal body weight and home range size (Harestad & Bunnell 1979), Cashdan (1992:260) calculated the home range for a 65-kg hunter-gatherer. The predicted home range for a carnivorous hunter-gatherer with a diet of which more than 90% consists of meat, is *c.* 3900 square kilometres. From this, we estimate *c.* 97,000 square kilometres for a band of 25 persons. This size approximates the combined area of Estonia and Latvia, or with small additions, the area known as the Leningrad region (**Fig. 2**). This suggests that a home range of this size might just about be large enough to have provided Cretaceous flint from Lithuania to, for example, Pulli in Estonia or Carboniferous flint from Russia to Ristola, Finland but not both varieties of flint to southern Finland at the same time.

To evaluate the estimate derived from comparative animal ecology, it can be compared with ethnographic hunter-gatherer data. Kelly (1983) studied the relationship between diet and size of the home range and found that these are strongly correlated for hunter-gatherers. A linear model based on re-tabulated ethnographic datasets (Kelly 1995:Table 3–1, 4–1) gives the equation $\log_{10}y = 0.0282x + 2.0333$ ($R^2 = 0.5565$) for diet and home range size (**Fig. 5**).[3] From this we estimate a home range of 37,265 square kilometres for a group (25 individuals) with 90% hunted food in their diet. This implies that it is reasonable to question whether Early Mesolithic home ranges actually were of the magnitude of *c.* 100,000 square kilometres and extended from, for example, the Carboniferous formation to Finland.

Residential mobility

The shape and orientation of home ranges in the landscape can and do vary. Therefore, it is possible to explore the distances hunter-gatherers move inside their home range in another way. An increase in the dependence on hunted foods and in the associated range size will necessarily also increase the distances travelled in the course of residential moves. The total distance travelled during a year should, therefore, be a function of the percentage of hunted terrestrial food in the diet. This is illustrated in **Figure 6** for contemporary hunter-gatherers (Binford 2001:Table 5.01). It is possible to use this interdependence as a model for all hunter-gatherers.

[3] The original model ($\log_{10}y = 0{,}024x + 2{,}06$, Kelly 1995:130) gives 16 596 square kilometres, but it does not seem to agree with the original graph (Kelly 1995: fig 4-8).

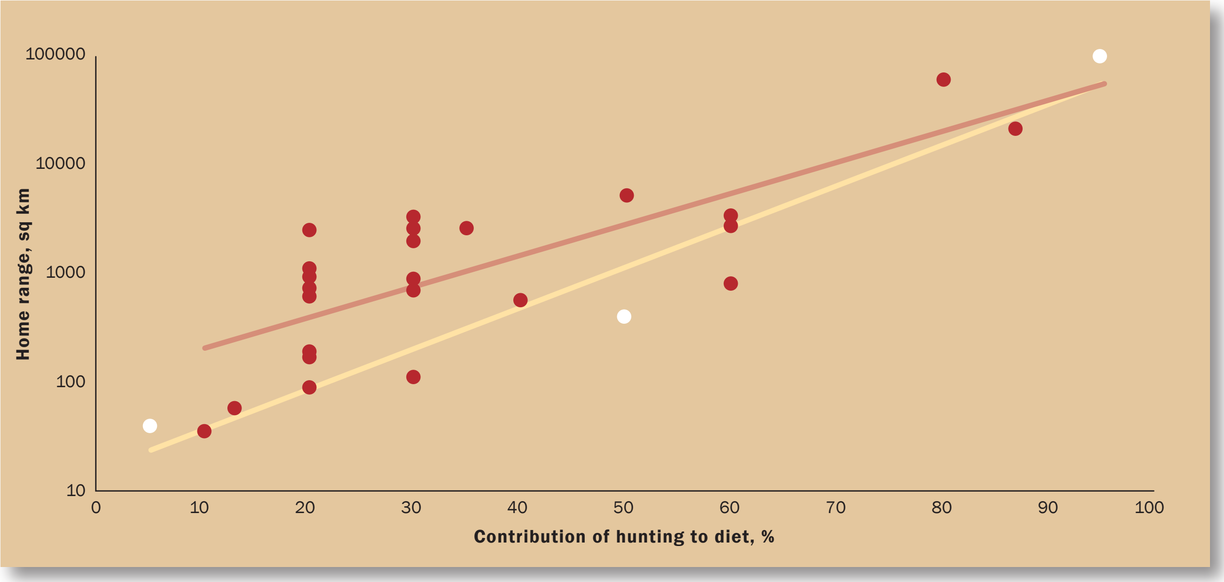


Figure 5. Comparison of diet and range size. White dots: range size estimates for a band of 25 hunter-gatherers (65 kg) based on Harestad & Bunnel (1979); red dots: ethnographic hunter-gatherer cases (Kelly 1995).

To study the relationship between the distances travelled in annual residential moves and the distances from flint source areas, we developed a simple model (**Fig. 7**). It illustrates the time needed to travel the distance from flint source areas to southern Finland in the course of annual residential moves by ethnographic foragers.

Of all of the non-mounted hunter-gatherers listed in comparative ethnographic datasets (Kelly 1995, Binford 2001), the Nunamiut travel annually the longest distance in the course of their residential moves (**Fig. 6**). Binford estimates the total distance travelled by the Nunamiut to be 806 km, while Kelly's estimate is 725 km. Therefore,

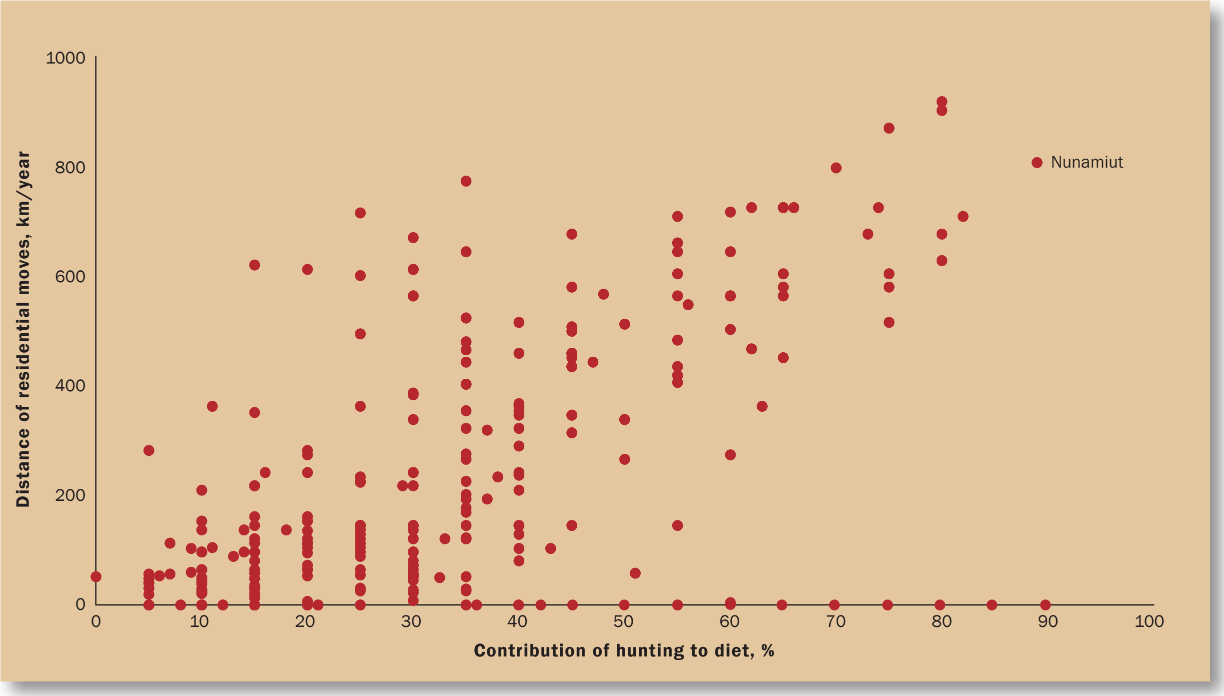


Figure 6. The contribution of hunting to diet (%) and the total distance of residential moves (km/year) for ethnographically documented hunter-gatherers. Data from Binford 2001.

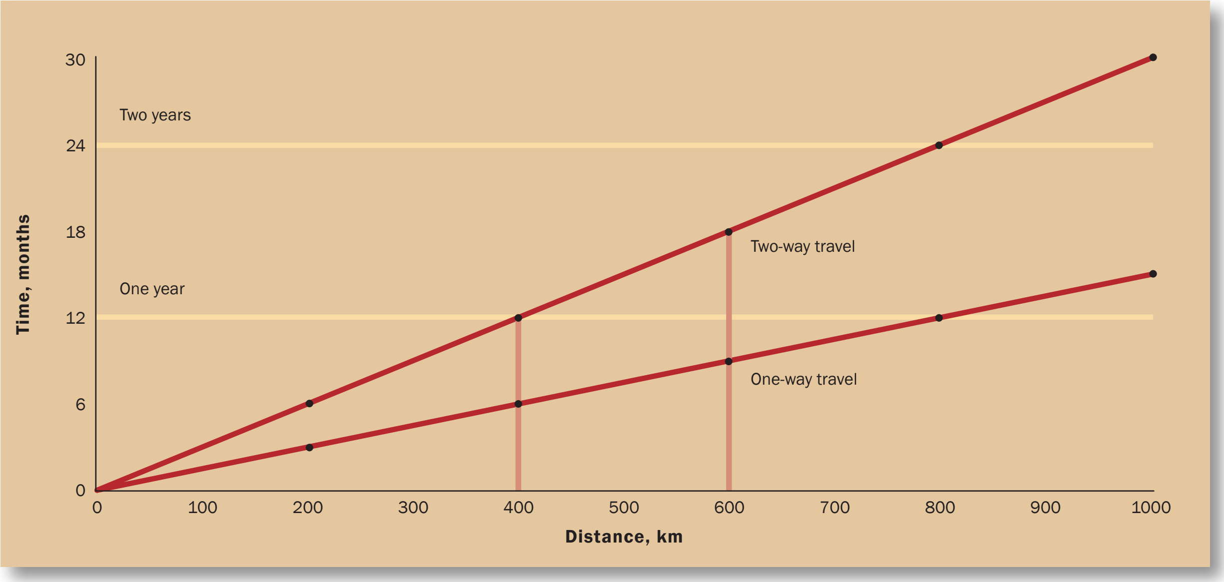


Figure 7. The time required to travel the distances from Carboniferous (400 km) and Cretaceous (600 km) formations to Ristola, southern Finland in the course of residential moves (residential speed 800 km/year).

of all of the non-mounted cases, the Nunamiut would take the least time to travel the distance from known flint sources to southern Finland in the course of their annual residential moves. By using Binford's estimate, we can determine the maximum speed (800 km/year) for our model hunter-gatherers (**Fig. 7**).

For the sake of simplicity, let us assume that southern Finland and a flint source were both within the same residential core area and, therefore, used within a hypothetical annual round by Early Mesolithic foragers. The closest Carboniferous flint sources to Ristola, for example, are c. 400 kilometres away. Cretaceous sources lie farther away and are located some 600 km south as the crow flies. As illustrated in the model (**Fig. 7**), if the Nunamiut equivalent model foragers started from these flint sources, they would travel 400 km in six months, assuming they were moving in one direction only. After this, they would still have another half a year to return back to the sources and complete their annual round, so to speak. If they started from flint sources that were even farther away, e.g., the source areas of Cretaceous flint, it would take nine months to get to southern Finland following a straight line. Naturally, it would take much longer if they did not follow the straight line, e.g., if they did not cross the Gulf of Finland.

As this model illustrates, the distance the model foragers travel in the course of their residential moves could just about take them to southern Finland from Carboniferous sources and back in one year. From Cretaceous sources, our model hunter-gatherers could not reach southern Finland and return in one year. Furthermore, to reach Finland, their residential sites should form a linear pattern. This seems an unlikely presumption for hunter-gatherers who lived in the late Preboreal environment, which was a mosaic of resource patches, rivers, and lakes, etc. The nature of the local geography and environment suggest that in southern Finland, the East Baltic, and adjacent areas of Russia, there was no large-scale zonation of resources. This implies that the settlement systems were unlikely to be like the ones documented for contemporary pastoral groups, with long annual shifts from one environment to another, e.g., from arctic coasts to forested inland areas. This lack of linearity in the settlement pattern is supported by the refuse faunas that show the use of a diversity of resources at many sites but little evidence for spatial patterns that could support distinctive environmental zones in the area (e.g., Koltsov & Zhilin 1999; Ukkonen 2001; Veski *et al.* 2005).

On the basis of the hunter-gatherer dataset (**Fig. 6**), it is possible to project additional paces for the model (**Fig. 7**). For example, assuming 100% hunted food, visual inspection of the graph (**Fig. 6**) gives a maximum total travel distance of around 1200 km a year. This is a very large increase (50%) with respect to the Nunamiut distance. With this maximum speed, the hunters would reach southern Finland in half a year if they started from Cretaceous sources and some months earlier if they started from Carboniferous sources. To summarise, an ethnographic dataset of contemporary hunter-gatherers that mirrors multiple physical and social environments indicates that the total travel distance of annual residential moves should not exceed this, and it is not easy to see a reason why prehistoric foragers might have deviated markedly from this pattern. However, this issue can be studied further in future studies, for example, by building separate models for the pedestrian foragers and hunter-gatherers who use other means of transportation, i.e., dog sledges or horses. By using these data, it should be possible to model residential mobility in varying situations and take into account the availability of resources, presence of competitors, etc. It suffices to say here that even with the maximum speed, it takes a relatively long time for our model foragers to reach southern Finland from the flint sources in the course of their annual residential moves. This has implications for the lithic collections that we will elaborate below in the lithic section.

If the exotic lithic materials found in Finland were personally and habitually procured by the inhabitants who resided in southern Finland, e.g., Ristola, then their annual range would have been much larger than that documented for the Nunamiut. A circular home range would have equalled the size of Estonia, Latvia, much of Lithuania or Belarus, Leningrad and Pskov regions, and parts of southern Finland put together (see **Fig. 1**). This means that the area would have totalled more than 400,000 square kilometres. This is more than ten times the size documented for the Nunamiut home range and many times larger than the areas documented for even the mounted foragers of other areas in North America. The area is also much larger than the prediction derived theoretically from comparative ecology i.e., 97,000 sq km. In principle, an elongated 1000-kilometre-long and 100-kilometre-wide stretch of land could be as large as the predicted home range, cover both flint formations and reach to southern Finland at the same time. However, a home range of this kind seems rather unlikely in the local environment, as discussed above. It is more likely that an elongated home range extending from the Cretaceous formation through the Carboniferous belt to southern Finland would have been somewhere between 200,000 and 400,000 square kilometres in size. Given the discussion on lifetime ranges of arctic hunter-gatherers it can be questioned whether most Early Mesolithic individuals living in southern Finland would have encountered both flint sources during their whole lifetime.

If these areas seem rather large, how large home ranges might the Early Mesolithic hunter-gatherers in northern Europe then have had? We suggest that the estimates derived from ethnographic data and comparative ecology give us a good framework and help to understand the magnitude of the Mesolithic home ranges in north-eastern Europe. Obviously, this discussion does not mean that some Early Mesolithic home ranges could not have been occasionally *c.* 100,000 square kilometres or larger, even though a few ethnographic cases imply it was unlikely. Nevertheless, the discussion above implies that we need theoretically strong and sound argumentation and detailed analyses of archaeological data to support ultrahigh mobility inside an enormous home range, which deviates from the ethnographic and ecological data, to explain the exotics in southern Finland.

Logistical mobility, scouting and journeys

Long-distance trips from base camps or beyond the residential core area are well known in the ethnographic record. For example, a combination of both ethnohistorical and archaeological data indicates that the North American Pawnee transported lithics hundreds of kilometres while on bison hunting trips (Holen 1991). Long-distance trips have also been proposed to explain the presence of exotics in southern Finland (Zhilin 2003). However, in the Early Mesolithic context long-distance hunting trips are not theoretically predicted. In the Early Mesolithic northern European boreal forest, the anticipated returns from hunting were likely to be relatively small. Even the highest ranked resources are found in relatively small aggregates. The main targeted large mammal species and probably the only one available at the time in southern Finland was European elk (see Rankama & Ukkonen 2001). Elk is found either alone or in small herds, and although the species is widely dispersed, the mosaic-like nature of the environment means that suitable patches to locate elk are found generally everywhere on a large scale.

From an evolutionary perspective, long-distance hunting does not represent good tactics in such a situ-

Borough	Site	Lab code	BP	Std	calBC (1 sigma range)	Median	Km	Flint
Orimattila	Myllykoski	Hela-552	9480	90	9119–8637	8829	218	No
Lappeenranta	Saarenoja 2	Hela-728	9350	75	8735–8490	8614	169	Yes
Joensuu	Rahakangas 1	Hela-882	9405	80	8787–8567	8693	300	Yes
Juankoski	Helvetinhaudanpuro	Hela-918	9200	75	8532–8306	8425	370	Yes
	Pulli	TA-245	9600	120	9183–8823	8987	0	Yes
	Veretye I	Le-1469	9600	80	9173–8837	8995	0	Yes
	Baseline	Combined	9600	67	9158–8837	8995	0	

Figure 8. Earliest dates from selected Early Mesolithic finds from southern Finland, Estonia and Russia (**see also fig 9**). Dates are calibrated using OxCal4.1 and IntCal09 calibration curve (Bronk Ramsey 2009; Reimer *et al*. 2009).

ation. The longer the distance, the higher the travel and transportation costs, and inversely, the closer to home the hunting took place, the higher the total efficiency, all else being equal. This implies to us that long-distance hunting is unlikely to explain Early Mesolithic exotics in southern Finland. In the future, we need to attempt to model logistical mobility in relation to residential mobility and address questions such as: how long distances were beneficial to travel for hunting purposes, and how might these trips have enhanced fitness in the Early Mesolithic context. It is reasonable to suggest that as the population density in relation to available resources was relatively sparse in the Early Mesolithic, the options to move around were not restricted by the presence of other groups (see Kelly 1995). Given the small number of human foragers, the availability of high-ranking food patches was relatively high. Therefore, mobility is likely to have been organised around residential mobility, as predicted by the marginal value theorem (Charnov 1976; Hanski *et al.* 1998), rather than long-distance logistical trips from more stable residential camps. Therefore, we suggest that Early Mesolithic hunter-gatherers made frequent residential moves, spent only a relatively short time in a patch, and used only a fraction of the resources available in the patch in contrast to their successors. This should be readily detectable in the archaeological record.

Related to the special long-distance logistical trips, it is worth considering scouting activity and journeys beyond the home range. Information and knowledge of new areas and environments helps in planning the future and, therefore, reduces uncertainty and makes life less risky. From an evolutionary perspective, this means that it is worthwhile to invest time and energy to gain experience and information of new areas. To understand the role of scouting activity in relation to the spread of exotics, we need to address the magnitude and the effects of this kind of mobility. If exotics begin to be increasingly found in most or many early sites, as it now seems, scouting activity may not be a good basis for explaining the exotics. Furthermore, if the sites that contain exotics are separated by hundreds of years, as it now seems, the scouting of uninhabited land may not be a good explanation (see **Fig. 8**). If scouting was the cause for the exotics, one would expect to see relatively homogenous site assemblages, for example, a small number of raw material varieties at each site. These sites can also be expected to have sparse distribution over the landscape. These are the results of small parties of hunter-gatherers scouting the vast areas and carrying around a minimum amount of tool stone to minimise travel costs.

Special long-distance journeys to visit other groups might leave another kind of sign in the archaeological record. For example, Boas (1964:167) remarks that the Central Eskimo journeys may cover 800 km back and forth. These trips would be long enough to spread exotic materials to camp sites far away from the sources, for example, to southern Finland from a Carboniferous formation. Furthermore, a long-distance journey offers a physical mechanism for the movement of exotic stone between parties living far away from each other. This may lead to site assemblages where a small amount of exotics is found among a larger set of local lithic materials. However, special journeys alone cannot explain why the exotic lithics in Finland are found at the earliest sites, and we need a mechanism that can explain the beginning and the end of the spread of flint at the same time.

Migration and long-term mobility

Direct migration as a main distributive mechanism behind the exotics in Finland is favoured in many discussions reviewed above. If we simplify, two options for human dispersal into Finland exist: the colonisation was either a slow process in which new areas were gradually settled, or it involved long-distance migrations northwards from flint source areas to form new home ranges. The former case could have been possible in the course of long term mobility as home and lifetime ranges gradually shifted towards the north. The migration hypothesis put forth to explain the exotics implicitly suggests the latter. As we will elaborate below, the high mobility hypothesis implicitly argues that the pioneers must have migrated long distances very quickly without depleting their flint tool kits.

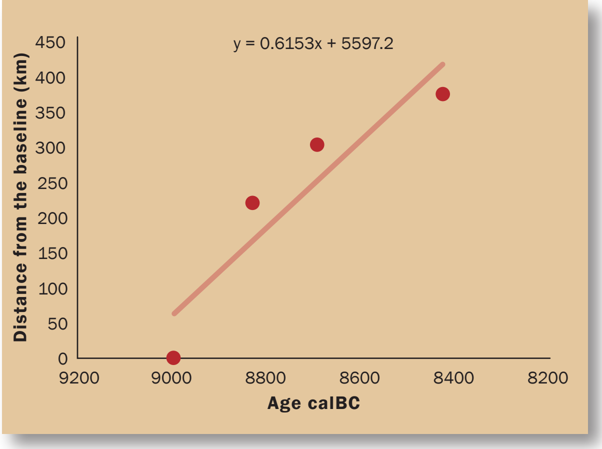


Figure 9. Analysis of colonization front line speed in southern Finland (y=0.6153x + 5597.2). Data from Carpelan 1999; Pesonen 2005; Takala 2004.

Modelling hunter-gatherer migration to an unknown destination obviously does not match any historic case, but ethnographic data can, nevertheless, be utilised to learn about the colonisation process. As noted above, it is possible to break migration down to residential moves. If we take the Nunamiut residential mobility speed as the maximum migration speed, we can make an educated estimate about the pace of the migration and compare this to other data. As illustrated in **Figure 7**, our model foragers travel from Carboniferous flint areas to Finland in six months and from southern to northern Finland (c. 1000 km) in 15 months. On an archaeological time scale, this means that all of eastern Fennoscandia was colonised simultaneously. Currently, the dating evidence does not support this. Carpelan (1999) estimated, on the basis of the known radiocarbon data, that the colonisation frontline speed would have been 0.69 km per calendar year. We retain the original baseline through Pulli and Veretye I to estimate the distances for the new site and radiocarbon data and to update the frontline speed for southern Finland (**Fig. 9**). By fitting a linear trend line through the series of earliest calibrated dates (per area), the frontline speed becomes about 0.62 km per year. This gives 14 kilometres in a generation (20 years). This slow frontline speed suggests that dispersal was a relatively slow process, possibly through the gradual adjustment of home ranges and/or the movement of the younger generation to new areas to form new bands.

It follows from the slow frontline speed that if exotics were related to the earliest phase of dispersal, these were unlikely to be distributed through direct migration from flint areas. In this context, it may not be accidental that the Orimattila Myllykoski site, the earliest currently known site in southern Finland, has not produced exotic lithic materials (Takala 2004:149–150). Clearly, the frontline speed itself tells little about the actual way individuals move. New waves of long-distance migration that have followed, or jumped over the initial frontline, can be a mechanism that explains the slow frontline speed and the exotics as well.

In southern Finland, the dated Early Mesolithic sites that contain flint fall c. 200 years apart (**Fig. 8**). If migration brought the exotics to southern Finland, these data mean that the known Early Mesolithic flint exotics cannot result from a single migration but must be the result of several individual long-distance migrations. Possible further evidence for long-distance migration comes from northern Finland. Rankama and Kankaanpää (2007:57; 2008:896) suggest that the material from Sujala site from northern Finland implies the migration of a group over long distances, i.e., a thousand kilometres in a generation. If Sujala and southern Finnish flint sites are evidence of long-distance migration, it means that new migration waves followed each other and that these gradually went further and further by jumping over the earlier frontline.

Which one of the polarised alternatives approximates the prehistoric reality? Was the colonisation the result of a slow adjustment of the home ranges in the frontline or the result of multiple long-distance migrations? Evolutionary theory offers a reason and argumentation for both views. Habitat selection models, e.g., the Ideal Free Distribution model, predict that the most productive patches should be selected first and the others filled up in diminishing order (Hanski *et al*. 1998). Therefore, these models predict the spatial and temporal structure of the dispersal process. As individuals are free to position themselves in the landscape in relation to resources, the move into a new area should occur when the foraging returns in the old environment have fallen below what can be expected to be found in the new environment (plus costs of the move). From this it is possible to deduce both the close-range movement and the long-distance migration. It is possible to argue that foragers moved to new areas slowly because the general direction of the colonisation was towards the north, i.e., away from the most productive environments. Therefore, it was beneficial to move short distances only. It is also possible to assert that new uninhabited areas that lacked other foragers had higher productivity-to-consumer ratios, and therefore, it was beneficial to migrate from far behind the existing frontline. The new areas would then provide higher returns and benefits than the old one. In the future, this issue can be addressed through systematic modelling to understand the effects of different variables on hunter-gatherer decision-making to move to new areas.

If the exotics in southern Finland and the Sujala technology in northern Finland were to be explained by long-distance migration, then it obviously should have been quite common. This leads to archaeological implications that can be tested to a degree. Given the short discussion on Ideal Free Distribution, the migrations should have led to a systematic and patterned formation of the archaeological record, i.e., the exotic raw materials from different geological formations should be distributed to different areas and show evidence of zonation in the direction of colonisation: for example, Cretaceous flint in Estonia and Latvia (e.g., Pulli, Zvejnieki), Carboniferous flint in southern Finland, Paleozoic flint in Central Finland and so forth. This is a logical deduction from the general logic of the evolutionary argument and of the habitat selection models. This can be tested through future field and analytical work.

Lithic evidence

Theory of raw material procurement, reduction and curation

Understanding lithic reduction is essential to understand the spread of exotic raw materials into southern Finland. Because flintknapping is a reductive process, the available piece of flint becomes smaller and smaller every time it is being worked. Therefore, in general, it can be expected that the farther away from the source areas the foragers move, the smaller their supply of flint becomes, and because of this, the smaller the cores, blanks and tools become. This has been shown to be true in many empirical cases. Munday (1979) demonstrated this in Middle Palaeolithic Negev, Israel (also Marks *et al.* 1991), and Newman (1994) found that flake volume and thickness correlated negatively with distance to raw material sources in the North American Southwest.

To fill up lithic stock, new raw material must be located and procured. If the hunter-gatherers were highly mobile and had large ranges through which they moved frequently, then lithic assemblages should mirror these areas to a degree. For example, during the hypothetical moves between central Russian flint areas and southern Finland, there would have been a need to add to the decreasing tool stone stock. As a consequence, new raw material varieties would have been procured along the way, and the percentage of these would have increased in the supply at the same time as Cretaceous and Carboniferous flint decreased. Ingbar (1994) provides a good simulation study on how proportions of different raw materials in archaeological assemblages vary in relation to different lithic sources used during the annual round. A nearby archaeological example can be found from Late Mesolithic northern Lapland, where hunter-gatherers moved between coastal zone and inland and raw materials were flowing between these areas (see Manninen 2009). In our case, the varieties of Paleozoic flint from Latvia, Estonia, or Russia, must have been present in tool kits when the foragers ended up in Finland. If they started from the Carboniferous or Cretaceous source areas, the other varieties of raw materials should also be much more numerous in the assemblages in Finland, as the last were procured from sources closer to Finland than the first. Furthermore, at the turning point and during the return trip to flint areas, the raw material supply would have been augmented with quartz and other local materials. For example, moving away from southern Finland the amount of quartz at the sites gradually decreases as new local raw materials are encountered and procured along the way. Paleozoic flint procured, for example, from the Pskov's region ends up in Valdai area sites and so forth. The systematic presence of different raw materials in southern Finnish sites is central to testing the hypothesis of high mobility – be it residential, logistic, or migration – between the flint areas, i.e., the Carboniferous and Cretaceous formations, and southern Finland. Therefore, the high mobility hypothesis argues that *flint from sources closer to Finland will be more common here than flint deriving from farther away, all else equal*.

Lithic tools, retouched or not, wear out relatively quickly. Therefore, they need to be sharpened constantly to keep the edges functional. As each sharpening action removes material, the size of the piece gradually diminishes. Consequently, most chipped lithics last for a relatively short time, i.e., minutes, hours, or, at most, days, after which they need to be replaced. For hunter-gatherers who habitually depend on lithic materials, the chipped lithic tool use-life can be expected to be relatively short. Ethnographically, archaeologically and experimentally documented cases support this (Frison 1968; Odell 1980; Shott 1989; Hayden 1979). As documented in ethnographic studies, obsidian hide scrapers, for example, are known to have been sharpened every few dozen or hundred strokes and may have lasted no more than an hour or two (Clark & Kurashina 1981; Gallagher 1977; Håland 1979). In a similar fashion, lithic projectiles do not last long and are literally disposable. In experiments, some projectiles have penetrated as many as 12 animal targets, but they may well break on the first shot (Odell & Cowan 1986; Frison 1989:771). Shott (2002) found the mean number of firings for a projectile to be 3–4.

This has obvious implications for the organisation of lithic technology. As stone tools wear out relatively quickly, they must be maintained and repaired, and new tools must be made constantly. It is evident that the further the hunter-gatherers move from the flint sources, the smaller the primary products they produce must become. Accordingly, to anticipate and compensate for the diminishing raw material stock and blank size, curation of tools is likely to occur. In other words, the use-life of existing tools is increased by re-sharpening the tools over and over again. There is very good reason to suspect that in areas far from good raw material sources, curation is likely to be much more extensive than in areas where flint is readily available. Thus, we should see a marked difference in tool reduction intensity between the flint areas and southern Finland and between material derived from distant and not-so-distant flint sources.

Each technology has its own features and attributes that are best suited for measuring and analysing reduction and curation. In the north-east European Early Mesolithic context, cores were regularly maintained by the removal of core tablets and by platform trimming (e.g., Burov 1999; Rankama & Kankaanpää 2008; Koltsov & Zhilin 1999). This means that core and blade size, especially the length, will depend on the distance to the source area. This will also affect the tools made on blades, which can be predicted to be smaller in Finland than their counterparts closer to the flint source areas. This effect is further strengthened by the increased attempt to lengthen tool use-life by sharpening and reshaping them. The differences in the lithic artefacts can be observed by examining the dimensions and the mass of the flint tools. End scraper length in particular can be expected to strongly depend on the availability of flint. In Early Mesolithic north-eastern Europe, these should be useful measures, together with the other ones cited above, to study reduction and distribution mechanisms.

To summarise, two implications are clear. First, if flint and tool kits were carried along with highly mobile individuals from flint source areas to Finland, flint material, if present this far, should be highly reduced and curated. This means that both primary products and secondary products should be the smaller the longer the distance from the lithic source. Second, on the way towards Finland, there was a need to add to the decreasing tool stone stock that was carried along. As a consequence, new raw material varieties were procured along the way, and the percentage of these increased in the supply at the same time as, for example, the amount of Cretaceous and Carboniferous flint decreased. The varieties of Paleozoic flint, from Latvia and Estonia, for example, should have been present in tool kits when the foragers ended up in Finland. If they started from the Carboniferous or Cretaceous source areas, the other varieties of raw materials should also have been much more numerous in the assemblages in Finland, as they were procured from sources that were closer than the others. At the turning point and during the return trip to flint areas, the raw material supply was filled with quartz and other local materials. Consequently, the archaeological lithic assemblages in and around southern Finland should be systematically structured as discussed above.

	Cretaceous	Carboniferous
Total artefacts	45	270
Blade / retouched blade	2 / 12	30 / 37
Blade / flake	14 / 11	67 / 170

Figure 10. Ristola flint data. Data from Takala 2004:Fig 109.

Evidence for raw material procurement

The Ristola flint assemblage is so far the only relatively large collection of Early Mesolithic flint from one site in Finland for which published data exist. It consists of 315 flint artefacts, though lithics altogether total more than 58,000 artefacts (Takala 2004:Figs. 65, 84, 106). The site is large (several hundred metres long) and includes material and radiocarbon dates from several different periods (Takala 2004). Furthermore, field ploughing has affected site formation by mixing layers at the site (Takala 2004). The problematic history of the Ristola site – the possible presence of flint artefacts from different periods, the high prehistoric use intensity implied by the large lithic collection, and the later ploughing – complicates the use of the site material in studying the spread of exotic raw materials to Finland.

The reported flint material varieties at Ristola derive from two major geological formations, Cretaceous and Carboniferous flint, but no flint from the closer Paleozoic sources present, for example, in Estonia, has been reported (Takala 2004:107–109; Kinnunen *et al.* 1985:50). These determinations are based on the microfossil content of flint. Two blade arrowheads made of a sandstone-resembling raw material of unknown origin (Takala 2004:101) may suggest a spread of raw materials from sources other than the Cretaceous or Carboniferous ones. At the Helvetinhaudanpuro site in eastern Finland, a single flake, which is one of six pieces found at the site, resembles the Paleozoic material from Estonia, and a single piece has also been reported from Kuurmanpohja in south-eastern Finland (Jussila *et al*. 2006:58; 2007:150, 157). In general, the available data from Finland are, therefore, in gross contradiction with the high mobility hypothesis and its implications on raw material procurement discussed above: Paleozoic flint is practically nonexistent, although it should be strongly present.

This either means that no raw material was procured in the area between southern Finland and the Carboniferous or Cretaceous flint belts or that no movement between these areas took place. The latter seems a more likely explanation, given the discussion above concerning mobility, lithic use-lives, and the data we have from Finland, Estonia and Latvia. The fact that local lithic material, mainly quartz, was used heavily in Finland at the Early Mesolithic sites (Jussila *et al.* 2006; 2007; Takala 2004) implies that local materials were considered suitable, accepted, and commonly used in general. Although the Paleozoic flint may have been of lower quality than Carboniferous or Cretaceous material, its properties were clearly much closer to those of these flint varieties than quartz, and therefore, it was better suited for the required tasks and the existing hafts. This predicts that Paleozoic flint should have been on the list of used materials and, therefore, that this material should be present in southern Finland, too. Furthermore, local Paleozoic flint was used at the Early Mesolithic Pulli site in Estonia and at the Zvejnieki II site in Latvia (Jaanits 1990:7; Zagorska 1993:102) at the time colonisation reached southern Finland. It was, thus, generally known and used by Early Mesolithic foragers in the area.

The absence of Paleozoic flint in Finland implies that flint did not end up in Ristola with immigrants from Estonia, as suggested by Edgren (1984) and Takala (2004), nor is it likely that that the immigrants came from any area where Paleozoic flint material was readily available. That the flint material found at Ristola was not brought from the south, i.e., Estonia, is further supported by the data on the ratios of Carboniferous and Cretaceous materials found at the site and what is known from other sites in neighbouring countries. For example, in Estonia, at the Early Mesolithic Pulli site, Cretaceous flint is well-represented and forms approximately two-thirds of the material, whereas Carboniferous material is scarce (Jaanits 1990:7; Jussila *et al.* 2007:157; Zhilin 2003:691). This is in contradiction to the ratios found at Ristola, where Carboniferous flint predominates (**Fig. 10**), and it contradicts the earlier arguments (Edgren 1984; Takala 2004) that immigrants to Ristola came from the south.

The nearly complete absence of Paleozoic flint reported thus far from sites in Finland does not support high residential or logistical mobility between the Cretaceous and Carboniferous flint areas and southern Finland either. Furthermore, in the Carboniferous areas of the Upper Volga region in Central Russia, the sites contain little if any Cretaceous flint (Zhilin 2003). The same applies to quartz in sedimentary rock areas. For example, at the Pulli site in Estonia, the proportion of quartz is very small: only 0.7% (Jussila *et al*. 2007:159). To us, this implies that the home ranges were not large enough to cover, for example, both the Cretaceous and Carboniferous belts. This also provides an archaeological estimate of Early Mesolithic home ranges in northeastern Europe that is in line with the above discussion concerning the predicted home ranges. It seems that Early Mesolithic home ranges in general were not large enough to reach southern Finland from Lithuania, central Russia, the area south of Lake Onega, or even from the Paleozoic zone. However, not all of the data agree with this. The common presence of Cretaceous flint at Pulli is best explained through personal procurement and, therefore, through high mobility. It is unlikely that exchange or trade could explain the presence of this flint at Pulli. Relying mainly on trade to achieve the major part of the lithic materials that are needed and used everyday would not be a good strategy for mobile hunter-gatherers. Cretaceous flint at Pulli suggests that some home ranges extended 300 to 400 kilometres north from the Cretaceous flint sources. The size of these areas may have been somewhere around 60,000 to 80,000 square kilometres (300–400 x 200 km) in size.

To keep things simple, we have not discussed core efficiency and core use-lives here but simply assumed them to be constant. In reality, core efficiency affects core use-lives and, therefore, affects the formation and nature of archaeological lithic assemblages. Elsewhere we suggest that the conical core reduction strategy was preferred by mobile hunter-gatherers in the area and that this affected assemblage formation (Hertell & Tallavaara, *this volume*). To make large conical cores on the small Paleozoic material may not have been a viable option, and large nodule size may have been preferred. Furthermore, mobile hunter-gatherers elsewhere preferred high-quality lithic materials (Amick 2002; Hofman 1991). In the present context, this might denote the preference for good-quality and large-nodule-size Carboniferous or Cretaceous flint over the Paleozoic material. This complicates model building and suggests that the flint material ratios found in southern Finland need not be linearly related to raw material proximity. Nevertheless, travelling hundreds of kilometres from the Carboniferous or Cretaceous formations means that the original cores would have been heavily reduced by the time hunter-gatherers were in the Paleozoic zone. Thus, there was a need to fill up the lithic stock carried along, and this affected lithic assemblage formation and raw material proportions, as Pulli demonstrates. The current nonexistence or low proportion of Paleozoic lithic materials from southern Finland is contrary to the expectations of high mobility.

Evidence for reduction and curation

The issue of southern Finnish exotics can also be approached through the study of reduction and curation. If the proposed route for flint through Estonia were correct, then the minimum distances from both source areas, i.e., the Carboniferous and Cretaceous formations, to Ristola would be around 600 km. This suggests that the reduction intensity, on average, should be similar for the two flint varieties. Our analyses, however, suggest that this is not the case.

The Ristola material shows that the reduction intensity of the flint varieties at the site is related to the linear distance to the flint source. This is supported, first, by a simplistic proxy, i.e., the absolute amount of flint. The amount of Carboniferous flint that originates from sources that are closer to Ristola than the Cretaceous sources is higher in the assemblage (**Fig. 10**). The same results are also seen in the relative ratios of blades to tools, blades to flakes and for tool sizes. These mirror core sizes and curation, and therefore, distance to the sources. For Cretaceous flint, the blade/retouched blade ratio (specified tools excluded) is 2/12, whereas for Carboniferous flint, the ratio is 30/37 (Takala 2004:Fig. 109). Clearly, a relatively larger amount of blades/fragments of Cretaceous flint are retouched and, therefore, are more curated than ones of Carboniferous flint. The same also applies to the blade and flake ratios. For Cretaceous flint the blade/flake ratio (specified tools excluded) is 14/11, whereas for Carboniferous flint it is 67/170.

Data on tool size further suggest that Cretaceous flint came to Ristola along a longer path than did Carbon-

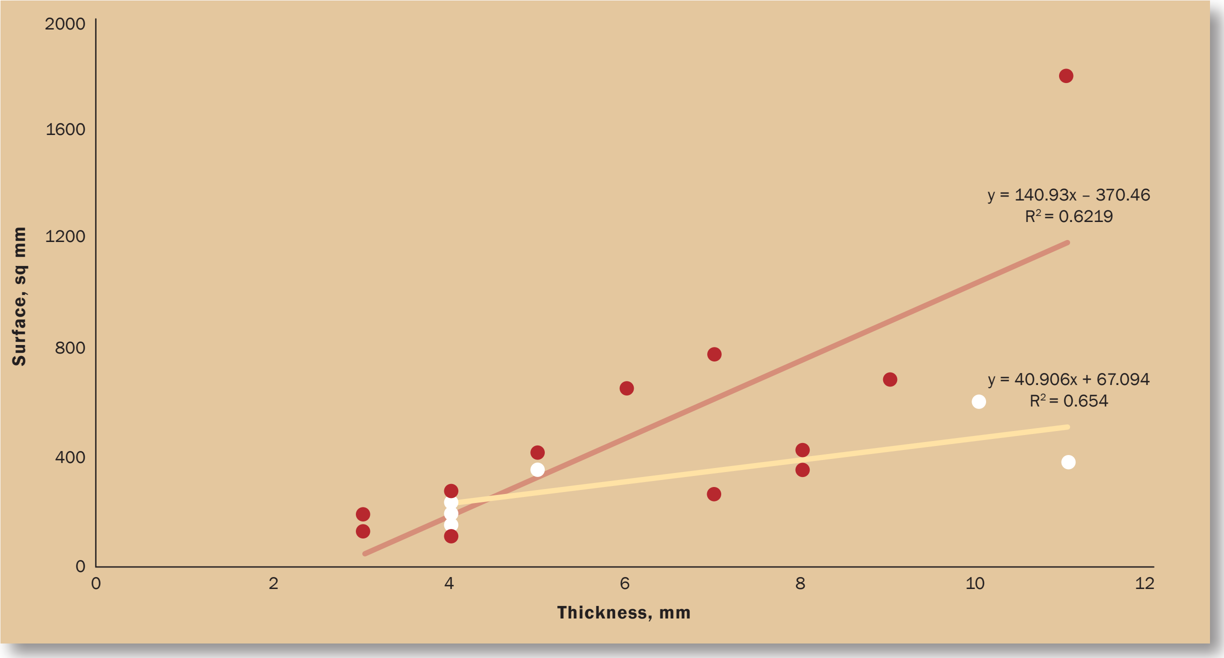


Figure 11. Reduction analyses of Ristola flint scrapers. Red =Carboniferous (n=14), white =Cretaceous (n=6). Data from Takala 2004: Figs. 130, 138.

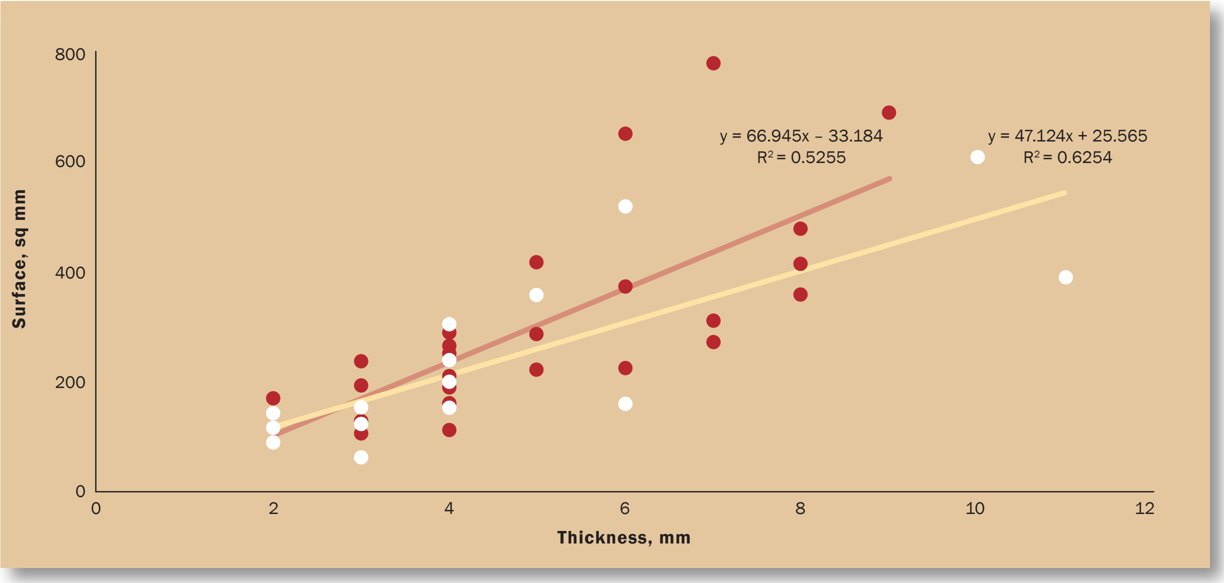


Figure 12. Reduction analyses of all tools (arrowheads and inserts excluded) from Ristola. Red =Carboniferous (n=28), white =Cretaceous (n=15). One large Carboniferous outlier excluded. Data from Takala 2004:Figs. 126, 130, 132, 136, 138.

iferous flint. The measure of reduction and/or curation is dependent, as expected, on the raw material variant and its relative distance to the geological formation. For all tools, the surface-area (length x width)-to-thickness ratio is higher for Carboniferous than for Cretaceous tools. The same applies if the scrapers are examined separately (**Figs. 11, 12**). All of the above figures suggest that Cretaceous flint had a longer distance to travel to Ristola than did Carboniferous flint. This is the result of the natural raw material distribution in relation to the site and implies that the routes along which the flint material was brought to Ristola were different and variable. To summarise, there are currently no data to support the argument that both Carboniferous and Cretaceous flint came to Ristola from the south, i.e., through Estonia.

Little comparative data suitable for studying lithic reduction and curation exist in the monographic treatments of the north-west Russian Mesolithic (e.g., Koltsov & Zhilin 1999; Oshibkina 1983; 2006; Sorokin 2006). Oshibkina has made comparative data on blades and scraper size in Veretye I available (Oshibkina 1997). At Veretye I, the blade-to-retouched-blade ratio is clearly higher than the ratios at Ristola (**Fig. 13**). Not surprisingly, the general availability of flint around Veretye I resulted in less intensive use and curation of blades compared to Ristola.

Metric values of scrapers are given for Veretye I type 1 scrapers, i.e., round scrapers (Oshibkina 1997:61). It is reasonable to suggest that the retouched round scraper form developed, at least in part, under an intensive reduction regime (e.g., Dibble 1995). This means that type 1 scrapers are likely to be more heavily reduced and, therefore, smaller than other scraper types. Nevertheless, it is a proper proxy for scraper and tool size in Veretye I.

In comparison to Ristola, the Veretye I scrapers are clearly larger. Approximately 73 percent of the Veretye scrapers are larger than 25 mm in maximum size, whereas at Ristola, most scrapers and other tools are smaller than 25 mm in size (**Fig. 13**). This implies that the overall reduction intensity was higher at Ristola. This difference is emphasised when considering the argument above that Veretye type 1 scrapers are more intensively reduced than other scrapers. The comparison between Ristola and Veretye I suggests that the artefacts of exotic raw material found in Ristola are heavily reduced and curated. This fits the high mobility model but need not contradict exchange.

We suspect that not all flint was equally distributed. A pattern that sheds light on the distribution is found at Central Russian Butovo Culture sites, i.e., on and around the Carboniferous formation. Single regular blades, inserts and especially symmetric arrowheads of Cretaceous flint are found at Belivo 4a, Kurevaniha 5, Pekunovo, Prislon 1, Sukontsevo 3 and Zaborovje 2 (Zhilin 2003:690). This hints at a mechanism for the distribution of arrowheads and, especially, arrowheads of Cretaceous flint in north-eastern Europe. Zhilin (2003:692) has suggested that the exotics at Butovo sites were either exchanged or part of the tool kits that were carried along while hunter-gatherers moved around in the area but favours the latter option. We suspect that if this was the case, the Butovo Culture assemblages should also show evidence of heavily curated tools of Cretaceous flint, especially scrapers and other multifunctional tools, rather than only regular blades, inserts and arrowheads of high symmetry. It seems to us that the presence of Cretaceous arrowheads at Ristola and at Butovo Culture sites is better explained by the selective exchange of specific artefacts, e.g., hafted arrowheads and inserts, and symmetric blades for their production. The pattern seems to indicate that special artefacts were flowing from Cretaceous areas to the north and north-east. It suffices to say here that there must be a reason for the emerging distribution pattern of exotics. The high quality of Cretaceous flint is undoubtedly an important factor to be considered to understand the reason for exchange. However, given the fact that many of the artefacts were projectile points with short use-life and the fact that the flint was exchanged to areas where high-quality flint was readily available, the physical quality of the flint itself may be of relatively little importance. We suggest that it is not unreasonable to argue for social causes of exchange. Whatever the case, the above and other similar unexpected patterns can be utilised to refine our understanding of the flint distribution mechanisms and the exact way transfers took place when more data become available from other sites in the future.

Blades		
	Veretye I	**Ristola (specific tools excluded)**
Not retouched	1183	32
Retouched	129	49
Ratio	9.2	0.7
Scrapers		
	Veretye I (type 1)	**Ristola (all scrapers)**
20–25 mm	150	15
25–35	290	4
35–60	119	1

Figure 13. Comparison of Veretye I and Ristola blades and scrapers. Data from Takala 2004; Oshibkina 1997.

Evidence for the raw material variability and intrasite spatial distribution at Ristola

At Ristola, the spatial distribution of flint is a further key to understand the site and its assemblage formation. Schulz (1996) observed that the flint material was distributed over a long stretch of the Ristola site. Judging by the data on find distributions (Takala 2004), exotic finds are spread over an area that covers 50–100 x 50 metres. This fits well with the reported raw material diversity, which is very large given the small size of the flint assemblage. Of the two major exotic raw material groups present at Ristola, Carboniferous and Cretaceous flint, the flake category alone (181 pieces) can be further separated into at least 17 different minor raw material varieties (Takala 2004:113, Fig. 106). This means that the material represents at least 17 different cores and, therefore, at least 17 individual knapping sequences. On average, this makes a very small amount of debitage per raw material variety (315/17). Other published Mesolithic flint collections in Finland parallel the Ristola case. In Helvetinhaudanpuro, all six pieces of flint seem to be made of different materials (Jussila *et al.* 2007). At the Syväys 1 site in eastern Finland, the flint material of eight blades, for which a general Mesolithic date can be suggested, is diverse, and all of the blades are made of different raw materials (Hertell & Manninen 2006:42). We suggest that the available data on Mesolithic flint at these sites suggest gradual accumulation.

For example, in the Ristola case, we suggest that the flint was not discarded at the site during one occupational episode. Rather, it seems that the site was used repeatedly, e.g., once a year as a part of an annual round, or over a number of decades, and this gradually resulted in the deposited flint assemblage. This explains the diversity of the lithic raw materials and their wide distribution and low density at the site. Together with what has been discussed earlier, this means that local groups that lived in southern Finland occasionally received small amounts of flint, possibly not every year or even every decade but over a few decades or a few hundred years. They used this material within the local settlement system. Some of the material was left at Ristola, and other pieces were left at other sites, residential or logistic; it is this slow process of accumulation that explains the assemblage characteristics. In a strict sense of the word, the Ristola flint material, therefore, is not an assemblage but a slowly accumulated collection of items separated by long periods of time.

These hypotheses can be tested by nodule analysis (Larson & Kornfeld 1997; Tallavaara 2005), systematic refitting and analyses of intrasite spatial patterning at the Ristola and at the other Early Mesolithic sites. These methods should allow us to have good control on the formation of the sites and the site assemblages. On a larger scale, we need published and quantified data on raw material surveys from different geological areas to understand the natural lithic raw material distribution, availability, patchiness, predictability of locations, nodule size and quality, and so forth. It is acknowledged that major differences exist between different areas and that these differences have affected the organisation of the lithic technologies in the area (e.g., Koltsov & Zhilin 1999; Kriiska *et al. this volume*). We also need tests on the mechanical properties of different varieties of flint, e.g., from a flintknapper's perspective, and further geochemical sourcing of archaeological collections (e.g., Matiskainen *et al.* 1989; Galibin & Timofeev 1993). These data should allow for systematic modelling to understand lithic preferences, reduction strategies, and the whole organisation of lithic technologies. We recognise that these are integral to the study of the spread of exotics and the whole colonisation process in north-eastern Europe.

Summary of lithic evidence

Based on the above discussion on the Ristola lithic assemblage, it seems reasonable to conclude that the material was unlikely to have come to the site with individuals who personally procured it from the source areas. The material gives little support to the argument that immigrants from the south brought the material with them. Migration can explain the Carboniferous part of the flint assemblage, but this would mean that the source areas should be found east of Finland, where Paleozoic flint is not available, or possibly south-east, where it was possible to traverse the Paleozoic zone quickly without procuring local Paleozoic flint. However, high mobility, either through migration or some other form, is a poor explanation for the presence of all of the Ristola exotic material as explained above in detail. Instead, we suggest that the exchange of lithic materials and tools between several parties and different regions is a more elegant explanation for the Ristola material.

Exchange explains why lithic material at Ristola is highly variable, originates from two distant geological formations, and represents several individual nodules and, therefore, multiple cores and knapping episodes. In addition, exchange explains why the Ristola flint material composition differs from that of the Central Russian and Estonian sites. Furthermore, exchange explains the observed ratios of reduction and curation in the lithic data, although high mobility is not counter-indicated by these. Cretaceous flint came from longer distances and from a different direction than Carboniferous flint. However, the exchange network *per se* does not explain why the presence of exotics seems to be related to the colonisation phase. We now turn to discuss a mechanism of Early Mesolithic exotic distribution and its diachronic patterning.

From high mobility to gift exchange – case "breeding population"

From an evolutionary ecological perspective, fertility and mating are essential for theory building, and the number of surviving and reproducing offspring is commonly used as a measure of fitness. Fitness or evolutionary success is known to be density-dependent (the Allee effect in ecology, Stephens *et al.* 1999). During dispersal, population density was probably very low, and this has implications for archaeology. A small population density is a threat to both survival and reproduction. A small number of individuals means that although individuals of opposite sex are available, many of them may be too young or too old or already have spouses. Another result of the slow growth rates that characterise populations with small numbers of individuals is that in the beginning, many individuals are closely related, e.g., they are genetically separated only by a few generations, if any. This can lead to problems especially if cultural mating taboos are in operation. Therefore, a small number of individuals denotes a high risk that no spouse can be found at all, and the possibility to reproduce is severely threatened. To overcome these situations, mates need to be sought over wide areas, and energy needs to be invested to attract and secure a mate.

MacDonald and Hewlett (1999) studied population density and mating distance and found that these are inversely correlated ($y = -8{,}5659Ln(x) + 27{,}362$, $r=0.92$, $n=11$): the higher the density, the shorter the mean distance between mates. The minimum estimates for North American Late Pleistocene and European Upper Palaeolithic population densities are of the magnitude 0.3–0.07 individuals per one hundred square kilometres (Bocquet-Appel *et al.* 2005:Table 5; MacDonald 1998:Table 3). It is reasonable to assume that the Early Mesolithic population densities in the present case were not smaller than this. If we use the model of population density and mean mating distance, we can estimate Early Mesolithic mean mating distances. Assuming that population densities were of the magnitude 0.01, the model gives rather modest mating distances that are below 100 km.[4] MacDonald and Hewlett's (1999:Fig. 6) data also show that the maximum mating distance can be four times the mean distance, as it is for the Agta. This suggests that maximum mating distances could have been considerable, possibly 200–300 km, in Early Mesolithic northern Europe, too.

For a hypothetical Nunamiut equivalent group residing in southern Finland, e.g., in and around Ristola, this suggests that the mean mating distance extends to Estonia and the Leningrad region. Most mates would have come from a person's own and neighbouring groups. This is also what Rogers (1969), for example, found for the Cree-Ojibwa in the Canadian East Arctic, where most incoming spouses came from neighbouring groups. Some, however, would have found spouses from much farther away; in our case, for example, from the Pskov region or East Karelia.

From an evolutionary perspective, it is good to search for mates over long distances, not just in order to locate one, but because mating distance increases fertility. Labouriau and Amorim (2008), for example, found that human fertility increases with marital distance and reduction in inbreeding. It is likely that in the Early Mesolithic, reduction in inbreeding and, thus, an increase in fertility was best achieved when mates were received from long distances. Increasing distance, however, will also increase the cost of searching and attracting mates or simply maintaining contacts with a possible mate pool. Therefore, it is reasonable to expect that there should be a point after which increasing distance will no longer increase fertility as fast as the costs will rise. For example, the data from contemporary Denmark (Labouriau & Amorim 2008:Fig. 1, 2) show that growth in fertility decreases markedly when mating distance exceeds 20 km. At the same time, the size of the area, and related costs, will increase exponentially. It can be expected that

[4] In the original model, increasing population density leads to a situation in which mating distance becomes negative. This suggests that the model does not give proper estimates for high population densities. Low-population-density distances, however, also give somewhat unrealistic values. See Riede 2009:Fig. 2.4 for an application of the data.

in archaeological cases, this threshold should be visible if gifts are exchanged between the groups.

As females are typically the limiting factor in reproduction, the female choice of mates can be considered to be important in this context. Furthermore, the sex ratios in Early Mesolithic contexts may have enhanced the role of females as the limiting factor, when measured by the sheer number of individuals of opposite sexes. Hewlett (1991) found that with increasing male contribution to the diet, the juvenile sex ratio was increasingly biased in favour of males, probably due to different investment on children. It is not unlikely that this was the situation in the Early Mesolithic, too. Sex ratios from the Mesolithic Olenij Ostrov cemetery in Russia support this (adult male/female ratio 1.34) (Jacobs 1995:376; see also O'Shea & Zvelebil 1984:25). If the juvenile sex ratio is not stabilised during maturation, by the time reproductive age is reached the excess of males will create a competition for females. From an evolutionary perspective, an uneven sex ratio is an unstable situation, to which males needed to respond. Low population density combined with biased sex ratios can be expected to lead to very high investment in searching, attracting and contacting potential mates. This may result in archaeological manifestations.

MacDonald (1998), for example, has suggested that Folsom hunters travelled long distances to find mates and maintain social networks, and this explains the presence of exotic stone at some sites in North America. Assuming similar personal lithic procurement and transportation in the present case should lead to a situation in which raw materials mirror, to some degree, the mate search area. As most mates are typically found within a close range and the percentage of marriages decreases with distance, explaining southern Finnish Carboniferous and Cretaceous exotics by mate search mobility is equally as problematic as the other mobility options discussed above. If this mechanism were to explain the presence of exotics in southern Finland, Paleozoic flint from, for example, Estonia should be markedly present in southern Finland, as this is the area were most spouses would have been acquired.

In the following, we build a simple and general model on this basis to explain the appearance and the disappearance of exotic materials in Early Mesolithic southern Finland. This should be understood as an alternative model that currently explains better the existing archaeological record of exotics than the mobility models discussed above. In the following formulation, we define a breeding population as a group of individuals that has the opportunity to mate with each other.

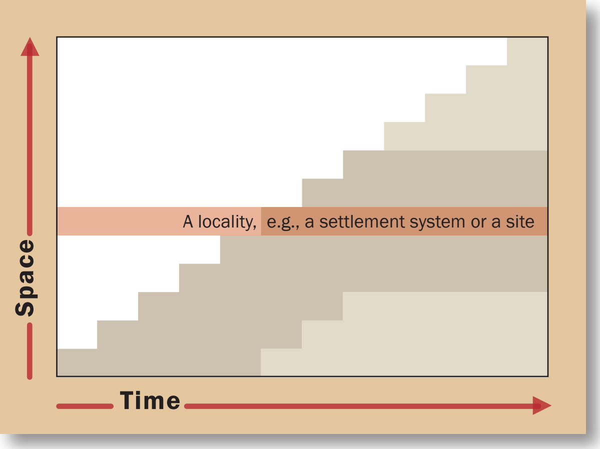


Figure 14. A time-space model of changes in the breeding population cover deriving from proceeding colonisation, seen from the perspective of a locality. White = uninhabited, light grey = populated areas, grey = breeding population.

Initial model building – breeding population characteristics

Let us assume, for the sake of simplicity, that population density and the size of a breeding population are constant. Let us further assume that a breeding population is a closed system that will form between interacting individuals and, therefore, those who live next to each other. Given these assumptions, from the perspective of the frontline pioneers, the spatial location of the breeding population will shift in concert with the proceeding colonisation (**Fig. 14**). The individuals of the pioneer frontline are always on the outer zone of the breeding population, and they must maintain contacts with groups behind the frontline. This is not the case for the individuals in the backlines. This is best illustrated by thinking of the location, e.g., the site, the river valley, the home range, etc., in which an individual lives. As colonisation proceeds, the location will first be on the frontline, but later, as the front line proceeds beyond the location, it becomes surrounded by a resident population. Therefore, the geographic position of the potential breeding population for individuals living in the location will change over the course of time.

The same result as above is achieved even if population density is not constant but is allowed to vary (**Fig. 15**).

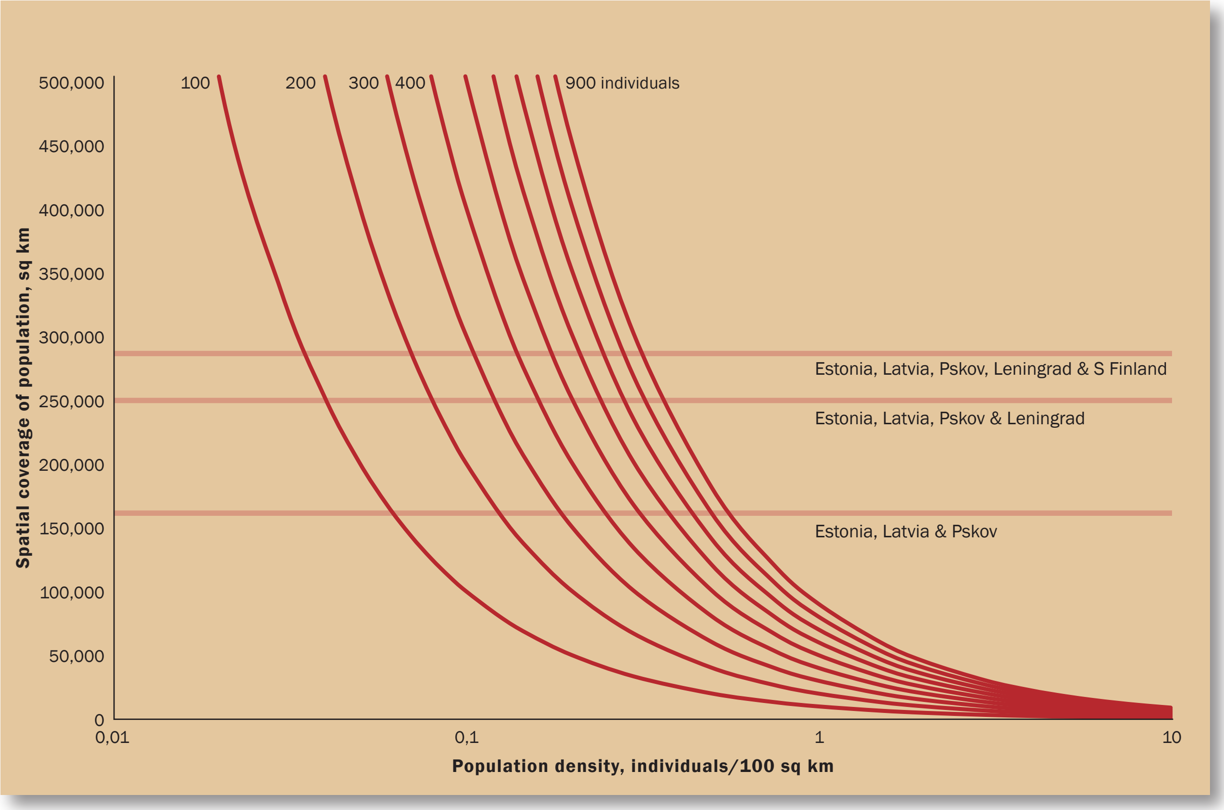


Figure 15. Relationships between population density, breeding population size, and its spatial extent.

It is likely that during dispersal population density is lowest at the pioneer frontline. As population density grows after the colonisation of an area, the spatial extent of a breeding population will diminish. Although fluctuations in population density are likely to have occurred, in the long-term, prehistoric populations must have grown to survive. This means that the spatial extent of a breeding population of a constant size will diminish in time. In reality, there is no need for the breeding population to be of a constant size, nor a closed unit, as real life examples inform us that this is not the case. Nevertheless, it can be argued that the simple model captures the essence of reality accurately enough and, therefore, does what models do: it helps us to understand how the world functions.

Incorporating variation in the model – risk and foraging returns

When we explore only the availability of spouses, there is no mutual interest between the frontline pioneers and the backline groups in mating. The former do have the need to maintain contact with the latter to secure mating opportunities, but the opposite is not true. From the backliner's perspective, potential spouses are available in all directions. If this mechanism alone were operating in the population, the archaeological signature would be different from a situation where further factors were added to the model. To build a more realistic model, we explore other factors that affect the selection of a spouse than the general availability of potential mates. One thing can be considered essential for the model presented here: the potential gain would have been higher after moving into a new area than it would have been if the group had stayed in the old area.

Moving into a new environment can be highly risky if no prior knowledge about the environment and the resources, animal behaviour, water sources, etc., exists. In this context, we define risk to be *uncertainty of future foraging returns* and further define *uncertainty* as variance. Higher risk must always come with higher potential benefits; otherwise, no one would ever venture to move into a new area. In the present case, the risk involved in migration was not very high. This is due to the structure of the Late Preboreal environment in north-eastern Europe.

The local environment is and was patchy. It repeats itself over and over again on the landscape. When pioneers arrived in a new area, specific information, e.g., on animal paths, nests, etc., was not available, but the general structure of the environment remained much the same. The kinds of patches where, e.g., European elk or beaver, water fowl, etc., were likely to be found were well known, as they remained the same from area to area. Furthermore, as the frontline proceeded slowly, i.e., around 14 km in a generation as discussed above, on average, new areas came to be inhabited relatively slowly. The colonisation of north-eastern Europe, thus, was slow enough for the environment to remain sufficiently similar from one generation to the next for all of the culturally learned behaviours to be applied in full suit in each new area. As long as the general concepts of how to cope in the environment are mastered, the specifics of localities can be learned quite quickly. This is familiar to those who fish, pick berries, gather mushrooms, etc.

Incorporating variation in the model – sexual selection

It follows from the above discussion that one option for the backliners was to actively seek to benefit from the higher return rates in the newly inhabited areas. One solution was to marry frontliners. Evolutionary theory suggests that an individual should select a spouse who maximises his/her fitness. Those mates who are better able to contribute to the support of offspring, e.g., provision food to offspring to secure their survival and growth, should be selected over others. It would have been possible for the backline females to benefit from the higher foraging returns of the males in the frontline. By selecting a male who could produce higher-than-average energetic returns from foraging, it should have been possible for a female to optimise her evolutionary fitness. For males, other options were available, e.g., the possibility to migrate to a new home range, where higher-than-average potential returns could be expected with subsequent results. For example, Kaplan and Hill (1985, also Hill & Hurtado 1996) found that more efficient Ache hunters had more surviving offspring, and Bailey (1991) showed that efficient Efe hunters are also wealthier than others and that this is positively correlated with their marital status.

Furthermore, other forms of selection may operate at the same time. As the frontline pioneers are likely to be closely related as cousins, aunts, uncles, etc., to some of the backliners, kin selection can further help to refine an evolutionary explanation for the contact network in north-eastern Europe. Members of close kin can, among other things, seek a suitable partner for their frontline relatives and help in mating over large land areas. Gradually, over the course of generations, the effect of kin selection should lessen due to the genetic separation of the groups, and, accordingly, the contact network should gradually shrink and cease to function. In other words, this leads to the same results as those of the simple model discussed above (**Fig. 14**).

Summarising breeding population model expectations for archaeology

We assume that a breeding population, i.e., social network, was formed between individuals and groups that could benefit from being part of the network, as explained above. The system of exchange was embedded in these social relations, and the social relations functioned to help mate search and acquisition. Therefore, the exotic lithics and other perishable materials were the by-products of these relations, and the material goods, ideas, etc. flowed through the network from one group to next. However, gift-giving itself may have also played a more active role, especially in the Early Mesolithic when cohesion between individuals was beneficial in mate acquisition. When population density is very low, the potential mate pool covers enormous areas. For example, a group of 500 persons covers 500,000 square kilometres at a density of 0.1 ind/100 sq km. This approximates the size of all of modern-day Finland and Russian East Karelia put together (**Figs. 2, 15**). Travelling over such large areas frequently to, for example, have large seasonal aggregations is costly. Through gift-giving, it was possible to create obligations, enhance reciprocity, and build alliances to increase cohesion between individuals and families (Mauss 1990; Sahlins 1972).

In the earliest phase, when the population density was low and home ranges were large, the chain of groups between southern Finland and Cretaceous and Carboniferous formations was relatively short. Consequently, exotics spreading from these source areas reached southern Finland through only a few hands. From the perspective of the foragers living in southern Finland, proceeding colonisation gradually made it possible to acquire spouses from all directions. Increasing population density and decreasing home ranges increased the amount of links in the chain between southern Finland and Cretaceous and Carboniferous formations. Therefore, the probability of exotics spreading to southern Finland decreased with time.

From an archaeological perspective, the area where exotics end up on archaeological sites will change over the course of time. With time, the distance the exotics travel from their sources decreases as the population grows or as colonisation proceeds and the breeding population position changes. Therefore, the early sites of a specific archaeological research area are expected to contain material derived from farther away than are later sites. In other words, sites closer to the specific source of a given raw material received exotics over a longer period of time than sites that were situated farther away.

At archaeological sites, exotic materials are expected to be highly variable, as they originate from different sources and areas. In addition to exotic lithics, we expect refuse faunas to contain relatively high amounts of high-return-rate species in the early phases of colonisation. This is best studied location by location or by comparing contemporaneous backline and frontline locations.

Furthermore, we want to stress that the breeding population is not meant to be a general explanation. Instead, it is a situation-specific tool especially suitable for understanding the archaeological record in a low-population-density demographic situation. If it was a standard explanation, for example, in Finland (with a standard breeding population size), we should expect to see highly variable breeding population areas during the Stone Age. If, as many have suggested, archaeological materials, e.g., Stone Age pottery styles, were only related to ethnic groups that formed breeding populations, then we should expect to see the smallest spatial extensions of pottery styles during the mid-Holocene population peak (Siiriäinen 1981b; Tallavaara *et al.* 2010). The situation is clearly not so as quite the opposite is true. However, we argue that the low-population-density models are reasonably well grounded for exploring the colonisation situation in archaeology in general. On a very general level, therefore, our model agrees with Zhilin's (2003) distributive mechanism.

Final conclusion

We have discussed different variables of mobility within the context of the north-east European Mesolithic in an effort to understand how exotic lithic materials arrived in southern Finland and why they subsequently disappeared from the archaeological record. To summarise, it can be said that both theoretical arguments and the available archaeological data imply that Early Mesolithic flint was not distributed to southern Finland through population mobility. It is reasonable to say that few, if any, prehistoric foragers used the whole region covering southern Finland, Lithuania, and Central Russia during their annual cycle and that the emerging archaeological pattern of exotics in southern Finland is not the result of residential mobility inside a home range. In a similar fashion, logistical mobility seems an unlikely cause for the spread of exotics to southern Finland. Long-distance migration can be a mechanism that explains part of the exotics, but this must have originated from areas where Carboniferous flint was locally available and where Paleozoic flint was not encountered; this means areas south-east or east of Lake Ladoga. Currently, there is no evidence of migration from the south, i.e., Estonia, to southern Finland in the exotic lithic record.

In the case of the Ristola site, however, migration cannot explain all of the exotics, unless we assume that more than one migration from different regions reached the same site. Instead, we suggest that gift exchange explains the archaeological record better. The system of exchange was embedded in the social relations between individuals who formed breeding populations. The proceeding colonisation and population growth explain why the exchange network diminished in its spatial extent and why flint is mainly found on the earliest sites.

In the future, we will need both theoretical and practical work to understand the exotic distribution mechanism as part of the human dispersal process in northern Europe. We do not argue that the past hunter-gatherer land-use systems were analogous to that which is ethnographically documented but maintain that these data offer a way to understand hunter-gatherer life in Mesolithic northern Europe. We also suggest that there should be an attempt to build systematic theories of how the exotic spread and colonisation of northern Europe took place, instead of inconstantly adopting ideas to produce a mixed set of arguments. In this paper, we have discussed the issue from the evolutionary ecological perspective. We believe that the study of dispersal has huge potential and is one branch of archaeology where data from Finland and their careful analysis can significantly contribute to hunter-gatherer anthropology world-wide.

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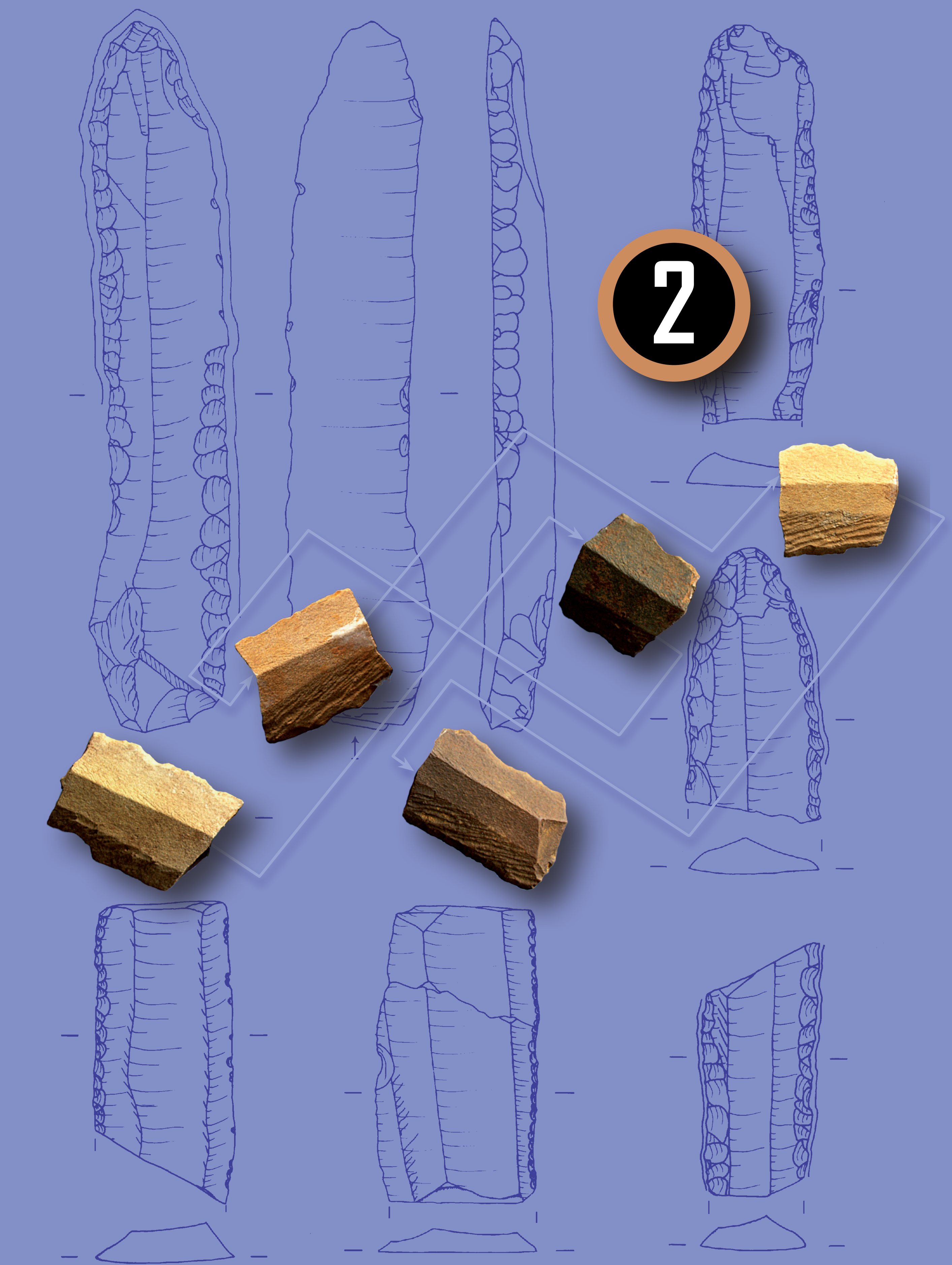
2

Spatial Patterns of the Early Mesolithic Sujala Site, Utsjoki, Finnish Lapland

Jarmo Kankaanpää & Tuija Rankama

ABSTRACT This paper discusses the spatial features of the Early Mesolithic Sujala site in Utsjoki, Finnish Lapland. It begins with a short description of the site and its lithic assemblage. The lithic evidence supports an interpretation as a single-component site with clear associations with the Post-Swiderian assemblages of North-west Russia. The spatial analyses study the distribution of the finds, which form four distinct clusters. One of these is interpreted as a dwelling with evidence of indoor blade production. Outside activities include core reduction and dumping of debris in specific spots.

KEYWORDS
Early Mesolithic, Lapland, Post-Swiderian, lithics, spatial analysis, blade production, pressure technology.

Introduction

The Early Mesolithic Sujala site lies in Utsjoki Borough, northernmost Finnish Lapland (**Fig. 1**). The site was discovered by Tuija Rankama and Jarmo Kankaanpää during an archaeological survey of Lake Vetsijärvi in 2002 (Rankama & Kankaanpää 2005; Rankama 2005). Two find areas some 200 m apart were identified in test excavations carried out in 2004, and one of these areas (Area 2) was excavated by Kankaanpää and Rankama in 2005–2006 (**Fig. 2**). The total contiguous excavated area of Area 2 was 77 square metres, all confined within an 11 x 10 m square. A number of 1 x 1 m test pits were dug outside this area, but they produced no finds.

Figure 1. Location of the Sujala site.

Figure 2. The eastern half of the Sujala site, excavated in 2005; the -5 cm level looking south. The large floor stain lies left of the north arrow (centre). Yellow markers are at 1 m intervals. Photograph by J. Kankaanpää.

Structural features of the site were limited to a roundish area of stained earth some 2.5 m in diameter in the northern part of the excavation and a much smaller dark stain towards the centre. Both stains contained charcoal and burnt bone. The larger stain correlates with a cluster of lithic finds that exhibited clear signs of the "wall effect" (Grøn 1995:7) over nearly half of its circumference. In the wall effect, the density of finds drops suddenly along a linear – in this case curved – zone, indicating the presence of a barrier (**Fig. 2, Fig. 3**). This suggests that the feature probably represented the floor of a small, round dwelling some 3.5 m in diameter – possibly a tent, since no depression or bank was discernible. The matrix was hard-packed sand containing stones of various sizes. The distribution of the charcoal suggests that a fire burned in the centre of the presumed dwelling, but no evidence of a purpose-built stone hearth could be perceived. The smaller stain was probably a refuse pit, judging from the small size and relative depth. The rest of the finds formed a fan-shaped pattern extending south-west from the presumed dwelling and containing several concentrations as well as what looks like a "toss zone". This area will be referred to as the courtyard. The location of the courtyard finds suggests that the door of the presumed dwelling was also towards the south-west.

Lithic finds numbered 6387, weighing a total of 3074 grams, and the site also produced 40 charcoal samples and some 620 grams of burnt bone. Osteological analysis of the latter (Lahti 2006) has identified wild reindeer (*Rangifer tarandus sp.*) as the predominant species. Birds are represented by divers (*Gavia*). Fish are not present in the material. Judging by the very limited – albeit relatively dense – areal distribution of the finds, the site appears to have been a small, short-term campsite used by reindeer hunters. The diver bones suggest that the occupation spanned at least part of the open water period. The finds consist primarily of lithic artefacts and waste associated with a blade industry. Over 99% of the lithic finds are of a very fine-grained cherty material described by geologists as weakly metamorphosed sandstone (R. Kesola *pers. comm.* 2005; 2006; A. Siedlecka *pers. comm.* 2009) but referred to henceforth

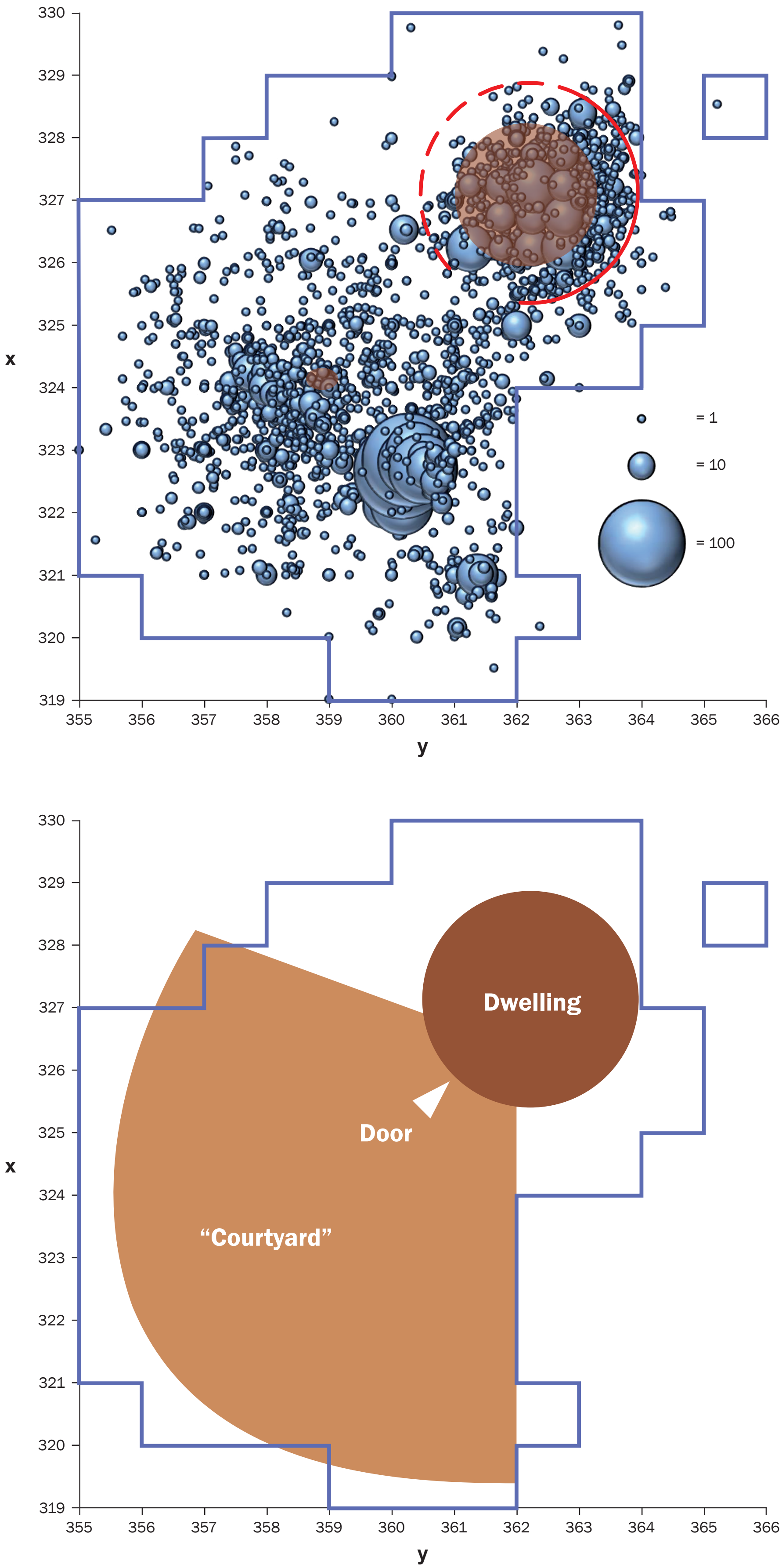

Figure 3. The distribution of chert artefacts in Area 2 at Sujala and the location of features mentioned in the text. The blue line marks the extent of the excavation, the blue bubbles the location and numbers of chert finds, and the dark roundel and oval the location of the stains with bone and charcoal. The continuous red line denotes the "wall effect" and the dotted red line the outline of the suggested dwelling. Grid in metres.

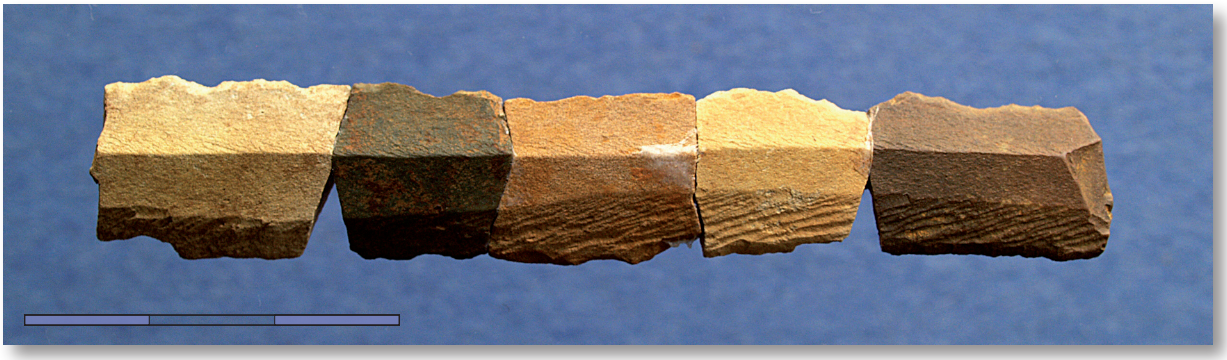

Figure 4. Refitted blade showing colour variation. Scale in centimetres. Refit by L. Koxvold, photograph by J. Kankaanpää. For the catalogue numbers of this and the subsequent artefact illustrations, see **Appendix**.

simply as "chert". The material is not local but probably derives from the Varanger Peninsula in Norwegian Finnmark, some 60–100 km north of the site. The material exhibits notable colour variation that is probably due to a combination of post-depositional oxidisation and ferrous staining (**Fig. 4**). Most pieces are shades of brown or green, but the original colour is nearly black while pieces that have been exposed on the surface for an extended period are nearly white. The colour appears to correlate roughly with find depth, the darkest pieces tending to be found in the deepest layers.

Five radiocarbon dates ranging from 8930 BP to 9265 BP place the site in the latter half of the ninth millennium calBC (**Fig. 5**; see also Rankama & Kankaanpää 2007). As will be presented below, the artefact types and blade technology exhibit affinities with the Post-Swiderian complex of northern/central Russia and the eastern Baltic rather than with the contemporaneous, Ahrensburg-derived Early Mesolithic occupation of the nearby coastal areas of Norwegian Finnmark. The discovery of the Sujala site thus revealed a previously unknown interface between two populations deriving from opposite ends of Early post-glacial continental Europe.

The aim of this article is to examine the spatial distribution of different classes of lithic finds at the Sujala site to see if they reflect discrete activity areas, and to attempt a preliminary interpretation as to how activities at the site relating to the production and use of lithic implements might be reconstructed. To this end, it is necessary to begin with a brief description of the general character of the finds.

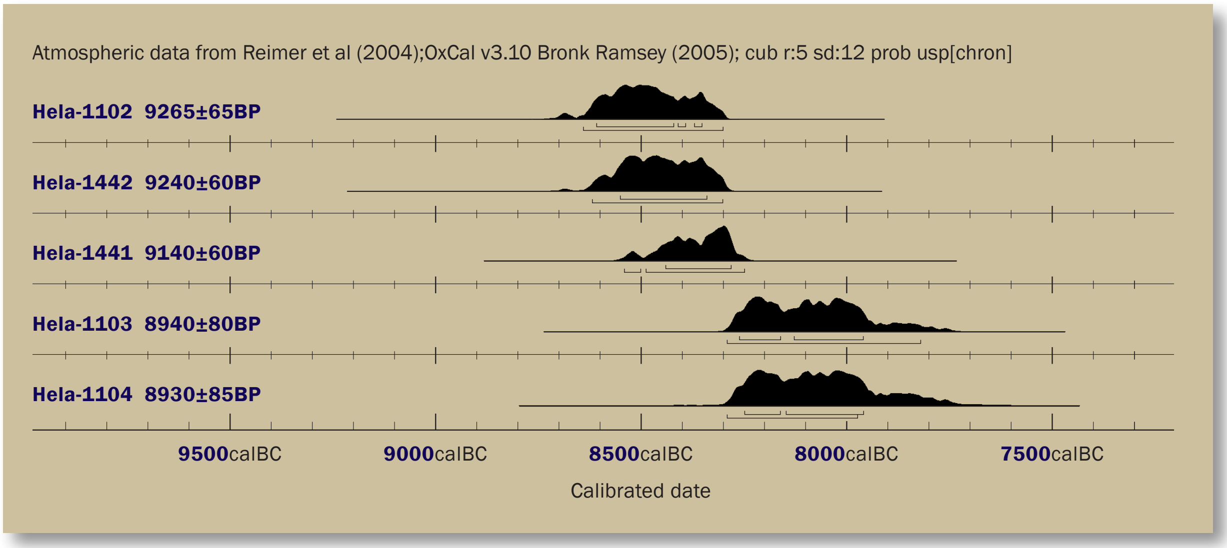

Figure 5. Oxcal calibration of Sujala radiocarbon dates. Hela-1102, 1141 and 1142 are on birch charcoal, Hela-1103 and 1104 are on burnt bone.

The general character of the assemblage

The Sujala lithic technology will not be discussed in detail here. Information on this topic may be found in earlier publications (Kankaanpää & Rankama 2009; Rankama & Kankaanpää 2007; 2008) and more will be published later. The data presented below are based on a number of analyses that have been described elsewhere (Rankama & Kankaanpää 2007).

Figure 6 shows the breakdown of the chert artefacts from Area 2 into categories and the number of pieces in each category.

These data can be condensed into a few technological units (**Fig. 7**). As the table indicates, the assemblage consists almost exclusively of the remains of blade and blade tool production. Most of the artefacts classified as flakes probably derive from platform rejuvenation but lack such diagnostic features that would allow their classification as core tablets. The large number of unclassified pieces consists of small, non-classifiable, fragments.

The absence of cortex or original outer surface indicates that the primary shaping of the cores did not take place at the site. There are some indications, such as the partial crest on the large blade in **Figure 11:a**, that initial core shaping involved forming a bifacial crest on a block of raw material. The standard core shape was the conical single-platform core, such as the one shown in **Figure 8**. The blade scars on three sides of the core are even and parallel-sided, suggesting the use of the pressure technique. The core base is flat (**Fig. 8:f**). Some core base fragments recovered from the site (Kankaanpää & Rankama 2009:Fig. 7.5:41–43) suggest that if the core base became too conical, it was habitually removed to reduce the danger of overshooting during blade detachment (cf. Binder 1984:82).

The striking platform of this core was shaped by radial detachments of core tablets with hinge terminations (**Fig. 8:e**). This was the standard for platform preparation at the site (**Fig. 9**). The deliberate use of hinge terminations in the core tablets was probably intended to prevent the tablets from overshooting and destroying the core angle at the opposite edge of the platform. This was not always successful (**Fig. 8:d**). The conical core type and especially the method of platform rejuvenation are among the key diagnostics of the Sujala blade tech-

Area 2 chert artefacts	2004–2006
Blade cores, incl. fragments	14
Tanged points, incl. fragments	47
Tanged point preforms, incl. fragments	2
Blades and blade fragments, unretouched	1739
Blades and blade fragments, retouched	401
Blade scrapers, incl. fragmentary	18
Blade burins, incl. fragmentary	45
Blade side scraper-burins	1
Blade borers/reamers	1
Blade inserts	2
Blade tools, unspecified	9
Microburins	1
Burin spalls incl. fragments	48
Burin spall implements	1
Piercers on a trimming blade	1
Core tablets	356
Burins on core tablet	1
Retouched core tablets	12
Core face rejuvenation blades/flakes	8
Core shaping blades/flakes	16
Core-edge trimming flakes, unretouched	1368
Core-edge trimming flakes, retouched	4
Blade-like flakes	4
Flakes, unretouched	142
Flake tools, retouched	12
Flake tools, other	1
Fragments, unretouched	2069
Fragments, retouched	18
Total	**6341**

Figure 6. Chert artefacts from Area 2 at Sujala.

Area 2 chert artefacts	2004–2006
Blade cores and core fragments	14
Blades and blade fragments, including implements	2266
Core trimming and rejuvenation debris and implements thereof	1766
Flakes and flake fragments, including implements	155
Burin spalls and implements thereof	49
Blade-like flakes	4
Unclassified fragments, unretouched and retouched	2087
Total	**6341**

Figure 7. Technological units within the Area 2 assemblage at Sujala.

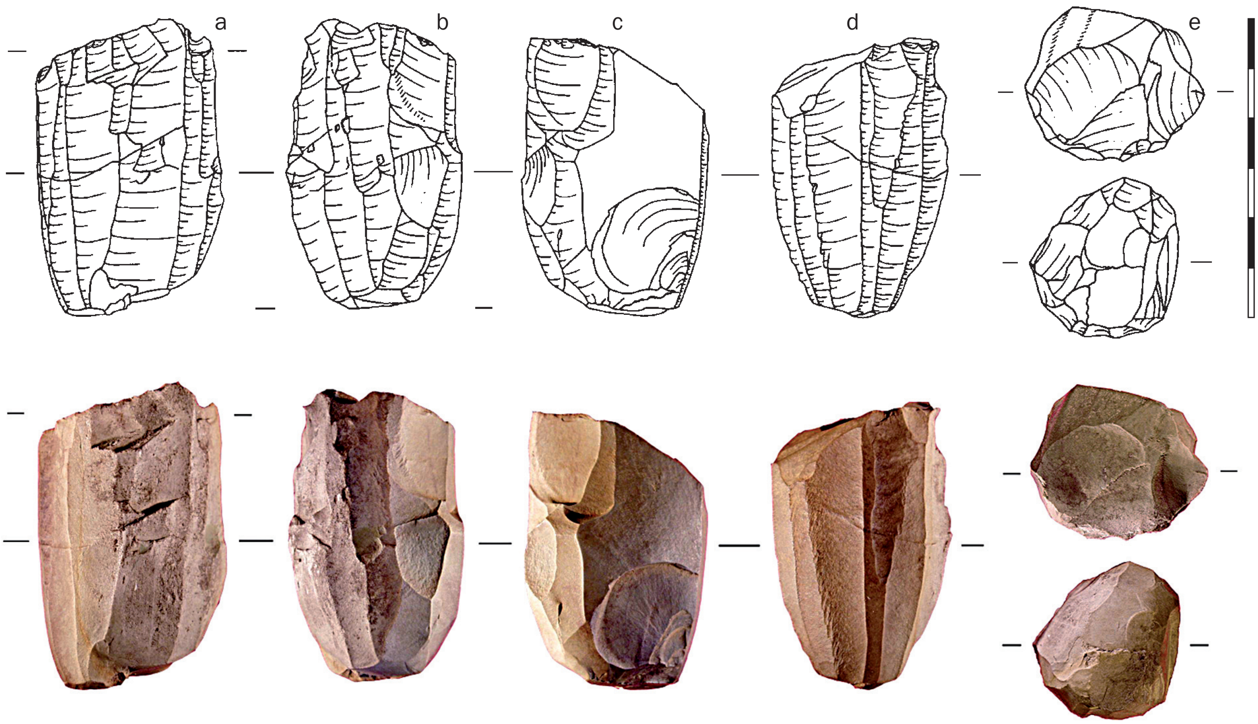

Figure 8. Blade core from Sujala. a-d) the four faces of the core; e) the striking platform; f) the base of the core. Scale in centimetres. Drawings by T. Rankama. Photographs by J. Kankaanpää.

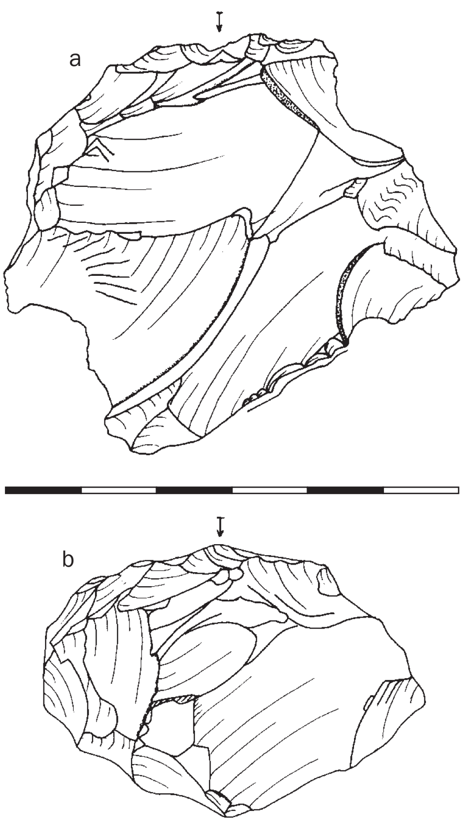

Figure 9. Core tablets from Sujala. Scale in centimetres. Drawings by T. Rankama.

nology. This method of platform rejuvenation is also a key feature that separates it from the blade technology prevalent in Scandinavia at the time of the Sujala occupation, where the platform was, as a rule, plain (Sørensen 2006:287; M. Sørensen *pers. comm.* 2009).

Special care was taken in preparing the platform for each blade removal. This resulted in a large number of core-edge trimming flakes (cf. **Fig. 6**). The careful preparation can be seen also in the blades (**Fig. 10**) which are extremely regular. The dorsal ridges and blade edges are straight and parallel. The proximal ends always have a lip on the ventral side, suggesting the use of a soft fabricator. The blades, thus, also bear strong evidence of the pressure technique, where the body weight was applied to the core with the help of a crutch or, in the case of the wider blades, a lever mechanism, the exact nature of which is as yet unknown (J. Pelegrin & M. Sørensen, *pers. comm.* 2009; see Inizan *et al.* 1999:Fig. 30; Pelegrin 1984).

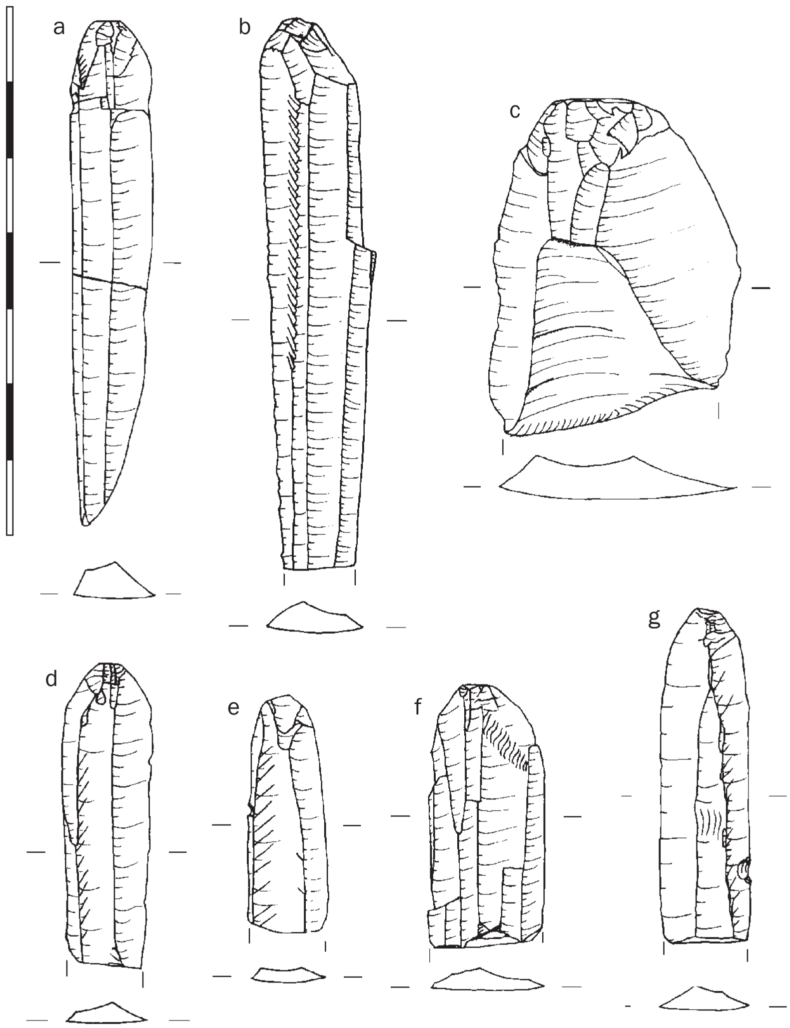

Figure 10. Complete blade and proximal fragments from Sujala. c) is a *languette* fracture. Scale in centimetres. Drawings by T. Rankama.

Most of the fragmentary blades shown in **Figure 10** are fairly narrow, but much wider ones, such as **Figure 10:c** (a *languette* fracture of a longer blade), also occur. In the measured proximal ends, blade widths range between 2.2 and 43.3 mm, with an average of 13.2 mm.

In addition to extremely regular edges and dorsal ridges, the blades also have a remarkably straight side profile (e.g., **Fig. 11:a**). Another common characteristic feature is semi-abrupt retouch that runs along the edges of the blades (**Fig. 11**). The retouched edges often show distinct signs of wear.

Another very typical feature of the Sujala assemblage is the manner of intentional snapping of the blades. The exact method of the snapping has yet to be ascertained. Although some diagonal unintentional snaps occur, most of the snaps are perpendicular to the long axis of the blade and may have been achieved by simply bending the blade against the edge of a hard surface. This often accidentally produces triangular edge fragments (M. Sørensen *pers. comm.* 2010), which are common in the Sujala assemblage.

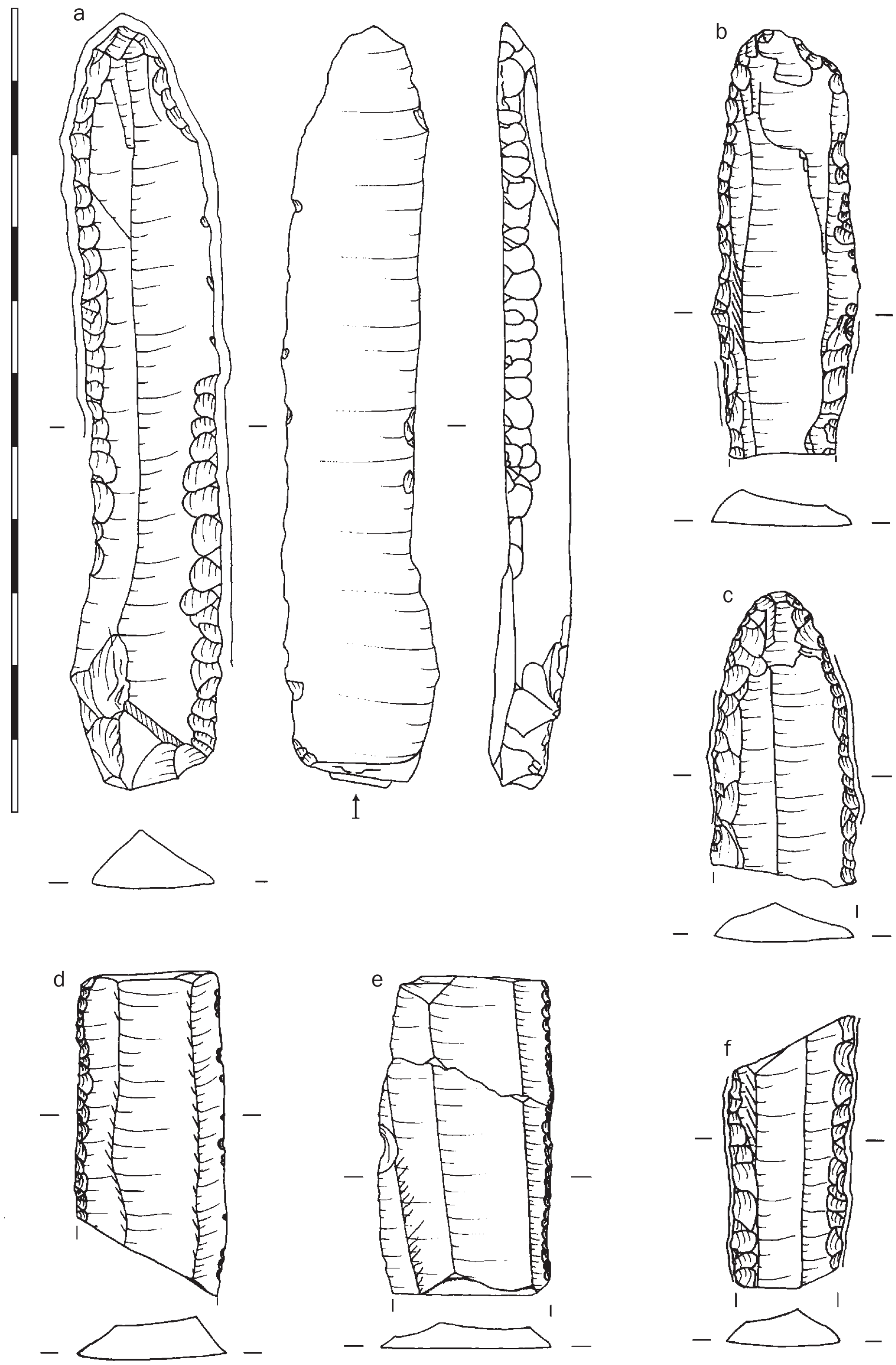

Figure 11. Edge-retouched blades from Sujala. Scale in centimetres. Drawings by T. Rankama.

There is no unequivocal evidence of the microburin technique,[1] and no microliths so common in western European blade assemblages occur. While the snapping at Sujala often took place after the retouching of the blade edges (**Fig. 12**), the snapped surfaces are never retouched. The only exceptions to this are the few scrapers. Instead of microliths, there are a large number of intentionally snapped short rectangular blade segments, the corners of which often show evidence of wear (**Fig. 13**).

The blades were used in several different ways. The irregular bilateral damage along the edges of some long blades, as well as use wear on the corners of snapped blades, indicate use without any secondary modification. On the other hand the retouch along the edges of many blades seems frequently to have been only the first step in their use life: often the tools were recycled and used again for a different function. This applies especially to

[1] The assemblage includes only one (accidental?) microburin.

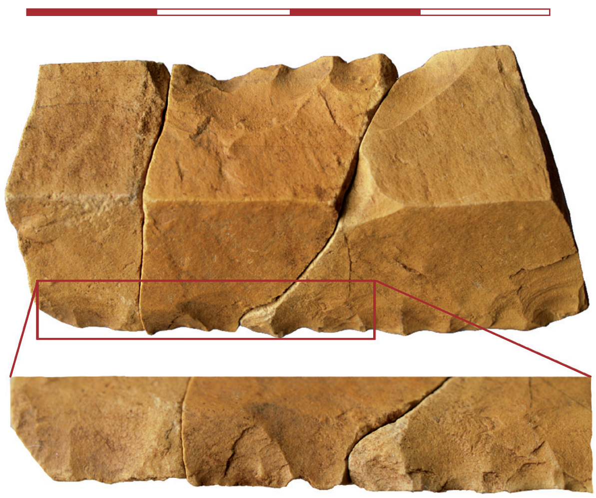

Figure 12. Snapped blade with retouched edges from Sujala. In the bottom picture the artefact has been tilted to show the retouch better. Scale in centimetres. Refit by S. Coulson. Photographs by J. Kankaanpää.

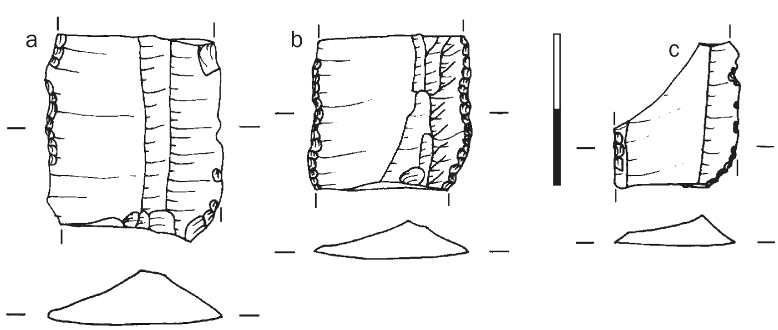

Figure 13. Short rectangular blade segments from Sujala. Scale in centimetres. Drawings by T. Rankama.

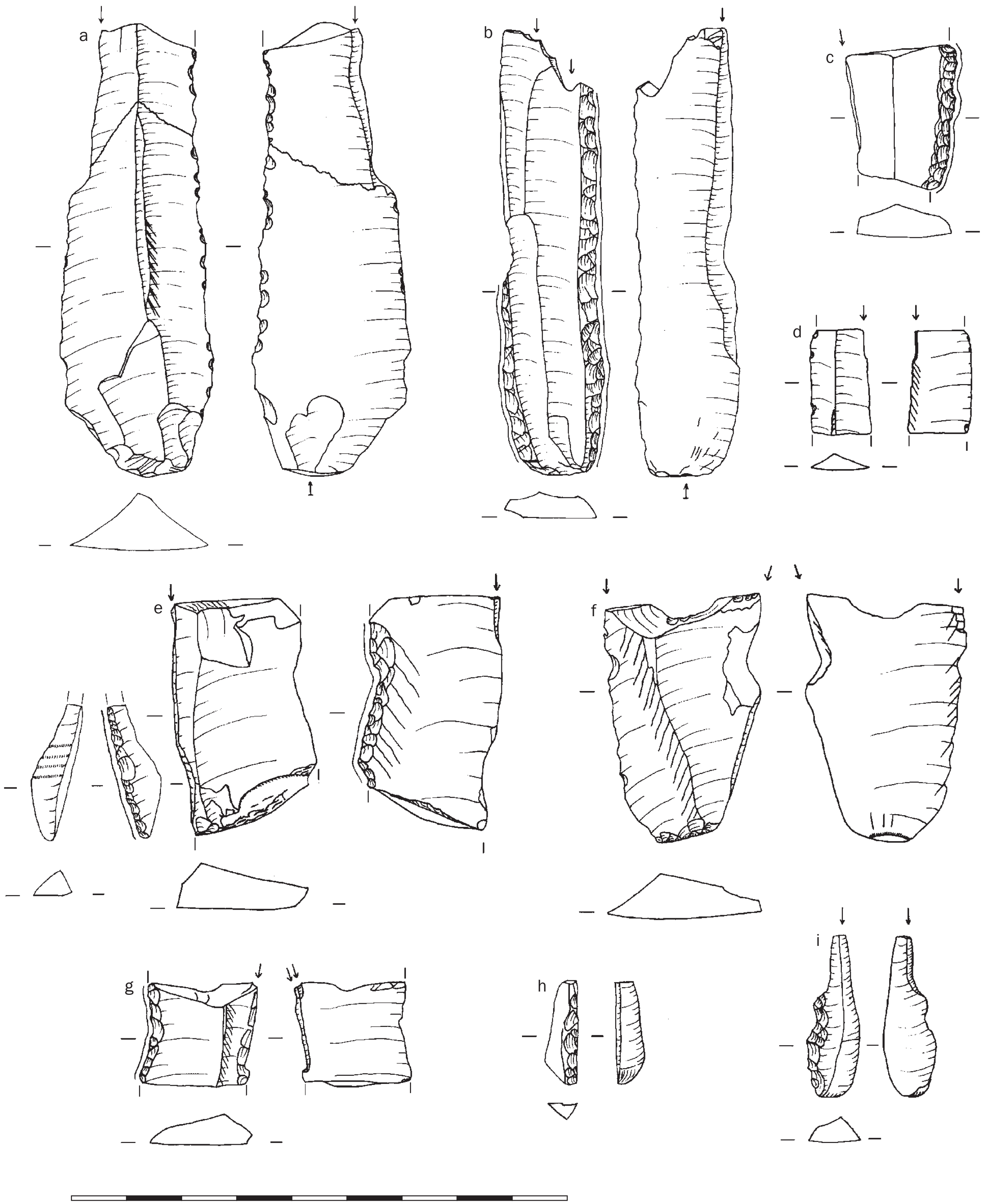

Figure 14. Burins and burin spalls from Sujala. Scale in centimetres. Drawings by T. Rankama.

the burins, which were usually manufactured from edge-retouched blades exhibiting use wear. Evidence of this can be seen both in the burins and in the burin spalls (**Fig. 14**). The burin in **Figure 14:a** has bilateral damage to one edge, suggesting use for sawing antler before burination (M. Zhilin *pers comm.* 2006). Some burins were rejuvenated several times (e.g., **Fig. 14:b**).

The end scrapers are a small and varied group of artefacts with little in common (**Fig. 15**). They include a couple of unusual-looking stemmed scrapers, one where the stem has been shaped by retouch that shows signs of wear (**Fig. 15:a**), and another where the stem has been shaped by burin blows (**Fig. 15:b**).

All of the arrowheads (**Fig. 16**) were manufactured according to the same basic plan. They are all tanged and the ventral side of their tip has invasive retouch from both edges meeting at the centre. They are aligned in the same direction as the blade, with the tang at the proximal and the tip at the distal end of the blade. The alignment follows the main dorsal ridge of the blade. The preform (**Fig. 16:h**) suggests that tip retouch was the first stage of point manufacture. The tang is diamond shaped with either bifacial or unifacial retouch, depending on the original shape of the blade.

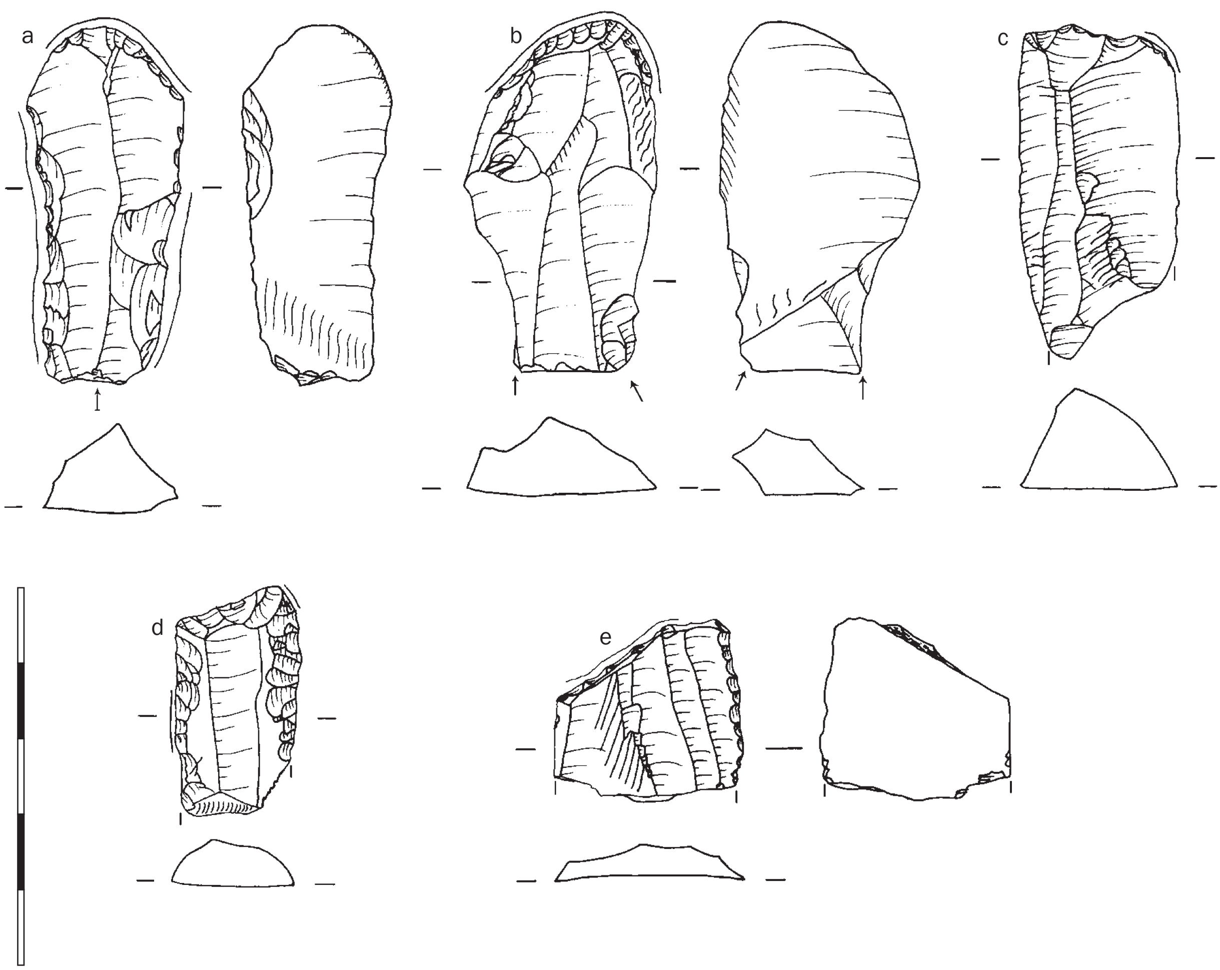

Figure 15. Scrapers from Sujala. Scale in centimetres. Drawings by T. Rankama.

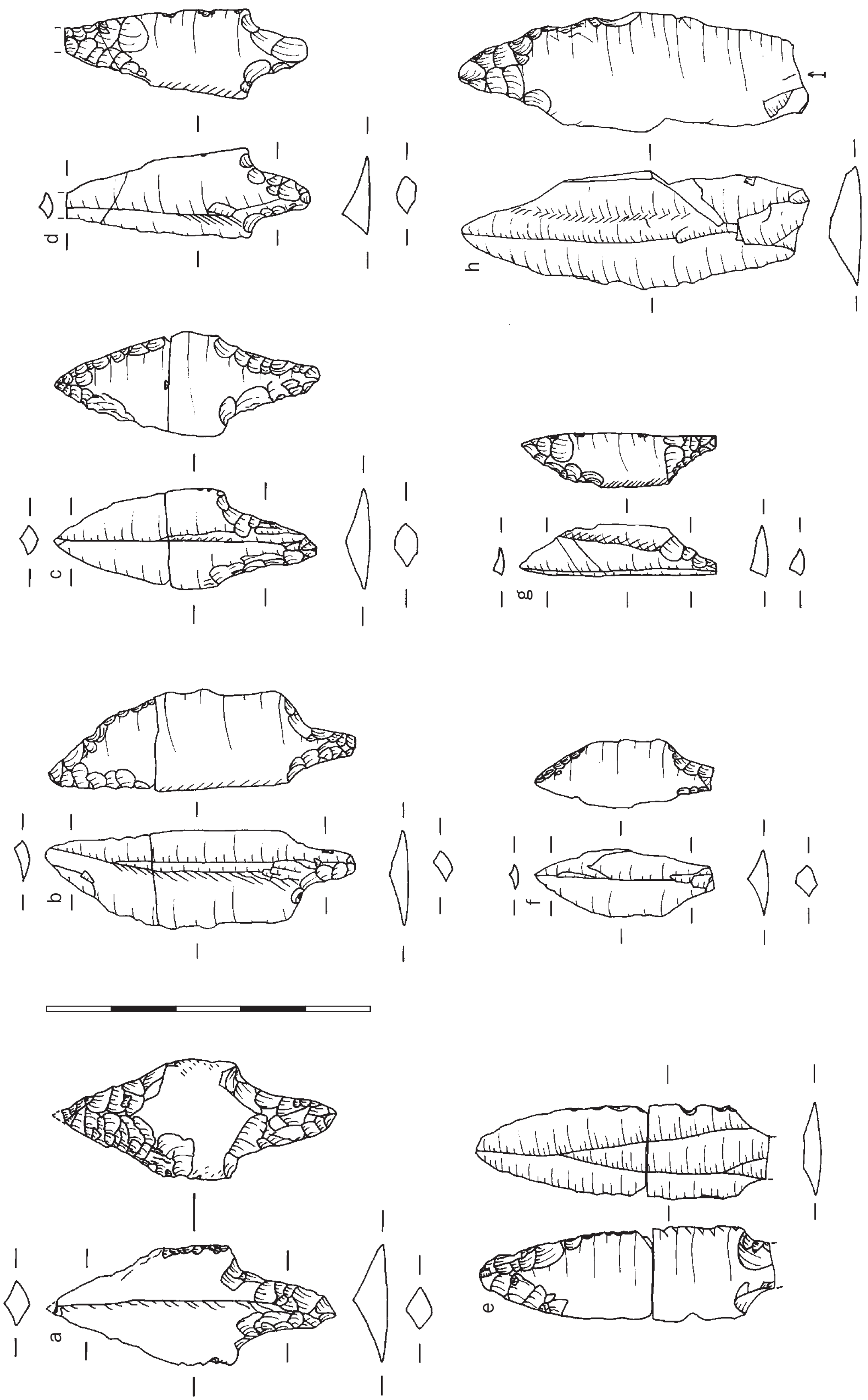

Figure 16. Tanged points (a–g) and a preform (h) from Sujala. Scale in centimetres. Drawings by T. Rankama.

Summary

The results of the analyses of the Sujala lithic assemblage indicate on-site blade production from cores that were apparently produced elsewhere and brought to the site ready-shaped. The amount of raw material carried to the site was considerable – the recovered material weighs 3074 grams and represents only a part of the whole, since a range of artefacts will have been carried away from the site when leaving. The blades were used as tools either with or without secondary modification. Recycling of used and retouched blades was common. The amount of core reduction, the varied tool kit, and the substantial evidence of tool use indicate that the site does not represent a hunter's overnight visit but rather a camp site of some duration used by a small group that included skilled chert knappers, visiting the area in pursuit of reindeer and waterfowl.

The type of arrowhead, the pressure technology, the method of platform rejuvenation, the method of snapping the blades, and the absence of the microburin technique are among the characteristics that indicate that the people who left this assemblage at the Sujala site had an origin east or south-east of Finland. The closest parallels to the assemblage can be found among the Post-Swiderian complexes of north-western Russia, especially assemblages of the Butovo culture, the centre of which lies in the Moscow region (e.g., Koltsov & Zhilin 1999; Sorokin 1981; Žilin 2006).The Sujala population, thus, was not related to the Early Mesolithic "Komsa" inhabitants of the north Norwegian coast, who are believed to have originated in north-western Europe (Bjerck 1994; Fuglestvedt 1999; Grydeland 2005; Olsen 1994; Sandmo 1986) and whose blade technology differed from theirs in almost every respect (see Woodman 1993; 1999). Since the Sujala raw material indicates contacts with the coastal sphere, this situation produces the potential for communication and exchange of ideas between two Early Mesolithic populations of completely different origins: an interface with intriguing possibilities for further research.

The spatial analysis

During excavation, the provenance of all finds was recorded manually: horizontally to within the nearest centimetre for individual finds and within a radius of five centimetres for clusters, vertically by 2.5 cm or 5 cm (2005, spit 1) artificial layer. In some cases, dense concentrations of small finds were excavated in 20 x 20 cm squares and sieved with a 2 mm sieve. All excavated soil was put through a 4 mm sieve to catch unnoticed finds. In order to retrieve small bone fragments, all excavated soil from the large dark stain was put through a 2 mm sieve, spit 1 in 50 x 50 cm quadrates (quarter-squares) and spits 2a and 2b in 20 x 20 cm squares, and this also produced quite a number of exceedingly small (<0.02 g) chert artefacts. No clear stratigraphy was observed. Maximum find depth was c. 20 centimetres, with the majority (>99%) of lithic finds deriving from the top 10 centimetres. The site is interpreted as a single-component (in all likelihood a single-event) site on the basis of site structure, the radiocarbon dates, and the uniformity and uniqueness of the lithic assemblage. The vertical distribution, such as there is, has presumably been produced by trampling and natural turbation (primarily cryoturbation and root action, possibly also rodent burrowing) and is thus practically useless as a chronological indicator. It might be suspected that the finds closest to the surface have suffered more post-depositional displacement than the deeper ones, especially by traffic along the track that now runs across the site. However, a comparison of the find scatters of the different layers shows no clear evidence of this, nor do the observed clusters show any correlation with the topographical features of the site (natural depressions, wheel ruts, etc.). The spatial analyses presented below therefore combine all excavation layers on the assumption that any post-depositional misplacement will have resulted primarily in unstructured "noise" rather than in a structured skewing of the spatial patterns. This assumption is supported by the very clear differences in the distributions of the various find categories, as may be observed below.

Sujala Area 2 is, so far, the only site in northern Scandinavia with this type of lithic assemblage to be fully excavated. Since it apparently contains only one dwelling with associated features, spatial analyses cannot as of yet look for recurring patterns as suggested by, e.g., Grøn (1995:10). Instead, one is limited to searching for patterns within a single case, and conclusions will consequently be less secure with no guarantee of general applicability.

Weight grams	Total finds	% of total	Sieve finds	% of class	No prov.	"Accepted" finds
≤0.1	3612	57.0	93	2.6	1	3518
0.11 – 0.99	1891	29.8	422	22.3	3	1466
1.0 – 9.9	772	12.2	41	4.3	0	731
10.0 ≤	66	1.0	0	0.0	1	65
total	**6341**		**556**	**8.8**	**5**	**5780**

Figure 17. Percentages of chert weight classes in total finds as compared to finds from 4 mm sieve.

The assemblage from Sujala Area 2 can be divided into four finds categories: chert, other lithic materials, burnt bone, and charcoal. There are several reasons for dividing the lithics into chert and other materials. First, it is specifically the chert that renders the site unique in Finland. Artefacts made from a similar raw material have been found in a number of other archaeological sites in northern Finnish Lapland, but these finds are limited to very small numbers or to individual pieces in assemblages dominated by quartz. The chert at Sujala also forms a technological unit: all identified chert derives from a blade industry of a very specific type, of which Sujala represents the first published reduction site in Finland[2]. Comparable end products, including pressure blades and Post-Swiderian style arrowpoints made from imported flint, are known from, e.g., the Ristola site in Lahti and the Saarenoja 2 site in Joutseno, but in much smaller numbers (see Takala 2004:101–102, 106; Jussila 2001; Jussila & Matiskainen 2003). Finally, chert forms the great majority of the Sujala finds, 6341 pieces or over 99% of all lithic finds from Area 2. The remaining lithic finds from Sujala Area 2 – 46 pieces in all – consist primarily of quartz. With the exception of a single conical quartz blade core, they do not display any unique traits, nor do they differ to any notable degree from the quartz artefacts that characterize most Finnish Stone Age and Early Metal Age sites. Though the distribution pattern suggests that these lithics belong to the same occupation as the chert, the fact that quartz is ubiquitous in the Finnish Stone Age while the Sujala chert is practically unique nevertheless renders it prudent to treat the chert and the other lithics as separate categories.

In the following spatial analysis, the total Area 2 chert assemblage of 6341 pieces is considered when calculating expected values, but for obvious reasons finds whose provenance is known only to the square metre (i.e., full-square sieve finds, total: 556 pieces) and finds of unknown original provenance (back dirt finds and unplotted surface finds, total: 5 pieces) are not included in the actual clusters or the outlier group used in the cluster analysis (see below). The remaining "accepted" finds total 5780 pieces or some 91% of all chert finds. Leaving out full-square sieve finds might naturally be thought to have a skewing effect on the results since one would expect sieve finds to consist primarily of small objects, the larger ones being more readily noticed during trowelling. However, the reality is not quite that straightforward. If all finds are divided into four weight classes[3], ≤0.1 g, 0.11–0.99 g, 1–9.9 g, and ≥10 g (**Fig. 17**), it may be noted that the class with the largest proportion of full-square sieve finds is not the smallest class but the second-smallest, the 422 sieve finds in the 0.11–0.99 g class accounting for 22.3% of all finds in that size group and no less than 75.9% of all sieve finds.

[2] Further excavation in 2009 at the Saarenoja 2 site has also produced evidence of on-site core reduction (Aivar Kriiska *pers. comm.* 2009), but the results were still unpublished when this article went to press and precise data was thus unavailable.

[3] Only separately catalogued finds were weighed individually. For this calculation, finds catalogued – and thus also weighed – as multiple-find units (e.g., all trimming flakes from a 20 x 20 x 2.5 cm square) were assigned an "average" weight derived by dividing the total weight of the unit by the total number of finds. Since the actual weights of the individual pieces in grouped finds vary, the "averaging" system tends to introduce a slight skew towards the small end of the weight scale since some heavier-than-average members of grouped finds would probably actually belong to the next higher weight group.

Type	All finds A2	% of total	Sieve finds	% of category	% of expected
Unidentified fragment	2069	32.6	143	6.9	78.8
Blade/blade segment	1739	27.4	210	12.1	137.7
Core trimming flake	1368	21.6	99	7.2	82.5
Retouched blade/segment	401	6.3	40	10.0	113.8
Core tablet	356	5.6	34	9.6	108.9
Flake	167	2.6	10	6.0	68.3
Other tools	176	2.8	10	5.7	64.8
Other waste	65	1.0	10	15.4	175.5
totals	**6341**	**100.0**	**556**	**8.8**	**100.0**

Figure 18. Percentage of 4 mm sieve finds as compared to all finds in different chert find categories.

The picture is similar when looking at the tendencies of different find groups to be found in the sieve (**Fig. 18**; the groups will be discussed later).

The "% of expected" column shows the proportion (as per cent) of sieve finds in each category as compared to the average proportion of sieve finds in all categories (=8.8%). If this figure were close to 100% in all groups, the effect of sieving could be said to be random, i.e., statistically meaningless. This is obviously not the case. Out of the four largest find categories, the smallest find types – unidentified fragments and core trimming flakes – are in fact underrepresented in the sieve finds, while the larger types – retouched and unretouched blade segments – are overrepresented (**Fig. 18**). One possible explanation is that the smallest finds were so small that they would have slipped through the 4 mm mesh of the large sieve employed at the back dirt pile. However, it should be noted that locations where clusters of very small finds and/or bone were observed (and which produced the majority of the very small finds) were first sieved in small sections with a 2 mm mesh kitchen sieve, and consequently there would have been nothing left to be caught in the larger sieve. The finds recovered with the 2 mm sieve actually complement the 4 mm sieve finds: 1084 pieces or 30% of the smallest size class (<0.1 mm) came from the 2 mm sieve while the figures for the next two size groups falls to 4.5% and 1.7% respectively (**Fig. 19**). The number of 2 mm sieve finds in the smallest category may seem very high – nearly a third of the whole size class – but it should be noted that excavating concentrations of small finds directly into the sieve in small blocks was employed intentionally as an excavation tactic when it became clear that recovering these finds by regular trowel-and-tweezers excavation would take an inordinate amount of time. The small size of the blocks (usually 20 x 20 cm in 5 cm or 2.5 cm spits) also means that find provenance is known to within c. 10 cm, which is within the accuracy limit used in the present distribution analysis. 2 mm sieve finds are consequently included in the "accepted" category. The aforementioned 2 mm sieve finds from the 50 x 50 cm Spit 1 quadrates in the area of the large stain/dwelling are also included, since the quadrates all fall completely within Cluster 1.

Weight g	Finds, 2 mm mesh	% of total	Finds, 4 mm mesh	% of total	Combined sieve finds	% of total
≤0.1	1084	30.0	93	2.6	1177	32.6
0.11 – 0.99	86	4.5	422	22.3	508	26.9
1.0 – 9.9	13	1.7	41	5.3	54	7.0
10.0 ≤	0	0	0	0	0	0
totals	**1183**		**556**		**1739**	**27.4**

Figure 19. Chert finds from 2 mm mesh sieve and 4 mm mesh sieve as per cent of total finds.

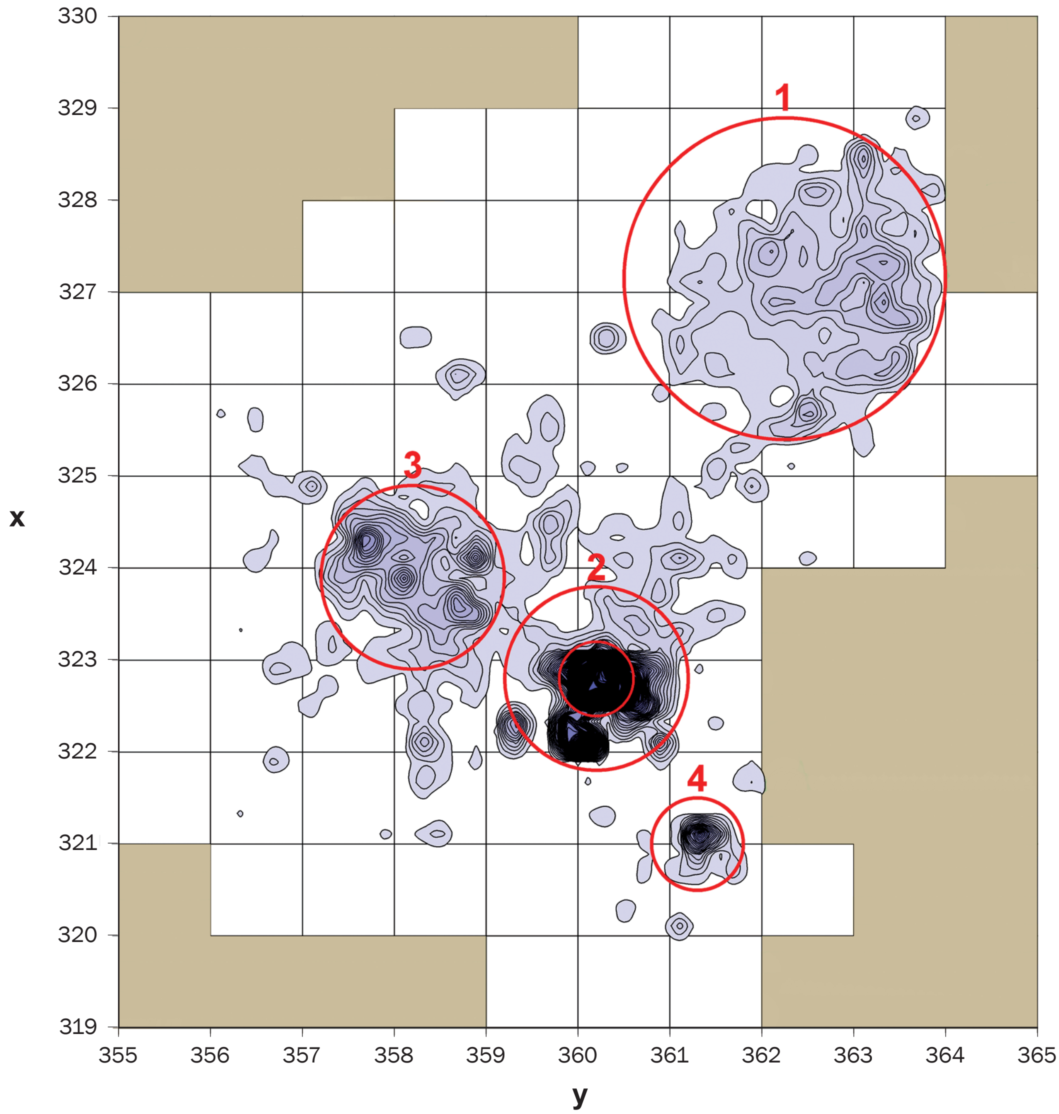

Figure 20. Sujala excavation grid with chert find density (grid 20 cm, curve interval 2; grey = unexcavated) and sampled clusters (red). Only finds with location accuracy to 10 cm or less are included, hence the sieve finds from the 50 x 50 cm quadrates in Cluster 1 are not shown.

Plotting the chert finds as a density map based on a 20 cm grid (**Fig. 20**) reveals three major concentrations and one minor one. One major concentration, hereafter referred to as Cluster 1, corresponds to the large bone-and-charcoal stain interpreted as a dwelling floor, near the north-eastern corner of the excavation. A second major concentration, Cluster 2, is located slightly south of the middle. The third major concentration, Cluster 3, lies immediately north-west of this. A smaller concentration, Cluster 4, lies in the southern part of the excavation. Several smaller clusters can also be distinguished, but most of them appear to be "appendages" of clusters 2 and 3.

In order to facilitate sampling, circular cluster boundaries were placed "by eye" to cover the perceived distinct clusters. The symmetric shape of the sampling areas was chosen in order to allow filtering of the find catalogue using a simple trigonometric formula; the actual clusters, of course, are more or less irregular. Chert finds numbers from the clusters are presented in **Fig. 21**. Altogether, the four sampled clusters accounted for 4773 chert artefacts or nearly 83% of all "accepted" chert finds, the remaining 1007 finds (17%) with accurate provenance data lying outside the clusters.

Type	Area 2 total		Cluster 1		Cluster 2		Cl. 2 80 cm		Cluster 3		Cluster 4		Outside	
	nr.	%	nr.	% exp.	nr.	% exp.	nr.	% exp.	nr.	% exp.	nr.	% exp.	nr.	% exp.
Fragment	2069	32.6	416	87.2	1038	126.6	789	129.5	216	98.4	54	131.3	202	61.5
Blade	1739	27.4	426	106.2	514	74.6	341	66.6	182	98.6	33	95.5	371	134.3
Trimming flake	1368	21.6	208	65.9	801	147.8	649	**161.1**	167	115.0	7	**25.8**	86	**39.6**
Retouched blade	401	6.3	155	**167.6**	26	**16.4**	7	**5.9**	28	65.8	3	**37.6**	148	**232.4**
Core tablet	356	5.6	108	131.6	93	65.9	67	63.9	33	87.3	23	**325.1**	65	115.0
Flake	167	2.6	66	**171.4**	15	**22.7**	7	**14.2**	19	107.2	5	**150.7**	52	**196.1**
Other tools	176	2.8	62	**152.8**	18	**25.8**	4	**7.7**	20	107.1	1	**28.6**	64	**229.0**
Other waste	65	1.0	21	140.1	7	**27.2**	3	**15.7**	8	116.0	0	**0.0**	19	**184.1**
sum/% of total	**6341**	**100.0**	**1462**	**23.1**	**2512**	**39.6**	**1867**	**29.4**	**673**	**10.6**	**126**	**2.0**	**1007**	**15.9**

Figure 21. Total number and percentage of different categories of chert finds from Area 2 compared to size of categories in different clusters as percent of expected values.

The question arises, whether the find concentrations represent specific activities and thus reflect the structure of the site and the behaviour of its occupants. One method of studying this is through a statistical analysis of the contents of the clusters.

For the purpose of this analysis, the finds were divided into eight find classes: 1) unidentified fragments, 2) blades and blade segments, 3) core trimming flakes, 4) retouched blades and blade segments, 5) core tablets, 6) other flakes, 7) other tools (burins, scrapers, tanged points, retouched flakes and other retouched tools, and tools identified by wear), and 8) other waste (burin spalls, cores, core fragments, and core preparation/rejuvenation blades and flakes). The actual numbers of finds in these classes in each cluster were compared to the "expected" numbers based on the volumes of the total classes as compared to the total number of finds using a contingency table; in other words, the relative sizes of the classes in the individual samples were evaluated *vis-á-vis* their proportions in the complete assemblage. The results are presented in **Figure 21** as per cent of the expected figure, thus giving an indication of which classes are overrepresented and which underrepresented in each cluster. Percentages differing more than 10% from the total mean are shown in red (more than average) or blue (less than average); percentages more than 50% over or under the mean are in boldface.

The results are suggestive. In Cluster 1, consisting of the finds from the presumed dwelling, the percentages show exactly the opposite tendency as those of Cluster 2, the largest "courtyard" cluster. The difference is particularly noticeable in the numbers of retouched blade segments, other tools, and flakes, which are much higher than expected in Cluster 1 (168%, 153%, and 171%, respectively) and much lower than expected in Cluster 2 (16%, 26%, and 23%, respectively). The difference is even more pronounced when only the central 0.8 metres of Cluster 2 are considered, the figures here being 6%, 8%, and 14%, respectively. The same applies – though to a slightly lesser degree – also to blade segments, core tablets, and other waste, which are slightly to moderately high in Cluster 1 (106%, 132%, and 140%) and clearly low in cluster 2 (75%, 66%, and 27%). With unidentified fragments and core trimming flakes, the situation is reversed; both are slightly low in Cluster 1 (87% and 66%) and high in Cluster 2 (127% and 148%, respectively). Again, the figures for the central area of Cluster 2 are even higher (130% and 161%).

We cannot say that Cluster 2 is the full negative of Cluster 1 since the majority of finds from both clusters (72% for Cluster 1 and no less than 94% for Cluster 2) consists of unidentified fragments, blade segments, and trimming flakes, albeit in different proportions. Nevertheless, the impression is that Cluster 2 consists primarily of core reduction waste, a large part of which was probably dumped in the vicinity of 322.80/360.30 in one single event and may have originated from the area of Cluster 1, in other words, from inside the dwelling. One reason for assuming dumping rather than primary core reduction is that the concentration is so small in area – in our experience, fly-off from normal core trimming would have formed a larger pattern.

The fact that most of the finds belonging to the categories that are "underrepresented" in the dwelling (as represented by Cluster 1) and "overrepresented" in the courtyard (as represented by Cluster 2), i.e., unidentified fragments and core trimming flakes, are on average very small in size and weight, runs counter to the common observation that it is specifically the small waste that remains in the house while the large waste (>4 cm) tends to get cleaned out (e.g., Grøn 1995:5; 1998:12). However, it is possible that the core reduction indoors took place on a skin apron or rug that was then shaken out outside. Another reason for presuming an apron is the fact that the "outdoors" concentrations of core reduction waste did not contain any burnt bone or charcoal, both of which were abundant in the matrix of Cluster 1. Flecks of bone and charcoal would inevitably have accompanied waste swept or shovelled directly off the floor, and swept or shovelled it would have been, as it is quite unthinkable that anyone would have taken the trouble to pick up the hundreds of minuscule trimming flakes individually by hand.

It is of course also possible that the reduction itself was carried out in the courtyard, but that would not explain the presence of a higher-than-expected number of core tablets in the "indoors" Cluster 1 and a corresponding lower-than-expected number of core tablets in Cluster 2. It would be convenient to presume that the explanation lies simply in the fragments and trimming flakes having been collected from one location and deposited in the other. However, it is rather difficult to imagine why (considering that both core tablets and trimming flakes are produced by the same operation, i.e., core reduction) specifically the small debitage would have been thrown out and the large debitage left lying on the floor. One possible explanation would be that the larger pieces were intentionally saved for use as, or for working into, tools. A preliminary classification of the collection for cataloguing purposes suggests that core tablet tools were in fact part of the toolkit although they were not very common; so far, eleven retouched core tablet tools and one core tablet tool with use wear have been identified.

The extremely dense and localized cluster lying within a 40 cm radius of the centre of Cluster 2 suggests a single event. Total finds from this area number 1867 or some 32% of all "accepted" finds from Area 2. However, this cluster contained only eleven retouched tools: seven retouched blade segments, two retouched fragments, one blade sidescraper/burin, and one blade burin. It contained neither tanged points nor endscrapers. Particularly the low number of retouched blade segments is statistically highly significant since it represents only 6% of the expected value, which would have been 117. The four "other tools", the retouched fragments and scrapers, are also highly significant as a group since the expected value was 52. The fact that the cluster has high values for unidentified fragments and core trimming flakes (130% and 161%, respectively) and low values for everything else strongly suggests that it consists primarily of debitage from one or several episodes of core reduction rather than from the general cleaning of a living or working floor, which could be expected to also contain depleted and broken tools, fragments of broken and mended weapons, etc..

Cluster 3 differs from Cluster 2 in not having a strong central concentration. The distribution rather resembles Cluster 1, but there are no signs suggestive of a dwelling, i.e., no staining, burnt bone, charcoal, or other evidence of fire. The cluster also appears to thin out evenly at the edges, without evidence of the wall effect (vide Figure 3). The presence of both waste and various tools suggests it was a "general purpose" activity site that was probably used recurrently for diverse tasks including tool making and tool use. The statistics do not support its use as a dump in the manner of Cluster 2.

Cluster 4 is problematic. The very high number of core tablets is partly illusory because some are fragmentary and have been refitted; the true number is 16. This, nevertheless, is still c. 2.4 times the expected number (6.7). The figure for trimming flakes should also be corrected down to 5, since three are fragments of a single flake. Even with these corrections, however, the figures are odd. The high number of core tablets as compared to the very low number of trimming flakes suggests platform shaping, but there are also a respectable number of blades – in fact, over six times the number of trimming flakes. The number of trimming flakes as compared to fragments is also very small, which is curious because these two classes tend to co-vary in the other clusters. The cluster obviously represents some kind of selection, but if so, it is difficult to understand why the number of unusable fragments is so high. All of the fragments are very small, under 0.2 grams by weight, so they clearly are pure waste.

The finds that remain outside the four clusters also present interesting statistics. As with Cluster 1, unidentified fragments and trimming flakes are under-represented, while blade segments and core tablets are moderately, and retouched blade segments, flakes, other tools and other waste strongly, overrepresented. This result, combined with the tendency of core reduction waste to concentrate in the clusters, suggests that core reduction and tool making were carried out in limited, fixed locations while other lithics-related activities such as tool use and maintenance were less localized.

Discussion and conclusions

The above analysis of the spatial distribution of the chert finds from the Sujala site suggests that based on the distribution of trimming flakes, basic core reduction (i.e., blade production) appears to have been carried out primarily in two locations: inside the presumed dwelling (Cluster 1) and in the courtyard (Cluster 2). However, the complementary asymmetry as regards the proportions of core tablets to other core reduction waste in these two locations renders it more likely that a major part of the reduction debris in the courtyard was originally derived from inside the dwelling, which still retained the largest number of core tablets. An apron or rug could have been used to catch the small debris, which was subsequently dumped outside, most of it in the middle of Cluster 2. The tight cluster of the dump site (central Cluster 2) indicates that the debris was not simply tossed out but carefully poured from the apron/rug.

The distribution of finds in the courtyard suggests that the door of the dwelling was to the south-west. Thus, the dump site would have been almost directly in front of the door at a distance of 3–4 metres. As regards the use of the "inside" space, there is a tendency for lithic finds (particularly flakes, blades, and core tablets) to cluster towards the south-eastern side of the dwelling, i.e., to the right of the door when going in. This tendency is not shared by the bone or charcoal, both of which cluster around the centre. The apparent "skewed" distribution of the lithics may be related to an age and/or gender-determined ordering of the inside space, as found with many historical hunter-gatherers (e.g., Itkonen 1948:184).

Judging by the distribution, the fashioning, use, and maintenance of chert tools were carried out primarily in the dwelling and in the area of Cluster 3 but also in various non-specific locations around the site. Which of these three categories the distribution reflects requires more detailed study.

Cluster 4 may represent an episode of core shaping since the relative number of core tablets is abnormally high. However, the extremely low number of trimming flakes as compared to core tablets, blades, and fragments is difficult to explain. The high number of very small fragments speaks against a selection by size.

The floor of the dwelling was not regularly cleaned out, judging by the fact that there are no traces of a concentration of debris, charcoal, or bone at or directly outside the presumed door, although the small "rubbish pit" may suggest a single cleaning event where the debris was carefully buried for some unknown reason. Lithic debris not caught by the apron/rug remained on the floor. The distribution also does not support a sweeping or scraping of the floor towards the walls, as the bone and charcoal cluster towards the centre. Non-cleaning of the floor suggests a covering of branches, which would also necessitate the use of an apron or rug for core reduction in order to retain the blades themselves. Branch or twig flooring is well documented from many historical subarctic hunter-gatherer cultures (e.g., Itkonen 1948 :184) and has been identified in, e.g., the submerged Møllegabet II Late Mesolithic site in Denmark (Grøn *in press*).

It might be wondered why an operation as precise as blade manufacture should be performed inside a presumably rather badly lit dwelling rather than outside, considering that the site was probably inhabited during the warmer season. The first calm, warm day at Vetsijärvi provided the answer: insects. Mosquitoes and blood-sucking black flies abound in Lapland, as elsewhere in the tundra and taiga zone. They are particularly numerous near water, where they lay their eggs. As any northern archaeologist will know, black flies are particularly pesky because they attack your face the moment you put your head down. The best way to avoid them is to be inside, preferably with a smudge fire to keep the mosquitoes at bay as well. Though the use of smudge fires for keeping insects away from both people and animals is well documented ethnographically, it has generally been ignored in the archaeological literature, where smudge fires – when mentioned at all – are usually connected to pottery making or skin tanning (e.g., Binford 1967; but see Grøn *in press*).

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Appendix List of catalogue numbers of the artefacts shown in the illustrations

Figure 4.	KM 35224:1306+1381+1513+1787 KM 35917:645
Figure 8.	KM 34574:204
Figure 9.	a) KM 35224:2245 b) KM 35224:377
Figure 10.	a) KM 35917:749+750 b) KM 35224:2135 c) KM 35224:448 d) KM 35917:756 e) KM 35917:655 f) KM 35227:1013 g) KM 35917:832
Figure 11.	a) KM 35917:404 b) KM 35224:1891 c) KM 35224:447 d) KM 35224:1065 e) KM 35224:779 f) KM 35224:2085
Figure 12.	KM 35224:950+958+969
Figure 13.	a) KM 34574:20 b) KM 34574:258 c) KM 34574:201
Figure 14.	a) KM 35224:600 b) KM 35224:499 c) KM 35224:1845 d) KM 35224:1330 e) KM 35224:1011+1337 f) KM 35224:1782 g) KM 35224:1122 h) KM 35224:446 i) KM35224:220
Figure 15.	a) KM 35917:208 b) KM 35917:967 c) KM 35224:172 d) KM 35224:348 e) KM 35224:332
Figure 16.	a) KM 34574:296 b) KM 35224:861+35917:705 c) KM 35917:989 d) KM 35917:827 e) KM 35224:427+438 f) KM 35917:11 g) KM 35917:181 h) KM 35224:191


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Stone Age Flint Technology in South-Western Estonia: Results from the Pärnu Bay Area

Aivar Kriiska, Esa Hertell & Mikael A. Manninen

ABSTRACT **The paper reports the results of technological analyses on flint assemblages found in 1996–2002 in the Pärnu Bay area, Estonia. The assemblages and their find contexts are described and the basic flaking methods and their products are discussed. A special emphasis is given to the bipolar and platform methods, the two basic flaking methods evident in the assemblages. Possible reduction sequences are studied and their relation to a variety of factors is discussed on the basis of artefact size. The study indicates that small raw material size and shape affected core technology. A variety of core reduction methods were used concurrently to achieve the goals and to deal with small nodule size. The study also indicates that the selection of methods was related to the availability of raw material. Finally the large scale patterning observed in the assemblages and its relation to the Holocene hunter-gatherer systems in the research area is discussed. It is suggested that changes in raw material usage were related to organisational changes evident in mobility and settlement patterns.**

KEYWORDS
Lithic economy, lithics, raw material procurement, flint, Mesolithic, Neolithic, Pärnu Bay area, Estonia.

Introduction

South-western Estonia has a special place in the history of Stone Age research in the East Baltic and northern Europe in general. Archaeological interest in the Pärnu Bay area (**Fig. 1**) was strong already in the beginning of the twentieth century. In these early years the Pärnu Society for Antiquities collected bone and antler artefacts and other stray finds from the lower reaches of the Pärnu River and from the banks of its tributaries. Academic research in the area started in the 1920s. At this time the prehistory of Pärnu was taken up by Richard Indreko, who carried out short-term archaeological inspections and test excavations near the mouth of Reiu River, one of the major tributaries of Pärnu River (Indreko 1929; 1939). Although excavations were carried out in many places, settlement sites were not found. (**Appendix I.**)

After the Early Mesolithic Pulli site was found in 1967 the Pärnu region became archaeologically widely acknowledged. Extensive archaeological excavations at Pulli in the 1960s and 1970s changed the existing view about the beginning of the Mesolithic in all of the countries east of the Baltic Sea. Many flint artefacts from the Pulli site have been widely published and the typology and technology of the artefacts has also been investigated (Jaanits 1973; 1981; Jaanits & Ilomets 1988; Jaanits & Jaanits 1975; 1978; Jaanits *et al.* 1982).

The questions posed on the Pulli material in the early studies were mainly geared towards culture-historical goals, that is, describing the material and seeking typological parallels for it in order to study its relations to culture groups that had been defined earlier. In northern Europe this kind of an approach has long traditions and

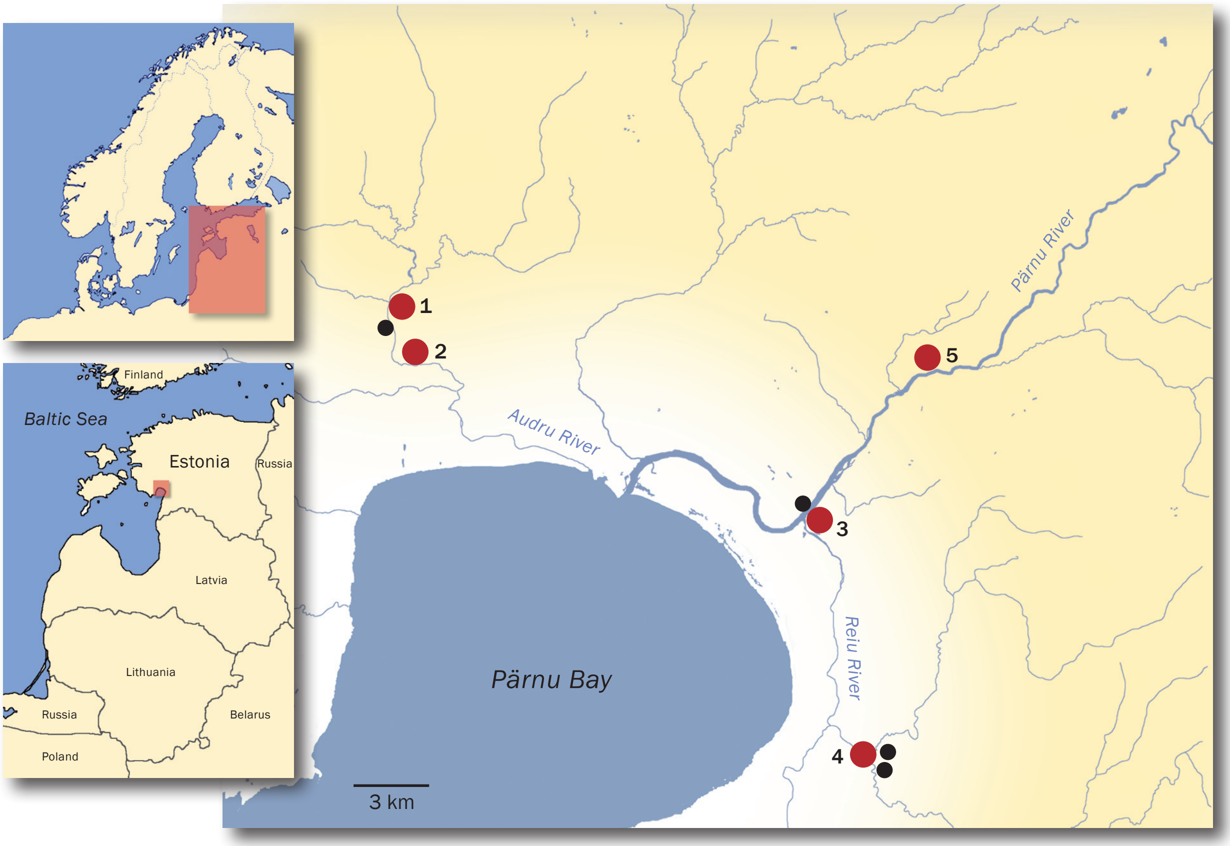

Figure 1. The study area and the sites discussed in the text: **1.** Lemmetsa II; **2.** Lemmetsa I; **3.** the Sindi-Lodja sites (Sindi-Lodja I, II, III and C); **4.** Metsaääre I; **5.** Pulli. Other sites: Malda, Jõekalda, Metsaääre II and III. Map by M. A. Manninen.

is still partly followed today. It is typical that those artefacts that are thought to describe a cultural group and therefore allow the periodisation and comparison of groups, and consequently tracing the origin of cultures, are given priority in publications. Often these are also the most visually impressive artefacts. As a consequence, the products of simple technologies and artefacts of more modest appearance are not usually discussed. Technological approaches that consider the whole of the lithic variation present help overcome some of the shortages of this kind of approaches.

Theoretical approaches that emphasise processes related to stone tool life-cycle, i.e., the study of technological organisation in general and especially raw material economy, have developed significantly during the last decades (e.g., Blades 2000; Carr 1994; Dibble 1995; Fisher & Eriksen 2002; Kuhn 1995; Montet-White & Holen 1991; Nelson 1991). Consequently, in this paper we will concentrate our efforts on the questions how and why lithic assemblages in the Pärnu region came into being and how the variation observed can be linked with the organisational diversity evident in hunter-gatherer socio-cultural systems in the area. Some specific themes were given priority in the analysis. Since all of the assemblages contained artefacts from both bipolar and platform reduction, the question whether these are parts of the same sequence in which a switch to bipolar reduction occurs as the core gets smaller (e.g., Andrefsky 1994a; Callahan 1987; Shott 1989), or two methods used separately for different purposes, was explored. The questions studied also included whether all platform reduction at a site belongs to the same sequence or if several different platform methods were in use, and further, in case several methods were used, what could be the explanation for the use of several core types. Another important theme involved questions related to the origin and nature of the flint raw materials.

Site	Artefact typological date (including pottery)	Radiocarbon date	Shore displacement chronology	Most probable date
Sindi-Lodja I, Mesolithic cultural layer	9000–5500 calBC	7350–6400 calBC	–	7000–6500 calBC
Sindi-Lodja II	9000–5500 calBC	7300–6650 calBC	–	7000–6500 calBC
Find-spot C in Sindi-Lodja	9000–3500 calBC	–	–	Date for none *in situ* material 7000–3500 calBC
Metsaääre I	7000–5500 calBC	–	–	7000–5000 calBC
Sindi-Lodja III	5000–2000 calBC	–	4000–3250 calBC	4000–2000 calBC
Lemmetsa I	4200–1800 calBC	–	3900–3200 calBC	3600–1800 calBC
Lemmetsa II	4200–3500 calBC	–	4150–3600 calBC	4000–3500 calBC

Figure 2. The dating of the sites. See site descriptions for specific radiocarbon dates. Shore displacement dates according to Jussila & Kriiska (2004).

The studied material derives from sites found in the Pärnu region during the years 1996–2002[1] in projects led by Aivar Kriiska. It includes four Mesolithic and three Neolithic flint assemblages from the sites Sindi-Lodja I, II, and III, Metsaääre I and Lemmetsa I and II, and from find-spot C in Sindi-Lodja (**Figs. 1, 2, 3**). The division into Mesolithic and Neolithic sites is based on radiocarbon dates and artefact typology. Flint is the common denominator in these assemblages and the focus of the present study. However, the lithic assemblages contain also ground stone tools and quartz debitage. Quartz forms an important part especially of the Neolithic assemblages, but was excluded from the analyses presented in this paper due to a shortage of time, and therefore the role of quartz is discussed only on a general level.

In the presentation of the analyses we concentrate on the way the artefacts were produced and try to provide readily usable and easily accessible data. The finds have been examined by Kriiska during cataloguing and an additional technological analysis of the flint material was conducted by Esa Hertell and Mikael A. Manninen before the 2003 field season. In eastern Fennoscandia and the Baltic countries proper quantitative metric data allowing the evaluation and study of, e.g., reduction intensity in and between sites in Mesolithic and Neolithic contexts have only recently begun to appear in publications (e.g., Oshibkina 1997; Takala 2004). The lack of this kind of data is a hindrance to studies where comparative data are needed from large areas, for instance in the study of colonisation, mobility, settlement patterns, exchange, and so forth. Since hunter-gatherer land-use systems are composed of multiple sites, the lithic technological organisation, or the whole cultural system, cannot be studied unless we have good comparative data from many sites in a variety of settings. Given the nature of archaeological work and the amount of information needed from large areas, pooled efforts are needed to accumulate the required data. In this paper we provide selected metric data on core and flake dimensions of the assemblages for future research.

The environmental setting

The Pärnu region lies on a geological border zone between Silurian and Devonian sedimentary rocks (e.g., Persits *et al.* 1997), a fact affecting the lithic raw material situation. The Silurian sediments are known to contain small flint pebbles (e.g., Baltrūnas *et al.* 2006:17; Jussila *et al.* 2006:57–58; 2007:157–158; Kriiska & Tvauri 2007:40–41), and flints presumably deriving from these formations are known from the glacial moraines in Estonia and northern Latvia (e.g., Jussila *et al.* 2006:57–58; Zagorska 1992:107, Fig. 5). Besides flint, tool-quality quartz pebbles are also found in Quaternary sediments.

[1] A total of 10 new sites have been located in these projects. Three sites (Lemmetsa I, Lemmetsa II and Malda) are located on the lower reaches of the Audru River (Kriiska & Saluäär 2000) and other three sites (Metsaääre I, II and III) on the middle reaches of the Reiu River (Kriiska 2001a:28–30). An additional four sites (Jõekalda and Sindi-Lodja I, II, III) lie on the bank of the Pärnu River (Kriiska 2001a:21–28). Many stray finds have also been collected in several places from the sediments of the Pärnu River (Kriiska 2001a; Kriiska *et al.* 2002; Kriiska *et al.* 2003). It is now clear that remains of prehistoric sites have been preserved in a wide territory between the mouth of the Reiu River and the Paikuse village.

Figure 3. The Sindi-Lodja I site at the confluence of the rivers Reiu and Pärnu. Photograph by M. A. Manninen.

The Pärnu Lowland became free of the Scandinavian Glacier at the end of the Weichselian Glaciation, approximately 11,500 calBC.[2] After the retreat of the glacier the area was covered by the Baltic Ice Lake for two thousand years. Since the compensating land upheaval in south-western Estonia after the Ice Age has been relatively small, the waters in the Baltic Sea have several times inundated and again vacated parts of the Pärnu region. During the last 11,600 years there have been three regressive and two transgressive phases. (Andrén *et al.* 1999; Jussila & Kriiska 2004:Table 3; Kriiska & Lõugas 2009:Fig.26.4; Kriiska & Tvauri 2002:19; Raukas *et al.* 1995a:122; Veski *et al.* 2004.)

The sites of the coastal region that were settled during the regressive phases were often flooded during transgressive phases and consequently buried under sediment. Traces of Mesolithic occupation have been found under water- and wind-deposited sediments up to six meters in thickness (Kriiska & Lõugas 2009:168). Due to the isostatic and eustatic changes, the river deltas have been constantly reshaped.

The changes in shore-line in the course of prehistory are of importance for the archaeology of the region. The changing shoreline prevented the continuous use of many coastal sites and consequently the mixing of assemblages from different phases of the Stone Age. The fact that many sites have been covered by sediment has also helped preserve organic material that otherwise would have been destroyed.

After the Ice Age, the emerging sediments were soon covered by undergrowth, bushes and trees (e.g., Raukas 1992). The best opportunities to find lithic materials in this kind of an environment are at the open shorelines and riverbanks, where the vegetation cover is minimal or nonexistent. During prehistory, the changing shoreline washed new areas and rearranged sediments, and consequently provided new opportunities to acquire lithic raw materials from the coastal sediment deposits.

The analytical methods

All artefacts were treated individually in the analyses. Classification was based on the techno-typological attributes of each artefact (see e.g., Andrefsky 1998), besides which the presence of cortex was recorded and basic measurements of length, width and thickness were taken. A theoretical volume for each artefact was also calculated from these measurements (length x width x thickness). The maximum thickness and width were

[2] Here and henceforth all dates have been calibrated with OxCal 4.1 (Bronk-Ramsey 2009) using the IntCal 09 curve (Reimer et al. 2009). Dates BP ± 1σ, and calBC range at 2σ.

measured at straight angles to the length of the artefact.

Flakes were divided into three main categories according to the mode of detachment: "behind-the-edge" platform flakes, "on-the-edge" bifacial flakes, and bipolar "on anvil" flakes. The length of complete flakes was measured from the point of percussion to the distal tip. Blades were distinguished from flakes on the basis of their length/width ratio. Flakes at least twice as long as their maximum width were considered to be blades. Since there was clear evidence of systematic blade production from prepared cores in the Mesolithic assemblages, an additional distinction was made between prismatic blades with straight margins and straight dorsal ridges and bladeflakes, i.e., artefacts that metrically fall in the blade category but have a somewhat irregular shape and lack straight dorsal ridges.

Objective pieces with distinct scars from flake or blade removals were classified as cores or core fragments. An additional division was made within the core category on the basis of the knapping method used and how the core had been treated. A total of eleven different core types were distinguished using these criteria (**Appendix II**). However, the different types of bipolar cores are treated together in the analyses since it is not clear whether they represent a single opportunistic method or possibly different bipolar methods. The lengths of single platform, opposite platform and bipolar cores were measured in the direction of flake removals. The length of the other cores was considered to be the measure between the two points farthest apart.

All the artefacts not included in the above mentioned categories were classified as debris. This category therefore includes split nodules, blocky pieces brought to the sites that bear no evidence of flake removals, tiny chips and fragments, angular shatter, etc. The length of these artefacts that are neither flakes nor cores was in this analysis considered to be the measure between the two points farthest apart.

A secondary classification was made to distinguish retouched tools from the artefacts that showed no evidence of secondary modification. Since the assemblages were recovered from a variety of contexts (from river banks and beds, ploughed fields, and excavations of undisturbed layers) comparison between the assemblages is complicated. This holds true especially when it comes to tools, since natural retouch is known to develop, for example, by ploughing and when artefacts roll in water (Manninen 2007; Miller 1982; Odell 2003:66–74). When defining tools, care was therefore taken not to confuse naturally retouched pieces with man-made tools. In practice this often meant accepting only the clearest cases as tools and ignoring many pieces with possible wear traces. Nor was any specific typology attempted in the classification of tools and other implements although some conventional categories such as scrapers, burins and bifaces were used (**Appendix II**). Artefacts interpreted as modern strike-a-lights were recorded but not studied further.

The sites and assemblage analyses

Sindi-Lodja I

Stone Age finds have been obtained from four different deposits in Sindi-Lodja I (Kriiska *et al.* 2002:27–32; Kriiska *et al.* 2003). The analysed lithic material[3] derives from a Mesolithic layer dated from soil samples to 7780±100 BP, 7030–6440 calBC (Ta-2826) and 8070±70 BP, 7300–6710 calBC (Ua-17013).

The Sindi-Lodja I lithic assemblage consists of only 18 artefacts. Although too small to be used in more detailed analyses, it is clear that the assemblage includes artefacts from blade production and/or use. For

[3] At the most investigated area of Sind-Lodja I (test excavation C in Kriiska *et al.* 2003) a 10–20 cm thick layer of humus lies directly under the surface and covers a layer consisting of dark grey sand up to 80 cm in thickness. Structures deriving from a Modern Age building were detected in the sand layer. Both layers contained mostly modern artefacts but to some extent also Stone Age, most probably Neolithic, flint artefacts. This material was not included in the technological analysis (for a discussion of this material see Kriiska *et al.* 2002:27–32; 2003:25–29).

Below the upper cultural layer of Sindi-Lodja I, yellow sediment sands of the Litorina Sea were observed and below these a sloping peat layer (in the excavated area 115 cm in thickness) was revealed. A polished stone adze, some flint flakes, and scrapers were found on top of the peat or in its upper part. These objects were probably lost in the river before the above mentioned stratified sands began to form. The peat has been radiocarbon dated to 7425±100 BP (Ta-2824), which corresponds with a 95.4% probability to 6450–6080 calBC.

Under the peat a 40 cm thick layer of gyttja had been sporadically preserved, the upper part of which contained prehistoric artefacts and animal bones. These artefacts probably sunk to the river/sea bottom near a settlement. A 5–30 cm thick organic layer was observed beneath the gyttja layer. This is the cultural layer of a Mesolithic settlement site. This layer, however, was present in its original position only in a few places. The cultural layer slopes steeply towards the south and, consequently, the elevation of the layer varied strongly over the excavated area. The layer has yielded stone, bone, and antler artefacts (flint and quartz flakes, flint blades, cores and tools, and a grinding stone), as well as animal bones. The artefacts analysed in this study derive from this layer.

example, one exhausted blade core (**Fig. 4**) is present in the assemblage alongside with artefacts from ordinary bipolar and freehand platform flake production. Tools include scrapers and cutting tools. The flint raw-material is mainly of a dark grey colour, but some artefacts of an almost black translucent flint are also present. The analysed artefacts are small. The length of the cores and detached pieces is less than 30 mm for all but one blade (**Appendix III**).

Figure 4. Side view of a narrow-face blade core from Sindi-Lodja I (PäMu 15260/A2553:110). Photograph by A. Kriiska.

Sindi-Lodja II

At the Sindi-Lodja II site the section of a Mesolithic cultural layer can be seen in the steep bank of the Pärnu River almost five metres above the river surface. Although partly collapsed and washed into the river, the layer has still been preserved in an area that is at least 45 metres long and stretching at least 15 metres inland from the river bank (Kriiska *et al.* 2002:27–32). A radiocarbon sample obtained from a piece of wood found in the Mesolithic layer dates the settlement traces to 8035±80 BP, 7190–6680 calBC (Ta-2769).

The flint material found in the Mesolithic cultural layer of Sindi-Lodja II and in the river in front of the site consists mainly of dark grey and black flints. Some lighter grey and brownish flints are also present. The assemblage includes clear evidence of blade production or/and use along with artefacts from flake production

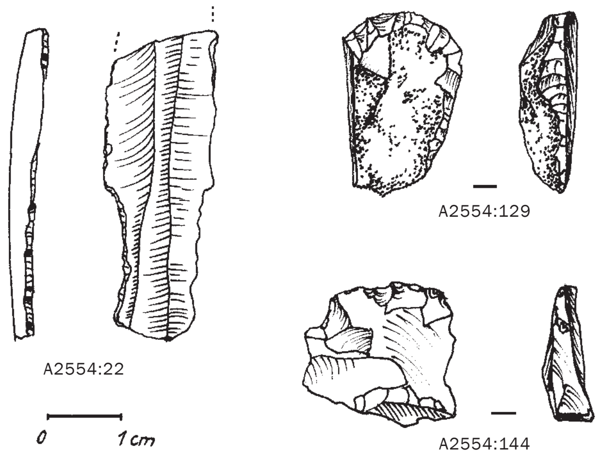

Figure 5. Examples of flint artefacts in the Sindi-Lodja II assemblage (PäMu 15261/A2554). Retouched blade (:22), a scraper on a cortical flake (:129), and a retouched flake (:144). Drawings by Kristel Külljastinen.

(**Fig. 5**). A total of 330 flint artefacts from the site and 170 artefacts found in the river in front of the site were included in the analysis.[4] A fragment of a small pressure flaked typologically Neolithic bifacial point was also found in the river in front of the site, indicating that some younger material may be mixed in the finds collected from the river sediments.

Flakes are more common than blades in the Sindi-Lodja II assemblage (**Appendix II**). The flake assemblage itself is dominated by platform flakes over bipolar flakes. The Sindi-Lodja II flake assemblage indicates no clear difference in size between bipolar and platform flakes (**Fig. 6**). Therefore, a sequential change from larger platform cores to smaller bipolar cores does not seem likely. There are at least three things that further support this interpretation. First, the distribution of flake lengths is quite similar in both groups. Although there is a high proportion of small (below 10 mm) platform flakes, this size class probably represents waste from tool manufacture and trimming of cores rather than blanks for tool edges or other implements. Second, the flake volumes (LxWxT) show no clear difference between the bipolar and platform flakes (**Fig. 7**). This is also the case with cortical flakes: there is cortex on 53% of the platform flakes and on 50% of the bipolar flakes.

The cores, however, show a somewhat contradic-

[4] There are also artefacts from the river sediments in front of the Sindi-Lodja II site in the mixed assemblage discussed individually in Appendix II.

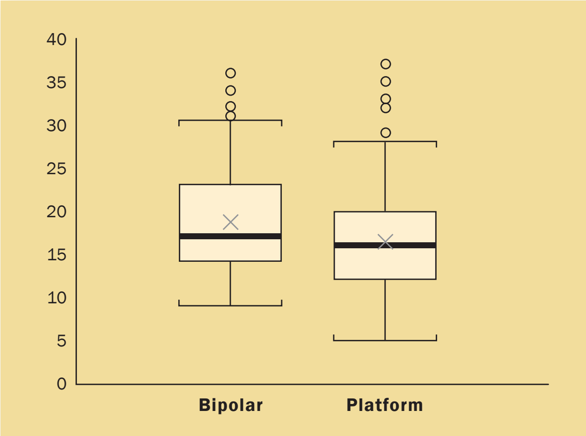

Figure 6. Sindi-Lodja II lengths of bipolar and platform flakes. Vertical axis in millimetres.

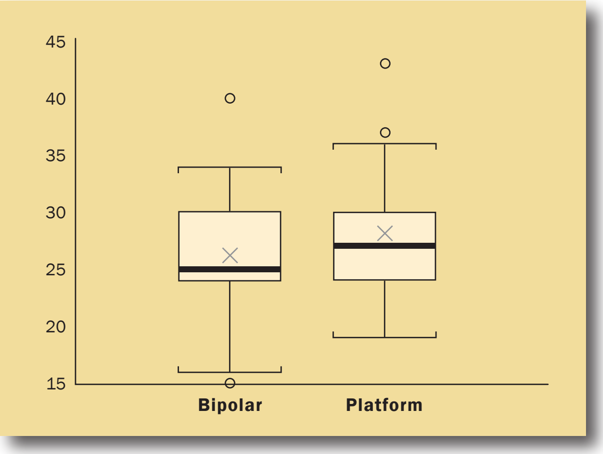

Figure 8. Sindi-Lodja II. Bipolar and platform core lengths. Vertical axis in millimetres.

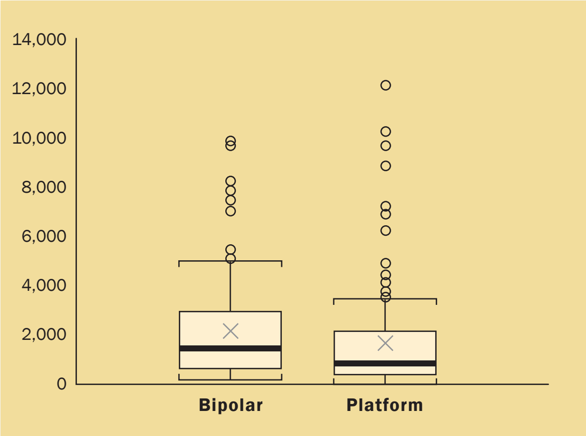

Figure 7. Sindi-Lodja II. Bipolar and platform flake volumes. Vertical axis in cubic millimetres.

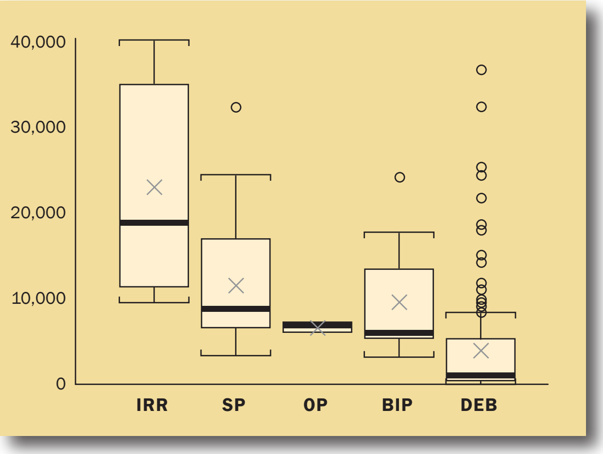

Figure 9. Sindi-Lodja II core volumes: irregular platform cores (IRR), single platform cores (SP), opposite platform cores (OP), bipolar cores (BIP), debris (DEB). Scale in cubic millimetres.

tory pattern. The length, i.e., the principal flaking axis, of the cores shows a similar pattern as the flake length data (**Fig. 8**), but the data on core volume suggest that bipolar cores on average were reduced farther than platform cores (**Fig. 9**). The size difference between cores is so small, however, that this evidence must be considered only suggestive. One explanation for the contradiction between the flake and core data could be that larger platform flakes were retouched and consequently modified into several smaller flakes.

The fact that the size range for irregular cores is the largest among platform cores suggests that platform flaking methods may also have succeeded each other to a degree. This seems to be best indicated in the case of single platform cores, which suggests a reduction continuum from producing flakes to producing blades (**Fig 10**).

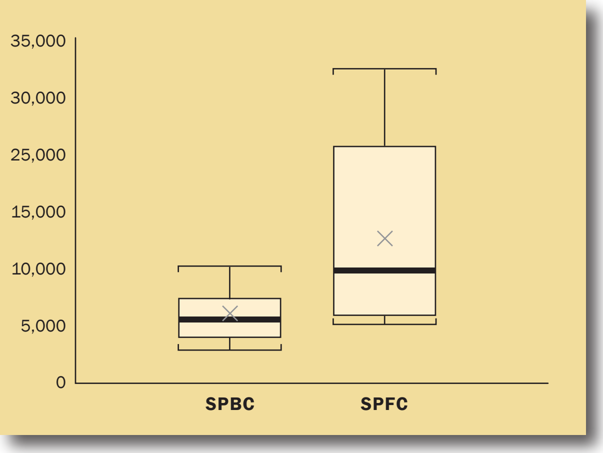

Figure 10. Sindi-Lodja II single platform core volumes: blade cores (SPBC) and flake cores (SPFC). Vertical axis in cubic millimetres.

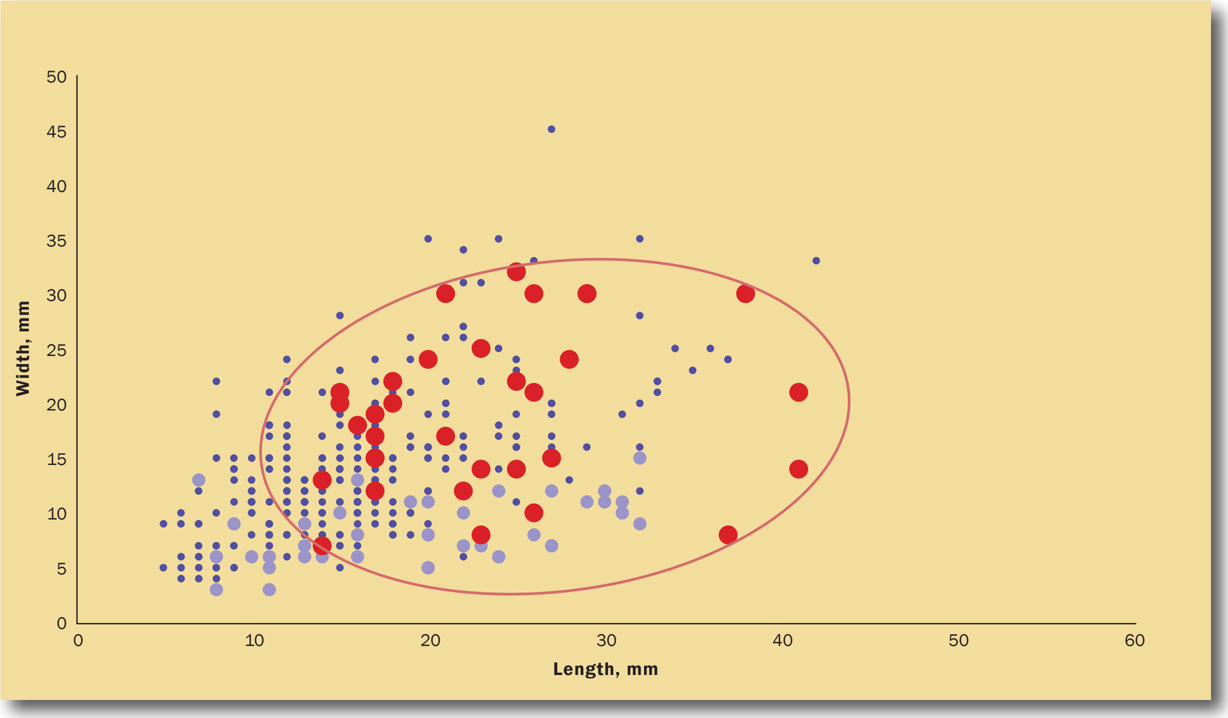

Figure 11. Sindi-Lodja II flakes and flake fragments (blue dots), blades and blade fragments (light blue dots) and tools (red dots).

Single platform cores bearing scars from flake removals alone have a larger size range than cores with scars also from the production of small blades. The fact that the cores for producing blades were often relatively small is also indicated by the blades, bladeflakes and blade fragments that show a median width of eight millimetres (**Appendix IV**). The single platform core size therefore could indicate a continuum from the production of flakes to the production of blades. As the reduction went on and core sizes diminished cores became more regular and began increasingly to exhibit the characteristics of blade cores. This resulted in the pattern presented here (**Fig. 10**). However, this explanation leaves open the question why the larger cores were not used for blade production.

This question can be approached from another direction by asking to what degree knappers actually changed from one platform method to another. There is evidence to suggest that, for example, the irregular and single platform core types represent, at least to a degree, independent types of reduction methods. The size ranges of all major core types have a good deal of overlap and the lower end of the size range for all major core types is rather similar. This indicates that the knappers utilised alternative tactics to deal with diminishing core size and that there was no single static concept of how to proceed with core reduction. Some cores were reduced by flaking from irregularly alternating platforms, others from a single platform, and others yet by bipolar flaking. Even the production of blades can be seen as a tactic for maximising core use-life.

In addition, the different core types produce blanks of different shapes and qualities. For instance, the irregular platform cores produce somewhat irregular flakes, whereas the single platform cores produce more elongated parallel sided flakes and blades. The fact that the size ranges of different core types that produce clearly different kinds of blanks have rather similar lower ends implies that the alternative core types are at least partly related to the need for different kinds of blanks.

The generally small size of cores and detached pieces in the Sindi-Lodja II assemblage is, in part, the result of small raw material size, i.e., small irregular nodules. Another reason most probably is the scarcity of raw material and possibly, as a consequence of this, a tendency to produce also small flakes. As demonstrated earlier (**Fig. 8**), some cores were pushed to a 20 to 15 mm length before being abandoned. This size probably marks the lowest acceptable flake size, but is obviously also a result of flaking small pieces – as the core size gets this small it becomes increasingly difficult to produce flakes even from bipolar cores that are often considered a response to small raw material size (e.g., Andrefsky 1994a; Shott 1989).

The fact that extremely small pieces were used to obtain blanks or edges for tools is supported by the flint debris found at the Sindi-Lodja II site. The debris volumes (LxWxT) demonstrate that only a few pieces equal the largest core volumes (**Fig. 9**). Since even the largest cores had passed the threshold of acceptable minimum size for a core and been rejected at the site, it seems that not many pieces of raw material that had potential for further use were left at the site. This is additional evidence for a scarcity of raw material.

At the same time, the retouched tools in the Sindi-Lodja II assemblage are relatively large when compared with unretouched flakes (**Fig. 11**). This suggests that the largest pieces, i.e., the pieces that had the most future potential for use and the strongest edges, were most commonly and intensively used and retouched. It was at a length of approximately 15–20 mm that the retouched tools were considered to have no more future potential and were discarded.

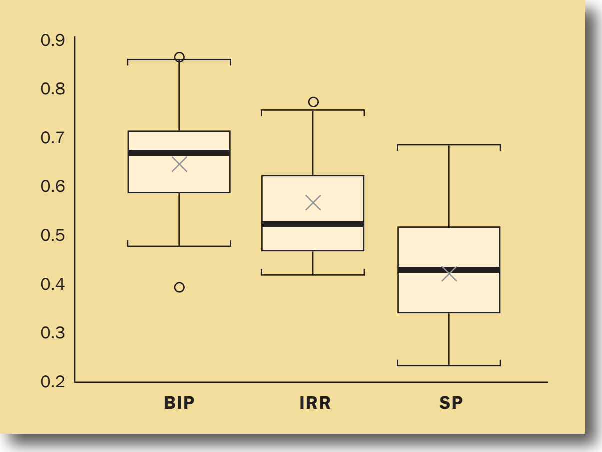

Figure 12. Sindi-Lodja II and Sindi-Lodja C core shape indices (minimum dimension divided by maximum dimension): bipolar (BIP), irregular (IRR), and single platform (SP) cores.

Find-spot C at Sindi-Lodja

The flint material from find-spot C at Sindi-Lodja includes mainly debitage from flake production, although some blade fragments and an exhausted single-platform blade core are also included. The flint raw material is mainly dark grey. The analysed flint assemblage consists of 77 artefacts. Typologically, most of the flint artefacts are Mesolithic, but some sherds of Typical Comb Ware have also been collected from the river sediments on the present waterfront (Kriiska *et al.* 2002). All of the finds probably represent a site destroyed by the river.

The small size of the Sindi-Lodja C assemblage is a major obstacle in making proper inferences about reduction sequences. Flake sizes show no clear differences between the platform and bipolar flakes. This would suggest that no succession from platform to bipolar reduction took place. In fact the size range of the bipolar flakes is wider than that of the platform flakes (excluding one outlier). However, the percentage of cortical flakes is higher among the platform flakes (90%) than the bipolar flakes (45%). This suggests that flaking may have been initiated with a platform method and that most of the pieces reduced with bipolar reduction had most of the cortex already removed. However, a more accurate measurement of the amount of cortical surface on flakes would be required to test this proposition.

Leaving the issue of possible reduction sequences aside, there is evidence that the occupants of the site employed alternative strategies to deal with the problem of the small raw material pieces. The small size of all of the cores implies that the flaking methods used to reduce small pieces and/or diminishing cores varied. Choosing between alternative methods is likely to have been situational and related to different variables, e.g., the shape of the needed blanks, the shape and size of the core/piece of flint under reduction, and so forth.

This is supported by a comparison of the combined volumes of different core types in Sindi-Lodja II and C assemblages.[5] If the functional properties of the blanks and cores did not matter to the knappers we would expect to see a pattern where the dimensions of different core types are not systematically clustered. The Sindi-Lodja II and find-spot C cores imply that this was not the case.

To calculate a shape index, the minimum dimension of each core (bipolar, single platform, and irregular platform core) from Sindi-Lodja II and find-spot C was divided by its maximum dimension (**Fig. 12**). The core types form clusters although a good deal of overlap exists between different types. Bipolar cores show less variation in their maximum and minimum measurements

[5] The mixed assemblage from the river in front of Sindi-Lodja II and find-spot C (see Appendix II) is included in the comparison.

than other cores. This means that single platform cores are relatively flatter than, for example, bipolar cores, which in turn are more cube-like. These two groups have relatively little overlap in their shape index range. This is somewhat surprising, given that these two core types actually have a similar unidirectional flaking axis. This implies that, supposing that these two different methods were applied on pieces of flint with a similar shape, the methods were suited for producing different kinds of blanks. Alternatively, the methods might have been applied on pieces that were different to begin with.

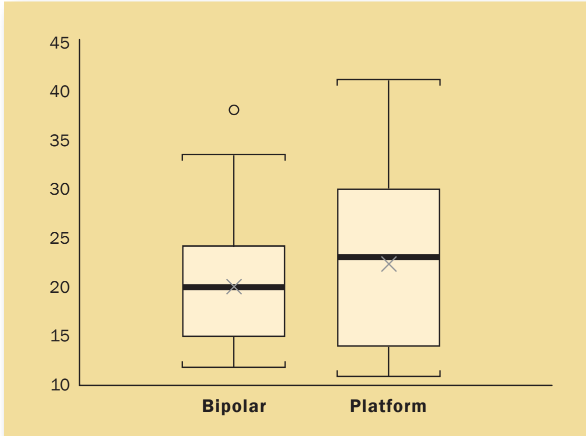

Figure 14. Metsaääre I flake lengths. Vertical axis in millimetres.

Metsaääre I

At the Metsaääre I site finds have been collected from the surface of a field 100 metres in length and 20 metres in width. Since the area has been under intensive cultivation, the cultural layer is in most places mixed by ploughing. Field walking has yielded finds (small flint and quartz artefacts, a stone adze, etc.; Kriiska 2001) that date the site typologically to the Mesolithic.

The Metsaääre I flint assemblage derives mainly from flake production but includes also evidence of blade production and use (**Fig. 13**). The assemblage consists of 151 artefacts. The flint raw material is mainly light yellowish grey, but other light and dark grey and brown flints are also present. Some of the blades were made of the same raw material as most of the flake assemblage. These, together with two bipolar flakes that bear evidence of blade removals on their dorsal sides, constitute clear evidence of on-site blade production. The median width of the blades is 10 mm and, as at Sindi-Lodja II, all are less than 16 mm in width (**Appendix IV**).

The flake assemblage is dominated by bipolar flakes. A comparison of flake sizes (**Fig. 14**) shows that the platform flakes fall slightly more often in the largest size category than the bipolar flakes. This might indicate that bipolar flakes in general were produced from somewhat smaller cores and that bipolar reduction was partly successive to platform reduction in the general operational scheme, but does not exclude an independent use of the methods. A sequence where platform reduction preceded bipolar reduction is supported by the larger number of platform flakes on which cortex is present:

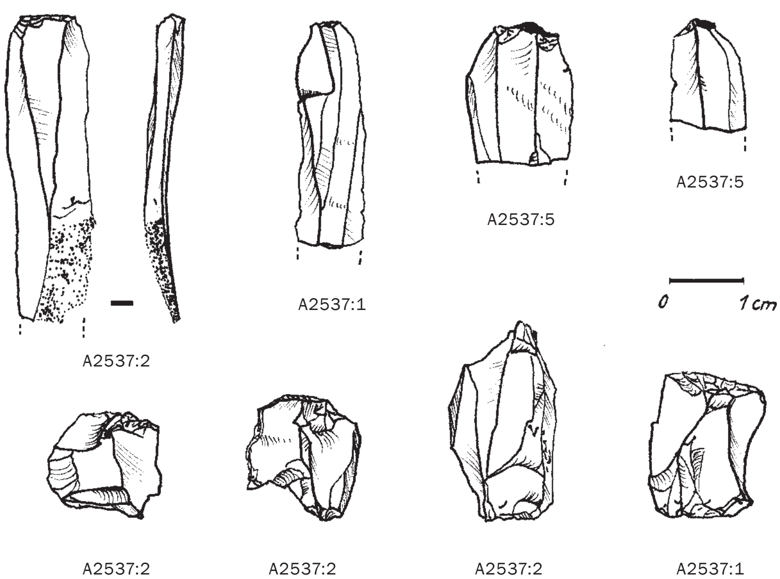

Figure 13. Examples of flint artefacts in the Metsaääre I assemblage (PäMu 15211/A2537). Top row: blades/blade fragments, bottom row: three bipolar cores and a scraper (far right). Drawings by K. Külljastinen.

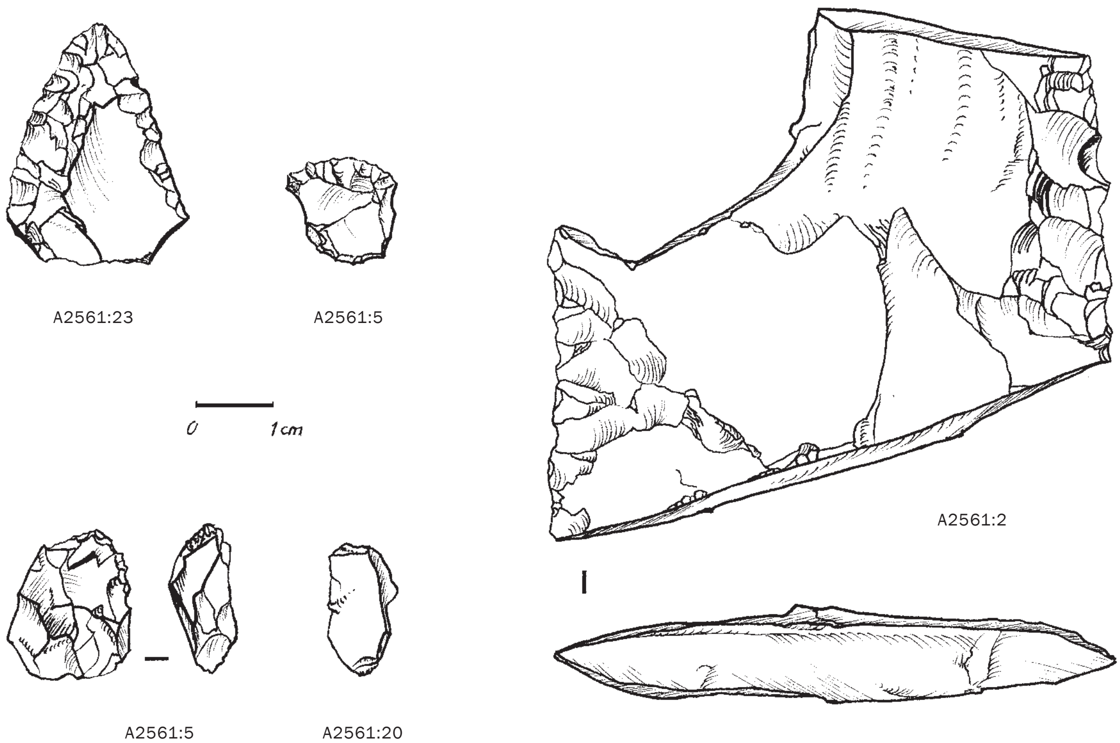

Figure 15. Examples of flint artefacts in the Sindi-Lodja III assemblage (PäMu 15425/A2561). To the left, top row: unifacially worked point (:23), scraper on flake (:5). Bottom row: bipolar core (:5), bipolar flake (:20). To the right: dagger fragment (:2). Drawings by K. Külljastinen.

58%, as opposed to only 38% of the bipolar flakes. The small number of cores precludes drawing further conclusions about possible reduction sequences. However, the core data illustrate again the small size of all of the cores. The maximum dimension is at or below 25 mm. This is in good agreement with the flake size, the cortex data, and with the data from the other studied sites.

Sindi-Lodja III

At the Sindi-Lodja III site, finds have been obtained from the surface, test-pits, and test excavations at the site. The largest find category is pot sherds. Material from the Typical Comb Ware period is the most abundant, but Late Comb Ware, Corded Ware and pottery of the Narva type are also present (Kriiska & Lõugas 2009:170). On the basis of shore-displacement chronology and artefact typology, the main use period of the site can be dated to *c.* 4000–3500 calBC, but there is also evidence of occupation from the 3rd millennium calBC.

The finds collected from the site and from the river in front of the site include flint artefacts, as well as some artefacts made of quartz. In total, the flint assemblage is small, amounting to no more than 48 artefacts (**Fig. 15**). The flint raw material varies from black to yellowish grey, but light grey is the most common colour. Excavations carried out at the site in 2003 and 2004, after the completion of these analyses, yielded several bifacial points typical of the Neolithic, but in the analysed assemblage there is only one, unifacially worked point/cutting tool. In addition, a fragment of a large bifacially worked dagger made of black flint has been recovered from the site. Typo-chronologically the dagger fragment dates to the end of the Scandinavian Neolithic period (*c.* 2000 calBC; for the dating, see Apel 2001).

The small flint assemblage is comprised mainly of bipolar and platform flakes. Bipolar flakes are more common. Intact flakes are small and suggest a small core size. The available bipolar cores support this conclusion. Due to the small size of the assemblage the flake size data shows no clear patterning in flake dimensions and is of little value for the study of the reduction continuum. However, the fact than flake length falls mainly under 30 mm again indicates small core size.

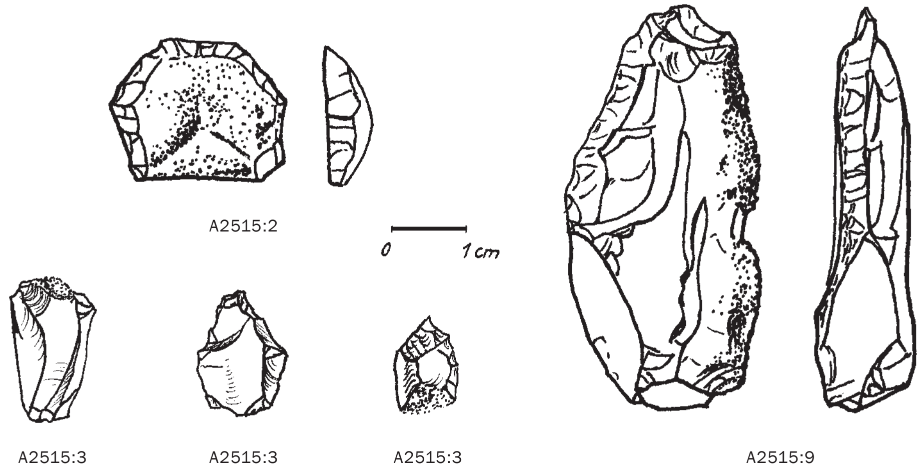

Figure 16. Examples of flint artefacts in the Lemmetsa I assemblage. Top row, left: scraper on cortical flake (:2). Bottom row: bipolar core (:3), bipolar flake (:3), scraper on cortical flake (:3). To the right: scraper on cortical flake (:9). Drawings by K. Külljastinen.

Lemmetsa I

Since 1996, finds have been repeatedly surface collected at the Lemmetsa I site and in 1997 a small test excavation was carried out. The Stone Age cultural layer at the site is almost entirely mixed with a ploughed layer approximately 30 cm in thickness (Kriiska & Saluäär 2000).

Four settlement phases can be distinguished in the finds from Lemmetsa I, two of which can be dated to the Stone Age. Typo-chronologically, most of the pot sherds from the site date to the Late Comb Ware period. It is probable that most of the other artefacts found (small flaked items of flint and quartz, stone processing debris, stone adzes, amber pieces, etc.) also date to the same period. Some artefacts that belong typologically to the Corded Ware Culture, such as pot sherds, a triangular marginally retouched flint point and a battle-axe of Continental type (*Külasema*-type in Estonia), have also been obtained.

The beginning of the water-connected Late Comb Ware period occupation at the mouth of the river can be dated through shore-displacement to *c.* 3850–3200 calBC (Kriiska & Jussila 2004:Table 2), but artefact typology suggests that more intensive occupation took place somewhat later and the site had occupation phases well into the 3rd millennium BC.

A total of 126 flint artefacts from the Lemmetsa I site were included in the analysis. It should be noted, however, that the flint assemblage from the site is considerably smaller (17% of the lithics), than the quartz assemblage. The flint raw-material is variable and includes light grey, reddish orange, brown, beige, white and dark grey flints. The flint artefacts seem in average much smaller than the quartz artefacts. Most of the flint assemblage is very fragmentary and a triangular point made of black flint stands out as exceptional. (**Figs. 16, 17, 18**)

Figure 17. Bifacial margin-retouched triangular flint arrowhead from the Lemmetsa I assemblage (PäMu 14642/A2515:3). Photograph by A. Kriiska.

Site	Lenght	Width	Thickness	Shape
Lemmetsa I	25*	18	3	Triangular
Lemmetsa II	72	34	9	Leaf-shaped
Lemmetsa II	52	23	5	Leaf-shaped
Lemmetsa II	41	18	6	Leaf-shaped

Figure 18. The sizes and shapes of bifacially flaked flint points in the Lemmetsa I and II assemblages. * Tip missing

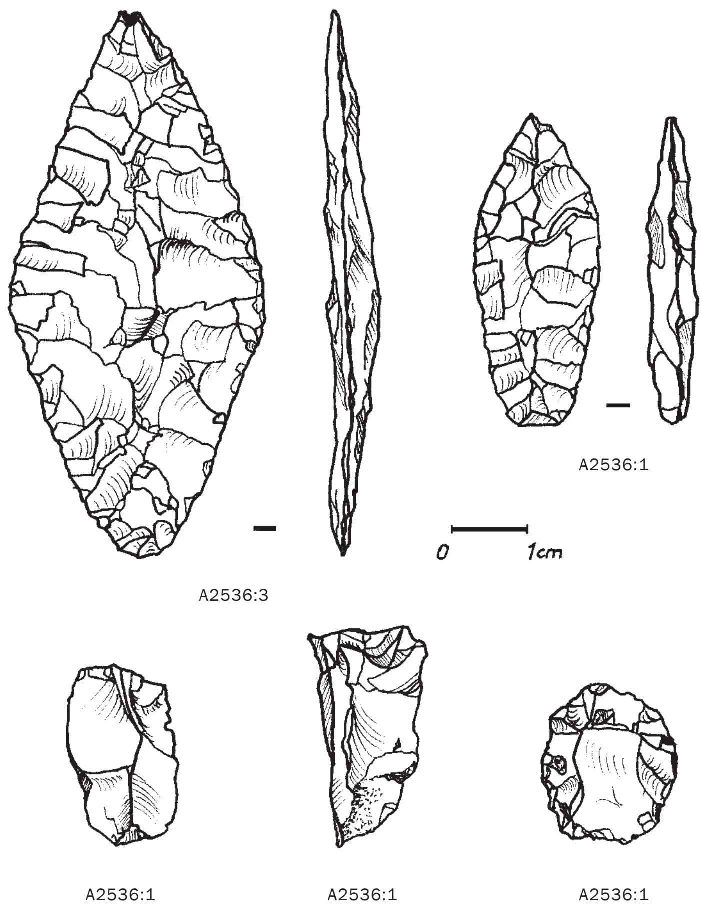

Figure 19. Examples of flint artefacts in the Lemmetsa II assemblage (PäMu 15210/A2536). Top row: bifacial points. Bottom row, from left: bipolar core, platform core, scraper on flake. Drawings by K. Külljastinen.

Small bipolar flakes dominate the flint flake assemblage. Intact platform flakes are too few for making meaningful comparisons of flake dimensions. The length of the bipolar flakes ranges between 12 and 28 mm. Although slightly higher, the core length is in agreement with the flake data. All of this implies small core, as well as raw material, size – an interpretation supported by the presence of cortex on 65% of the flakes, as well as by two flint nodules with a maximum dimension below 25 mm collected at the site.

Lemmetsa II

Since 1998, recurrent survey trips to the Lemmetsa II site have resulted in a collection of surface finds (pot sherds, small artefacts of flint and quartz, stone adzes, etc.). Due to long-term cultivation in the recent past, the Stone Age cultural layers have been seriously disturbed and mixed by ploughing (Kriiska & Saluäär 2000).

The Lemmetsa II finds date typologically, and by shore displacement, to the Typical and Late Comb Ware periods. Typical Comb Ware dominates clearly among the pot sherds. There are also traces of Iron Age and later activity at the site. Shore-displacement chronology dates the sea-connected Typical Comb Ware settlement to *c.* 4160–3600 calBC (Jussila & Kriiska 2004:Table 2) but the site has most likely also been occupied later, at the time of the forming of the Audru River.

The analysed Lemmetsa II flint material consists of 275 artefacts. Flint slightly outnumbers quartz in the total lithic assemblage (54% and 46%, respectively). There are many different flint raw materials in the assemblage, including a variety of greys (i.a., a translucent grey), brown, reddish, and black flints. Several bifacial points stand out among the artefacts (**Figs. 18, 19**). There are 3 leaf-shaped points, 1 biface rough-out and a burnt tip of a bifacial point.

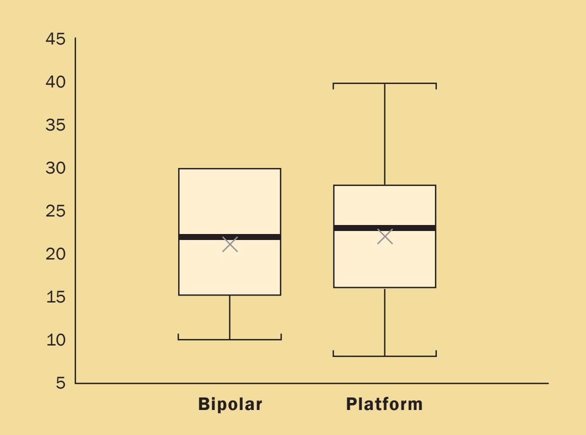

Figure 20. Lemmetsa II flake lengths. Scale in millimetres.

The main component in the flint assemblage is, nevertheless, material from simple flake production. However, finds include also ten diagnostic flakes and flake fragments that derive from bifacial production. The selection and possible trade of large disc-shaped biface thinning flakes for use as blanks has been suggested by Jan Apel (2001:216–229) to have taken place in the Late Neolithic in eastern central Sweden. However, the small size of the Lemmetsa II flakes suggests that they represent local reduction rather than flakes imported for further use as biface blanks. The largest three of these artefacts are further retouched into flake tools.

Intact platform flakes are more numerous than bipolar flakes. The flakes show little variation in length, although some platform flakes are exceptionally large (**Fig. 20**). The proportions of cortical flakes agree with general flake length. A slightly larger number of platform flakes than bipolar ones bear cortex: 58% and 50% respectively. This suggests that the two methods are not successive reduction stages, although platform reduction may have been, on occasion, preferred on larger pieces of raw material. The core size data seems to support this conclusion to a degree, since rejected platform cores are larger than bipolar cores.

Relatively large flakes and fragments were modified for retouched tools in the assemblage (**Fig. 21**), which is not surprising, given the generally small size of the artefacts. The bifacial points are among the largest tools and only the very largest flake tools equal the size of the smallest bifacial points.

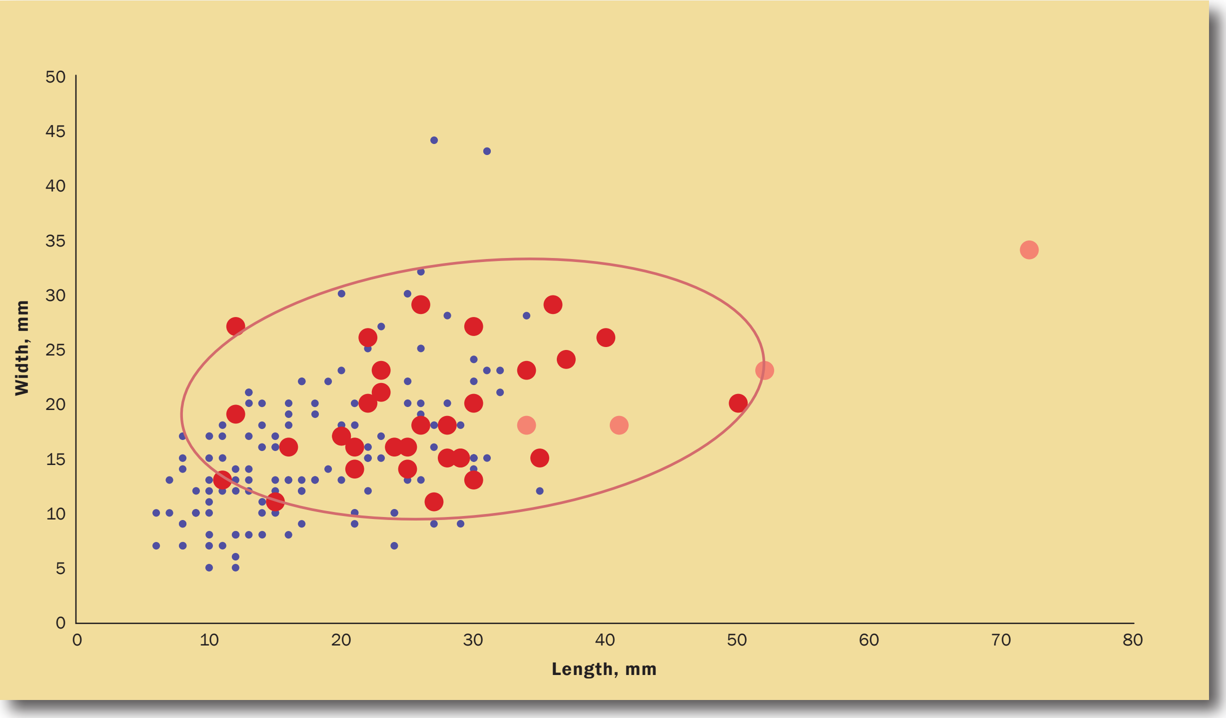

Figure 21. Lemmetsa II. Flakes and flake fragments (blue dots), bifaces (pink dots), tools (red dots).

Summarising and expanding on the results

Raw materials

Flints of many different colours and textures are present in the studied assemblages (besides opaque greys, browns, and yellows of different shades, also some translucent black and grey varieties). This material can be roughly divided into local and imported flints. The division is by no means clear-cut and no geo-chemical sourcing or other provenience analyses have been carried out on the material. However, something can be said about probable sources of raw material on the basis of visual comparison between the assemblages and samples from known outcrops. It appears that flint has been imported to the Pärnu area both during the Mesolithic and the Neolithic.

The Mesolithic finds from the Sindi-Lodja sites include some blades and tools of brownish black translucent flint of high quality, most probably deriving from outcrops of Cretaceous flint-bearing formations that are known to exist, for instance, in Lithuania, Poland, Belarus, and southern Scandinavia (e.g., Baltrūnas *et al*. 2006; Herforth & Albers 1999:Abb.1; Sulgostowska 2002:9). The same kind of flint is prevalent in the Early Mesolithic Pulli assemblage, and is present also in several other Mesolithic assemblages in Estonia and adjacent areas (Jaanits 1989:32; Jussila *et al*. 2007:157; Kriiska & Tvauri 2007:42). However, the low quality and the large cortex percentage of the rest of the black and dark grey flint from Sindi-Lodja suggests that it was not, at least not exclusively, acquired from the large outcrops of Cretaceous flint several hundreds of kilometres away, where good quality raw material is abundant, but rather from some, possibly nowadays unknown, glacial moraine sources closer to the Sindi-Lodja sites.

The triangular point from Lemmetsa I and the bifacial dagger fragment from Sindi-Lodja III have also been made of the black translucent high quality flint. These artefacts, however, were probably imported to the sites ready-made, since no corresponding debitage has been found. The main part of the Neolithic import consists of multicoloured flints that derive most probably from the Carboniferous formation ranging from the Moscow area to the White Sea. Carboniferous flint from Central Russia was imported to the East Baltic region during the Mesolithic and Neolithic (Galibin & Timofeev 1993; Jussila *et al.* 2007:157–158; Kriiska & Tvauri 2007:42) and is also the main flint type in the analysed Neolithic flint assemblages in Finland (Costopoulos 2003; Kinnunen *et al*. 1985; Manninen *et al*. 2003; Matiskainen *et al.* 1989). It has even been found in Comb Ware contexts in northern Sweden (Halén1996).

The Neolithic flint import in Estonia appears analogous to the Neolithic flint import in Finland, and is presumably associated with the manufacture of Typical Comb Ware period bifacial points (Manninen *et al.* 2003). It is precisely the bifacial points that are most clearly made of imported flint also in the Neolithic Pärnu assemblages. The points differ in colour and texture from the majority of the flint assemblages, and it is evident that the raw material pieces used in their manufacture were much larger than the nodules typical for the local Silurian flint.[6] This notion is further validated by evidence suggesting that the bifacial points were manufactured from large flake blanks, which means that they derive originally from even larger pieces of raw material. Although flake scars from pressure flaking usually cover the whole surface of the Typical Comb Ware period bifacial points, sometimes the original flake blank can still be seen.

Most of the flint artefacts in the studied Pärnu assemblages originate from small, mainly grey, brown, and yellowish pebbles and nodules that are most likely of local origin. In all of the analysed assemblages, cortex is present in 38–64% of the artefacts, which is a clear indication that the original nodules were small. As a point of comparison, in the Raikuu Martinniemi 3 assemblage in Kerimäki, south-eastern Finland, which only includes imported flint, the amount of artefacts containing cortex is as low as 6% (Hertell & Manninen *analysis on file*). However, the distribution of Silurian flint by glacial processes in Estonia could mean that this kind of flint may also have been acquired over considerable distances. The presence of chalk covered blocky pieces in some of the studied assemblages suggests that brownish Silurian flint was also quarried for raw material. Since there are no accessible chalk formations in the Pärnu region, this flint must derive from elsewhere, possibly from Central Estonia. This also makes it likely that some of the small flint nodules could also have been imported to the Pärnu Bay area from other parts

[6] The split nodules in the assemblages have a diameter of less than 5 cm, a size typical for the Silurian flints from quaternary deposits in Estonia.

of Estonia. Whether this was the case is a question that must be left open at this stage.

Besides the change in the geological source for imported flint, another marked change takes place in raw material procurement practices during the Stone Age in the Pärnu region. Quartz is practically absent in the Mesolithic assemblages, but is a common raw material during the Neolithic. For example, the Lemmetsa I and II lithic assemblages contain 83% and 46% of quartz, respectively – strikingly high figures when compared with the Mesolithic assemblages. This change, as well as the different flint raw materials used in the research area, is important when considering the flint technology also in relation to other topics, such as mobility and trade.

Tools, blank production, and core technology

The presence of bifacially flaked points of different sizes and shapes in the Neolithic assemblages is in line with the general picture from other parts of Estonia (e.g., Kriiska & Tvauri 2002:64) where bifacial points are also mainly found in Typical Comb Ware, and later, contexts.

In Estonia, triangular (or heart-shaped) points of the kind included in the Lemmetsa I assemblage belong typo-chronologically to the Corded Ware Culture. These points seem to represent a different tradition than the leaf shaped bifacial points. This tradition originated in Neolithic Central Europe and entered Estonia mainly from the south (Kriiska & Saluäär 2000:25–26). In Finland, heart-shaped flint points have been reported only from one mixed Typical Comb Ware/Corded Ware context (Luoto 1987:12–15).

Technologically, the triangular/heart-shaped points in Estonia differ from the leaf-shaped (Comb Ware) bifacial flint points in the way the blank has been worked. In the Comb Ware period points flake scars usually cover the whole surface of the point and only occasionally small areas of the original flake blank surface can be seen, as in the case of one of the Lemmetsa II points. The triangular Corded Ware Culture points have usually been retouched only around the margins, leaving the centre of the original flake blank untouched (see figures in Kriiska & Saluäär 2000:Fig. 8 and Kriiska & Tvauri 2002:77).

In general, the Mesolithic and Neolithic secondary production was mainly aimed at making small tools like scrapers and knives on flakes.[7] The main difference in tool categories between the time periods is the presence of bifaces in the Neolithic assemblages. In the Lemmetsa II assemblage there are also ten diagnostic flakes deriving from bifacial reduction and a biface rough-out indicating that it was not only ready-made bifacial points that entered the Pärnu area in the Neolithic but also a new technology.

The production of flakes from different kinds of cores is the backbone of both the Mesolithic and the Neolithic flint technology. This can be further illustrated by arranging the assemblages in two temporal groups (**Fig. 22, Appendix V**). The debitage size distribution is virtually identical in both groups and no diachronic change can be seen. Despite the source critical problems, such as the partly mixed nature of some of the assemblages, the emerging picture is not in disagreement with the impression gained from any of the assemblages from chronologically more or less closed contexts. Therefore, this pattern is likely to be the result of the prevailing use of raw material pieces of a similar size throughout the Mesolithic and the Neolithic.

No definite conclusion can be reached on the question whether the knapping sequences involved a switch from platform reduction to bipolar reduction. It seems that the ways to deal with diminishing core size were variable and therefore there seems to be no direct sequential linkage between platform reduction and bipolar reduction. Both reduction methods were parts of the same technological system, and bipolar reduction was sometimes used on exhausted platform cores.

The Mesolithic and Neolithic core reduction strategies, however, were partly different. Both the Mesolithic and Neolithic assemblages contain parallel-sided flakes, i.e., blades and blade-flakes, but no convincing evidence of systematic blade production at the Neolithic sites was observed. The fact that prismatic blade – and, to a degree, also bladeflake – production in the Pärnu area was a distinctly Mesolithic technological feature is best illustrated by the absence of blade cores in the Neolithic assemblages, especially the single platform cores suitable for producing parallel-sided flakes and blades.

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[7] In the Mesolithic assemblages, ten blades/blade fragments are retouched. However, many blades are also snapped, which may sometimes represent intentional truncation. There is no evidence of the microburin technique at these sites. This is typical for many of the East Baltic Mesolithic sites, i.e., Kunda sites north of the Janislawice culture (cf. Ostrauskas 2000:172–175). However, in the Early Mesolithic Pulli assemblage there are also microburins (A. Kriiska personal observation). Single microburins in quartz have been reported also in Finland (cf., Schulz 1990; 1996).

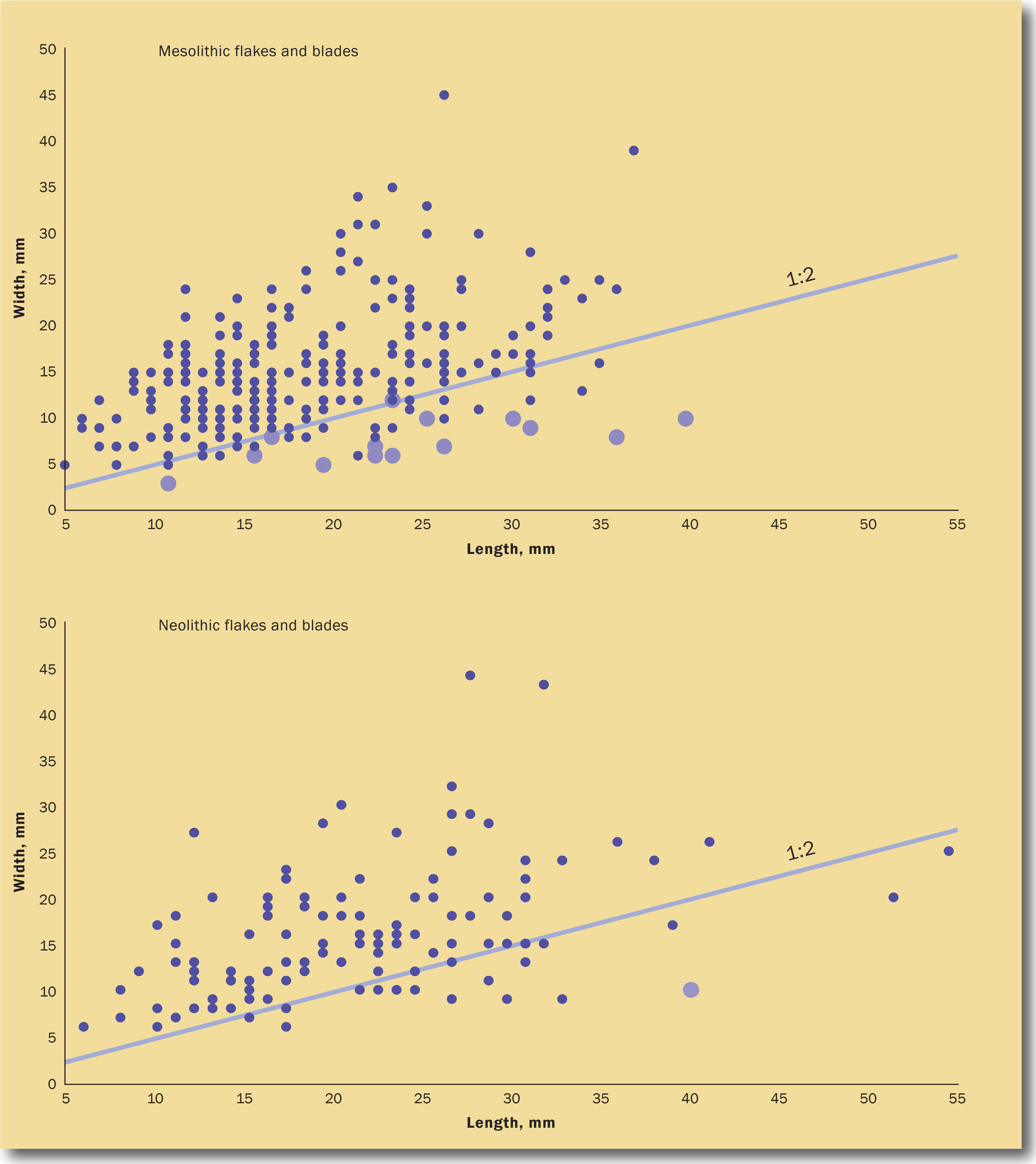

Figure 22. The dimensions of flakes, bladeflakes and blades (light blue) in the combined Mesolithic and Neolithic assemblages.

A variety of methods were employed for making blades and parallel-sided flakes during the Mesolithic. More than one centimetre wide, elaborate, and 'classic' prismatic blades, possibly produced from conical cores, are present in the Sindi-Lodja I, II and Metsaääre I assemblages. It is also clear that other smaller, and often less elaborate, blades were produced from smaller cores that were not treated in a similar fashion as the conical cores. Only a narrow core face was used for producing small, somewhat irregular, blades, making these pieces burin-like or sometimes handle core-like in shape.

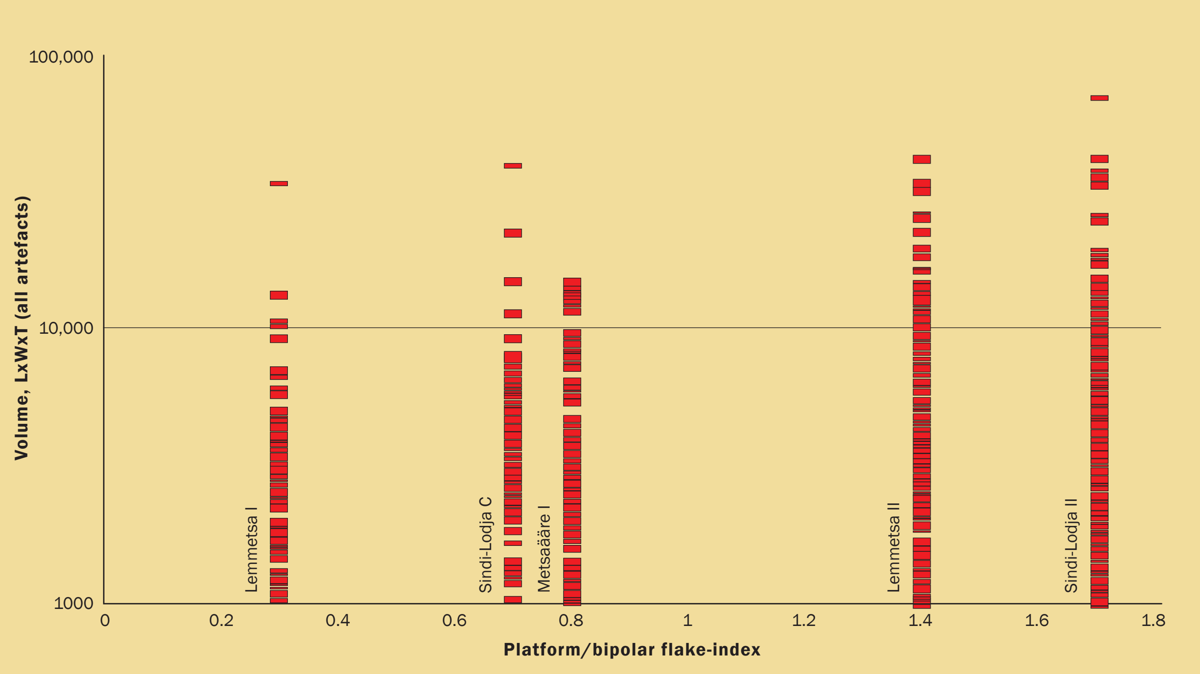

Figure 23. The platform/bipolar index in relation to artefact volume.

Moving beyond the question of parallel-sided flakes, the variability in core reduction methods is best demonstrated when comparing all the blank production methods in the Pärnu assemblages. As discussed above, the archaeological evidence implies that the decision to use a given method depended on the situation at the Sindi-Lodja II and C sites. The major core types produced different kinds of blanks and the different kinds of reduction methods were applied on pieces of different shapes and dimensions – these facts probably affected the selection of a method in each particular case. This pattern is obvious at least in the Mesolithic assemblages. Since platform cores are absent from the Neolithic assemblages, a similar comparison is not possible.

It must be borne in mind that the decision to use one or the other of the general knapping schemes – platform or bipolar – was not only related to the above-mentioned circumstances but also to raw material availability at the sites. Intuitively, it makes sense that as the raw material for stone tools is, or becomes, scarce, this is compensated for by increasing reliance on methods that conserve material and/or methods that allow the utilisation of increasingly small pieces. Since the bipolar method is well suited for the reduction of small pieces, we should expect to see increasing reliance on the bipolar method as the tool stone material grows scarce. For example, Goodyear (1993) found that the presence of bipolar cores correlated negatively with the measures of raw material abundance at the Paleo-Indian sites in north-eastern United States, and Andrefsky (1994b) found that the percentage of bipolar cores was higher for rare non-local lithic materials than for local raw materials in north-eastern Washington, United States.

Comparing the proportions of diagnostic platform vs. bipolar flakes by dividing the amount of platform flakes by the amount of bipolar flakes in an assemblage, i.e., the platform/bipolar (P/B) index, gives support to this expectation. Since the P/B index shows the proportions of the two flake types in an assemblage, the higher the index, the greater the proportion of platform flakes. As a consequence, the P/B index is expected to show decreasing values in a situation of decreasing availability of flint.

This hypothesis finds some support in the analysed assemblages when we use the artefact volumes of each site as a proxy for the availability of tool stone material at the site. In the diagram in **Figure 23**, the artefact volumes in each of the larger assemblages are contrasted to the P/B index.[8] Excluding the outliers, it appears that *the larger* the

8 The Sindi-Lodja I, III, and Sind Lodja II+C assemblages were excluded because of their small size (see **Appendix II**).

proportion of platform flakes, i.e., the higher the index, *the larger* pieces were left at the site. In other words, the greater the proportion of bipolar flakes in an assemblage the less relatively large pieces are included in it.

This implies that the choice between the platform and bipolar methods was related to the availability of raw material for stone tools. When relatively large pieces were scarce, bipolar reduction was used more often than when raw material and large pieces were more easily available. It seems evident that the increasing use of bipolar reduction is related to the availability of raw material for stone tools and is therefore situational. However, the artefact volumes also correlate to some degree with assemblage size and therefore the effect of assemblage size to the P/B-index should be studied further when the research material allows it.

If the high P/B index values are related to the better availability of raw material it would be reasonable to expect that a similar correlation between raw material availability and tool use should also exist. As the raw material for stone tools becomes scarce the availability of flakes suitable for use also decreases. In such a situation we should expect to see increasing tool curation, in this case an increasing rate of retouch on flake edges, executed in order to increase their use-life. This should be apparent as high tool percentages when contrasted to blades and/or flakes.

When contrasting the tool percentages (**Appendix II**) with the P/B indices, a trend is revealed for all cases except Lemmetsa II (**Fig. 24**). For the four cases, the P/B index explains 86% of the variation in tool percentages. Lemmetsa II clearly deviates from the pattern, but the reason for this is not obvious. As noted above, the source critical problems related to the varying recovery contexts and field work methods make comparison between the assemblages problematic. These factors probably affect, to a degree, both the P/B index and the tool ratio, and although both of these seem to match the expectations to some extent, the bias deriving from the different fieldwork methods and find contexts is difficult to avoid. Nevertheless, the figure suggests an emerging pattern in keeping with the expectation, which may become stronger in the future with more assemblages under comparison.

In order to understand the raw material economy better, core volumes can be compared between assemblages. It is reasonable to expect that in a situation where raw material for stone tools is scarce, cores are utilised more effectively than in a situation where raw material is easily available. This means that we should see a pattern in which small core size correlates with poor availability of flint. This kind of correlation at sites where other raw materials than flint were also used – quartz in the Pärnu area – would indicate, in addition, that flint was favoured over them.

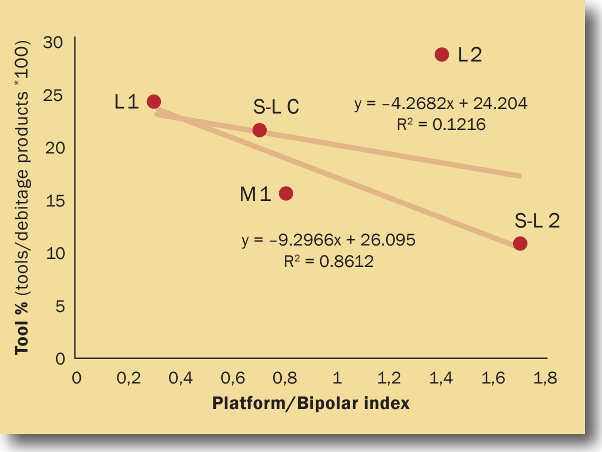

Figure 24. Comparison of the platform/bipolar index and tool percentage (tools/debitage) for Lemmetsa I (L1), Sindi-Lodja C (S-L C), Metsaääre I (M1), Lemmetsa II (L2), and Sindi-Lodja II (S-L2).

To study this, the amount of flint in the total lithic assemblage, i.e., the availability of flint in relation to its need can be taken as a proxy measure. If quartz was used to compensate for the inadequate flint supply in the Neolithic, we would expect to see a pattern where flint cores were utilised more economically in Neolithic contexts. If quartz was not used to compensate for the lack of flint, then there should be no difference in core size between the Mesolithic and the Neolithic.

By arranging the assemblages into two temporal groups, Mesolithic and Neolithic, a pattern that is consistent with the prediction of economical flint use emerges (**Fig. 25**). At the Neolithic sites the bipolar cores are smaller. This pattern, however, does not seem to be consistent with the P/B index/artefact volume comparison discussed earlier that showed no temporal patterning. Instead, it showed that the high P/B index was related to the presence of large pieces of flint in an assemblage. On the other hand, the fact that bipolar cores are smaller at Neolithic sites is in agreement with the high relative flint tool ratios in the Neolithic (**Appendix II**).

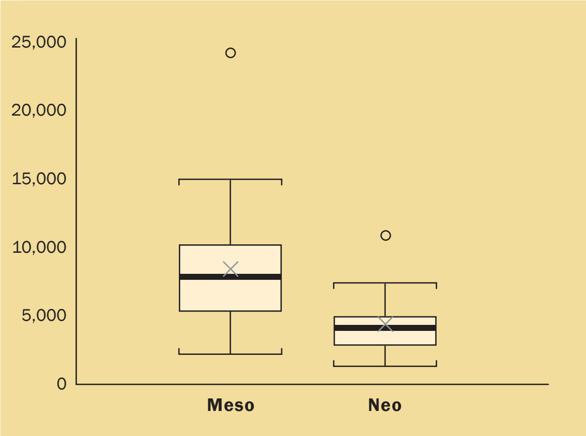

Figure 25. The volumes of Mesolithic and Neolithic bipolar cores. Scale in cubic millimetres.

It is clear that many of the issues and explanations discussed here are complex. One obvious reason for this is that sites are not equal in their settings and contents, and therefore a site assemblage is not a constant that is only related to the availability of raw material in the surrounding area. As the tactics for provisioning places and individuals differ, assemblages differ accordingly (Henry 1995; Kuhn 1995). However, it is likely that with increasing data these issues can be studied further in the future.

When it comes to tools and other implements, as already noted, it is common that the largest blanks were retouched. This is also in good agreement with general economical predictions on raw material use. The largest pieces had the most future potential for use and consequently they were the pieces that were carried along, used, sharpened, and re-sharpened. Therefore these pieces in general exhibit clear retouch, a feature that is probably generated on many of the tools through a process of repeated use and sharpening.

Discussion

The variation in blank production methods observed in the Pärnu Bay area is not without counterparts in neighbouring regions. One can easily see this by looking into blade producing methods – the most common interest area among researchers working with lithics in the neighbouring countries.

The flexibility in blade production is well documented at Mesolithic sites in the Peri-Baltic region. For example, at Veretye I in north-western Russia, different kinds of "handle core"-types for the production of small blades are found in addition to the more elaborate conical blade cores (e.g., Oshibkina 1997:43, 153) and an equally high variation in core treatment practices seems to be present also at sites in central Russia (e.g., Koltsov & Zhilin 1999; Lozovski 1999:Figs. 1,2). The illustrations published by Oshibkina (e.g., 1997:Fig. 25) imply that it is not uncommon at Veretye I that core thickness, i.e., core face width, in some "handle" cores is less than 20 mm. These examples illustrate the small size of some of the blades that were produced at these sites.

In connection with these small blades, a note on the burin-like cores in the Mesolithic Pärnu assemblages is required. It is not always clear, whether these are burins or cores for producing small blades, but we suggest a core function. The same kind of 'burin-like' small blade production could be suggested also for assemblages from other Mesolithic sites in the surrounding areas. However, these kinds of artefacts are usually interpreted as burins (see e.g., Sorokin 2002).

In this connection, it is also worth discussing the wedge-like pieces, i.e., bipolar cores. In the Pärnu Bay area, the use of the bipolar method to produce flakes seems to be associated with the general nature and size of the raw material pieces.[9] However, as the analyses suggest, this alone does not explain the whole spectrum of bipolar reduction. It seems that the bipolar method was a salient part of the Mesolithic and Neolithic lithic technologies in north-eastern Europe although its use varied in relation to the general access to and availability of raw material.

One of the important features of the Pärnu assemblages is the change in the lithic procurement tactics that takes place in the course of the Stone Age. The Mesolithic assemblages consist mainly of flint, whereas the Neolithic sites also contain a large quantity of quartz. The large scale change that can be seen in the Pärnu Bay area brings forth a question that goes into the very basics of all archaeological inquiry, i.e., how to explain cultural change.

A similar change in raw material use has also been observed in other parts of coastal Estonia. For example, on the coastal islands the use of quartz increases in the Late Mesolithic. On the Saaremaa, Hiiumaa and Ruhnu Islands Late Mesolithic and Neolithic lithic assemblages consist of 41,2–98,1% quartz (Kriiska 2002:36). It is clear

[9] For a similar situation in Gotland, see Rundkvist *et al.* 2004:18.

that there was no clear-cut change, no single event, after which foragers in the area began to utilise quartz. The decisions of how to select and procure lithic raw materials were related to a number of variables in settings that were undergoing gradual change throughout the Stone Age.

A scenario that explains the increasing reliance on quartz can be presented. In the Pärnu Bay area much of the data suggests that flint was not abundant at the studied sites at any time. The abundance of flint, however, is not a constant but a relative factor that depends on the amount of resources and consumers. Consequently, much of the change can be explained by understanding the way foragers position themselves in the landscape and in relation to other, non-lithic, resources. These decisions are mirrored in the lithic raw material selection and use and, therefore, in the archaeological assemblages.

From the Late Mesolithic onwards the foraging strategies changed from a reliance on terrestrial resources to a more aquatic resource use in the coastal area. The associated change in the way people positioned themselves in relation to the resources is seen, e.g., in the colonisation of the large islands, Saaremaa and Hiiumaa (Kriiska 2001b). The colonisation of the islands implies a marked reorganisation of the mobility strategies and the associated settlement pattern. With the increasing use of marine resources it is likely that the amount of residential mobility decreased, which in turn meant longer periods of continuous occupation at a single site. This relaxed also the constraints on tool kit size and weight. Although quartz is generally easily available around sites, it has higher transportation costs than flint (Tallavaara *et al.* 2010). Therefore, it is reasonable to expect a reorganisation of lithic selection and use strategies with decreasing residential mobility, as the benefit from high quality raw material is smaller than for mobile groups.

Further, the large land areas utilised in hunting land mammals facilitate the detection and procurement of relatively scarce flint resources from large territories. With the change to a more marine diet the diminishing terrestrial range reduces the amount of available places from which lithic raw materials can be procured.

In the Pärnu Bay area, most of the flint raw material seems to have been collected from sedimentary deposits that have a patchy distribution. As a consequence, no single specific location for collecting lithic raw materials probably existed. Rather, the raw materials were collected from the open shorelines in an opportunistic way. The increase in the length of occupation at the sites combined with the long use history of many sources led to the gradual depletion of the surrounding lithic sources.

Since it appears that in the Pärnu Bay area the available flint was already quite effectively exploited in the course of the Mesolithic, a large-scale intensification of flint use with the increasing length of occupation of the sites was not a viable option. This meant that other lithic resources were required to compensate for the poor availability of flint. As a consequence, the use of quartz began to grow. This scenario is readily testable in other areas around the Baltic Sea and in the Peri-Baltic regions. It is within this general scenario that we can incorporate in the research other important factors, such as risk management, which must have had an effect on the technological organisation of the groups in question.

Raw material use is also known to be related to cultural preferences that show no clear association with economic behaviour. For instance, preferences of certain lithic raw materials related to spiritual beliefs have been reported (e.g., Taçon 1991). There is, however, no contradiction between these kinds of choices and the lithic economical scenario presented here. The scenario should be taken as a benchmark to which other cultural choices beyond economical behaviour are compared – when assemblages do not fit into this scenario a different, cultural, explanation must be sought.

Conclusion

In this paper we have studied lithic raw material procurement and the reduction of flint at Stone Age sites in the Pärnu Bay area, Estonia. We have provided quantitative metric data on assemblage characteristics. We hope that these data can be used as comparative material in studies concerning lithic technology, not only in the Pärnu region, but also in the surrounding areas.

The analyses of seven Mesolithic and Neolithic flint assemblages show a rather uniform technological character. With the exception of the Mesolithic blades and Neolithic bifaces, the general character of the primary production in flint shows little or no evidence of change over several millennia. All assemblages are flake-dominated and produced by simple platform and bipolar methods.

The flint technology at all sites seems to have been dominated by strategies that made use of small flakes and cores. This phenomenon is related to the dimensions, quality, and availability of raw materials. The cores demonstrate that despite the small size of raw material pieces, different reduction methods were employed. This can be explained by a need for different types of blanks, but also as a response to the different shapes of the cores.

An analysis of the use of different lithic raw materials in the assemblages was not included in this study. However, it seems evident that the observed changes in the use of flint and quartz, i.e., in the lithic technological organisation, were related to other socio-cultural factors. The archaeological record suggests a major reorganisation of hunter-gatherer foraging strategies, including mobility, settlement patterns, and associated demography, during the study period. Much work needs to be done to make proper and reliable inferences about these issues.

However, we believe that the study of lithic technology, using different and sometimes diverging approaches, will become a central field in future studies concerning this region. As a consequence, the changes seen in the lithic procurement tactics, the use of different raw materials, the choices between reduction methods, and so forth, in essence, the whole technological organisation, will gradually become understandable. In this way the study of technological organisation becomes meaningful to the study of the cultural system as a whole. We believe that the theoretical orientation used in this paper, if more widely accepted, will help in gaining a better understanding of the past cultural systems in this area.

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Appendix I. The history of Stone Age research in the lower reaches of the Pärnu River 1/2

In the beginning of the twentieth century, when Estonian archaeology was still relatively young, *Altertumforschende Gesellschaft zu Pernau* (the Pärnu Society for Antiquities) came to the fore and for a while had a leading role in Stone Age research in the whole of Estonia. The society, founded in 1896, was not unique. Associations of a similar kind were common in Europe at the time. The originality of the Pärnu society was in its markedly intensive interest in archaeology and especially in Stone Age research (Põltsam 1997; Kriiska 1997).

The main reason for this interest was the large amount of stray finds gathered from the lower reaches of the Pärnu River and from the banks of its tributaries. The first Stone Age artefacts were collected in 1901 at the mouth of the Reiu River by veterinary surgeon and future active amateur archaeologist Eduard Glück, a member of the *Altertumforschende Gesellschaft zu Pernau* (Glück 1906, 272). A couple of years later Friedrich Rambach, a manufacturer interested in archaeology, started another large collection of Stone Age artefacts from the same area (Indreko 1932:283).

The artefacts collected by these Baltogermans formed the basis of the large collection of more than a thousand artefacts – mostly of bone and antler – from the lower reaches of the Pärnu River. Most of the finds were catalogued and published in the publications of the society (see Kriiska 1997). Archaeological excavations were carried out in 1905 near the main find-spot at the mouth of the Reiu River, but they did not provide the hoped-for results (Frank 1906).

The collections were later augmented by brewery owner Eduard Bliebernicht, also a member of the *Altertumforschende Gesellschaft zu Pernau*. His efforts in collecting and preserving Stone Age finds gathered during gravel digging in the Pärnu River were especially important. Bliebernicht also published an article (Bliebernicht 1924) on the prehistoric finds from the lower reaches of the Pärnu River, but his work ended with the beginning of the Second World War. In addition, August Laury and Johan Pajo were also instrumental in gathering artefacts from the lower reaches of the Pärnu River (Indreko 1932).

Antler artefact collected from the Pärnu River. Collections of the Pärnu Museum (PäMu 6 / A 2092). Length 36.2 cm. Photograph by M. A. Manninen.

Appendix I. The history of Stone Age research in the lower reaches of the Pärnu River 2/2

Academic research in the area began in the 1920s. At this time, the prehistory of Pärnu county, including the traces of settlement from the mouth of the Reiu River, was taken up by Richard Indreko, who was one of the first generation of Estonian professional archaeologists. He catalogued Rambach's collection (Indreko 1926) and later the Stone Age artefacts gathered from the lower reaches of the Pärnu River by veterinary Johan Pajo (Indreko 1932). Indreko also carried out short-term archaeological inspections and test excavations near the mouth of the Reiu River (1929; 1939). Although excavations were carried out in many places, settlement sites were not discovered.

After the war, Stone Age research on the lower reaches of the Pärnu River came to a standstill: only stray finds were occasionally added to the collections. Indreko had moved to Sweden, Blibernicht to Germany, and in general the focus of archaeological research was directed to other parts of Estonia. The discovery of the Preboreal Pulli settlement site in 1967 was then impetus for a new period of intensive research. In 1968–1973 and 1975–1976 an area of more than 1100 m² was investigated at the site in archaeological excavations led by Lembit Jaanits (Jaanits & Jaanits 1975; Jaanits & Jaanits 1978).

This work changed drastically the existing conception about the beginning of the Mesolithic in all of the Baltic countries. Many flint artefacts from the Pulli site have been widely published and the typology and, partly, the technology of the flint artefacts has been investigated (Jaanits 1973; 1981; Jaanits & Jaanits 1975; 1978; Jaanits *et al.* 1982; Jaanits & Ilomets 1988).

After a few survey trips (1969 by Lembit Jaanits and 1974 by Kaarel Jaanits) to the banks of the Pärnu River, research was activated again at the end of 1990s under the leadeship of Aivar Kriiska (e.g., Kriiska 2001; Kriiska & Saluäär 2000; Kriiska *et al.* 2002; Kriiska *et al.* 2003). The attention that was previously concentrated mainly on the lower reaches of the Pärnu River, was partly turned on the shores of the rivers Audru and Reiu, where traces of Stone Age settlements have been detected during the last decades.

Appendix II. Artefact inventory

Artefact inventory of analysed assemblages	Mesolithic					Neolithic		
	Sindi-Lodja I	Sindi-Lodja II	Sindi-Lodja C	S-L II + S-L C	Metsaääre I	Sindi-Lodja III	Lemmetsa I	Lemmetsa II
All artefacts, total	18	500	77	26	151	48	126	275
Blank production								
Cores, total*	3	35	7	8	6	3	7	20
Blade cores, single platform	1	7	1					
Flake core, single platform		7		2	1			
Flake cores, opposite platform		2						
Flake cores, irregular		6	5	2				3
Flake cores, discoidal		1						
Flake cores, single removal		1			1			1
Flake cores, bipolar pillow shaped		4		2	3	3	5	9
Flake cores, bipolar with platform	2	3	1	2	1		1	2
Flake cores, bipolar multidirectional		3						
Flake cores, mixed bipolar & irregular platform		1						
Bifacial points and fragments							1	5
Flakes and blades, total**	12	330	56	13	110	33	79	184
Blades & fragments	4	39	5		15		1	0
Flakes & fragments***	8	291	51	13	95	33	78	184
Debris	3	134	14	5	35	12	41	71
Diagnostic flakes								
Total****	5	213	34	11	70	19	33	106
Platform	3	135	14	8	30	6	7	56
Bipolar	2	78	20	3	40	13	26	40
Bifacial								10
Tools								
Total*****	6	36	12	5	17	3	19	52
Scrapers, scraper fragments	3	13	3	4	6		8	8
Denticulates		1						
Burins					3			
Retouched blades and blade fragments	2	7	1		1			
Retouched pieces******	1	15	8	1	7	2	10	39
Bifacial points and fragments							1	5
Unifacial point/cutting tool						1		
Strike-a-lights							7	16
Indices								
Blades & fragments / Flakes & fragments	0.5	0.1	0.1	0	0.2	0	0	0
Platform / Bipolar flakes	1.5	1.7	0.7	2.7	0.8	0.5	0.3	1.4
Tools / Flakes and blades	0.5	0.1	0.2	0.4	0.2	0.1	0.2	0.3

* Core fragments included, ** Tools included, *** Bladeflakes included, **** Diagnostic fragments included, ***** Tool fragments included, ****** Retouched and/or used flakes, fragments, cores, and debris.

Appendix III. Individual core dimensions

Core dimensions*	Sindi-Lodja I	Sindi-Lodja II	Sindi-Lodja C	S-L II & S-L C	Metsaääre I	Sindi-Lodja III	Lemmetsa I	Lemmetsa II
Length (millimetres)								
Blade cores, single platform	23	37 21 24 37 21 28	32					
Flake cores, single platform		43 30 21 30 29 36 35		42	21			
Flake cores, opposite platform		22 27						
Flake cores, irregular		27 27 24 30 24 27	38 21 21 21	22 20				20 48 36
Flake cores, discoidal		19						
Flake cores, bipolar pillow shaped		30 19			25 13 25	20 15	20 20 32	30 28 24 23 23 18
Flake cores, bipolar with platform	22 27	24 28 15	18	24 15	16		39	27
Flake cores, bipolar multidirectional		25 40 32						
Flake cores,mixed bipolar & irregular platform		18						
Width (millimetres)								
Blade cores, single platform	21	13 23 13 20 11 9	10					
Flake cores, single platform		37 18 22 33 23 37 12		23	24			
Flake cores, opposite platform		18 20						
Flake cores, irregular		30 16 36 27 46 25	36 22 20 13	21 16				18 34 26
Flake cores, discoidal		13						
Flake cores, single removal					22			32
Flake cores, bipolar pillow shaped		22 21			23 15 17	15 14	21 11 24	16 18 15 18 17 15
Flake cores, bipolar with platform	17 28	16 19 19	18	24 12	15		13	15
Flake cores, bipolar multidirectional		22 27 19						
Flake cores,mixed bipolar & irregular platform		18						
Thickness (millimetres)								
Blade cores, single platform	15	18 7 21 16 20 15	19					
Flake cores, single platform		20 11 15 17 10 18 27		10	17			
Flake cores, opposite platform		17 11						
Flake cores, irregular		23 7 40 14 36 14	16 16 13 19	10 10				18 20 12
Flake cores, discoidal		12						
Flake cores, single removal					19			16
Flake cores, bipolar pillow shaped		20 14			22 – 10	9 6	12 9 14	9 8 9 11 10 9
Flake cores, bipolar with platform	14 11	14 11 11	21	14 12	10		14	12
Flake cores, bipolar multidirectional		18 22 23						
Flake cores,mixed bipolar & irregular platform		24						

* Fragments not included

Appendix IV. Blade widths

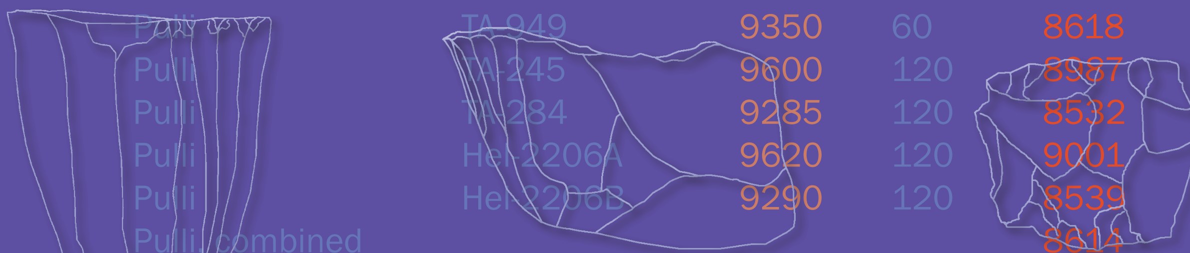
Blade width	3mm	4mm	5mm	6mm	7mm	8mm	9mm	10mm	11mm	12mm	13mm	14mm	15mm	16mm	17mm	18mm	Total	Median	Mean
Sindi-Lodja I					1	1		1		1		1				1	6	10	11.5
Sindi-Lodja II	2		2	8	6	5	3	5	4	4	2	1	1				43	8	8.2
Find-spot C						2			2				1				5	11	10.6
Metsaääre I		1	1	1	2		3	5	1		1	2	1				18	10	9.6
Lemmetsa I								1									1	10	10
Total	2	1	3	9	9	8	6	12	7	5	3	4	3			1	73	9	9.1

Appendix V. Flake dimensions

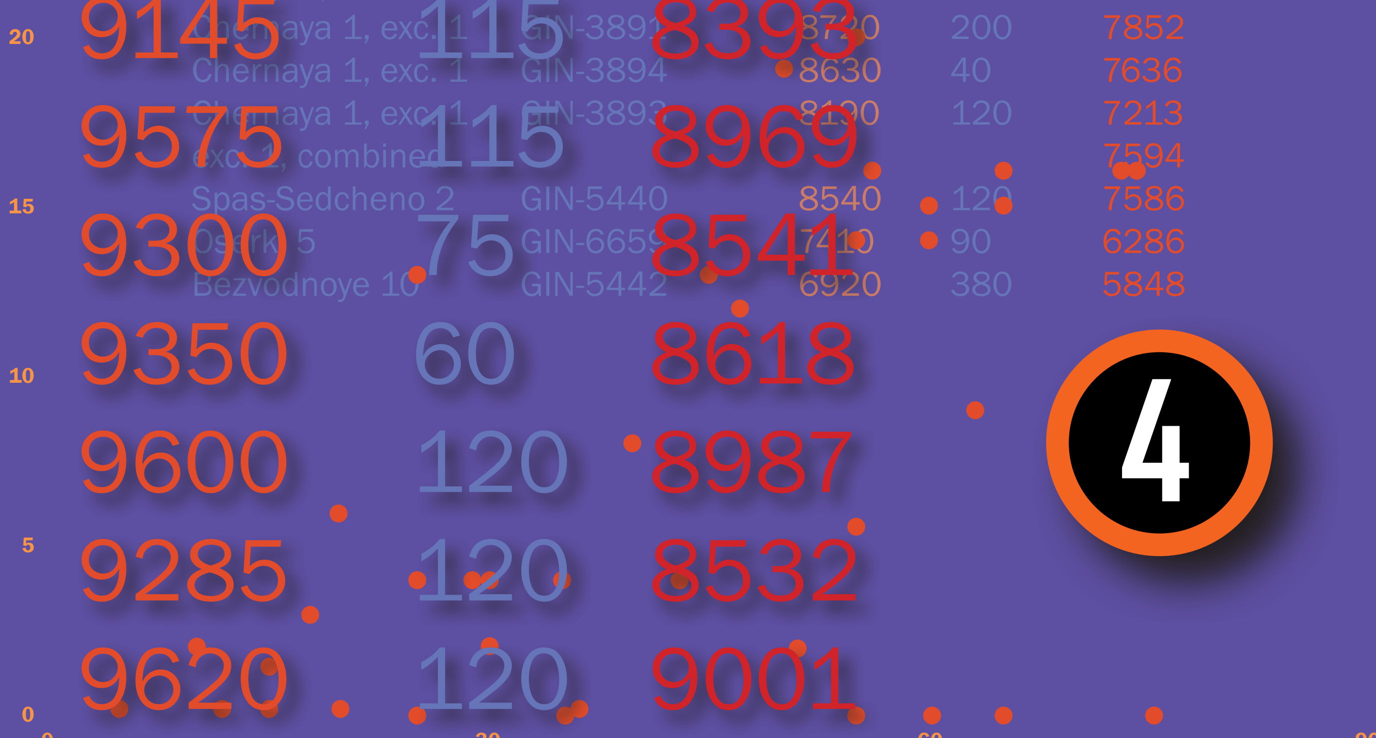
Flake dimensions*	Flake length, mm		Flake width, mm		Flake thickness, mm		Flake volume (LxWxT)	
Mesolithic	Bipolar, n=130	Platform, n=152	Bipolar, n=130	Platform, n=152	Bipolar, n= 130	Platform, n=152	Bipolar, n= 130	Platform, n=152
Minimum value	8	5	6	5	2	1	182	25
25th percentile	14.25	12	11	11	4	3	690	498
Median value	18.5	16.5	14.5	14	6	5	1434	1035
75th percentile	23.75	22	18	17	8	6	3009	2389.5
Maximum value	38	128	39	52	13	26	14820	66560
Neolithic	Bipolar, n=44	Platform, n=32	Bipolar, n=44	Platform, n=32	Bipolar, n=44	Platform, n=32	Bipolar, n=44	Platform, n=32
Minimum value	10	6	6	6	1	1	112	36
25th percentile	15.75	13.5	11	14.5	3	3	595.5	561
Median value	20.5	20	13.5	18	5	5	1435	1953
75th percentile	25.25	25.25	17	24.25	7	7.25	2438.75	3862.5
Maximum value	38	32	26	44	12	19	8640	25327

* Fragments not included

Pulli	Ua-13352	9095	90	8324
Pulli	Ua-13351	9385	105	8672
Pulli	Ua-13353	9145	115	8393
Pulli	TA-176	9575	115	8969
Pulli	TA-175	9300	75	8541
Pulli	TA-949	9350	60	8618
Pulli	TA-245	9600	120	8987
Pulli	TA-284	9285	120	8532
Pulli	Hel-2206A	9620	120	9001
Pulli	Hel-2206B	9290	120	8539
Pulli, combined				8614
Butovo, exc. 1987	GIN-5441	9310	110	8560
Sujala	Hela-1102	9265	65	8492
Sujala	Hela-1441	9140	60	8367
Sujala	Hela-1103	8940	80	8091
Sujala	Hela-1104	8930	85	8079
Sujala	Hela-1442	9240	60	8460
Sujala, combined				8319
Kultino 3	Tln-1406	8850	200	7978
Malaya Lamna 3	*	8800	90	7904
Chernaya 1, exc. 2	GIN-3551	8730	300	7875
Veretye I	GIN-4031	9050	80	8265
Veretye I	GIN-4869 Mg-P	8790	100	7893
Veretye I	LE-1472	8750	70	7807
Veretye I	GIN-2452.U	8560	120	7614
Veretye I	GIN-4030	8520	80	7560
Veretye I	GIN-2452.D	8520	130	7566
Veretye I, combined				7755
Chernaya 1, exc. 1	GIN-3891	8720	200	7852
Chernaya 1, exc. 1	GIN-3894	8630	40	7636
Chernaya 1, exc. 1	GIN-3893	8190	120	7213
exc. 1, combined				7594
Spas-Sedcheno 2	GIN-5440	8540	120	7586
Oserki 5	GIN-6659	7410	90	6286
Bezvodnoye 10	GIN-5442	6920	380	5848



^{14}C age	STD	Median age cal BC
9095	90	8324
9385	105	8672
9145	115	8393
9575	115	8969
9300	75	8541
9350	60	8618
9600	120	8987
9285	120	8532
9620	120	9001
9290	120	8539



4

Hunter-Gatherer Mobility and the Organisation of Core Technology in Mesolithic North-Eastern Europe

Esa Hertell & Miikka Tallavaara

ABSTRACT **This paper discusses the relationship between forager mobility and Mesolithic core technology in north-eastern Europe. It is suggested that due to its efficiency and the potential to produce a wide diversity of tool blanks, conical blade core reduction was a generalised production strategy suitable for mobile foragers. Other reduction methods used in parallel with conical blade core reduction provided different solutions to tool blank acquisition. An irregular flake core is a less efficient way to turn raw stone into tool blanks. This strategy is expected to have been employed with decreasing mobility, when there was less demand for core efficiency. To test these expectations, we used faunal data from Finland, Estonia and Russia to measure the level of mobility. Regression analyses suggest that the lithic core data and mobility indicators are correlated. This indicates that hunter-gatherers intentionally varied their reduction strategies in relation to the constraints posed by mobility. The conical blade core strategy correlates positively with indicators of high mobility. Irregular flake core reduction was increasingly employed when the duration of site occupation was increasing. During the Mesolithic, there was an increase in the emphasis on irregular flake core reduction and a decrease in conical core reduction. The link between high mobility and the conical core strategy suggests that it was a beneficial strategy during the post-glacial human dispersal to the north. The archaeological record further suggests that hunter-gatherers over large areas in north-eastern Europe made similar decisions and selected to employ similar core reduction strategies.**

KEYWORDS
Mobility, foraging, lithics, core technology, Mesolithic, northern Europe.

Introduction

During the past decades, archaeologists have increasingly began to study variation in lithic technologies and its correlates to explain the organisation of lithic technology (e.g., Andrefsky 1994; Bamforth 1991; Bousman 1993; Carr 1994; Hertell 2006; Kuhn 1995; Neeley 2002; Nelson 1991; Tallavaara 2005; Torrence 1989). This kind of a systemic approach assumes that lithic technology is linked to other areas of culture, as well as to extra-cultural factors. For example, the geology of north-eastern Europe is highly variable, and it can be said that geology and the natural availability of rocks have affected the organisation of lithic technologies more than anything else in this area. In areas where cherts and other good-quality lithic materials were not found, quartz and other local rocks were commonly used. The different raw materials were flaked and treated in different ways, and this resulted in a highly diverse and rich archaeological record in the area. For example, numerous blades and bifaces were made of chert, whereas quartz was flaked mainly through simple platform and bipolar reduction,

Figure 1. Sites discussed in the text. 1) Sujala, 2) Veretye I, 3) Pulli, 4) Butovo, Kultino 3, 5) Ozerki 5, 6) Malaya Lamna 3, 7) Chernaya 1, 8) Spas-Sedcheno 2, 9) Bezvodnoye 10. Data from Koltsov & Zhilin 1999b; Oshibkina 1997; Rankama & Kankaanpää 2007.

and various rocks of igneous origin were pecked and polished. In this paper, we go beyond the effect of the local geology and the different raw material varieties to study the variability in Mesolithic core technology in Estonia, Finland and north-western Russia.

One of the basic premises of research on the organisation of technology is that individuals should organise their technology according to their needs and that technologies are best seen as strategies for solving problems of some form (e.g., Bousman 1993; Kuhn 1995). Mesolithic foragers did not make blades just because they inherited blade technologies from their ancestors, who had made blades throughout their lives. The variability in archaeological assemblages also means that Mesolithic foragers were not tied to one specific production strategy, but, instead, employed a variety of core reduction methods. Because different raw materials, reduction strategies, and tools have variable costs and benefits for the user, different technological solutions have different outcomes. Selecting one strategy over others means gaining something at the cost of something else. For example, choosing to configure a core to make blades means that long, slender tool blanks can be produced, but at the same time, an opportunity to make something else from the same piece of stone is lost.

Research on the organisation of technology has stressed the impact of hunter-gatherer mobility on the technology (Bamforth 1991; Blades 2003; Kelly 1988; Kuhn 1994; Larson & Kornfeld 1997; Parry & Kelly 1987). Instead of collecting lithic raw materials at their sites, mobile individuals need to provision themselves with adequate supplies of tool stone (Kuhn 1995). It is generally acknowledged that mobile foragers cannot carry large supplies of raw material with them, and the technology needs to be adjusted to the constraints of mobile life. In such a situation, different solutions to lithic reduction, i.e., behavioural variants, may have highly different outcomes. When time or energy, or any other factor, is limited, selecting one solution may have far-reaching effects. From a wider evolutionary perspective, optimal technologies ultimately provide fitness benefits to those who invent, adopt, or use them (Bousman 1993; Kuhn 2004; Ugan *et al.* 2003).

Our aim is to test the hypothesis that the variability in the Mesolithic core technology in north-eastern Europe is related to the variability in hunter-gatherer mobility. We present a simple qualitative cost-benefit analysis of Mesolithic core technologies in relation to hunter-gatherer mobility and provisioning strategies. To test the suggested link between core technology and mobility, we analyse the archaeological lithic core and faunal data from Estonia, Finland and Russia (**Fig. 1**). The results of these analyses support the idea that mobility-related factors played a role in the selection of core reduction strategies in the area. This provides an explanation to the variation and frequencies of different core types in the archaeological record.

Variation in Mesolithic blade production strategies

In general, the efficiency of a core (i.e., its use life and number of useful products), and therefore the amount of raw material that must be carried along, depends largely on the configuration, maintenance, and reduction strategy of the core (e.g., Brantingham & Kuhn 2001). Due to the different geometry of blades and flake blanks, blade reduction offers one solution to raw material scarcity by providing more edge per blank volume than flake reduction strategies (see also experimental results by Eren *et al.* 2008:957). The production of blades, therefore, extends core use life and increases the efficiency of raw material consumption. The standardised shape of a blade has potentially very few useless edge parts due to the high regularity. In contrast to flakes, the volume and mass of blades are positioned evenly along the blank, producing further benefits for the optimisation of raw material use (e.g., Bar-Yosef & Kuhn 1999:324). This is not the case, for example, with flakes from irregular cores where the ratio of the flake edge to its mass is smaller.

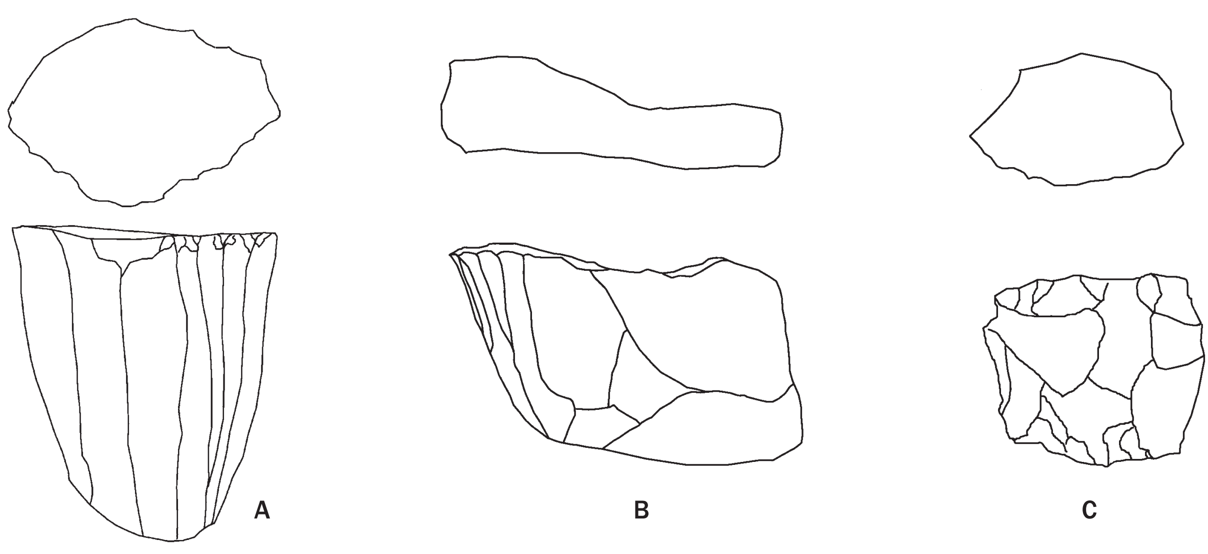


Figure 2. Schematic illustrations of different core types. A) conical core, B) narrow-face core, C) irregular core.
A & B adapted from Oshibkina 1997.

Archaeological data from Mesolithic sites in Finland, the East Baltic countries and north-western Russia suggest that variable strategies were employed in lithic core reduction and in blank production (Kriiska *et al. this volume*; Koltsov & Zhilin 1999a; 1999b; Oshibkina 1983; 1997; Rankama & Kankaanpää 2007). Three major strategies can be recognised in the published data. These are conical blade core, single-face or narrow-face blade core, and irregular core reduction (**Fig. 2**).

To understand the variable costs and benefits of the production strategies, it is helpful to treat them as idealised and somewhat polarised options for producing tool blanks. Some blades were produced from symmetrical conical cores. These cores often exhibit evidence that core maintenance was carried out by continuous shaping, adjustment and trimming of the platform (see Burov 1999a; Koltsov & Zhilin 1999a; 1999b; Rankama & Kankaanpää 2007; 2008). For example, at the Sujala site in northern Finland, where only the conical core strategy is present, platform preparation debitage constitutes 28% of the total lithic weight, whereas blades and exhausted cores amount to 50% and only 6.5%, respectively (Rankama & Kankaanpää 2007:51–52).

During the reduction process, conical core dimensions, and therefore the maximum potential blade width and length, diminish. Judging by the blade lengths, some reduction sequences began with relatively large cores that were probably up to 200 mm in length in the initial stages (Hertell & Manninen 2006:41). The large sizes of the initial stage cores are also supported by the maximum dimensions of the platform rejuvenation flakes, which in Sujala exceed 65 mm (Rankama & Kankaanpää 2007:51). Blade production from large cores reduced the cores, in some cases, to clearly below 100 mm in length. For example, at Sujala, the length of the recovered cores is around 50 to 60 mm. The available data also show that some cores had attained a pencil-like shape (e.g., Burov 1999a; Koltsov & Zhilin 1999b; Oshibkina 1983), implying that these cores were exhausted and that little potential for blade production remained.

Although the conical core reduction process seems to have a high overall symmetry, the strategy clearly was not to maintain a standardised blank size throughout the reduction process. For example, at Sujala, blade width varies widely, ranging from 2 to 43 mm (Rankama & Kankaanpää 2007:53). The large initial size of the blanks and the large size variation imply that a single core can provide tool blanks for a variety of tools of different sizes, e.g., large scrapers, butchering knives, burins and small inserts. Therefore, conical core reduction can be thought of as a generalised blade production strategy in the Mesolithic context of north-eastern Europe. It is a strategy that can provide most of the tool blanks required. It is also a strategy that suits the constraints of mobile life, where large supplies of lithic material or many cores cannot be carried along and where a wide variety of tool blanks need to be extracted from a single core.

Other blade reduction strategies were also employed by north-east European Mesolithic hunter-gatherers. To simplify, varieties of narrow single-face cores stand at the other end of the blade core variation. Oshibkina provides good illustrations of these core types from the area south-east of Lake Onega, but similar blade production strategies were also used in, e.g., Estonia (see Kriiska *et al. this volume*; Oshibkina 1997; 2006:149–151). In this strategy, blade dimensions, i.e., the length, width and thickness, remained relatively standardised during the reduction (e.g., experiments by Callahan 1985; Flenniken 1987). The narrow-face cores are optimised for producing blanks for a restricted set of lithic tools that are typically quite small and can, for example, be used as inserts. In other words, narrow-face core reduction is a specialised blade-production strategy. Instead of producing a large variety of blade blanks, this strategy yields a large number of standardised products. The relatively small size of the bladelets allows stones of variable size to be used as core blanks, and illustrations of archaeological cases seem to indicate that this was, indeed, the case (Kriiska *et al. this volume*; Oshibkina 1997:25).

Amorphous or irregular cores provide an alternative means of obtaining tool blanks. In contrast to systematic blade manufacture, this can be seen as the other end in the continuum of reduction strategies. It can be expected that irregular cores would be increasingly employed when the constraints posed by mobility are relaxed. When raw materials do not need to be carried along but can be collected and stored at the sites, the conical core strategy loses its relative efficiency. No systematic core configuration or continuous core maintenance are required in irregular flaking. Flakes can be detached as the need arises, with little consideration for core efficiency or the need to maintain tool-making potential in the future.

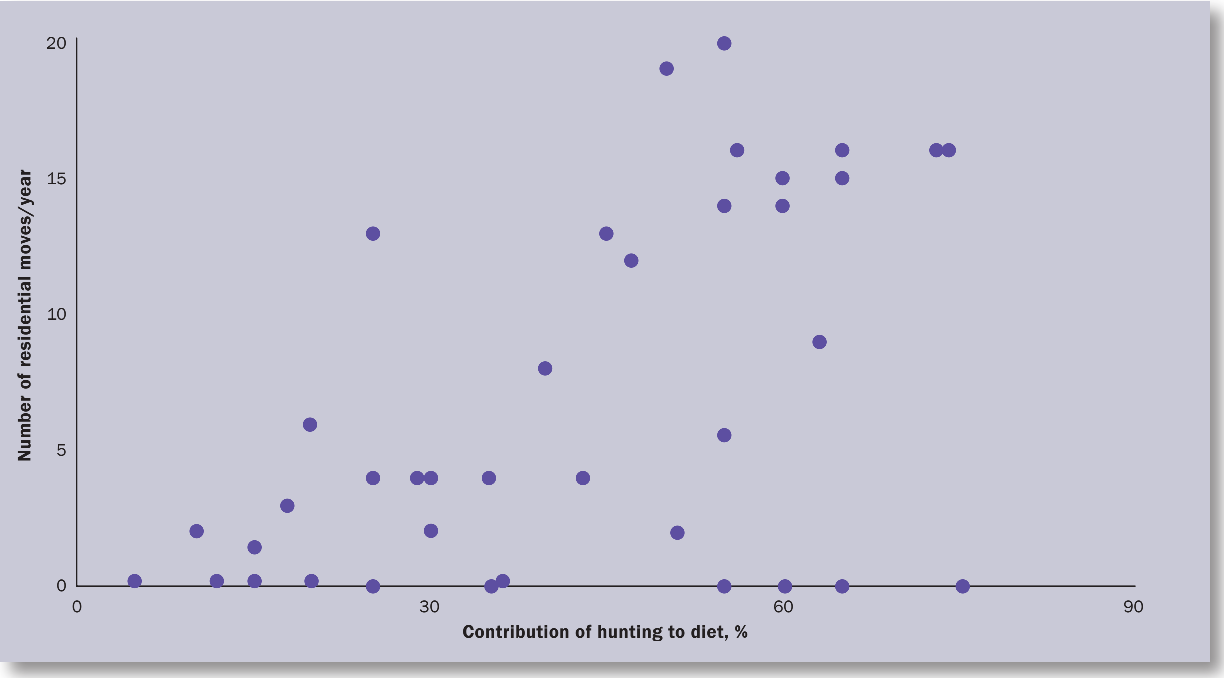


Figure 3. Residential mobility and percentage of hunting products in the diet of ethnographically documented boreal forest hunter-gatherers. Data from Binford 2001.

Methodology

The relationship between foraging and mobility

Both theoretical work and empirical analyses indicate that hunter-gatherer mobility is related to the food resources being used (e.g., Binford 1980; 2001; Kelly 1983; 1995). The theoretical interrelationship between diet and residential mobility is demonstrated in **Figure 3** for ethnographically documented hunter-gatherer groups living in a boreal environment. The groups whose diet was mainly based on foods hunted in terrestrial environments commonly made more than ten residential moves a year. However, much more extreme cases may have existed under different ecological circumstances. Marginal value theorem predicts that when resources are common and resource patches are frequently encountered, patch residence time is shorter and the proportion of consumed resources is smaller than in situations where resource patches are located farther away from each other. Increasing distance between resource patches makes it optimal to stay longer in a patch and consume a larger proportion of the resources (Charnov 1976; Hanski *et al*. 1998).

By targeting large land mammals, hunter-gatherers use only a fraction of the available resources in their environment. Accordingly, foragers targeting these species are typically highly mobile and frequently change their residential sites. For example, Kelly (1995:Table 4-1) estimates that the North American Montagnais, whose main prey was moose, changed their residential sites 50 times a year, i.e., almost once a week. When the duration of site occupation increases, the diet breadth is likely to widen accordingly, due to the pressure on the local resources caused by the hunting (e.g., Kaplan & Hill 1992). The relative amount of hunted large mammals, and their remains at a site then decreases. Increasing the length of a stay at a site results in the accumulation of an increasing amount of lithics and faunal remains on the site. If the growth rate is not the same for both categories, increasing site use leads to changing lithic to bone ratios. In Italy, Kuhn (1995:148-151) found that the relative abundance of animal remains was a suitable indicator of the degree of mobility. Therefore, three variables that employ faunal data to measure mobility can be tentatively suggested: the relative amount of large fauna in diet, faunal richness, and lithic to bone ratios. We studied these variables and their applicability in the present case.

Site	Conical core %	Narrow-face core %	Irregular core %	Other core %	Core total
Pulli	35.1	2.7	51.4	10.8	37
Butovo, excavation 1987	75	12.5	0	12.5	8
Sujala	100	0	0	0	3
Kultino 3	50	10	10	30	20
Malaya Lamna 3	8.9	15.8	71.3	4	101
Chernaya 1, excavation 2	31.3	25	37.5	6.3	16
Veretye I	40.7	15.7	26.9	16.7	324
Chernaya 1, excavation 1	30.8	23.1	38.5	7.7	26
Spas-Sedcheno 2	13.2	26.5	54.5	5.8	189
Oserki 5	19.1	14.9	61.7	4.3	47
Bezvodnoye 10	12.1	12.1	69.4	6.4	157

Figure 4. Core data for the sites. Core fragments excluded. Data from Koltsov & Zhilin 1999b; Oshibkina 1997; Rankama & Kankaanpää 2007.

Osteological and lithic data

To study whether mobility can explain the hunter-gatherer decision to use specific core strategies, we collected osteological and lithic data from published sites in Estonia, Finland and Central Russia (Koltsov & Zhilin 1999b; Oshibkina 1997; Rankama & Kankaanpää 2007; 2008). We used core data to estimate the popularity of the various core reduction strategies, because core data is generally available for the sites. Available debitage data did not allow distinguishing between different blade reduction strategies or separating core trimming flakes from flakes intentionally produced from flake cores. To increase the uniformity between the samples, data were collected only from sites that shared the same basic lithic repertoire and belonged to a single technocomplex. The resulting database that contains both lithic and faunal data consists of five sites: one from Estonia, one from northern Finland and three from Russia. To study the effects of sampling on osteological assemblages, data were also collected from Mesolithic sites where no lithic data were available (Chaix 2003; Koltsov & Zhilin 1999b). The lithic core data and osteological data are presented in **Figures 4** and **5**.

To further study whether the lithic core data show temporal patterning, we collected site-specific lithic core and radiocarbon data from the same area. This dataset contains 11 dated assemblages (**Fig. 4 & 6**). If a site had more than one radiocarbon date, the combined mean date was calculated using the combined function of OxCal 4.1 and was calibrated using the Intcal09 curve. In all of the cases (Chernaya 1, Pulli, Sujala and Veretye I), combining the dates is problematic because the date ranges are statistically too wide. Nevertheless, we used the combined dates as a rough age measure in the regression analyses.

In the original publications, the lithic core data were not presented in a uniform manner from one publication to another. To be able to study the current hypotheses and to make the data comparable between the cases, we regrouped the data published by Oshibkina (1997) and Koltsov & Zhilin (1999b). The different types of conical cores (types 1, 2 and 3) in the original Koltsov & Zhilin

	Pulli	Sujala	Kultino 3	Veretye I	Ozerki 5	Zamostje 2	Okaemovo 5	Nushpoly 11
Mammal IF, total	1011	13	123	2394	757	1595	358	99
Large fauna IF % (elk, reindeer & red deer)	44.4	100.0	78.1	60.9	60.2	35.2	57.5	52.5
Species richness	11	1	8	12	13	10	9	7
Core total	37	3	20	324	47			
Core total / mammal total	0.04	0.23	0.16	0.14	0.06			
Conical core %	35.1	100.0	50.0	40.7	19.1			
Irregular core %	51.4	0.0	10.0	26.9	61.7			
Narrow-face core %	2.7	0.0	10.0	15.7	14.9			

Figure 5. Data on mammal bone (mice excluded) and core types in the studied assemblages. IF = identified fragments. Data from Koltsov & Zhilin 1999b; Lõugas 1997; Oshibkina 1997; Rankama & Kankaanpää 2007.

(1999b) classification were combined, as were the three types of single-face cores (4, 5 and 8), and three types of irregular cores (6, 9 and 10). Type 1 is a pencil-shaped core and types 2–3 are conical or sub-conical cores. Types 4 and 8 are single- and double-platform end-face or single-face cores, and type 5 is a single-platform keel-shaped core. Types 6, 9 and 10 are irregular or amorphous cores with varying numbers of platforms. The original classification of Veretye I material contains two kinds of flake cores (discoidal and irregular), as well as conical blade cores (conical and conical-like; Oshibkina 1997). These were combined to form two groups: conical blade cores and irregular flake cores. Bipolar cores are not separated in the original data. In general, bipolar debitage is illustrated in Russian literature, but these pieces are often classified as burins (Kriiska *et al. this volume*).

For the sake of the analyses, we suggest that the discarded cores, at least to a degree, represent separate reduction strategies and not simply a continuum of cores that were discarded at different stages of reduction. However, the shape of cores can go through major changes during reduction. Because of this, the numbers of certain types of cores present in an assemblage may not be directly related to the frequency of the application of a particular core reduction strategy. This, together with the lumping of the core types, may cause additional noise in the data and complicate pattern recognition.

Taphonomic processes have affected faunal collections at the sites, complicating attempts to understand resource and site use. First, the Sujala bone assemblage differs from the others, as it consists of burnt bone fragments only. Second, it is acknowledged that there is variation in bone preservation depending on their size and density (e.g., Bartram & Marean 1999; Binford & Bertram 1977; Lyman 1984). **Figure 7** shows that at Pulli and at Veretye I, for which MNI counts have been published, the count of identified bones per individual is higher for larger species than for smaller species. This is in contrast to the expectation that a relatively higher amount of small mammal bones per individual will be brought to the residential sites, since species of different sizes are butchered and transported under different behavioural regimes. We suggest that the preservation of the bones of different species has been biased in favour of large mammals at these sites. The variable preservation of bones can be expected to cause additional noise in the data.

Site	Laboratory code	^{14}C age	STD	Median age calBC
Pulli	Ua-13352	9095	90	8324
Pulli	Ua-13351	9385	105	8672
Pulli	Ua-13353	9145	115	8393
Pulli	TA-176	9575	115	8969
Pulli	TA-175	9300	75	8541
Pulli	TA-949	9350	60	8618
Pulli	TA-245	9600	120	8987
Pulli	TA-284	9285	120	8532
Pulli	Hel-2206A	9620	120	9001
Pulli	Hel-2206B	9290	120	8539
Pulli, combined				**8614**
Butovo, exc. 1987	GIN-5441	9310	110	**8560**
Sujala	Hela-1102	9265	65	8492
Sujala	Hela-1441	9140	60	8367
Sujala	Hela-1103	8940	80	8091
Sujala	Hela-1104	8930	85	8079
Sujala	Hela-1442	9240	60	8460
Sujala, combined				**8319**
Kultino 3	Tln-1406	8850	200	**7978**
Malaya Lamna 3	*	8800	90	**7904**
Chernaya 1, exc. 2	GIN-3551	8730	300	**7875**
Veretye I	GIN-4031	9050	80	8265
Veretye I	GIN-4869.Mg-P	8790	100	7893
Veretye I	LE-1472	8750	70	7807
Veretye I	GIN-2452.U	8560	120	7614
Veretye I	GIN-4030	8520	80	7560
Veretye I	GIN-2452.D	8520	130	7566
Veretye I, combined				**7755**
Chernaya 1, exc. 1	GIN-3891	8720	200	7852
Chernaya 1, exc. 1	GIN-3894	8630	40	7636
Chernaya 1, exc. 1	GIN-3893	8190	120	7213
exc. 1, combined				**7594**
Spas-Sedcheno 2	GIN-5440	8540	120	**7586**
Oserki 5	GIN-6659	7410	90	**6286**
Bezvodnoye 10	GIN-5442	6920	380	**5848**

Figure 6. Dates for the sites with core data. *Laboratory code not published. Data from Koltsov & Zhilin 1999b; Oshibkina 1997; Rankama & Kankaanpää 2007; Veski *et al.* 2005.

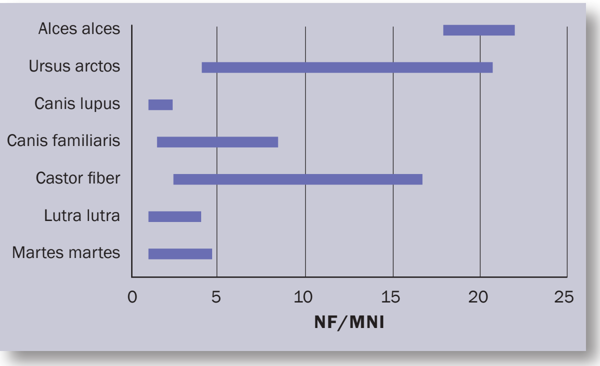


Figure 7. The number of bone fragments / minimum number of individuals at Pulli and Veretye I. The species are in decreasing size order from the left to the right. Only species that are present at both sites are included. Data from Lõugas 1997; Oshibkina 1997.

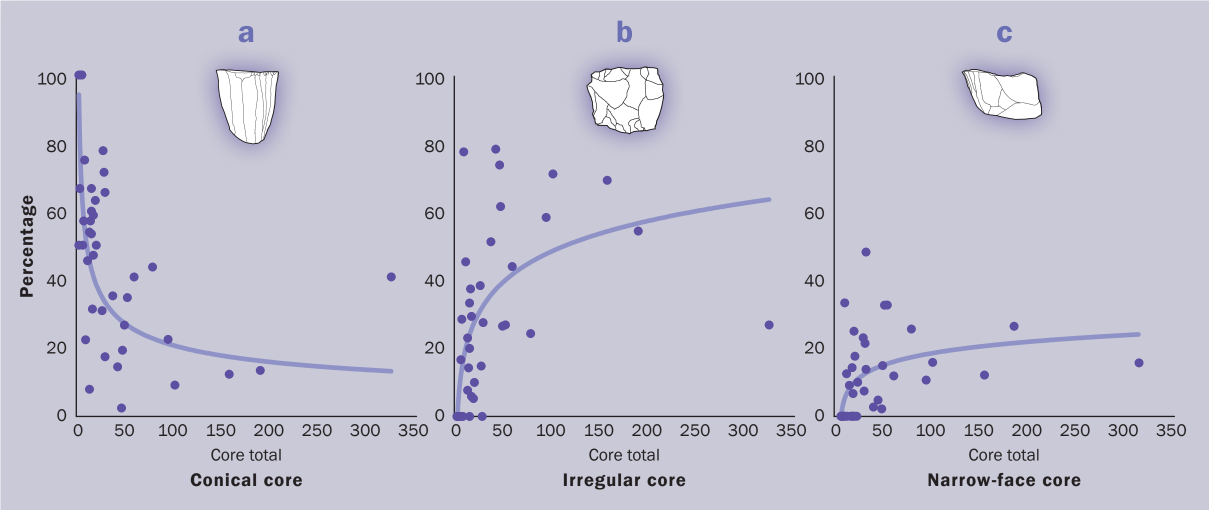


Figure 8:abc. Core assemblage sizes plotted against the percentages of conical, irregular and narrow-face cores. Data from Koltsov & Zhilin 1999b, Oshibkina 1997, Rankama & Kankaanpää 2007.

Study of the variation

Assemblage size and composition

Growing sample size may increase diversity and, therefore, have an effect on the proportions of different categories (animal species, core types) in an assemblage. Due to this, patterns observed in the archaeological data are not necessarily the result of past behavioural variability, but may be related to sample size. In the present cases, there is little information about the representativity of the archaeological assemblages, lithic or osteological. The Sujala site (find cluster 2) is the only one which we know has been excavated completely (Rankama & Kankaanpää 2007). Other sites need to be treated as samples.

Therefore, we first studied the proportion of conical, irregular and narrow-face cores in relation to the size of the core assemblages in Sujala, Veretye I and several sites in central Russia and the East Baltic (Koltsov and Zhilin 1999b:Table 1; Oshibkina 1997:Table 5; Rankama & Kankaanpää 2007). **Figure 8:c** shows that the number of narrow-face cores varies little with assemblage size. **Figures 8:a** and **8:b** further show that for small assemblages the conical core percentage is higher than the irregular core percentage, while the opposite is true for large assemblages. Small assemblages show a higher number of conical cores, while large assemblages show a higher number of irregular cores (**Fig. 9**). This pattern is not likely to be the result of sampling.

As a whole, irregular cores (n=680) are more common than conical cores (n=532) in the studied assemblages (Koltsov & Zhilin 1999b:Table 1, Oshibkina 1997:table 5; Rankama & Kankaanpää 2007). Therefore, if the composition of individual assemblages were purely the result of sample size, small assemblages should show high frequencies of irregular cores. Increasing sample size should decrease the proportion of irregular cores, but this is not the case. If conical cores were more common in the original core population instead of irregular cores, the average conical core percentage should be higher than the irregular core percentage both in small and large core samples, but again this is not the case. We suggest that different core reduction strategies were systematically employed in different circumstances, as discussed above. This explains the variation in site assemblages, their size and composition. Most notably the conical and irregular core patterns are mirror images of each other. This is consistent with the hypothesis that these core strategies were employed at the opposite ends of the mobility continuum. It is also supported by the Sujala site. As the site is excavated completely, the small core assemblage and small core diversity in the Sujala assemblage is not related to sampling, but is the direct result of past behaviour. Notably, the Sujala core assemblage composition parallels other small assemblages. These contain only conical cores (**Figure 8:a**).

Figure 10:a shows that increasing sample size increases richness in Mesolithic bone assemblages in

Estonia, Finland, and Russia until the threshold of *c.* 700 specimens is reached. In the present data set there are three sites that have more than 700 bone specimens: Ozerki 5, Pulli and Veretye I. **Figure 10:b** shows that the size of the bone assemblage and the size of the lithic core assemblage have a strong positive correlation. This is problematic, since the measures of lithic and faunal data (e.g., richness, percentages) will co-vary due to the sample size effect. These things suggest that in the present case the mammalian species richness is not a good proxy for measuring mobility. **Figure 10:c** further shows that assemblage size also largely explains the variation in the large mammal (European elk, reindeer and red deer) percentage. As a consequence, this measure is not without problems, either. However, there is reason to suspect that the large mammal percentage is not only an artefact of sample size. For the larger set of osteological data (**Figure 5**), bone assemblage size still explains almost 90% of the variation in richness but only 61% of the variation in large mammal percentage. This suggests that other factors than sample size have had an effect on the large mammal percentages. To have an additional measure, we further studied assemblage formation and the applicability of the lithic to bone ratio as an indicator of site use and mobility.

Sampling a standard lithic core and bone population should produce a relatively stable core to bone ratio pattern for the subpopulations. **Figure 5** shows that this is not case in the present context, and that the lithic core to bone ratio varies markedly. To a degree, the differences in the ratio may be related to the preservation of faunal remains at the sites, but these processes cannot be controlled properly beyond what has been discussed above. However, the Veretye I case suggests that preservation alone does not explain the variation in core to bone ratios. Despite the exceptionally good preservation of the organic material (osseous and wooden tools, birch bark containers, etc.), the Veretye I site has a high core to bone ratio when compared with Pulli and Ozerki 5. The relative amount of bones at Pulli, for example, is almost

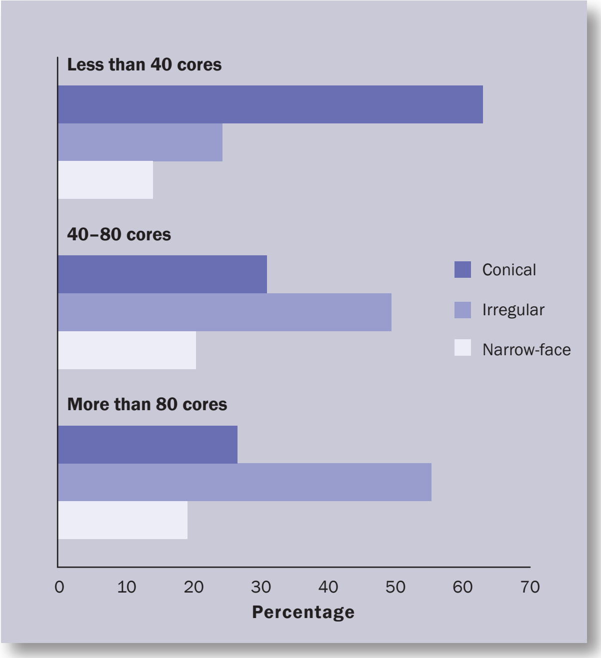


Figure 9. Conical, irregular and narrow-face core percentages in small, medium and large core assemblages (less than 40 cores, 40 to 80 cores, and more than 80 cores).

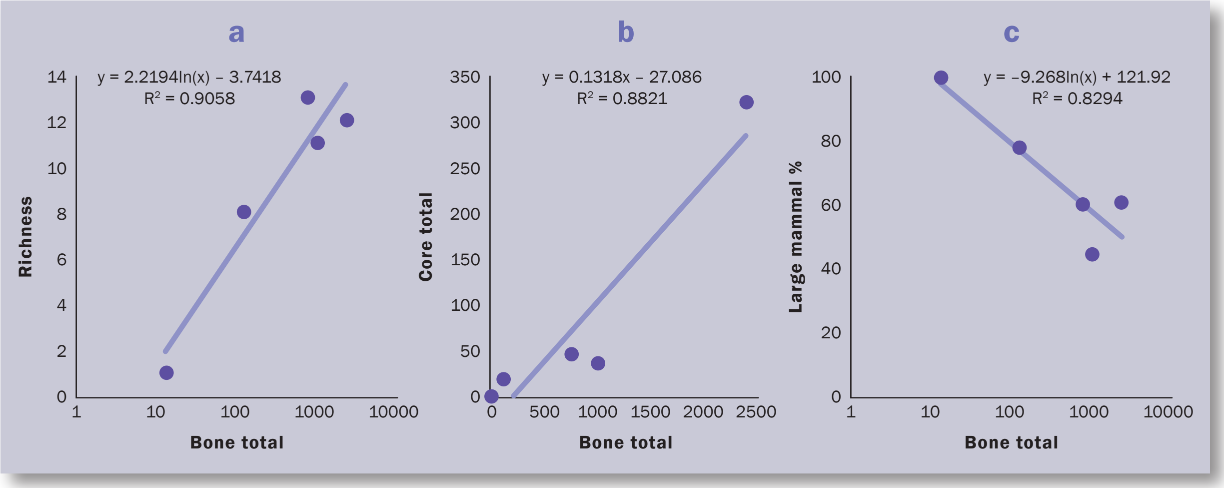


Figure 10:a. Mammal bone totals and species richness at the sites. **10:b.** Mammal bone totals and core totals at the sites. **10:c.** Bone totals and large mammal percentages.

four times higher than at Veretye I. This is in contradiction with the animal bone data that suggest that the Veretye I bone assemblage is better preserved than the Pulli assemblage: at Veretye I, almost all animal species are represented by more preserved bones per individual (**Fig. 7**). Therefore, we suggest that past behaviour explains at least part of the lithic core to bone ratio variation at these sites, and that this proxy can be used as an indicator of site use and mobility.

Increasing the length of a stay at a site means that a growing amount of lithics and faunal remains are brought to the site. As demonstrated above, faunal remains accumulate at a site much faster than lithic cores. The relative amount of bones at a site is expected to be the result of the strategies of bringing prey into the site. As explained above, in high mobility situations, foragers use only a fraction of the available resources in a patch, and a small amount of animal foods is brought to the site. In low mobility situations a diversity of animal species are hunted and brought back to the site. If this is the case, then the core to bone ratio can be expected to be patterned along the gradient of mobility and to correlate with the core reduction strategies. In other words, those assemblages that, as a result of low mobility, include a high relative number of bones should include a high number of irregular cores, while assemblages with a low relative number of bones should include a high number of conical cores.

To summarise, we suggest two variables that employ faunal data to measure mobility. The percentage of large land mammals is expected to be high in assemblages formed under a high mobility regime. This method is problematic due to the variation in osteological sample size and the unequal preservation favouring the bones of large animals. The core to bone ratio is not related to sampling, but is sensitive to bone preservation and identification. In this sense, we consider Sujala to be the most problematic assemblage, as burnt bone assemblages typically show low numbers of identified specimens when compared with unburnt assemblages. Due to the small bone assemblage, even a small change in the identified fragments results in a major change in core to bone ratio. Therefore, we studied the core to bone ratios and the core type percentages with and without Sujala.

Fauna and core reduction strategy – large mammals

If the conical blade core reduction strategy results from the need for a generalised core reduction strategy especially suitable for a mobile way of life, then there should be a positive correlation between the proportion of conical cores and indicators of high mobility. **Figure 11:a** shows that there is a positive correlation between the percentage of large land mammals and the frequency of conical cores in the assemblages. The proportion of large mammal bones explains *c.* 76% of the variation in conical core assemblages. **Figure 11:b** shows that the correlation between the large mammal percentage and irregular cores is negative. **Figure 11:c** shows that the large mammal percentage explains narrow-face core technology poorly.

Fauna and core reduction strategy – lithic to bone ratio

If irregular cores were employed in low mobility situations, when a relatively large amount of bones accumulated at the sites, then the high proportion of this core type should correlate with low core to bone ratios. **Figure 12:b** shows the negative correlation between core to bone ratios and irregular core percentages. The core to bone ratio explains *c.* 91% of the variation in irregular core percentages at the sites (*c.* 87% if Sujala is excluded). This is consistent with the mobility hypothesis, and with the previous finding that the large lithic assemblages have more irregular cores, as discussed above.

If the conical core strategy results from the need for a generalised core reduction policy especially suitable for a mobile lifestyle, then there should be a positive correlation between the proportion of conical cores and indicators of high mobility. **Figure 12:a** shows that there is a positive correlation between core to bone ratio and the percentage of conical cores. The core to bone ratio explains *c.* 78% of the variation in conical core proportions in the assemblages (*c.* 57% if Sujala is excluded).

Figure 12:c shows that the core to bone ratio does not correlate with narrow-face cores. Therefore, it seems that the use of narrow-face cores is not related to mobility. These cores seem to have been employed in variable contexts.

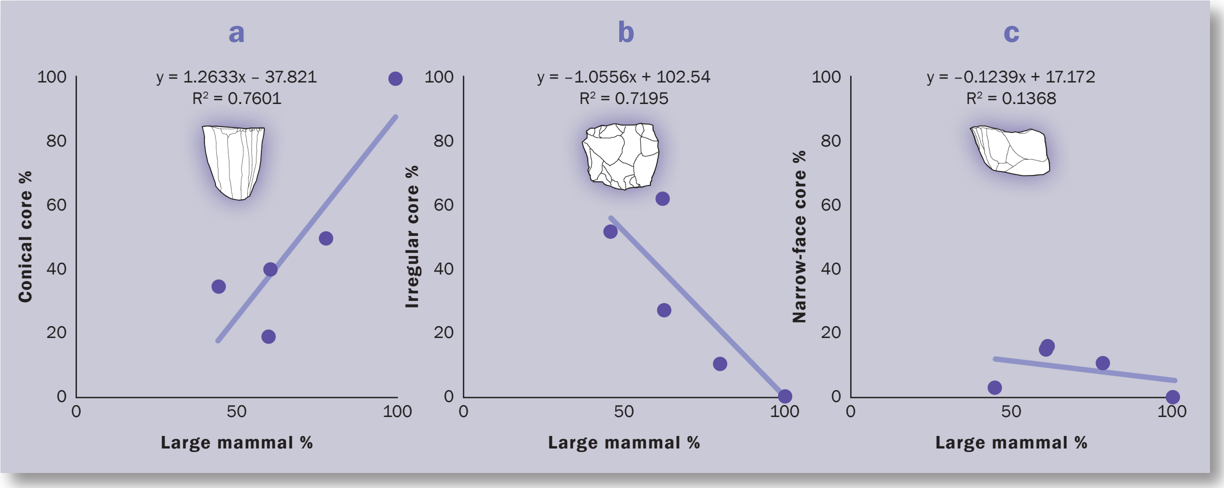


Figure 11:abc. The proportions of large mammals plotted against core type percentages.

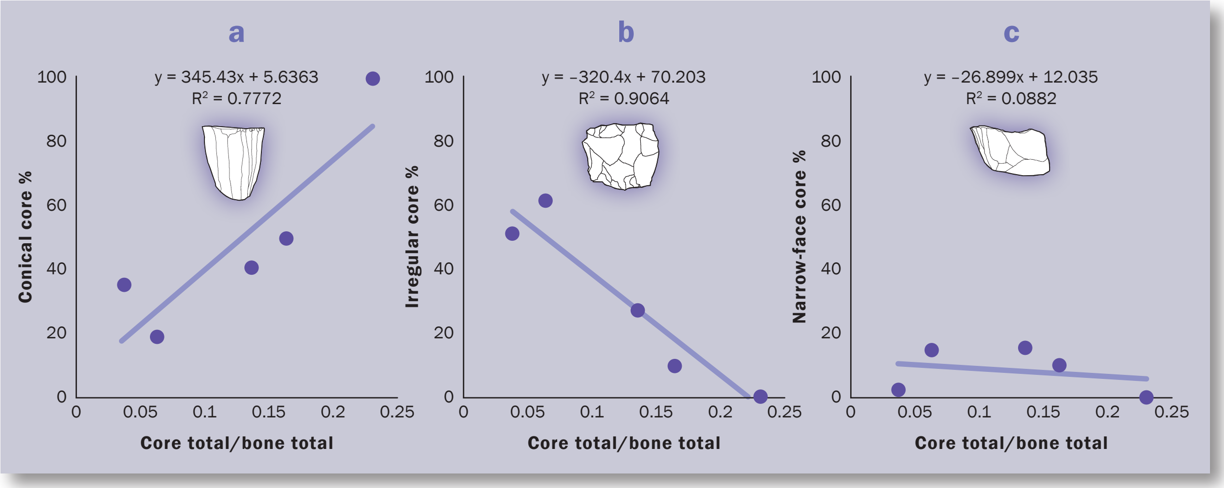


Figure 12:abc. Core to bone ratios plotted against core percentages at the studied sites.

Comparison between Sujala and Veretye I

The above results, i.e. the behavioural link between core assemblage size and composition on the one hand, and core data and faunal evidence on the other, suggest that the Mesolithic hunter-gatherers intentionally varied their core reduction strategies in relation to site use and mobility patterns. When the Mesolithic hunter-gatherer mobility level was high and there was a need to employ an easily transportable and versatile core technology, the technology was adapted accordingly by investing in a conical blade core strategy. If this is true, then archaeological data other than lithics and bones should also be patterned accordingly. Two sites, Sujala and Veretye I, provide data for testing the hypothesis further. For the other sites we lack similar data.

The Sujala site in northern Finland supports the hypothesis that high mobility and investment on conical core reduction strategy are related to each other. The evidence for the site use activities and housing is in good agreement with the lithic core (low diversity, investment in conical cores) and faunal data (low diversity, investment in large land mammals). The small site area with little evidence for structural remains and the patterning of finds around a hearth indicating easily transportable housing (Kankaanpää & Rankama *this volume*; Rankama & Kankaanpää 2007) all imply that the site was used for a relatively short time and that the mobility level of these hunter-gatherers was relatively high.

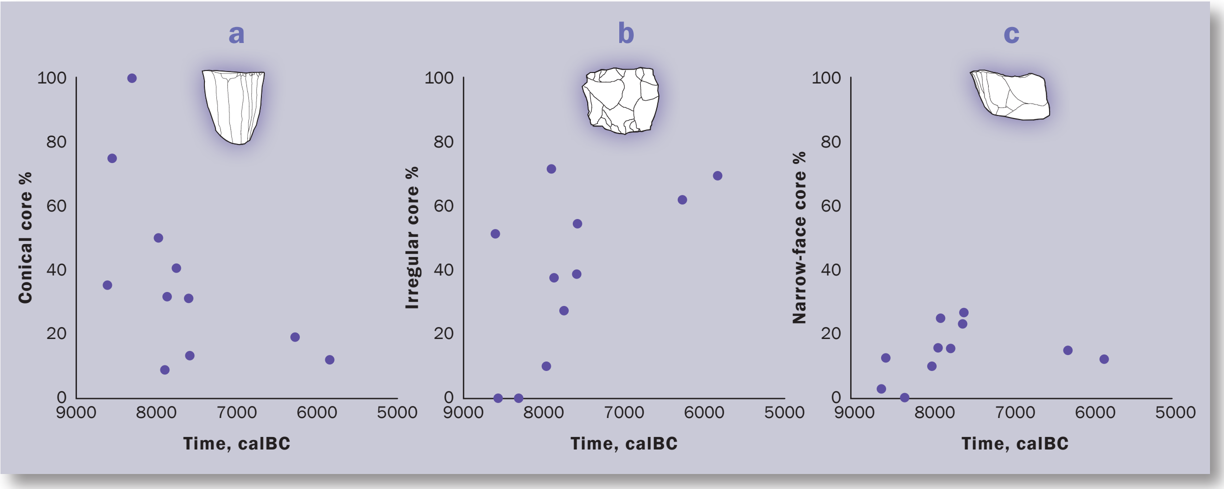


Figure 13:abc. Time and conical core percentages. Time and irregular core percentage. Time and narrow-face core percentages.

The archaeological data from Veretye I lend support to the association between decreasing mobility and decreasing reliance on conical core technology. Among other things, the Veretye I excavations revealed preserved wooden house structures that suggest a relatively low level of mobility when compared with Sujala. At Veretye I, lithic raw material and cores were also stored at the site in birch bark containers, most probably in anticipation of future use (Oshibkina 1989). Caching of lithic raw material at the site suggests that the emphasis was on provisioning sites, rather than individuals, a further indication of relatively low mobility (Kuhn 1995).

As a whole, it seems that as residential mobility decreased, the conical core reduction strategy was given less emphasis, suggesting that conical core reduction was either a relatively costly strategy to invest in or that the other reduction strategies had advantages that the conical core strategy could not offer. In such settings the use of conical cores was still profitable during hunting trips and other logistical activities, but it was less advantageous to employ that strategy alone.

Temporal patterning and core reduction strategy

Elsewhere, we have argued that Early Mesolithic hunter-gatherers in north-eastern Europe in general had larger home ranges and were more mobile than their successors (Hertell & Tallavaara *this volume*). This is mirrored in the osteological collections, which show a decreasing proportion of European elk through the Mesolithic.

If the Early Mesolithic hunter-gatherers in north-eastern Europe were more mobile than their successors, we would expect to see evidence of temporal changes in their lithic technology. In other words, the conical core percentage should decrease through time, while the irregular core proportion should increase. **Figure 13:a** shows that the use of the conical core reduction strategy decreased through time, although the correlation is rather modest. The narrow-face core shows no proper trend when the whole Mesolithic is considered, but there is a clear rising trend between 8600 and 7600 calBC (**Fig. 13:c**). After this period, the combined proportions of the two blade reduction strategies markedly diminished. The percentage of irregular cores shows an inverse pattern as compared with the conical cores (**Fig. 13:b**). This is mirrored in the central Russian Mesolithic Butovo complex sites, for which Koltsov and Zhilin demonstrated that the frequency of flakes increased from the middle boreal period onwards towards the end of the Mesolithic (Koltsov & Zhilin 1999b:135). Beyond the general pattern, the conical and irregular cores also show marked variation in core frequency in the Early Mesolithic. The figures may also indicate that frequency shifts grew less common through time (**Figs. 13:a, b**).

Discussion

The results show that lithic core assemblage size and composition are systematically related in Mesolithic north-eastern Europe. Small site assemblages have a high proportion of conical cores, and large assemblages have a high proportion of irregular cores. Site use intensity and core to bone ratios also correlate with the lithic core assemblage composition. These indicate that these hunter-gatherers intentionally varied their core technologies. We suggest that the hunter-gatherers employed different core reduction strategies as a response to the constraints that mobile life placed on technologies. Furthermore, the variation in intra-site data, housing, and lithic provisioning strategies at Sujala and Veretye I agrees well with the lithic core and faunal data. Thus, increasing mobility, decreasing occupation length, the provisioning of individuals, the increasing use of conical core reduction, and assemblage size are all related to each other. There is also a correlation between conical and irregular core technology and the proportion of large land mammals in the refuse fauna, although the effects of sampling complicate the interpretation of these patterns. Interestingly, narrow-face cores have little correlation with assemblage size or faunal indicators at the studied sites, but show a clear temporal trend.

The conical core reduction strategy employed in Mesolithic north-eastern Europe was a core technology suitable for ensuring tool stone availability and minimising weight and raw material consumption, while at the same time providing blanks for different needs from a single core. In this sense, the technology parallels the New World Late Pleistocene Clovis and Folsom bifacial core and tool technologies, which have been linked with the constraints posed by high-mobility regimes (Kelly 1988; Kelly & Todd 1988).

We suspect that the conical blade reduction strategy may have had a selective advantage over other reduction strategies, and that this was especially significant in the Early Mesolithic context. According to Koltsov and Zhilin, blade production in the central Russian Mesolithic Butovo complex was the most elaborate during its second stage, i.e., the Late Preboreal–Early Boreal, (Koltsov & Zhilin 1999b:135). This period corresponds to the time of the post-glacial human expansion northwards (e.g., into Finland) and may imply a link between high mobility, lithic technological organisation, and the colonisation of uninhabited lands. In a similar fashion, the increasing reliance on narrow-face blade cores after 8600 calBC coincides with the time period during which the colonisation reached the northern parts of Finland. This suggests that core technologies were related to forager niche and habitat selection. Filling up the available habitats in northern Europe gradually made it optimal to increase diet breadth and restricted the options for high mobility. This suggests a gradual relaxation of the need to maintain an efficient multi-purpose conical core technology. The other side of the coin, i.e., the growing popularity of the irregular core reduction strategy through the Mesolithic, parallels the large-scale pattern in North America, where the emphasis on informal core strategies was demonstrated to grow with diminishing mobility (Parry & Kelly 1987).

Hunter-gatherer mobility strategies can change markedly even during a single year, for example from one season to another. The emphasis on different core reduction strategies can therefore vary widely in a short time. In the winter, frozen ground and snow cover pose problems for raw material procurement. This implies that the core technology of mobile foragers, who cannot provision sites or collect raw material freely from snow-covered ground, tends towards raw material conservation and efficient core technology. The availability of transportation technology, however, is expected to diminish the constraints that mobility places on technologies (Binford 1990; Shott 1986:32). Transportation technology makes it possible to have extra tool stone on hand in times of need and therefore decreases the effect of mobility. In north-eastern Europe, osteological data show that Early Mesolithic hunter-gatherers mainly targeted terrestrial species, and that aquatic resources were of less importance (e.g., Koltsov & Zhilin 1999b; Lõugas 1997; Ukkonen 2001). The use of terrestrial resources implies a constant need to traverse dry land areas. Sledge runners preserved in bogs are known from the Early Mesolithic onwards and imply that sledges were used for transportation in the winter time (Aario 1934; 1935; Seger 1988:21; 1990:16). Dog bones further suggest that these animals may have been used as beasts of burden (Oshibkina 1997; Seger 1988:23; Schulz 1996:25; Ukkonen 2001). Summing up, we suggest that the north-east European Mesolithic, and especially the Early Mesolithic, archaeology makes an interesting case for future research on hunter-gatherer mobility and the organisation of technology. In this high-latitude area, the constraints that high mobility and winter conditions place on core technology act against transportation technology and its alleviating effect. These vectors, pulling in different directions, suggest a system that is not stable but is instead liable to change radically even with a small change in the underlying parameters. We suspect that this may explain the high variability observed in the core frequencies (seen in **Figures 13:abc**) in the Early Mesolithic.

In north-eastern Europe, the importance of aquatic resources increased during and after the Mesolithic (e.g., Kriiska 2001; Ukkonen 2001). This suggests that the transportation technology was simultaneously reorganised and that watercraft became increasingly important in hunter-gatherer adaptations at this time. As an increasing use of aquatic resources typically suggests diminishing residential mobility (Binford 2001, Kelly 1995), the increasing use of water transportation technology and reduced mobility parallel each other and act together to relax the constraints that mobility places on technologies. We further suggest that the use of advanced watercraft levelled any difference in the transportation costs between seasons. As a consequence, the variation of core frequencies is smaller in the Late Mesolithic, and, especially, in the Sub-Neolithic assemblages, in comparison with the Early Mesolithic assemblages. This kind of a trend may be seen in **Figures 13:a & b**, which show a high degree of variation in the percentages for the Early Mesolithic and lower variation in the Late Mesolithic, although data for the Late Mesolithic are currently scarce. Furthermore, coastal and inland areas show different changes in the foraging strategies (Koltsov & Zhilin 1999b; Lõugas 1997; Oshibkina 1997; Ukkonen 2001), which suggests that the core reduction strategies had different evolutionary trajectories from area to area. Hunter-gatherers allocating time to aquatic foraging had less constraints on core technology than inland hunters with a larger proportion of terrestrial resources in their diet. Therefore, we predict that inland foragers in the area were more efficient in their use of raw material. When tool stone availability is considered, this analysis also suggests that there was a change in the constraining factors with time. The importance of the availability of natural raw material and its effect on technological organisation is expected to grow in contrast to the constraints caused by mobility and the need to provision individuals. These predictions can be tested in future analyses.

The systematic production of symmetrical blades from conical blade cores requires more personal practice and skill than the detachment of flakes from irregular cores. Our results imply that the relatively higher investment in learning conical core blade production, possibly in childhood, was compensated for later in life by efficient core technology. Those who had technologies that allowed frequent camp moves for locating and consuming high-return-rate food patches had a selective advantage over others. Conical core technology provided one such advantage. We therefore suspect that when the symmetrical conical core reduction strategy came into use, it was adopted quickly by many hunter-gatherers in the area. This is supported by the archaeological distribution of conical core technology, which implies a convergent evolution among many hunter-gatherer groups. Similar core reduction strategies are found over a large area, from Central Russia to the Barents Sea and from the Baltic Sea to the Ural Mountains and beyond (e.g., Burov 1999b; Koltsov 1989; Koltsov & Zhilin 1999b; Kosinskaya 1997; Rankama & Kankaanpää 2008). The vast size of the area suggests that many groups adopted the technology. Our analyses imply that the adoption was due to the selective advantage of the technology. Inside this area, core reduction strategies may therefore have little value for archaeologists for analysing and distinguishing ethnic groups in time or space, but they can be fruitful from a systems perspective, as illustrated above. In other areas, such as North America and western Europe, different trajectories in cultural evolution caused selection to operate on a different set of behavioural variants in the Late Pleistocene and Early Holocene context.

Conclusion

Our results show that north-east European Mesolithic core technology is a fruitful subject for the study of technological organisation. The analyses suggest that core technologies are correlated with assemblage size and the faunal record. This implies a systemic link between different areas of hunter-gatherer life, in this case foraging, mobility and core technology. The symmetrical conical blade core reduction strategy was a technology adjusted to the constraints of mobile life. Irregular flake core and narrow-face blade core strategies were employed in different settings and were practised when there was less need to maximise the number and diversity of blanks from a single core.

For future research, it can be summarised that we expect the conical core technology, exemplified at Sujala, to be correlated with indicators of high residential mobility in the studied area in north-eastern Europe. Additionally, a diversification of blade and other core technologies can be expected when residential mobility decreases and the need for a multi-purpose conical core strategy diminishes. We have further suggested that the frequency shifts in the application of a core strategy diminish with time. If the conical core strategy was selectively advantageous in colonisation settings, we also expect to see a high frequency of symmetrical conical core technology correlated with dispersal towards the north. As new sites and new data become available, these suggestions can be tested further.

Acknowledgements

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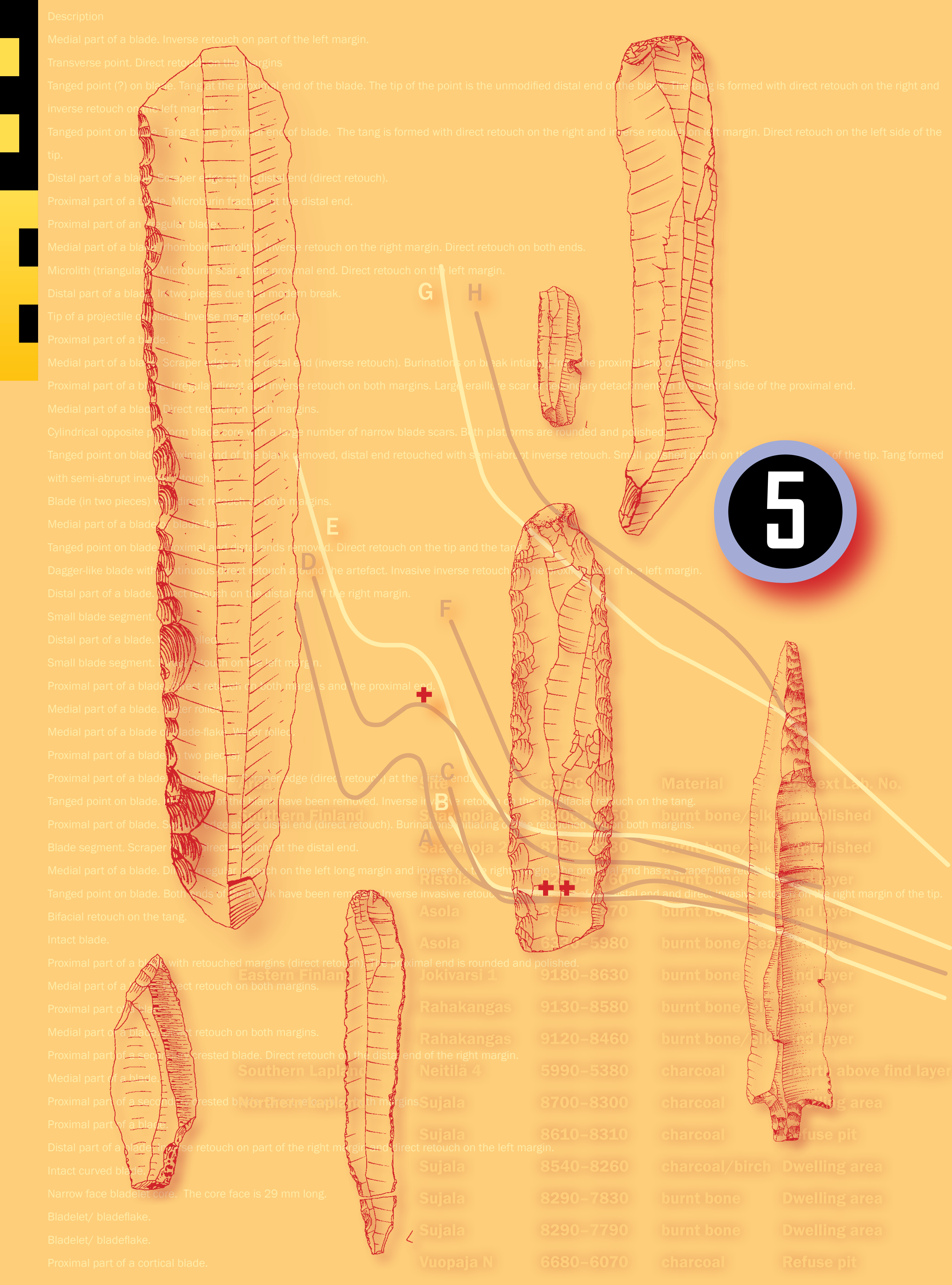

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Few and Far between – an Archive Survey of Finnish Blade Finds

Mikael A. Manninen & Esa Hertell

ABSTRACT Blades and blade-related finds are scarce in Finland, where ground and polished stone tools and simple flake-based technologies prevailed during most of the Stone Age. The few finds of blades deriving from systematic blade production have been largely ignored in the past. Recently, three excavated early post-glacial sites (Lahti Ristola, Lappeenranta Saarenoja 2 and Utsjoki Sujala, *c.* 8800–8000 calBC), with assemblages indicating elaborate blade technology, have brought blades and blade technologies into archaeological research focus in the area. This paper presents results of an archive survey conducted to map the temporal and geographical distribution of the blade finds currently kept in Finnish museum collections. The survey revealed 34 locations with prehistoric blade artefacts (including stray finds). The finds point towards three areas of origin: north-western Russia, southern Scandinavia, and northern Norway. According to contextual and technological details, most of the finds belong to the Mesolithic but later artefacts are also present.

KEYWORDS
Blade technology, blades, lithics, radiocarbon dates, shore-displacement chronology, typology, Finland.

Introduction

Ground and polished stone tools and simple flake-based technologies prevail in Stone Age assemblages in Finland, whereas artefacts indicating blade technology are markedly scarce (Hertell & Manninen 2005; Jussila *et al.* 2007; Luho 1956; Nuñez 1998; Rankama 2002; Rankama *et al.* 2006; Schulz 1990). Due to this scarcity, blade artefacts were rarely discussed in the archaeological literature in Finland prior to the 1980s (but see, e.g., Luho 1956; Meinander 1964). However, since the recognition of an Early Mesolithic component in the assemblage from the Ristola site in Lahti in the early 1980s, the presence of blades in the local archaeological record has become increasingly acknowledged (e.g., Edgren 1984; Hertell & Manninen 2006; Kinnunen *et al.* 1985; Matiskainen 1989; Matiskainen 1996; Pesonen 2005; Schulz 1996). Recently, three excavated early post-glacial sites (Lahti Ristola, Lappeenranta Saarenoja 2, and Utsjoki Sujala, *c.* 8800–8000 calBC) with assemblages indicating elaborate blade technology, have brought blades and blade technologies into archaeological research focus in the area (e.g., Jussila & Matiskainen 2003; Jussila *et al.* 2010; Kankaanpää & Rankama 2006; Kankaanpää & Rankama *this volume*; Rankama & Kankaanpää 2007a; b; 2008; Takala 2004; 2006; 2009).

In line with the growing interest in blade technologies, this paper provides an overview of blade finds from Finland. We present the results of an archive and literature survey conducted to map the temporal and geographical distribution of blade finds in the country. Special attention is given to stray finds and sites that have received little attention in earlier studies or are not currently being studied by others. In addition, we will discuss the results in relation to blades from neighbouring regions and the small number of published blade assemblages in Finland.

Definitions, survey methodology and the potential of the database

In this paper, we consider a blade to be a detached piece with a single point of fracture initiation that has a minimum length-to-width ratio of 2:1 in addition to straight parallel sides that run in the direction of the force of detachment and that consequently are more or less perpendicular to the platform remnant. According to our definition, a blade also has one or more dorsal ridges more or less parallel to the lateral edges. Consequently, some artefacts published as blades in earlier studies were excluded from the survey. Distinguishing between irregular blades and bladelike flakes using these criteria is uncertain in many cases, and therefore, we have used contextual evidence, and in some cases subjective opinion, when classifying ambiguous bladeflakes. Due to the problems in detecting many of these features reliably in quartz artefacts and the vast amount of unclassified quartz assemblages in museum collections against the handful of published analyses of quartz technology in Finland, we have excluded the possible rare quartz blades from this study (see Jussila *et al*. 2007; Luho 1956; Rankama & Kankaanpää *this volume;* Schulz 1990; Tallavaara 2007:49; but see Knutsson 1993; 1998; Siiriäinen 1981) and present blades made of raw materials other than vein quartz or quartz crystal.

The core platform and the core-face are usually prepared to facilitate the removal of a symmetrical blade. Archaeological collections and experimental studies indicate that there is a wide variety of ways to prepare blade removals. These include cresting of the core face prior to blade removals; grinding and faceting of the core platform during reduction; the regularisation of the core platform edge by trimming off overhangs; isolating platforms; maintaining the core face convexity; and controlling the shape of the distal end of the core (Bordes & Crabtree 1971; Flenniken & Hirth 2003; Giria & Bradley 1998; Inizan *et al*., 1999; Pelegrin 2006). Evidence for systematic platform preparation and the application of many of these core preparation and maintenance methods is also known in Finland, most notably from the Sujala site located in northern Finnish Lapland (Kankaanpää & Rankama 2006; *this volume*; Rankama & Kankaanpää 2007a; b; 2008). Our survey did not require evidence of such preparation, as its signs are not preserved in artefacts that lack the proximal end of the blade, such as blade sections and many types of tools made on blades.

The blade data were gathered from publications, the National Board of Antiquities archaeological find catalogue (KM), and unpublished reports. No systematic sampling (e.g., random sampling) was attempted. Instead, the current database was simply allowed to accumulate when blades, tools and cores were encountered in books, reports, or collections. Some artefacts were studied only on the basis of published reports, but blade artefacts available in the archives and collections in mainland Finland were examined and documented by the present authors when possible. Blade artefacts deemed to be modern, most notably gun flints, were excluded from the database. The resulting data (i.e., measurements and short descriptions of artefacts comprising a group accumulated during some 125 years from stray finds sent to the collections or from finds made in excavations and surveys) are presented here (see **Appendix I** for data). Additional finds that we have not had the chance to verify and/or document but that have been reported as blade artefacts are listed in **Appendix II**.[1]

Despite the data-collection strategy, it is unlikely that any large blade assemblage has gone unnoticed in this survey. Because of the way the data was collected, however, the database cannot be taken to prove the lack of blades in an area, or used to study the density of blade finds in statistical terms by comparing the density of finds between one area and the next.

[1] We wish to thank Petro Pesonen for providing information on many of these artefacts.

Figure 1. Blade finds from Southern Finland (see map for locations and Appendix III for catalogue numbers): a1–7) Ristola; b1–2) Asola; c1–5) Bötesberget; d1–3) Lammashaka; e) Siltapellonhaka; f) Sperrings; g) Pöllölä; h) Hietalahti 1; i) Teuronjoki; j) Saarenoja 2; k) Pöydänpäänniemi; l) Jönsas; m) Kirkonkylä. Scale in centimetres. National Museum of Finland.

Figure 2. Blade finds from eastern Finland: a) Jaakonsaari; b) Nilsiä; c) Kotiranta; d) Jokivarsi 1; e) Issakkalansärkkä; f) Joensuu; g) Niemenjärvi; h1–8) Syväys 1. Scale in centimetres. National Museum of Finland (a, c–h) and Kuopio Museum (b).

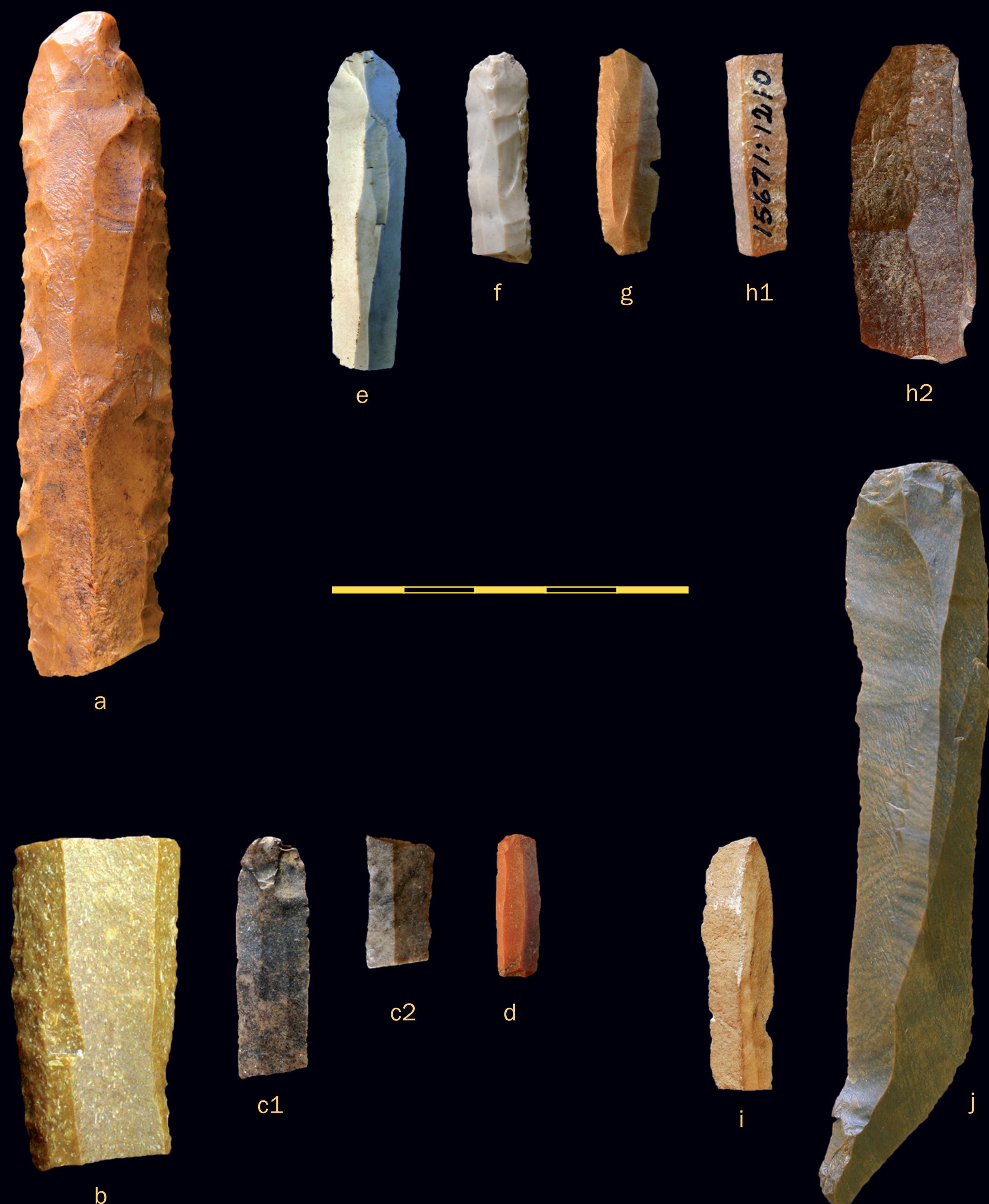


Figure 3. Blade finds from northern Ostrobothnia (a), Kainuu (b–d), southern Lapland (e–h), and northern Lapland (i–j): a) Myllykoski; b) Jussinlahti; c1–2) Kalmosärkkä; d) Vonkka 2; e) Pitkäniemi; f) Korkalon pelto; g) Keskioikarainen; h1–2) Neitilä 4; i) Vuopaja N; j) Rovaniemi. Scale in centimetres. National Museum of Finland.

Results

The survey revealed 34 prehistoric blade find locations and 13 additional locations where blade finds have been reported, but were not verified and/or documented in this study for logistical reasons, representing a total of 47 locations. This is a small number when compared to the total number of known Stone Age sites in Finland (*c.* 10,000 sites excluding stray find locations). If the three aforementioned excavated early post-glacial sites are excluded, blade artefacts in Finland are primarily single stray finds or single finds within site assemblages.

The group of artefacts documented in the survey consists of cores, blades and blade fragments, arrowheads, scrapers, burins, and other retouched tools on blades (**Figs. 1–3**)[2]. The raw material variation among the blade artefacts is considerable. Many artefacts appear to be made on varieties of eastern Carboniferous flint, but blades made of jasper, North-Norwegian cherts, and Cretaceous and possibly Tertiary flint seem to be represented as well (**Fig. 4, Appendix I**)[3]. The raw material classification, however, is based primarily on visual appearance, context, and artefact type, and only in a few cases has the origin of the raw material used to produce blades been studied petrologically (Kinnunen *et al.* 1985; Takala 2004:Fig. 110; Rankama & Kankaanpää 2008:888). In particular, the origin of grey and black flints is often difficult to determine from the visual appearance of the raw material, as different kinds of Cretaceous and Tertiary flints are found in the area stretching from southern Scandinavia to the Moscow region in Russia (e.g., Herforth & Albers 1999:Abb. 1). The colourful raw materials are more readily defined as eastern flints from the Carboniferous formation that stretches from the Moscow area north to the White Sea (e.g., Kinnunen *et al.* 1985), although they can be confused with North-Norwegian cherts (Hood 2006), Paleozoic flints available, for instance, in Estonia (Kriiska *et al. this volume*), and local jaspers (e.g., Kinnunen *et al.* 1985).

	No. of sites	No. of blade artefacts
Carboniferous flints	13	*c.* 300
Cretaceous flints	9	*c.* 150
Jasper	1	2
Silicified slate-like material	1	2
Northern chert	3	*c.* 3000
Undefined flint/chert	9	12

Figure 4. Raw materials of the Finnish blade artefacts (including published and a rough estimate of unpublished artefacts from Sujala, Ristola, Rahakangas 1, and Saarenoja 2). Provenance is suggested primarily according to the visual appearance of the raw material and should be considered tentative.

Spatial distribution of the blade finds

Present-day Finland was completely covered with ice during the last glacial cycle and gradually emerged from under the north-west-retreating Scandinavian ice sheet between *c.* 10,500 calBC and *c.* 8000 calBC (Saarnisto & Saarinen 2001; Johansson & Kujansuu 2005). In concert with the retreating of the ice, isostatic uplift was initiated, and large parts of the country emerged from the waters of the marine and lacustrine phases of the Baltic Sea Basin, i.e., the Baltic Ice Lake *c.* 10,500–9600 calBC, the Yoldia Sea *c.* 9600–8750 calBC, the Ancylus Lake *c.* 8750–6200 calBC, and the Litorina Sea *c.* 6200–1600 calBC (dates according to Andrén *et al.* 2000).

The geographical distribution of blade finds in Finland (**Fig. 5**) shows that although the locations are relatively widely spaced, blades have been found in most parts of the country, from southern Finland to northern Lapland. The primary exception is the western coastal area that was largely submerged during the Mesolithic and emerged only during later periods. The large Ancylus Lake archipelago in central Finland also seems to be currently lacking blade finds, although this could be partly a consequence of data-gathering methods. A large part of the artefacts derives from supra-aquatic areas in eastern and northern Finland (i.e., from areas that were never on the shore of the Baltic Sea basin), but an equal number of the blade finds are from locations that were on the coast during the Holocene. For the purpose of this paper, the locations with documented and/or published blades can be divided into five groups according to geographical distribution:

[2] All photographs and drawings by the authors.

[3] The terms *flint* and *chert* are used interchangeably in the literature when discussing the Carboniferous flint/chert, whereas the North-Norwegian flint-like fine grained raw materials are usually called *chert*. In this paper we use *flint* when discussing the Carboniferous chert/flint and *chert* when discussing the northern fine grained raw materials.

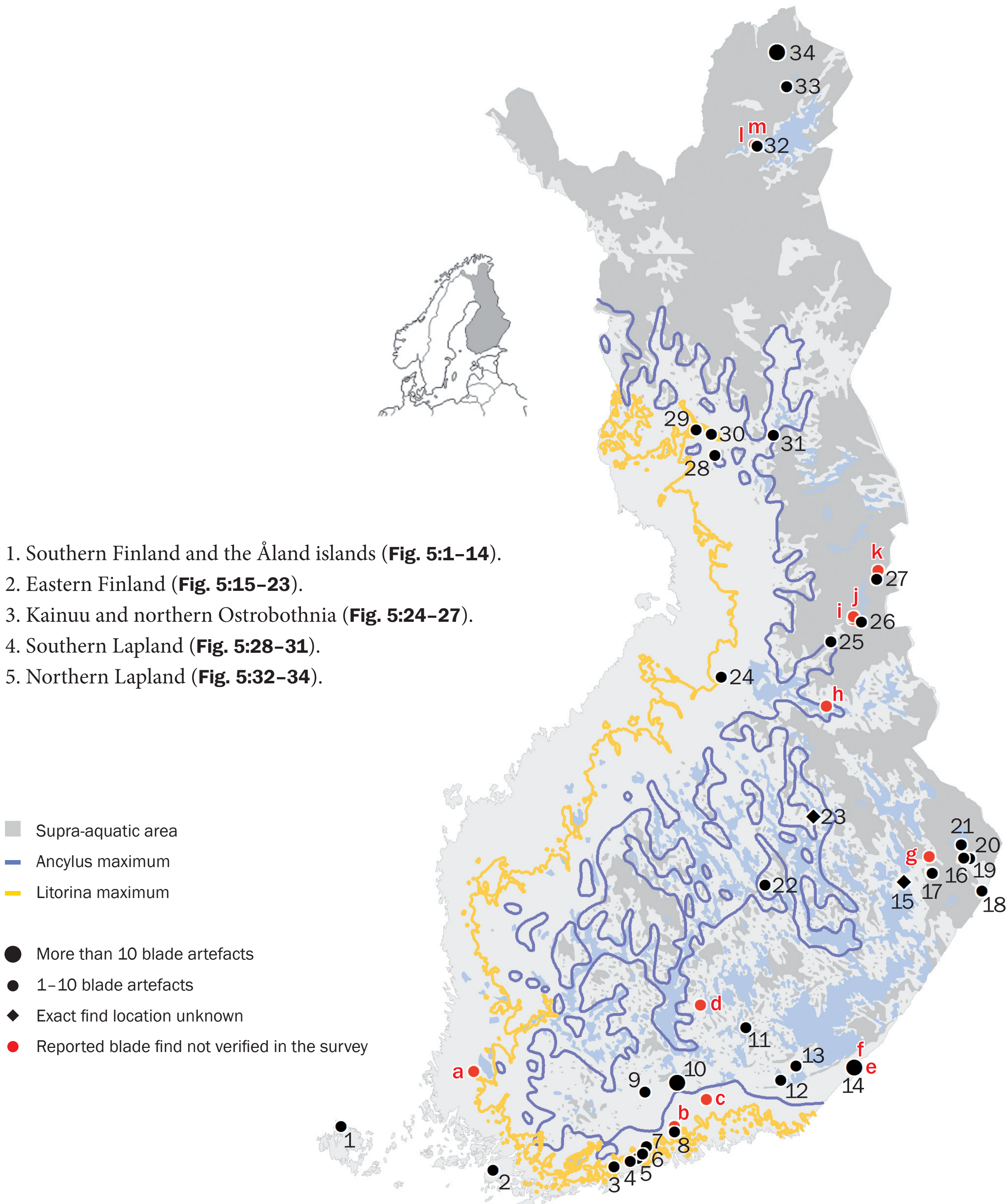


Figure 5. Blade find locations, supra-aquatic areas, the Ancylus transgression maximum (*c.* 8400 calBC), and the Litorina transgression maximum (*c.* 5600 calBC) in Finland (note that the highest shores are diachronic). Sites with published blades or blades documented in this survey (black dots and diamonds). **Southern Finland:** 1. Smikärr; 2. Bötesberget (Nordanå C); 3. Sperrings; 4. Jönsas; 5. Kirkonkylä; 6. Asola (Koivukylä 5); 7. Lammashaka; 8. Siltapellonhaka; 9. Teuronjoki; 10. Ristola; 11. Pöydänpäänniemi; 12. Hietalahti 1; 13. Pöllölä; 14. Saarenoja 2. **Eastern Finland:** 15. Joensuu; 16. Jokivarsi 1; 17. Rahakangas 1; 18. Niemenjärvi; 19. Issakkalansärkkä; 20. Jaakonsaari; 21. Syväys 1; 22. Kotiranta; 23. Nilsiä. **Kainuu & northern Ostrobothnia:** 24. Myllykoski; 25. Vonkka 2; 26. Jussinlahti; 27. Kalmosärkkä. **Southern Lapland:** 28. Pitkäniemi; 29. Korkalon pelto; 30. Keskioikarainen; 31. Neitilä 4. **Northern Lapland:** 32. Vuopaja N; 33. Rovaniemi; 34. Sujala. Sites with reported (unpublished) blades not verified in this survey (red dots): a) Kolmhaara; b) Taka-Piskulan Ruoksmaa; c) Tortola 2; d) Uusi Ruskeala C; e) Saarenoja-Muilamäki; f) Hiekkasilta-Hiekkakuoppa; g) Mäntyniemi; h) Kiikarusniemi; i) TB:n ranta; j) Kukkosaari; k) Tormuan särkkä; l) Saamenmuseo; m) Vuopaja.

Area	Site	calBC, 2σ	Material	Context	Lab. No.	BP	Publication
Southern Finland	Saarenoja 2	8800–8350	burnt bone/elk	unpublished	Hela-758	9350±75	Jussila *et al.* 2010
	Saarenoja 2	8750–8330	burnt bone/elk	unpublished	Hela-728	9310±75	Takala 2004
	Ristola	8250–7760	burnt bone	Find layer	Hela-727	8880±75	Takala 2004
	Asola	6650–6470	burnt bone	Find layer	Ua-32206	7740±50	Leskinen & Pesonen 2008
	Asola	6330–5980	burnt bone/ seal	Find layer	Ua-32207	7540±55	Leskinen & Pesonen 2008
Eastern Finland	Jokivarsi 1	9180–8630	burnt bone	Find layer	Ua-41027	9507±85	Pesonen *et al. unpublished*
	Rahakangas 1	9130–8580	burnt bone/elk	Find layer	Hela-2380	9461±61	Pesonen *et al.* 2010
	Rahakangas 1	9120–8460	burnt bone/elk	Find layer	Hela-882	9405±80	Pesonen 2005
Southern Lapland	Neitilä 4	5990–5380	charcoal	Hearth above find layer	Hel-191	6750±170	Kehusmaa 1972
Northern Lapland	Sujala	8700–8300	charcoal	Dwelling area	Hela-1102	9265±65	Kankaanpää & Rankama *this volume*
	Sujala	8610–8310	charcoal	Refuse pit	Hela-1442	9240±60	Kankaanpää & Rankama *this volume*
	Sujala	8540–8260	charcoal/birch	Dwelling area	Hela-1441	9140±60	Kankaanpää & Rankama *this volume*
	Sujala	8290–7830	burnt bone	Dwelling area	Hela-1103	8940±80	Kankaanpää & Rankama *this volume*
	Sujala	8290–7790	burnt bone	Dwelling area	Hela-1104	8930±85	Kankaanpää & Rankama *this volume*
	Vuopaja N	6680–6070	charcoal	Refuse pit	Hel-3570	7530±150	Arponen & Hintikainen 1995

Figure 6. Mesolithic radiocarbon dates from contexts dating blades in Finland. Calibrated in OxCal 4.1.7 (Bronk Ramsey 2010). Ua-32207 calibrated using Marine09 calibration curve (Reimer *et al.* 2009) with Delta_R LocalMarine -80 (Olsson 1980; Stuiver *et al.* 1986–2010). Atmospheric and marine data from Reimer *et al.* (2009).

Temporal distribution of the blade finds – Radiocarbon dates

Radiocarbon dates from contexts most securely dating blades in Finland are presented in **Figure 6**. Published data on Early Mesolithic blade technology exist for the Ristola and Sujala sites and, to a lesser degree, also for the Saarenoja 2 site. These sites have all yielded radiocarbon dates from the time period 8800–7800 calBC, as well as symmetric blades, Post-Swiderian tanged points, and other related Early Mesolithic artefact types. (Jussila *et al.* 2010; Jussila & Matiskainen 2003; Kankaanpää & Rankama 2006; 2009; *this volume*; Rankama & Kankaanpää 2005; 2006; 2007a; 2007b; 2008; Takala 2003; 2004; 2009; Takala *et al.* 2006.) The Sujala and Saarenoja 2 sites can be considered closed Early Mesolithic contexts, whereas the Ristola site is a ploughed field that contains artefacts from several time periods. In addition to the Mesolithic occupation, radiocarbon and artefactual data indicate Stone Age occupation of the site at least during the pottery Mesolithic/Neolithic Typical Comb Ware and Corded Ware periods (Takala 2004). For these reasons, the dated bone sample from Ristola that derives from a mixed layer, although from the same area as some of the blade finds, cannot be connected to them without some reservations.

Two Early Mesolithic blade sites (Rahakangas 1 and Jokivarsi 1) in eastern Finland are dated to 9200–8500 calBC. The Rahakangas 1 site has yielded some blades and blade fragments in excavations, whereas surface collecting and test pits at the Jokivarsi 1 site have yielded a scraper on blade. (Pesonen *et al. unpublished*; Pesonen 2005; Pesonen *et al.* 2010). The assumed connection between the dates and the blades at these sites is based on the proximity of the dated samples and the blade finds as well as the general artefact distributions at the sites.

In addition to the Early Mesolithic dates, there are two sites, Asola in southern Finland and Vuopaja N in northern Lapland, where dated samples can be considered to date blade artefacts to later parts of the Mesolithic. The 6680–6070 calBC date from Vuopaja N derives from a refuse pit with associated blade finds (Halinen 2005:Figs. 38E–G), and the site has also yielded blade artefacts in a pre-excavation survey (Siiriäinen 1982). In total, seven or eight blade artefacts (a core, a possible scraper on blade and five or six blades/ blade segments) have been reported from the site (Halinen 2005; Kankaanpää & Rankama 2005). The dates on burnt bone from Asola, 6650–6470 calBC (undetermined species) and 6330–5980 calBC (seal, corrected for reservoir effect), derive from the proximity of two conjoining pieces of a retouched flint blade (Leskinen & Pesonen 2008:68). There is also a fragment of another, more equivocal blade (KM 20164:94) from the site, but with the exception of these, other blade artefacts are not present in the excavation finds.

In addition to the more or less directly radiocarbon-dated blade contexts, there is one Late Mesolithic date (5990–5330 calBC) from the Neitilä 4 site in southern Lapland, indicating the age of a hearth located stratigraphically above the layer containing the two jasper blades found at the site and thus giving an *ante quem* dating for the blades (Kehusmaa 1972).

Temporal distribution of the blade finds – Shore-displacement chronology

Many of the blade find locations can be roughly dated using shore-displacement chronology. The method assumes that Stone Age sites in Finland have been shore-bound - which is not always the case (Jussila & Kriiska 2006; Manninen & Valtonen 2002; Taavitsainen 1982). Two major transgressive phases, the Ancylus and Litorina transgressions, further complicate the dating of sites with shore-displacement chronology. Despite these difficulties, the method has been proven to date sites with sufficient accuracy, especially when used to study the relative chronology of sites in a restricted area (e.g., Jussila & Kriiska 2004; Jussila *et al.* 2007; Kylli 2001; Siiriäinen 1974; Matiskainen 1989).

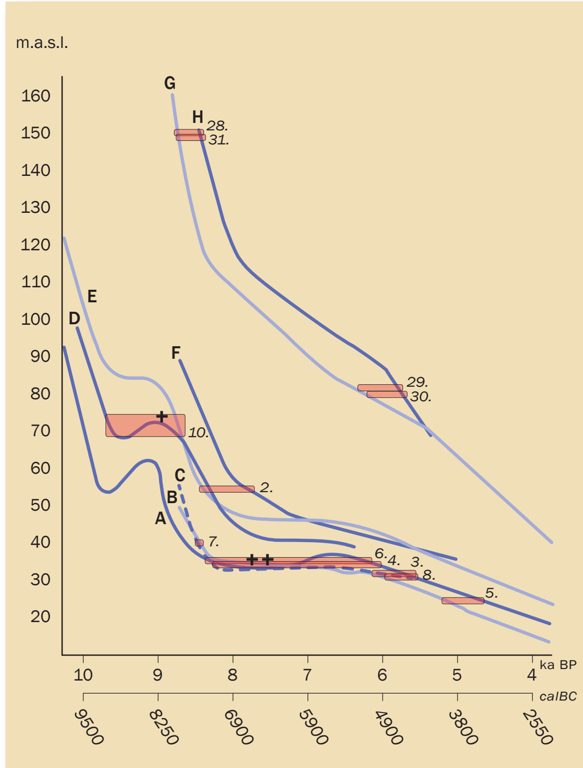


Figure 7. The maximum dates of blade finds in relation to shore displacement curves. The curves: A) Espoo area (Ristaniemi & Glückert 1987); B) Helsinki Region (Kylli 2001); C) Uplift zone 3,5 mm/yr (Matiskainen 1989); D) Ristola site (Takala 2004); E) Third Salpausselkä (Ristaniemi & Glückert 1987); F) Uplift zone 4,5 mm/yr (Matiskainen 1989); G & H) Area north of the Gulf of Bothnia (Saarnisto 1981 & Kylli 2001). Approximate shoreline dates for some of the blade sites in southern Finland and southern Lapland: 2. Bötesberget; 3. Sperrings; 4. Jönsas; 5. Kirkonkylä; 6. Asola; 7. Lammashaka; 8. Siltapellonhaka; 10. Ristola; 28. Pitkäniemi; 29. Korkalon pelto; 30. Keskioikarainen; 31. Neitilä 4. The three crosses mark the radiocarbon dates (uncalibrated BP) from the Ristola and Asola sites (see **Figure 6**.).

Two clusters of blade find locations, located in southern Finland and southern Lapland, are such that shore-displacement chronology can be used to study the relative age of blades as well as to give approximate *terminus post quem* dates for blade artefacts. In both areas, several of the blade find locations have emerged from the waters of the Baltic Sea Basin during the Holocene (**Figs. 5, 7**). However, it should be kept in mind that especially in southern Lapland the find locations are located next to small lakes or rivers and may consequently be considerably younger than the maximum age indicated by the Baltic shoreline date. As shown in the figure, shore-displacement curves in different studies have slight differences depending on the study material, exact study location, and other factors (see Kylli 2001), but they nevertheless agree quite well on a regional scale. Due to easier comparability, shore-displacement curves drawn using uncalibrated BP dates have been selected here. However, curves drawn using calibrated radiocarbon dates also give similar results for these areas (e.g., Hyvärinen 1999; Saarnisto 2005; Vuorela *et al.* 2009).

Shore-displacement chronology suggests that the blades from Pitkäniemi and Neitilä 4 in southern Lapland (curves G & H) have a maximum date somewhere between *c.* 7800 and 7500 calBC (8750–8500 BP), whereas the blades from Korkalon pelto and Keskioikarainen in the same general area have a maximum date somewhere between *c.* 5300 and 4650 calBC (6300–5800 BP).

Of the southern blade sites in the area of curves D, E, and F, Ristola has the earliest *post quem* date according to shore-displacement chronology. Takala (2004:145–147) suggests that, due to the Ancylus transgression, it is possible to shoreline-date the Ristola blade assemblage between *c.* 9200 and 7600 calBC (9700–8600 BP). The latter half of this time span is in good agreement with the *c.* 8250–7760 calBC radiocarbon date from the site. When it comes to the maximum date of the blades from the Bötesberget site, the curves diverge somewhat and give maximum dates between *c.* 7500 and 6400 calBC (8400–7700 BP) (see also Asplund 2008:52, 166–168).

The dating of shorelines in the area represented by curves A, B, and C is hampered by the Litorina transgression, which kept the shoreline relatively stable for an extended time period between *c.* 7200–5300 calBC (8200–6300 BP). However, only two of the blade sites, Asola and Jönsas, are on elevations coinciding with this time period, and the former site has also yielded the above-mentioned radiocarbon dates. The other sites are not affected by the transgressions and have the following maximum shore-line dates: Lammashaka 7500 calBC (8400 BP), Sperrings between 5000 and 4500 calBC (6100–5700 BP), Siltapellonhaka between 4900 and 4400 calBC (6000–5600 BP), and Kirkonkylä between 4000 and 3400 calBC (5200–4700 BP).

Some of the blade-find locations in other areas can also be given maximum dates with the same principle. The Saarenoja 2 site in Lappeenranta (former Joutseno) is located near to the highest Ancylus transgression shore-line but has a maximum shoreline date of *c.* 9400 calBC (Jussila *et al.* 2010; Jussila & Matiskainen 2003), the find location of the Myllykoski blade found in Siikalatva (former Kestilä) has emerged approximately at the Ancylus Lake/Litorina Sea interface (Koivunen 1985), and the Smikärr (lower) site in the Åland islands has a maximum date of *c.* 3300 calBC (Meinander 1964; Stenbäck 2003:92).

Temporal distribution of the blade finds – Typology

Blade cores

Blade cores are known from four locations in Finland (**Figs. 9 & 10**), and they represent at least three approaches to configuring a blade core.

Cores from the Sujala site (**Fig. 8:c**) show evidence of blade removals around a large part of the perimeter of the core and initiating from a single platform (e.g., Rankama & Kankaanpää 2008). Parallels for the cores can be found in Mesolithic contexts in northwestern Russia (Koltsov & Zhilin 1999b; Oshibkina 1997). In addition to the Sujala site, core tablets associated with this blade production technology have also been published from Ristola (Takala 2004:115).

A core deriving from the Vuopaja N site (**Fig. 8:b**) represents a strategy in which the original block is thinned from the sides and one narrow face becomes the core face (Siiriäinen 1982). These types of cores are known by a variety of names: handle core, keeled core, wedge-shaped core, and narrow face core, among others. During the Mesolithic, this kind of strategy of configuring a core and producing small bladelets was practised both east and west of Finland. In Sweden, it is dated to *c.* 6400–4300 calBC (Guinard & Groop 2007; Manninen & Knutsson *this volume*; Olofsson 2003). In Russia, a similar approach is documented, for example, at the Veretye I site in the Lake Onega region that has yielded dates falling between *c.* 9000 and 6500 calBC (9600–7700 BP) (Oshkibkina 1997).

A stray find from Eastern Finland, the Pöydänpäänniemi core, shows blade removals initiating from two opposite ends around most of the perimeter of the core (**Fig. 8:d**) and can be labelled an opposite platform blade core or cylindrical blade core. Parallels for the artefact are not easily found in the literature, but it has some common features with, for example, some Late Mesolithic cores in the Volga-Kama region (Vybornov 2009:Ris.193:1) and the cylindrical Scandinavian Middle Neolithic cores sometimes identified as Pitted Ware culture cores (Vang Petersen 1999:56–57; Bergsvik 2003:91–94). However, the rounded and polished ends of the core indicate secondary use as a strike-a-light (Koch 1990; Stapert & Johansen 1999). Strike-a-lights with polished ends are typical for the South-Scandinavian Neolithic/Bronze Age, but they have been used also

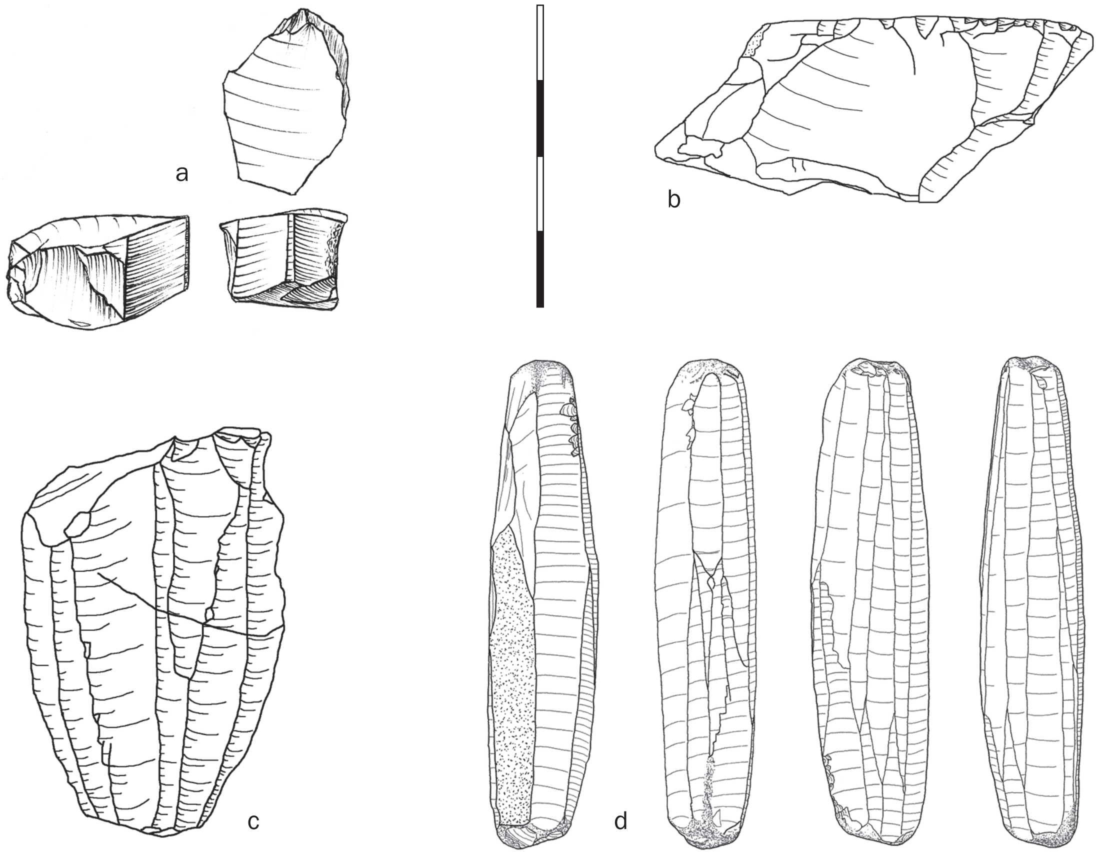


Figure 8. a) Saarenoja 2; b) Vuopaja N; c) Sujala; d) Pöydänpääniemi. B) drawn after Siiriäinen (1982); c) drawn after Rankama & Kankaanpää (2008). Scale in centimeters.

earlier in the area (e.g., Koch 1990; Lidén 1948:44; Vang Petersen 1999:140–141).

The finds from the 2008–2010 excavations at the Saarenoja 2 site also include cores (Jussila *et al*. 2010), but detailed information on this material is still unpublished. However, a blade core fragment from the year 2000 test excavation can be introduced here (**Fig. 8:a**). This is a blade core turned into a bipolar core in which the original blade core configuration is no longer discernible.

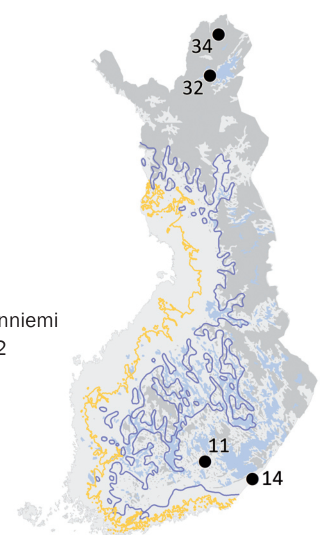


Figure 9. Locations with blade cores:
11. Pöydänpäänniemi
14. Saarenoja 2
32. Vuopaja N
34. Sujala

Areal group	Site	Quantity	Type	Data
Northern Lapland	Sujala	14*	Conical/sub-conical	Kankaanpää & Rankama *this volume*
Northern Lapland	Vuopaja N	1	Handle core like	Siiriäinen 1982
Southern Finland	Saarenoja 2	1+	Unpub.	Jussila *et al.* 2010
Southern Finland	Pöydänpäänniemi	1	Opposite platform	Appendix I

Figure 10. Blade cores. *including fragments; +more than one

Projectiles on blade

Arrowheads on blade are relatively common among the Finnish blade finds and are known from eleven sites/locations (**Figs. 11 & 12**). Based on their orientation, blade points can be divided into two groups: points oriented parallel to the longitudinal axis of the blade and points oriented at an angle to it. An orientation parallel to the longitudinal axis is more common in the Finnish material.

Most of the projectile points found in secure contexts, or within larger blade assemblages are Early Mesolithic points oriented parallel to the blank, namely, the points from Saarenoja 2 (Jussila *et al.* 2010), Sujala (Kankaanpää & Rankama *this volume*), and Ristola (Takala 2004) (**Fig. 13:b&c**). These points represent post-Swiderian points that are dated to *c.* 10,100–7500 calBC (Rankama & Kankaanpää 2008:895 and references). Points with parallel invasive retouch scars covering a large part of the ventral surface of the point can be considered to represent the Pulli sub-types, which are dated to *c.* 8950–7550 calBC (Butrimas & Ostrauskas 1999; Ostrauskas 2000:170; Takala 2006).

The other points with typical characteristics of Post-Swiderian points are a stray find from the Niemenjärvi Lake in Ilomantsi (Hertell & Manninen 2006; Meinander 1964:55) and another from an unknown location near Kuopio, most likely from Nilsiä (but see Matiskainen 1986:89)[4]. Both points have the characteristic bifacially retouched tang and invasive retouch on the ventral side of the tip (**Fig. 13:a&d**). A good parallel for the overall configuration of the Nilsiä point comes from the residential site of Popovo in Russia (Oshibkina 2004:Fig. 5), and it can be regarded as representing a large Pulli point. The point is exceptionally long, over 10 cm, although an even longer broken Pulli point has been published from the Ringuvenai site in Latvia (Ostrauskas 2000:Fig. 2).

Parallel orientation is also present in the Smikärr points (Meinander 1964) and the Kirkonkylä, Jönsas, and Lammashaka points, of which the last is a tip fragment (**Fig. 13:g–j**). The age and cultural affiliation of the Jönsas point, and especially the Kirkonkylä point, have been discussed in the literature by several authors (e.g., Leskinen & Pesonen 2008:68–69; Meinander 1964:56; Pesonen 2005; Takala 2004:142; 2006; Takala *et al.* 2006)

[4] Notes in the National Board of Antiquities' archive suggest that the point derives from Nilsiä and was donated to the Kuopio Historical society/Kuopio Museum either by Mr. Granit in 1884 or by Mr. Kronqwist in 1892. However, the find location is not known and it is possible that the point was originally found somewhere else.

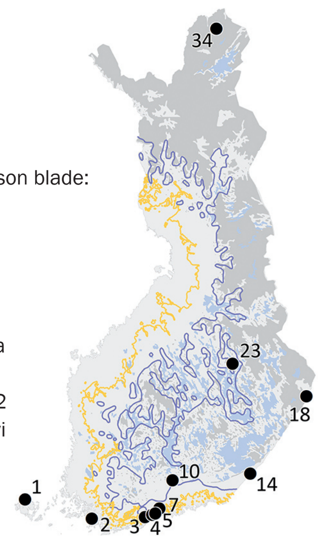


Figure 11. Locations with projectile pointson blade:
1. Smikärr
2. Bötesberget
3. Sperrings
4. Jönsas
5. Kirkonkylä
7. Lammashaka
10. Ristola
14. Saarenoja 2
18. Niemenjärvi
23. Nilsiä
34. Sujala

Areal group	Site	Quantity	Type	Typol. date**	Data
Northern Lapland	Sujala	49*	Post-Swiderian	c. 10100–7500 calBC	Kankaanpää & Rankama *this volume*
Eastern Finland	unknown/Nilsiä?	1	Post-Swiderian	c. 10100–7500 calBC	Appendix I
Eastern Finland	Niemenjärvi	1	Post-Swiderian	c. 10100–7500 calBC	Hertell & Manninen 2006; Appendix I
Southern Finland	Saarenoja 2	3+	Post-Swiderian	c. 10100–7500 calBC	Jussila *et al.* 2010; Rostedt *pers. comm.*
Southern Finland	Ristola	7	Post-Swiderian	c. 10100–7500 calBC	Takala 2004
Southern Finland	Lammashaka	1	Scandinavian A-type?	c. 2800–2600 calBC ?	Appendix I
Southern Finland	Jönsas	1	Scandinavian A-type	c. 2800–2600 calBC	Leskinen & Pesonen 2008; Appendix I
Southern Finland	Kirkonkylä	1	Scandinavian A-type	c. 2800–2600 calBC	Meinander 1964; Appendix I
Southern Finland	Sperrings	1	Transverse point	c. 6400–3900 calBC	Europaeus 1925; Appendix I
Southern Finland	Bötesberget	2	Microliths	c. 6400–3900 calBC	Appendix I
Åland	Smikärr	2	Scandinavian A-type	c. 2800–2600 calBC	Meinander 1964

Figure 12. Projectile points on blade.

* including fragments and preforms, ** see text for references

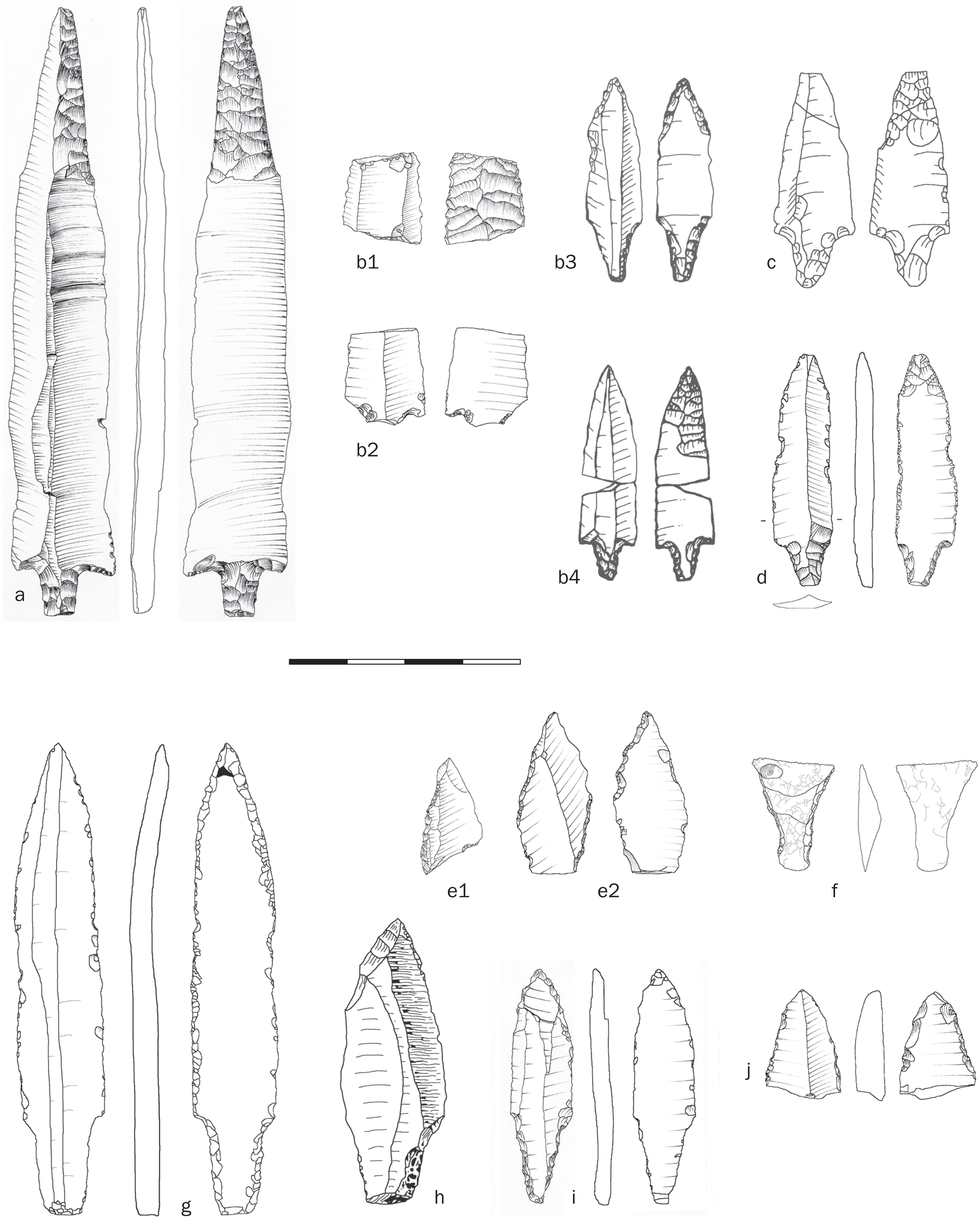


Figure 13. Projectile points on blade: a) Nilsiä; b1–4) Ristola; c) Sujala; d) Niemenjärvi; e1–2) Bötesberget; f) Sperrings; g) Kirkonkylä; h) Smikärr; i) Jönsas; j) Lammashaka. B3 & b4) drawn after Takala (2004); c) drawn after Kankaanpää & Rankama (*this volume*), h) drawn after Meinander (1964). Scale in centimetres.

and both a South-Scandinavian and a eastern Post-Swiderian origin have been suggested. However, as has been noted by some of these authors, the points lack the ventral invasive retouch typical for Post-Swiderian points.

The Smikärr points have been found in association with typical Eastern Swedish Pitted Ware pottery (Meinander 1964), whereas the Jönsas point derives from a multiperiod site and the find location of the Kirkonkylä point has yielded no other finds (Leskinen & Pesonen 2008:68–69; Meinander 1964). However, counterparts to the Jönsas and Kirkonkylä points can be found in southern Scandinavia in variants of type-A blade points (e.g., Glob 1952:Fig. 310, 311; Strinnholm 2001:Fig. 28). Type-A points are usually associated with the Pitted Ware culture and dated, allowing for regional variation, between *c.* 4000 and 2500 calBC (Bergsvik 2003:85–95; Meinander 1964; Strinnholm 2001:108; Vang Petersen 1999:17, 79–81).[5] A small ground and polished area on the ventral surface of the tip of the Kirkonkylä point could suggest a similar production strategy as for the Siretorp points in Blekinge, Sweden, which, according to Meinander (1964:41) are often made on blades struck from polished flint axes turned into blade cores.[6]

Points oriented against the long axis of the blade are known from the Bötesberget and Sperrings sites (**Fig. 13:e&f**). These points are microlithic transverse and oblique points. The Sperrings artefact is a burnt transverse point and is the only blade artefact from a site that otherwise has yielded mainly artefacts appended to the early phase of the pottery-Mesolithic Comb Ware culture (Europaeus 1927). The Bötesberget points belong to an assemblage that includes also other blade artefacts (see below) as well as flakes and debris of the same raw material. Asplund (2008:52–53) has suggested that the assemblage could have originated in the Estonian Mesolithic, but the microliths, and especially the microburin fracture used to produce the tip of at least one of the points, instead suggest an origin in southern Scandinavia. To our knowledge geometric microliths and the microburin technique are rare in the Estonian Mesolithic, whereas oblique and transverse points and geometric microliths of flint are common in the southern Baltic area, where they are dated to the time period 6400–3900 calBC (e.g., Edinborough 2009; Vang Petersen 1999).

[5] In Pitted Ware contexts in parts of Sweden north of Scania, tanged blade points and cylindrical blade cores are usually single finds and therefore some researchers have questioned whether the assemblages ascribed to the Pitted Ware culture in southern Scandinavia represent the same archaeological culture as the roughly contemporaneous Pitted Ware culture in eastern Sweden and the Åland islands (see Larsson 2008:56).

[6] We wish to thank Berit Valentin Eriksen for pointing out this detail that has gone unnoticed in previous research.

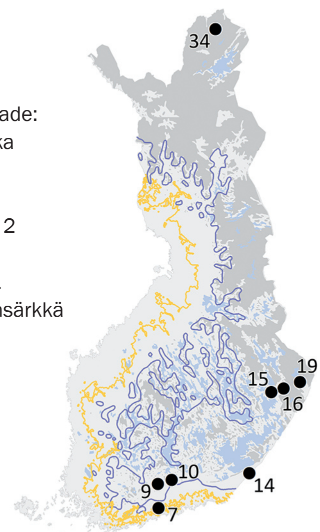


Figure 14. Locations with scrapers on blade:
7. Lammashaka
9. Teuronjoki
10. Ristola
14. Saarenoja 2
15. Joensuu
16. Jokivarsi 1
19. Issakkalansärkkä
34. Sujala

Areal group	Site	Quantity	Data
Northern Lapland	Sujala	19*	Kankaanpää & Rankama *this volume*
Eastern Finland	Issakkalansärkkä	1	Hertell & Manninen 2006; Appendix I
Eastern Finland	Jokivarsi 1	1	Pesonen 2005; Appendix I
Eastern Finland	unknown/Joensuu	1	Appendix I
Southern Finland	Saarenoja 2	unpub.	Jussila *et al.* 2010; Rostedt *pers. comm.*
Southern Finland	Ristola	15**	Takala 2004
Southern Finland	Teuronjoki	1	Matiskainen & Ruohonen 2004; Appendix I
Southern Finland	Lammashaka	1	Appendix I

Figure 15. Scrapers on blade. * including fragmentary & combined tools, ** including combined tools

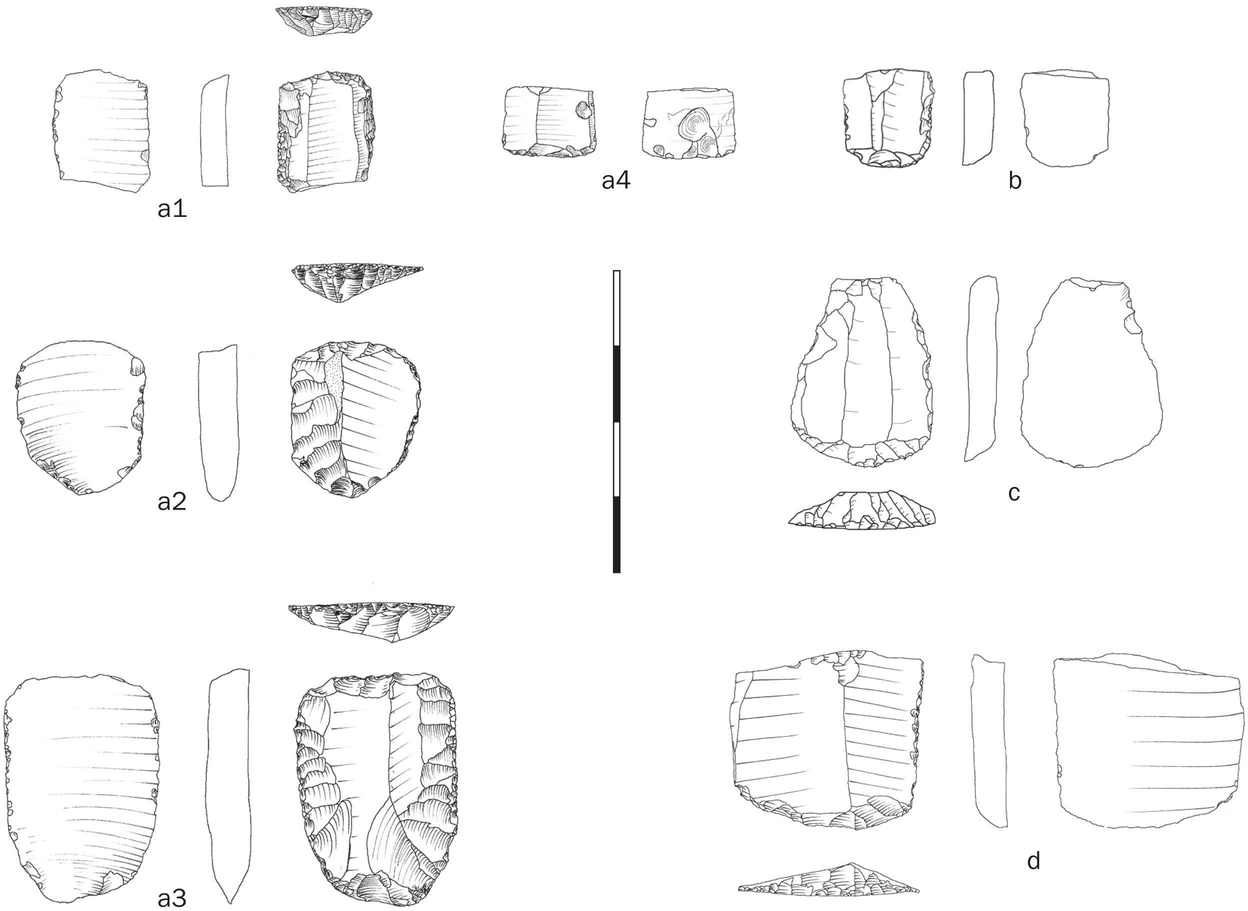


Figure 16. Scrapers on blade: a1–4) Ristola; b) Jokivarsi 1; c) Issakkalansärkkä; d) Teuronjoki. Scale in centimetres.

Scrapers and burins on blade

The division between typological scraping and cutting tools is generally acknowledged to be neither clear nor self-evident. Here we discuss only what we consider to be good classic examples of retouched scrapers with an edge angle close to 90 degrees. Most of them are end-scrapers, of which some have the retouched edge continuing on the sides of the blank and could therefore also be classified as double-scrapers, etc. (e.g., Takala 2004:122–123).

Scrapers on blade from eight locations are present in the survey data (**Figs. 14, 15 & 16**). In one case (Issakkalansärkkä), it is questionable as to whether the blank had in fact been a blade or a flake with parallel dorsal ridges, but we have nevertheless included it in the blade scraper category. Many blade artefacts in the collections classified as scrapers or tools (e.g., KM 18200:83 from Syväys 1 and KM 15563:2 from Espoo Kuusela) turned out to be modern strike-a-lights or single edged gun flints with signs of striking with steel on the worked margins (strike-a-lights) or characteristic use-wear on the unretouched edge (gun flints) (Kenmotsu 1990; Skertchly 1879).

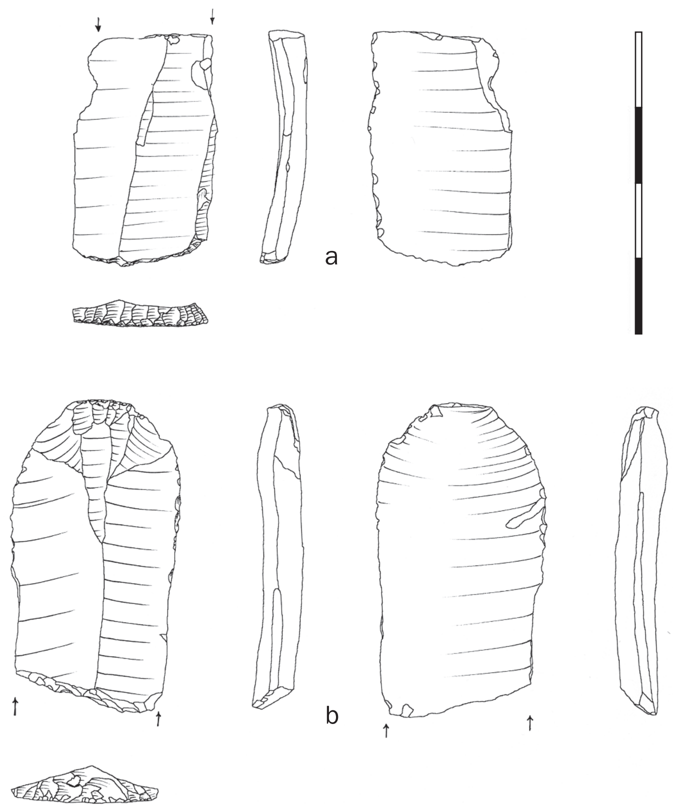


Figure 17. Burin/scrapers on blade: a) Lammashaka; b) Joensuu. Scale in centimetres.

Two previously unpublished artefacts have been classified as scraper/burins in the survey. Of these, the artefact from Joensuu (**Fig. 17:b**) has had burin spalls detached from the retouched end of the blade, whereas in the otherwise similar scraper/burin from Lammashaka (**Fig. 17:a**), the burin blows have been struck from the end opposite to the retouched edge. Including these artefacts, burins on blades are known from five locations (**Figs. 18 & 19**). The dating of the scrapers and burins on blade found in Finland cannot be determined solely on a typological basis, but it can be noted that, at least at the moment, most of them appear to derive from clear Early Mesolithic contexts (Sujala, Saarenoja 2, Ristola, and Jokivarsi 1).

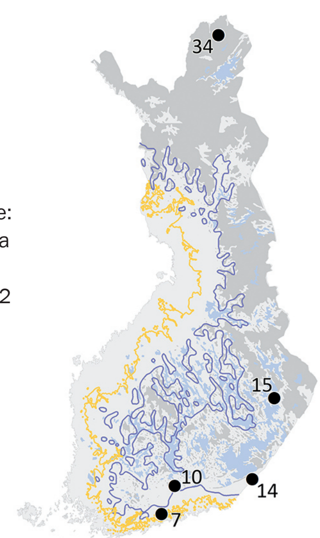


Figure 18. Locations with burins on blade:
7. Lammashaka
10. Ristola
14. Saarenoja 2
15. Joensuu
34. Sujala

Areal group	Site	Quantity	Data
Northern Lapland	Sujala	45*	Kankaanpää & Rankama *this volume*
Eastern Finland	unknown/Joensuu	1	Appendix I
Southern Finland	Saarenoja 2	unpub.	Jussila *et al.* 2010; Rostedt *pers. comm.*
Southern Finland	Ristola	12	Takala 2004
Southern Finland	Lammashaka	1	Appendix I

Figure 19. Burins on blade. * including fragmentary

Retouched and unmodified blades and blade segments

The remaining blade artefacts comprise a fairly heterogeneous group that includes unmodified blades, retouched blades (including inserts), and blade segments. Technological details and dimensions of these artefacts vary. The majority is found in the few excavated assemblages: mostly from Sujala, Ristola, and Saarenoja 2 but also from Syväys 1 (Hertell & Manninen 2006); Rahakangas 1 (Pesonen *et al*. 2010), Vuopaja N (Kankaanpää & Rankama 2005), Neitilä 4, and Bötesberget.

The only typo-chronologically datable artefacts in this group are the inserts. Clear examples of inserts made on blade are found in Finland only in the Early Mesolithic Ristola and Saarenoja 2 assemblages, and two possible inserts have also been published from the Sujala site (Jussila & Matiskainen 2003; Jussila *et al.* 2010; Rankama & Kankaanpää 2008:Fig. 7; Takala 2004:Fig. 141).

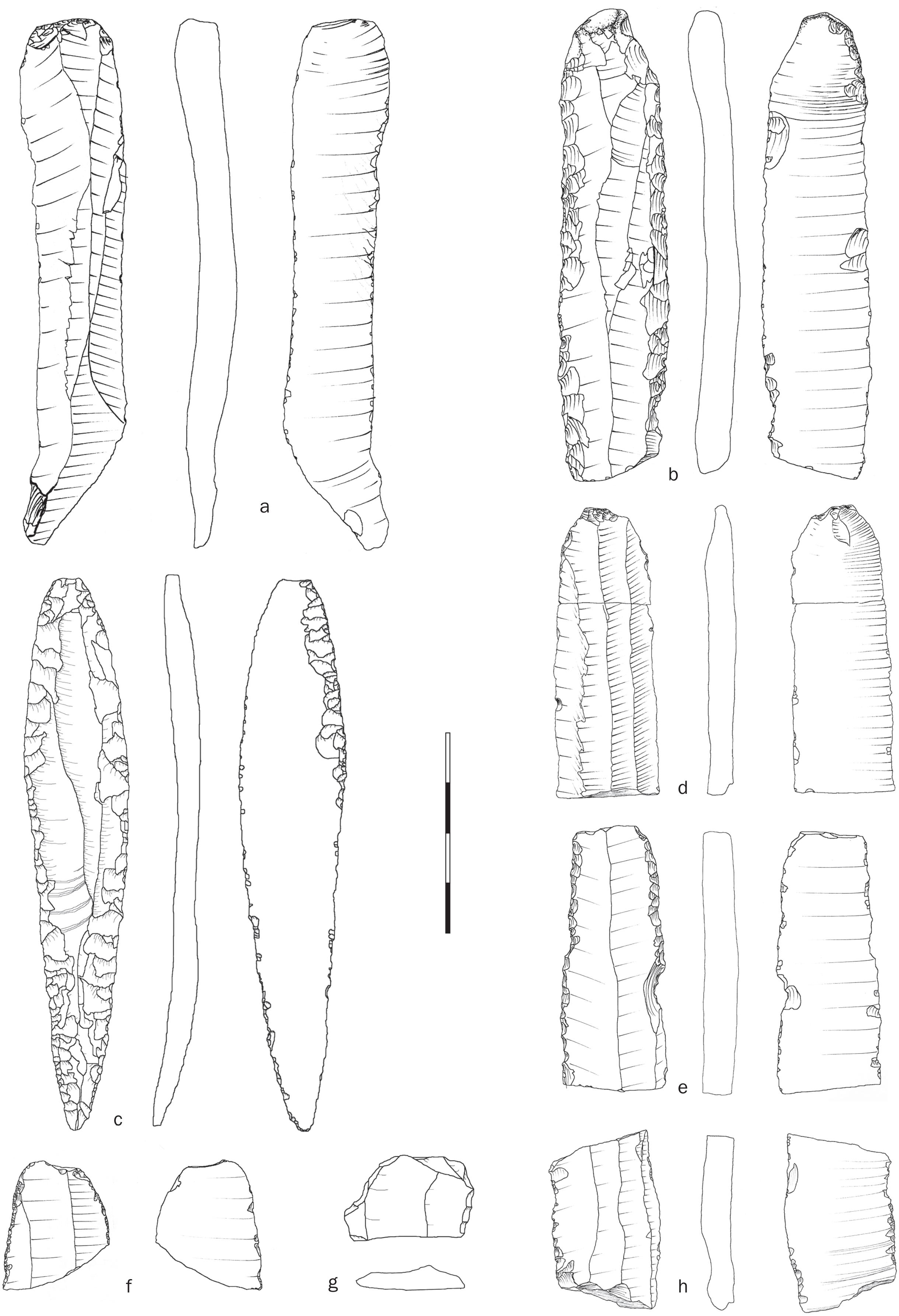
Most of the artefacts are unmodified and retouched blades and blade segments that show variation in production technology and size (**Fig. 20**). Clear differences are visible, for example, between the large platform remnant and long bulb of the (Inari) Rovaniemi blade (**Fig. 20:a**) and the small platform remnants and relatively thick and short bulbs of the Pitkäniemi and Kalmosärkkä blades (**Fig. 20:l&r**) – probably indicative of the use of direct percussion (Rovaniemi) *versus* pressure (Pitkäniemi and Kalmosärkkä) in their production. Blade production using pressure is considered an eastern trait in North-European Mesolithic contexts (Hartz *et al*. 2010; Koltsov & Zhilin 1999a; Ostrauskas 2000:175–176), whereas the direct percussion technique, alongside the raw material, suggests a North-Norwegian Early Mesolithic origin for the Rovaniemi blade (Kankaanpää & Rankama 2005:130).

With the exception of the Kotiranta blade discussed below, the widths of the blades listed in **Appendix I** vary between 5.5 mm and 25 mm. The published Early Mesolithic assemblages are in line with these numbers: blade width in the Sujala assemblage varies between 3–30 mm and un-retouched blades in the Ristola assemblage are 5–20 mm wide (Kankaanpää & Rankama 2006:Fig. 4; Takala 2004:Fig. 123). Hence, the often used division between microblades/bladelets (<10mm) and macroblades (>10mm), is not fruitful in a heterogeneous artefact group such as this that derives from a variety of sources and includes also blades from production technologies where the width of the end product diminishes as the production continues. However, some of the blades, such as the blade from Vonkka 2 (**Fig. 20:z**), may nevertheless derive from specialised microblade/bladelet production.

Only on one blade (**Fig. 20:x**, Bötseberget) is there a microburin scar. The majority of blades are intentionally or accidentally snapped perpendicular to the long axis of the blade. In some artefacts, the point of impact left from a blow directed on the dorsal side of the blade in order to generate the break is shown. This technique is present in the Sujala assemblage (e.g., Rankama & Kankaanpää 2008: 889), and impact marks that more or less certainly follow from this procedure are also present in blades documented in this survey (e.g., KM 14504:453, :475; KM 17875:66; KM 18501:1550; KM 31136; KM 35157:2).

There are also two probable strike-a-lights among the blades. A retouched blade used as a strike-a-light (**Fig. 20:b**) has been found in the Myllykoski rapids in Siikalatva. Koivunen (1985) has suggested that the artefact could be a Neolithic sickle originating in southern Scandinavia, but the artefact lacks the characteristic sickle gloss often found in such artefacts (e.g., Jensen 2000:Fig. 1). However, the proximal end of the blade shows similar rounding and polishing as the ends of the Pöydänpäänniemi core (see above), an indication of use as a strike-a-light. While the rounding of the Myllykoski blade suggests use with pyrite, the unevenly battered margins of the Pöllölä blade (**Fig. 20:i**) suggest that it may have been used for the same purpose, but in more recent times and with steel.

Figure 20. Retouched and un-retouched blades and blade segments: a) Rovaniemi; b) Myllykoski; c) Jaakonsaari; d) Ristola; e) Hietalahti 1; f) Lammashaka; g) Syväys 1; h) Ristola; i) Pöllölä; j) Jussinlahti; k) Syväys 1; l) Pitkäniemi; m) Asola; n, o & p) Syväys 1; q) Bötesberget; r) Kalmosärkkä; s) Asola; t) Bötesberget; u) Syväys 1; v) Neitilä 4; w) Ristola, å) Keskioikarainen; ä) Kalmosärkkä; â, ö) Syväys 1; x) Bötesberget; y) Siltapellonhaka; z) Vonkka 2. W) drawn after Takala (2004). Scale in centimetres. ▶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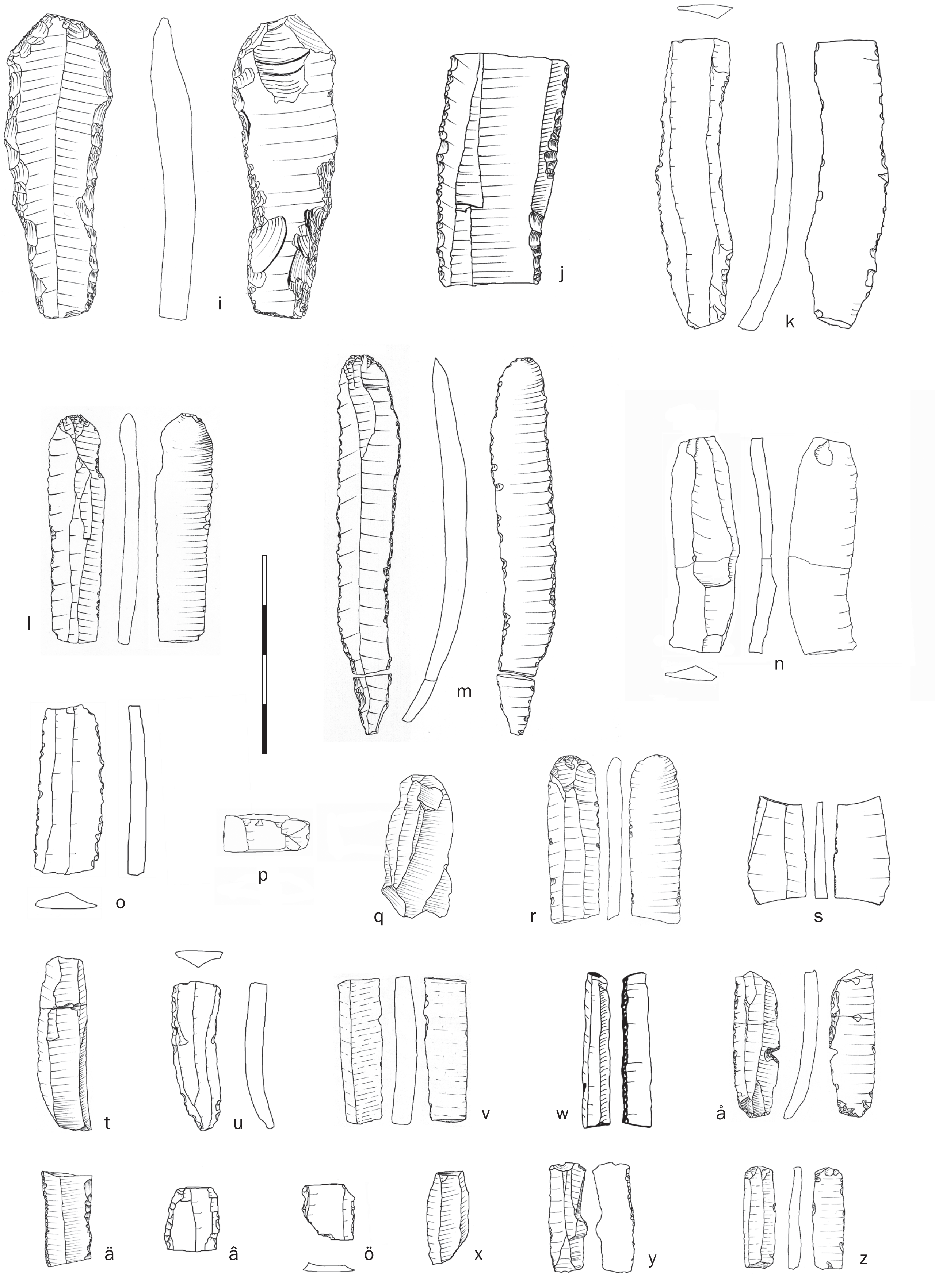
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A small group of core trimming/preparation blades can be also distinguished in the material. These include one cortical blade from the Vuopaja N site (**Fig. 21:c**) and three blades, from Vuopaja N (Siiriäinen 1982:Fig.4), Korkalon pelto, and Neitilä 4 (**Fig. 21:a&b**), that bear possible evidence of cresting of the original cores.

A somewhat enigmatic find among the retouched blades is the nearly 19 cm long, and originally even longer, regular blade from Kotiranta in Suonenjoki, eastern Finland (**Fig. 22**). Because both the proximal and distal ends of the blade have been removed, the length of the blade must initially have been over 20 centimetres. Almost all of the margins bear an irregular retouch, direct on one long margin and inverse on the other. The proximal end has a scraper-like retouch. The blade was found in 1986 on a ploughed forest floor without any associated artefacts (Aroalho 1986).

Blades of this size and regularity are not common in the archaeological record anywhere in the world. The length of the blade, as well as the regular scars left by the previous detachments, makes it likely that the blade was made using lever pressure. Jaques Pelegrin (2006) has studied the production of such regular over-20-cm-long blades in Near East and Europe, where they date mainly to *c*. 4000–2000 calBC. Of the seven production areas discussed by Pelegrin, the thickness of the Kotiranta blade in relation to its length and width has its closest parallels in Chalcolithic blades from Portugal. The origin of the raw material, a relatively coarse grey and white banded flint sprinkled with white dots, remains unknown. Due to a lack of context and parallels for the blade in northern Europe, it seems probable, albeit not certain, that the blade has been imported to the country far after the time of production.[7]

[7] We wish to thank Berit Valentin Eriksen, Jan Ingolf Kleppe, Helena Knutsson, Antonio Melgado, Jaques Pelegrin, Mikkel Sørensen, and Mikhail Zhilin for sharing an interest in finding the area of origin and source of raw material for the Kotiranta blade.

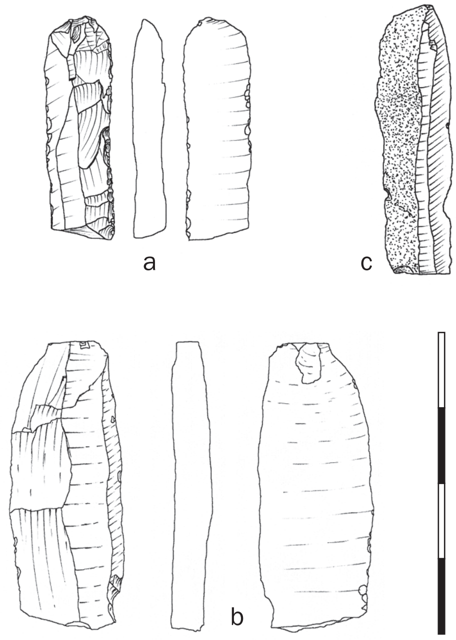

Figure 21. Core preparation blades: a) Korkalon pelto; b) Neitilä 4; c) Vuopaja N. Scale in centimetres.

Discussion and summary

The blade artefacts discussed in this study constitute a somewhat heterogeneous group of artefacts in terms of size, types, raw material, and date. The survey collection shows the presence of different technofunctional artefact groups, arrowheads and scrapers being the most common. Most blades are on the wider side of the 10 mm borderline between macroblades and microblades/bladelets, indicating at the most part a production and movement of relatively large blades, but the core from Vuopaja N, as well as possibly some of the smaller blades, suggests that bladelet production is also represented in the material.

The dating evidence for blade finds is summarised in **Figure 23**. The radiocarbon-dated contexts are all Mesolithic, but the shoreline and typological dates give a longer time span for blade use. Especially in southern Finland and southern Lapland, shore-displacement

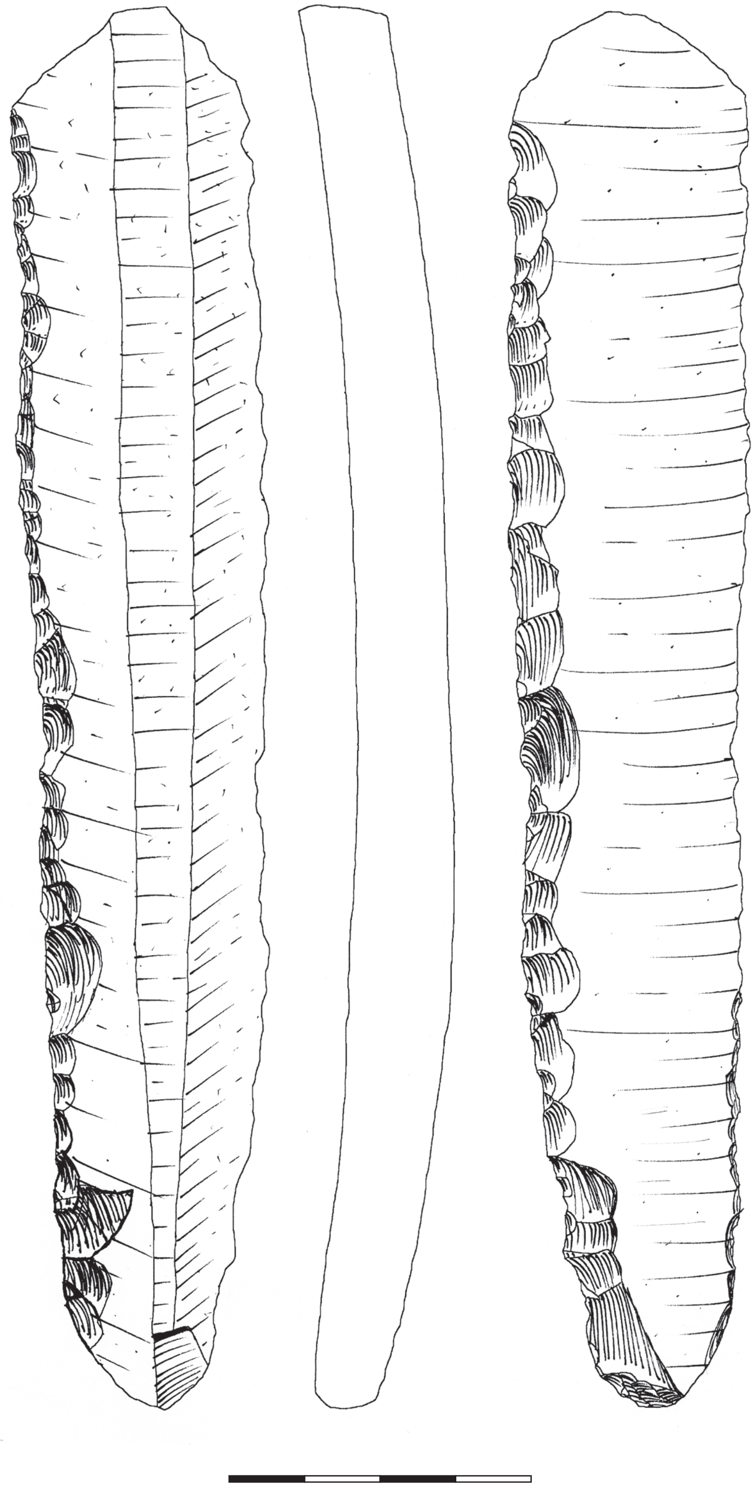

Figure 22. The Kotiranta blade (KM 23230). Scale in centimetres.

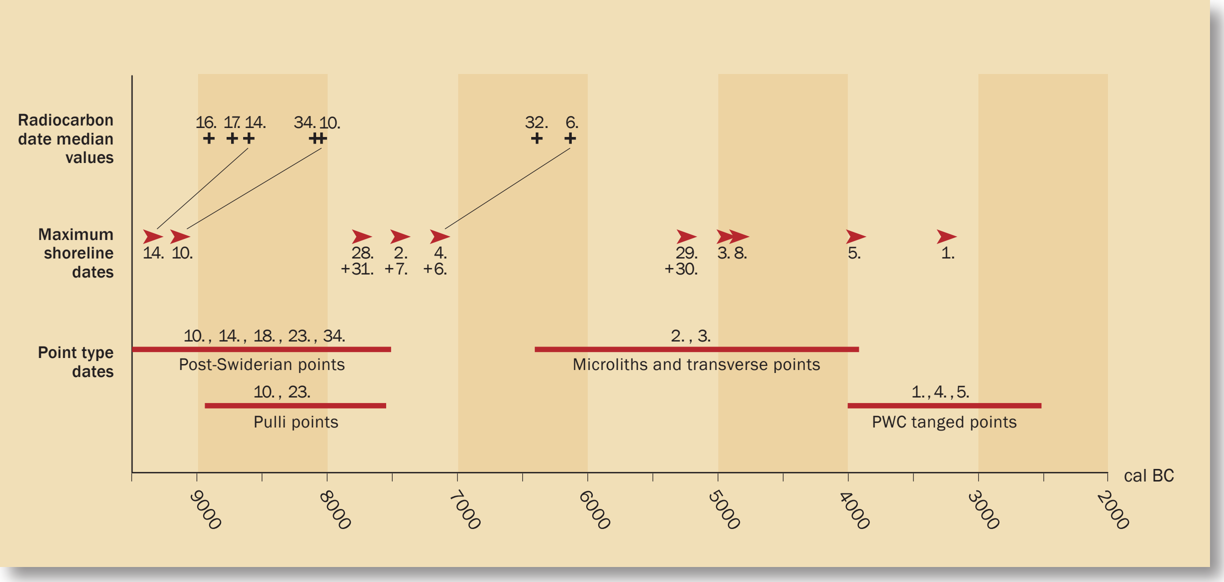

Figure 23. Assembled dates for the Finnish blade artefacts and find locations. PWC=Pitted Ware Culture.

chronology provides good evidence for blades below the Early Ancylus lake levels. In southern Finland, blades are found not only on Mesolithic shorelines, but also on elevations that clearly indicate Neolithic shorelines.

Technological details, raw material, and the division of artefact types indicate that most of the blades represent influences from Central Russia and, possibly, the East Baltic region. The microburin technique, combined with geometric microliths, common in southern Scandinavia but non-existent, for instance, in the standard sites of the East Baltic Kunda Culture (Ostrauskas 2000:172–175), has been detected only at the Bötesberget site at the south coast. In effect, alongside the single transverse point from Sperrings, the flint assemblage of the Bötesberget site can be considered the only Mesolithic site assemblage in Finland representing South-Scandinavian technological traits, thus indicating the existence of Mesolithic contacts between the South Baltic area and Finland.

Many non-diagnostic blade finds from supra-aquatic areas are beyond the radiocarbon, shoreline and typological dating methods. However, some clues for their temporal position can be found in neighbouring countries. In north-western Russia, the available data indicate a trend in which the role of blades in blank production decreases and the relative amount of flake blanks and bifaces increases from the Mesolithic to the Neolithic (e.g., Koltsov & Zhilin 1999b; Oshibkina 1997). This suggests that most of the non-diagnostic and undated blade artefacts of Carboniferous flint also date to the Mesolithic in Finland.

In southern Scandinavia, blades are more evenly distributed in time, but it nevertheless seems that excluding the probably Mesolithic Bötesberget site, in Finland, the relatively rare South-Scandinavian blade artefacts appear primarily in Neolithic (and possibly Bronze Age) coastal contexts, i.e., roughly at the same time as examples of other Scandinavian artefact types, such as Scandinavian axe types, flint daggers, and eastern-Swedish Pitted Ware pottery (e.g., Europaeus 1921; Laulumaa 2005). The Scandinavian type-A tanged points from the south coast and the Åland islands suggest that the same mechanism that produced isolated tanged points on Eastern Swedish Pitted Ware sites possibly extended as far east as mainland Finland. The blade artefacts surface collected from the Lammashaka site (a possible Pitted Ware Culture point fragment, a blade segment made of what looks like tertiary flint from South-Scandinavia, and a burin/scraper on blade), can be seen as suggesting a larger than average pottery Mesolithic/Neolithic blade assemblage in Finnish context.

A large number of blade artefacts in the current survey derive from southern Finland. This is not surprising, as it is in this area where most of the modern habitation is concentrated and, consequently, where most of the archaeological fieldwork has taken place. In this area, the

Holocene shorelines of the Baltic Sea basin are found relatively close to each other, and many sites of different ages are found starting from the Early Mesolithic. Southern Finland also has the largest variability of defined types and blade artefacts of different age. We suggest that the large variability of types is a statistical illusion related to the higher amount of finds in this area rather than evidence of any direct adaptive or cultural mechanisms.

In easternmost Finland an emerging high-density blade area can be recognised. Because of the relatively small amount of field work conducted in this area, and despite the unsystematic nature of the current survey, this density seems exceptionally high and suggests a mechanism resulting in a larger than average amount of blades in this area. This may be due to the early deglaciation and colonisation of the area (Pesonen *et al. in press*; Hertell & Manninen 2006).

Although most of the Stone Age coast is located in the southern half of the country, some finds from southern Lapland and Kainuu indicate an emerging possibility to chase and seriate blade sites from different prehistoric phases in the area using shore displacement chronology. The blade artefacts in southern Lapland and Kainuu also seem to be the northernmost blade finds of flint originating in Russia with the possible exception of the Vuopaja N site in Inari, northern Lapland. The emerging concentrations of blade finds in Kainuu and southern Lapland may be related to waterways that lead to White Sea (Huurre 1984), where flint is naturally available in the south-eastern coastal region.

The small number of sites in the northernmost part of Finland is likely to be the result of relatively limited field work activity in this area rather than a true reflection of the past. The presence of the three-thousand-blade short-term Sujala camp site in Utsjoki with signs of blade production using multiple cores alone implies that many unknown blade sites are hidden in the landscape in northern Finland. Because terrestrial hunters move often, the Sujala group must have occupied several camp sites in the course of their lives. Many of these sites can be expected to contain blades. If blades were made and blade manufacturing technology was passed from one generation to another over the decades, it is clear that dozens of Sujala-like blade sites are waiting for field archaeologists in the north, as evidenced by the recent discoveries across the border in northern Norway (Rankama & Kankaanpää 2010).

The raw materials used to produce the studied blades are highly variable. The raw materials of some of the artefacts show characteristic features of Cretaceous and Carboniferous flints, whereas the raw material sources of others are less clear and may include, in addition to North Norwegian cherts, local sources, Paleozoic flints (Jussila *et al*. 2007), and possibly even fine-grained volcanic rocks used in blade production in Dalarna, Central Sweden (Lannerbro 1992), to name a few. Blades made of jasper, such as the possible secondary crested blade from Neitilä 4, suggest that blade production employing local jasper may also have existed. Publications on blades from Dalarna show that elaborate blade technology was also applied to jasper in the area (e.g., Lannerbro 1992). In Finland jasper blade production sites, if present, are likely to be found in Lapland and in other areas where jasper is locally available.

The survey of blade finds presented here, although not comprehensive, illustrates the temporal and geographical distribution and scarcity of blades in archaeological assemblages in Finland. The blade find locations form five clusters, one in the south, one in the south-east, two in the north-east and finally, one in northernmost Finland. The finds show a trajectory of cultural developments where contacts of local groups grew into different directions in the course of time. In the Early Mesolithic, connections oriented towards the east and south-east were maintained in the whole area of present-day Finland. Later during the Mesolithic, regional differences seem to have emerged, and other, most notably South-Scandinavian, blade artefacts started to appear. As a rule of thumb, it can be stated that in Finland, most blades date to the Early Mesolithic, most blade find locations date to the Mesolithic, but flint and chert blades have been used throughout prehistory and up to modern times.

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Appendix I. The survey data.

1/2

Areal group	Municipality	Site	Description	Archive no.	L	W	T	Raw material*	Color	Publication
1	Askola	Siltapellon-haka	Medial part of a blade. Inverse retouch on part of the left margin.	KM 12933:1139	22	7.7	2.3	Cretaceous (Senonian)	light grey (grey dots)	Luho 1957
1	Espoo	Sperrings	Transverse point. Direct retouch on the margins.	KM 8313:118	20.3	15.3	4.2	Cretaceous?	burnt white	Europaeus 1927
1	Geta	Smikärr (nedre)	Tanged point (?) on blade. Tang at the proximal end of the blade. The tip of the point is the unmodified distal end of the blank. The tang is formed with direct retouch on the right and inverse retouch on the left margin.	KM 14103:218	40	15	6	Cretaceous?	yellowish grey	Meinander 1964
1	Geta	Smikärr (nedre)	Tanged point on blade. Tang at the proximal end of blade. The tang is formed with direct retouch on the right and inverse retouch on left margin. Direct retouch on the left side of the tip.	KM 14103:220	50	19	6	Cretaceous?	yellowish grey	Meinander 1964
1	Hausjärvi	Teuronjoki	Distal part of a blade. Scraper edge at the distal end (direct retouch).	KM 32983:213	23.5	25.1	5.7	Jasper (unknown age) or carboniferous chert	red	Matiskainen & Ruohonen 2004
1	Kemiönsaari	Bötesberget	Proximal part of a blade. Microburin fracture at the distal end.	KM 26616:252	18	8	3	Cretaceous (Senonian?)	light yellowish grey	–
1	Kemiönsaari	Bötesberget	Proximal part of an irregular blade.	KM 26616:324	28	20	5	Cretaceous (Senonian?)	light grey (white dots)	–
1	Kemiönsaari	Bötesberget	Medial part of a blade (rhomboid microlith). Inverse retouch on the right margin. Direct retouch on both ends.	KM 26616:436	28	13	3	Cretaceous (Senonian?)	light grey (white dots)	–
1	Kemiönsaari	Bötesberget	Microlith (triangular?). Microburin scar at the proximal end. Direct retouch on the left margin.	KM 26616:437	21	17	3	Cretaceous (Senonian?)	light yellowish grey	–
1	Kemiönsaari	Bötesberget	Distal part of a blade. In two pieces due to a modern break.	KM 26616:439	35	10	2	Cretaceous (Senonian?)	light yellowish grey	–
1	Kerava	Lammashaka	Tip of a projectile on blade. Inverse margin retouch.	KM 31690:1	18	13	5	Cretaceous (Senonian)	light grey (lighter dots)	–
1	Kerava	Lammashaka	Proximal part of a blade.	KM 31690:2	23	19	4	Tertiary? (Bryozoans?)	burnt (grey and orange inclusios)	–
1	Kerava	Lammashaka	Medial part of a blade. Scraper edge at the distal end (inverse retouch). Burinations on break intiating from the proximal end on both margins.	KM 34360:2	30	19	5	Cretaceous (Senonian)	light grey (lighter dots)	–
1	Lemi	Pöllölä	Proximal part of a blade. Irregular direct and inverse retouch on both margins. Large eraillure scar or secondary detachment on the ventral side of the proximal end.	KM 3359:5	61.2	21.8	8.1	Cretaceous (Senonian)	dark grey with lighter spots	–
1	Luumäki	Hietalahti 1	Medial part of a blade. Direct retouch on both margins.	KM 31136	53	21	7	Cretaceous (Senonian?)	banded light grey with yellow patina	–
1	Mäntyharju	Pöydänpään-niemi	Cylindrical opposite platform blade core with a large number of narrow blade scars. Both platforms are rounded and polished.	KM 34023	63.9	15.4	12.8	Cretaceous (Senonian?)	black with orange brown patina	–
1	Vantaa	Kirkonkylä	Tanged point on blade. Proximal end of the blank removed, distal end retouched with semi-abrupt inverse retouch. Small polished patch on the ventral surface of the tip. Tang formed with semi-abrupt inverse retouch.	KM 11606	81.4	14.6	4.1	Cretaceous (Senonian)	light grey	Meinander 1964
1	Vantaa	Asola	Blade (in two pieces) with direct retouch on both margins.	KM 20164:127+128	73	14	5	Cretaceous?	mottled/banded dark/ light grey with yellow patina	Leskinen & Peso-nen 2008
1	Vantaa	Asola	Medial part of a blade or blade-flake.	KM 20164:94	22	12	2	Carboniferous?	yellow	
1	Vantaa	Jönsas	Tanged point on blade. Proximal and distal ends removed. Direct retouch on the tip and the tang.	KM 19913:272	40.7	10.8	3.5	Cretaceous (Senonian, Falster?)	matte bluish grey patina	Takala 2004
2	Ilomantsi	Jaakonsaari	Dagger-like blade with continuous direct retouch around the artefact. Invasive inverse retouch on the proximal end of the left margin.	KM 13022	111,6	21	6	Carboniferous	chocolate brown	Hertell & Manninen 2006
2	Ilomantsi	Syväys 1	Distal part of a blade. Direct retouch on the distal end of the right margin.	KM 17875:21	58.1	14.3	4.6	Carboniferous?	light grey (light dots)	Hertell & Manninen 2006
2	Ilomantsi	Syväys 1	Small blade segment.	KM 17875:66	7.3	16.6	4.2	Carboniferous	light brown	Hertell & Manninen 2006
2	Ilomantsi	Syväys 1	Distal part of a blade. Water rolled.	KM 18200: 220	30.6	10	3.8	Carboniferous	white	Hertell & Manninen 2006
2	Ilomantsi	Syväys 1	Small blade segment. Direct retouch on the left margin.	KM 18200:190	11.1	10.1	2.1	Carboniferous?	light grey	Hertell & Manninen 2006

* Determinations based on the visual appearance of artefacts. The sub-division of Scandinavian flints is based on Högberg & Olausson 2007. ** Kinnunen *et al.* 1985.

Appendix I. The survey data. 2/2

Areal group	Municipality	Site	Description	Archive no.	L	W	T	Raw material*	Color	Publication
2	Ilomantsi	Syväys 1	Proximal part of a blade. Direct retouch on both margins and the proximal end.	KM 18200:253	12.6	10.9	3.8	Carboniferous	banded reddish grey and white	Hertell & Manninen 2006
2	Ilomantsi	Syväys 1	Medial part of a blade. Water rolled.	KM 18200:289	34.7	13.5	3.8	Carboniferous	orange brown	Hertell & Manninen 2006
2	Ilomantsi	Syväys 1	Medial part of a blade or blade-flake. Water rolled.	KM 18200:347	15.1	23.6	6.2	Carboniferous?	opaque black	Hertell & Manninen 2006
2	Ilomantsi	Syväys 1	Proximal part of a blade (in two pieces).	KM 18200:84	43.1	13.4	3.7	Carboniferous	orange brown	Hertell & Manninen 2006
2	Ilomantsi	Issakkalan-särkkä	Proximal part of a blade or blade-flake. Scraper edge (direct retouch) at the distal end.	KM 25214:4	25.3	18.8	4.1	Carboniferous	yellowish orange	Hertell & Manninen 2006
2	Ilomantsi	Niemenjärvi	Tanged point on blade. Both ends of the blank have been removed. Inverse invasive retouch on the tip. Bifacial retouch on the tang.	KM 7172:1	40.3	10.4	3.1	Carboniferous?	yellowish brown translucent	Meinander 1964
2	Joensuu	unknown	Proximal part of blade. Scraper edge at the distal end (direct retouch). Burinations initiating on the retouched end on both margins.	KM 2573:6	41	22	6	Carboniferous	purple translucent	–
2	Joensuu	Jokivarsi 1	Blade segment. Scraper edge (direct retouch) at the distal end.	KM 34160:1	13	13	4	Carboniferous	dotted yellow/brown	Pesonen 2005
2	Suonenjoki	Kotiranta	Medial part of a blade. Direct irregular retouch on the left long margin and inverse on the right margin. The proximal end has a scraper-like retouch	KM 23230	186	32.2	12.2	Tertiary? Jurassic?	layered grey with white bands and dots	–
2	Nilsiä(?)	unknown	Tanged point on blade. Both ends of the blank have been removed. Inverse invasive retouch on a large part of the distal end and direct invasive retouch on the right margin of the tip. Bifacial retouch on the tang.	Kuopio Museum 2371	104	18	6	Cretaceous?	dark brown	Matiskainen 1986
3	Hyrynsalmi	Vonkka 2	Intact blade.	KM 31384:230	20	6	3	Jasper (unknown age) or carboniferous chert	red	–
3	Siikalatva	Myllykoski	Proximal part of a blade with retouched margins (direct retouch). The proximal end is rounded and polished.	KM 23098	93.6	22.3	7.5	Cretaceous (Senonian?)	orange brown patina	Koivunen 1985
3	Suomussalmi	Kalmosärkkä	Medial part of a blade. Direct retouch on both margins.	KM 14504:453	19	10	3	Carboniferous	dotted light/dark brown (burnt?)	Huurre 1959
3	Suomussalmi	Kalmosärkkä	Proximal part of a blade.	KM 14504:475	34	10	3	Carboniferous	dotted light/dark brown (burnt?)	–
3	Suomussalmi	Jussinlahti	Medial part of a blade. Direct retouch on both margins.	KM 35157:2	46.4	24.1	6.5	Carboniferous	orange brown (small light dots)	–
4	Kemijärvi	Neitilä 4	Proximal part of a secondary crested blade. Direct retouch on the distal end of the right margin.	KM 15671:1181	45	18	6	Jasper (local**, unknown age)	red	–
4	Kemijärvi	Neitilä 4	Medial part of a blade.	KM 15671:1210	29	9	5	Jasper (local**, unknown age)	red	–
4	Rovaniemi	Korkalon pelto	Proximal part of a secondary crested blade. Direct retouch on both margins.	KM 15750:249	30	9	4	Carboniferous	light grey striped	Kotivuori 1996
4	Rovaniemi	Pitkäniemi	Proximal part of a blade.	KM 25587:1	46	11	3	Carboniferous	white	Kotivuori 1996
4	Rovaniemi	Keski-oikarainen	Distal part of a blade. Inverse retouch on part of the right margin and direct retouch on the left margin.	KM 30234:16	29	9	3	Carboniferous	mottled light/dark brown	Kotivuori 1996
5	Inari	Rovaniemi	Intact curved blade.	KM 23377:1	105	20.5	8.5	Northern (Norwegian?) chert (unknown age)	striped brown/grey	Kankaanpää & Rankama 2005
5	Inari	Vuopaja N	Narrow face bladelet core. The core face is 29 mm long.	KM 21437:1	58	19	25	Northern (Norwegian?) chert (unknown age)	weathered white	Siiriäinen 1982
5	Inari	Vuopaja N	Bladelet/ bladeflake.	KM 21437:2	25	7	–	Northern (Norwegian?) chert (unknown age)	white	Siiriäinen 1982
5	Inari	Vuopaja N	Bladelet/ bladeflake.	KM 21437:2	36	11	–	Northern (Norwegian?) chert (unknown age)	white	Siiriäinen 1982
5	Inari	Vuopaja N	Proximal part of a cortical blade.	KM 27810:22	35.6	10.3	3.9	Carboniferous?	yellowish brown (cortical)	–

* Determinations based on the visual appearance of artefacts. The sub-division of Scandinavian flints is based on Högberg & Olausson 2007. ** Kinnunen *et al.* 1985.

Appendix II. Additional possible blade finds.

Areal group	Municipality	Site	Archive no.
1	Askola	Taka-Piskulan Ruoksmaa	KM 13067:223
1	Eura (Honkilahti)	Kolmhaara	?
1	Hartola	Uusi Ruskeala c	KM 33916:1–33
1	Lappeenranta (Joutseno)	Hiekkasilta-Hiekkakuoppa	KM 32560
1	Lappeenranta (Joutseno)	Saarenoja-Muilamäki	KM 32559
1	Orimattila	Tortola 2	KM 31858:1–2
2	Joensuu (Eno)	Mäntyniemi	KM 34109:8
3	Hyrynsalmi	Vonkka 2	KM15393:612
3	Sotkamo	Kiikarusniemi	KM 28671:300
3	Suomussalmi	Kalmosärkkä	KM 14829:339, KM 14830:752
3	Suomussalmi	TB:n ranta	KM 29104:7
3	Suomussalmi	Tormuan särkkä	KM 18322:550
3	Suomussalmi	Kukkosaari	KM 25429:1
5	Inari*	Saamenmuseo	KM 22443:80, :109, :204, :255, :443, :599, :637, :1142
5	Inari*	Vuopaja	KM 23761:255, KM 28365:443
5	Inari*	Vuopaja N	KM 27810:22, :79, :94, :361

* Bladeflakes included

Appendix III. List of catalogue numbers of artefacts shown in the illustrations.

Figure 1.
a1) KM 18501:1524
a2) KM 18501:1550
a3) KM 18501:1004
a4) KM 18501:1221
a5) KM 18501:1182
a6) KM 18501:1227
a7) KM 18501:403
b1) KM 20164:94
b2) KM 20164:127+128
c1) KM 26616:439
c2) KM 26616:324
c3) KM 26616:436
c4) KM 26616:252
c5) KM 26616:437
d1) KM 34360:2
d2) KM 31690:2
d3) KM 31690:1
e) KM 12933:1139
f) KM 8313:118
g) KM 3359:5
h) KM 31136
i) KM 32983:213
j) KM 32558:17
k) KM 34023
l) KM 19913:272
m) KM 11606

Figure 2.
a) KM 13022
b) KHM 2371
c) KM 23230
d) KM 34160:1
e) KM 25214:4
f) KM 2573:6
g) KM 7172:1
h1) KM 17875:21
h2) KM 18200:84
h3) KM 18200:289
h4) KM 18200:220
h5) KM 17875:66
h6) KM 18200:253
h7) KM 18200:347
h8) KM 18200:190

Figure 3.
a) KM 23098
b) KM 35157:2
c1) KM 14504:475
c2) KM 14504:453
d) KM 31384:230
e) KM 25587:1
f) KM 15750:249
g) KM 30234:16
h1) KM 15671:1210
h2) KM 15671:1181
i) KM 21437:1
j) KM 23377:1

Figure 10.
a) KM 32558:17
b) KM 21437:1
c) KM 34574:204
d) KM 34023

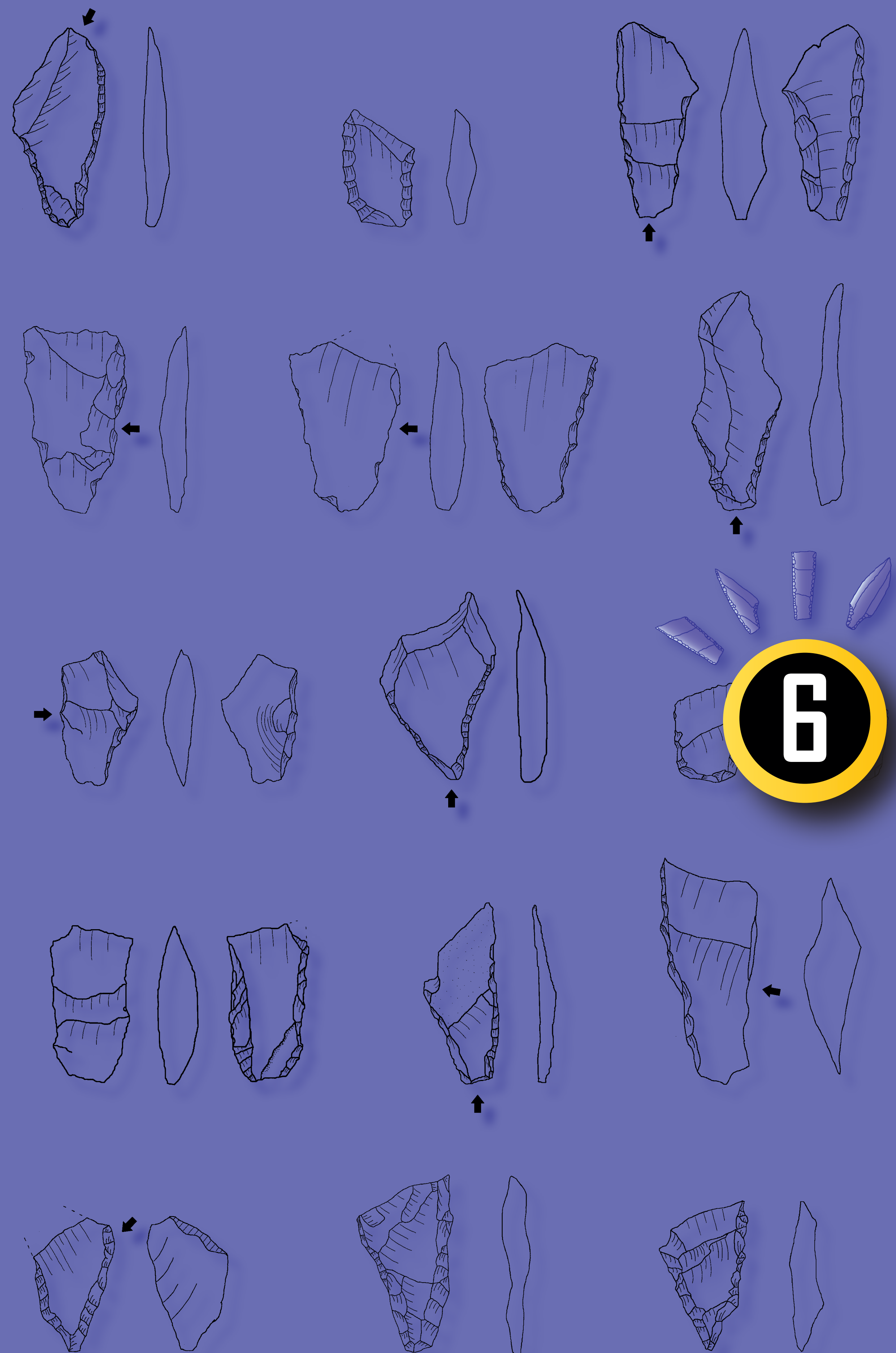
Figure 13.
a) KHM 2371
b1) KM 18501:1221
b2) KM 18501:403
b3) KM 30873:328
b4) KM 30873:1265a+b
c) KM 35917:8279
d) KM 7172:1
e1) KM 26616:437
e2) KM 26616:436
f) KM 8313:118
g) KM 11606
h) KM 14103:220
i) KM 19913:272
j) KM 31690:1

Figure 18.
a1) KM 18501:1212
a2) KM 18501:1217
a3) KM 18501:1004
a4) KM 18501:10
b) KM 34160:1
c) KM 25214:4
d) KM 32983:213

Figure 19.
a) KM 34360:2
b) KM 2573:6

Figure 20.
a) KM 23377:1
b) KM 23098
c) KM 13022
d) KM 18501:1524
e) KM 31136
f) KM 31690:2
g) KM 18200:347
h) KM 18501:1550
i) KM 3359:5
j) KM 35157:2
k) KM 17875:21
l) KM 25587:1
m) KM 20164:127+128
n) KM 18200:84
o) KM 18200:289
p) KM 17875:66
q) KM 26616:324
r) KM 14504:475
s) KM 20164:94
t) KM 26616:439
u) KM 18200: 220
v) KM 15671:1210
w) KM 31452:793
å) KM 30234:16
ä) KM 14504:453
â) KM 18200:253
ö) KM 18200:190
x) KM 26616:252
y) KM 12933:1139
z) KM 31384:230

Figure 21.
a) KM 15750:249
b) KM 15671:1181
c) KM 27810:22


6

Northern Inland Oblique Point Sites – a New Look into the Late Mesolithic Oblique Point Tradition in Eastern Fennoscandia

Mikael A. Manninen & Kjel Knutsson

ABSTRACT **The purpose of this paper is to make the first comprehensive survey of inland sites with oblique points in the northernmost parts of Fennoscandia. The chronological and technological relation of these points with similar points from Mesolithic contexts discussed in earlier Finnish, Norwegian and Swedish studies is also assessed. After a presentation and analysis of the available data it is concluded that the oblique points on the northern inland sites date mainly to *c.* 5800–4700 calBC and that at the time they were located in a boreal forest environment. It is further suggested that the discussed points in fact belong to a technological tradition that extended over the whole of eastern and northern Fennoscandia during the Late Mesolithic.**

KEYWORDS
Margin-retouched points, oblique points, inland sites, Late Mesolithic, Finland, Sweden, Norway, Lapland, northern Fennoscandia.

Introduction

The discovery of the first Mesolithic sites in northernmost Norway in 1925 (e.g., Bøe & Nummedal 1936; Tansem 1999) introduced small marginally retouched point types normally called double and single edged tanged points, oblique points and transverse points to the archaeology of northern Fennoscandia.

As a result of subsequent studies conducted at the Norwegian Barents Sea coast, this kind of points have come to be typo-chronological markers used in defining archaeological periods in the area. A typo-chronological sequence devised with the aid of radiocarbon dates and shore displacement chronology (Hesjedal *et al*. 1996; Olsen 1994) suggests a tripartite Mesolithic (Early Stone Age in Norwegian literature) timeline where points are considered typical for two phases. The points used during Phase I (*c.* 9500–8000 calBC) are usually defined as tanged and single edged points whereas the points from Phase III (*c.* 6400–4400 calBC) are called transverse points. However, defining this kind of points, which in reality often are no more than retouched edges, into specific types, is often problematic, especially without knowledge of their technological background. As the greater frequency of given point types (double-edged, single-edged, oblique and transverse) during different time periods should also be seen as tendencies rather than chronologically clear-cut occurrences (see below), in this paper we will henceforth lump together all the above mentioned point types under the general name *oblique point* (following Manninen 2005), unless otherwise indicated.

In many studies these points have been associated solely with a range of artefacts left on the sea shore by coastal groups. They have had a central role in the still continuing discussion on the early settlement of the coastal area - not least because of their likeness (see, e.g., Odner 1966:132) to Late Paleolithic and Early Mesolithic artefact types found further south in Scandinavia. Not until surveys in the late sixties and early seventies (Havas 1999:6; K. Helskog 1974) in the inner parts of Finnmark and Troms county, were a number of sites with similar points identified in the inland areas of northern Norway as well.

In southern and western Finland oblique points have also been known since the early twentieth century (Luho 1948; 1967; Matiskainen 1986; 1989) and are nowadays considered typical for the Late Mesolithic (*c.* 6500–4900 calBC). However, in northern Finland the first oblique points were found as late as the 1960's in excavations at the Neitilä 4 site in Kemijärvi, southern Finnish Lapland (Kehusmaa 1972:76) and only in the late 1980's and early 1990's, when excavation activities had begun, were the first oblique points identified in assemblages from northern Finnish Lapland (Arponen 1991; Halinen 1988; Kankaanpää 1988; Kotivuori 1987a,b).

In northern Sweden sites with Mesolithic oblique points were not recognized until the inland site Rastklippan, situated in southern Swedish Lapland, was discussed in a paper by Knutsson (1993). Through an excavation of the site in the same year, the recovered points could be dated to the Late Mesolithic. Although oblique points have been found also in a couple of other locations in Swedish Lapland, the material has so far not entered into any serious discussion concerning archaeological cultures in the area.

The growing number of oblique point sites found in the inland areas of northern Fennoscandia raises the question of their relation to the oblique points known from other parts of Fennoscandia. Although there is evidence of oblique point using groups using both the coast and the inland areas in northern Finnish Lapland and Finnmark during the Late Mesolithic (Manninen 2009), since evidence from the Barents region suggests that the exploration of inland areas by the maritime adapted population inhabiting the coast was possible already at an early stage (Kankaanpää & Rankama 2005:112), association with at least three archaeologically defined contexts can be suggested for the northern inland oblique point sites. These are: (1) the colonisation phase of the North Norwegian coastal areas, (2) Phase III of the Finnmark typochronology, and (3) the Late Mesolithic oblique point tradition of Southern Finland (see, e.g., Knutsson 1993; 2005b; Olsen 1994; Rankama 2003).

In this paper we evaluate the available data on the northern inland oblique point finds and discuss their date and position in the prehistory of Fennoscandia. The sites discussed are mainly in the counties of Norrbotten and Västerbotten in Sweden, in the counties of Finnmark and Troms in Norway and in the county of Lapland in Finland. As the aim here is to present and discuss inland sites, specific coastal sites are commented upon only when there is a need to contextualize and clarify some features of the inland sites. Oblique points dated to the Mesolithic are found also on the Russian Barents Sea coast and possibly also in the inner parts of Kola Peninsula (Šumkin n.d.:30–31, table IX:1–3; 1986:Fig.4; Woodman 1999:304) but since data on these sites are scarce they are not discussed further in this paper.

Survey of Inland Sites with Oblique Points

A survey of research literature, museum catalogues, and archived reports in Västerbotten county museum (Sweden), Tromsø museum (Norway) and The National Board of Antiquities (Finland) conducted for the purpose of this study revealed 31 inland sites with oblique points from the study area (**Fig. 1**). Short descriptions of the sites are provided in **Appendix I** and a glossary of place names used in the paper in **Appendix II**. In site names the spelling used by the site's namer is followed.

The known inland oblique point sites in the study area are mostly located on lake shores or on the banks of large rivers. This picture, however, is probably distorted due to the focus of modern habitation as well as archaeological field survey work on this type of locations. The area under discussion is largely uncultivated and sparsely populated. Many of the points have been found in field surveys and excavations associated with the building and use of modern infrastructure, especially hydroelectric dams. However, this fieldwork activity, as well as the few more strictly research-oriented field surveys and excavations, has covered only fraction of the vast research area, the best part of which has never been archaeologically surveyed.

When making the archive survey, we have accepted as oblique points only artefacts that have, besides the correct general shape, be it tanged, single edged, oblique or transverse, a backing retouch used to create the shape. Some pieces without retouch or with

Figure 1. The study area and the oblique point sites in northern Fennoscandia. The extent of the Baltic Sea at *c.* 6400 calBC is marked with light grey (following Andersson 2000). Larger dots: inland oblique point sites. Smaller dots: coastal oblique point sites. Sites discussed in the paper: 1. Rastklippan; 2. Lappviken; 3. Garaselet; 4. Tallholmen; 5. Kujala/Uutela; 6. Neitilä 4; 7. Lautasalmi; 8. Museotontti; 9. & 10. Kaunisniemi 2 & 3; 11. Satamasaari; 12. Kaidanvuono SW; 13. Kirakkajoen voimala; 14. Nellimjoen suu S; 15. Ahkioniemi 1&2; 16. Vuopaja; 17. Bealdojohnjalbmi 1; 18. Supru Suprunoja; 19. Mávdnaávži 2; 20. Jomppalanjärvi W; 21. Leinavatn I; 22. Devdis I; 23. Aksojavri; 24. Kautokeino Kirke; 25. Guosmmarjavrre 5; 26. Njallajavri, 27; Riggajåkka; 28. Peraddjanjarga; 29. Gasadaknes; 30. Noatun Neset; 31. Kjerringneset IV/Inganeset. Coastal sites: 32. Gammelkänt; 33. Kaaraneskoski 1; 34. Lossoas Hus & Gressbakken Øvre; 35. Nordli; 36. Mortensnes; 37. Slettnes; Coastal sites on the Barents Sea coast from Bøe & Nummedal (1936), Gjessing (1942), Odner (1966), Simonsen (1961) and on the Bothnian Bay from Moberg (1955) and Rankama (2009).

only a few inconclusive retouch scars, but nevertheless used as points, might be lost using these criteria. However, as it has become evident that the fracturing of lithic raw materials, especially quartz, produces fragments that are easily misinterpreted as points if only the general shape of the piece is taken into account (Knutsson 1998; see also Skandfer 2003:282) their application is essential. The oblique points from the inland sites discussed here (**Fig. 2**), have been, when possible, confirmed in this study using these criteria.

Some sites that have been reported to have yielded oblique points are excluded from this study as a consequence of applying the strict criteria. These are Virdnejavri 113 (Simonsen 1986:3–4; 1987:36 but see Havas 1999:9–10; Knutsson 1998); Pekkalanvaara Tunturipolku (Halinen 1995; 2005; Manninen 2009) and Rahajärvenkaita (Manninen 2009). All of these sites have yielded point-like artefacts that have un-diagnostic or insufficient modification.

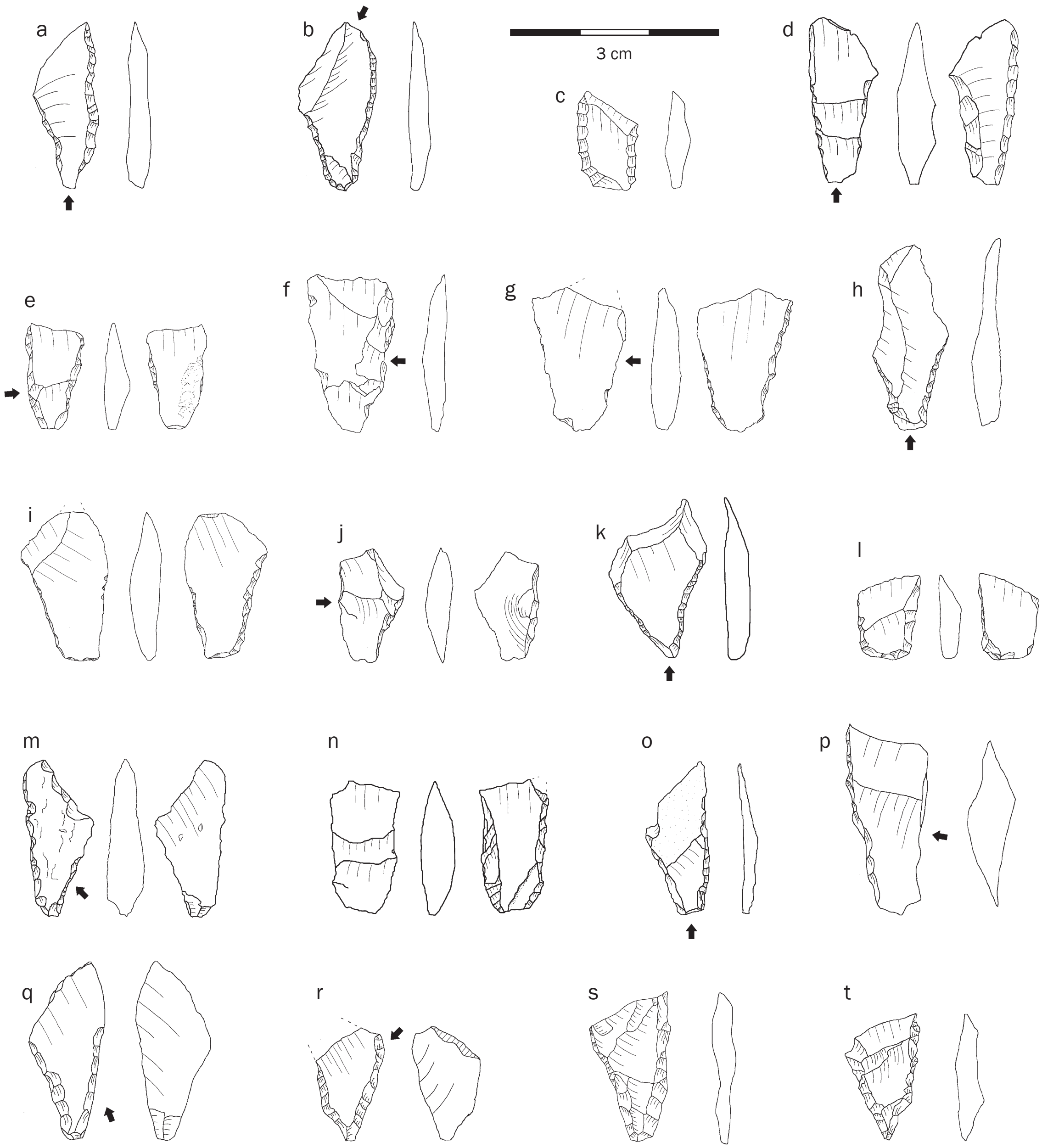


Figure 2. Examples of oblique points from the inland sites. When discernible the orientation of the original blank is marked with an arrow. a) Rastklippan 1969, quartzite; b) Rastklippan 1969, chert; c) Lappviken, porphyry; d) Tallholmen, quartzite; e) Lautasalmi (KM 15846:78), chert; f) Museotontti (KM 28464:289), quartz; g) Museotontti (KM 24464:620), quartz; h) Kaunisniemi 2 (KM 26039:42), chert; i) Satamasaari (KM 26010:4), chert; j) Nellimjoen suu S (KM 24375:454), chert; k) Vuopaja (KM 28365:446), chert; l) Vuopaja (KM28365:442), chert; m) Supru (KM 22685:13), quartz; n) Mávdnaávži 2 (KM 34675:199), chert; o) Mávdnaávži 2 (KM 34675:147), chert; p) Devdis I (Ts. 5720:i), quartzite; q) Devdis I (Ts. 5720:ag) quartzite; r) Aksujavri (Ts. 8479:x) chert; s) Riggajåkka (Ts. 5898:g), chert; t) Gasadaknes (Ts. 5895:di), chert. Drawings by M. A. Manninen, a–d and p–r re-drawn from sketches by K. Knutsson, s–t re-drawn from E. Helskog 1978:Fig. 3.1.1.

The Date of Oblique Points on the Inland Sites

The dating of oblique points in different parts of Fennoscandia is based on shore displacement chronology, typology and/or radiocarbon dates. As regards the inland sites discussed here, only the latter two methods have potential (for a discussion of the shore displacement of Lake Inari, see Arponen & Hintikainen 1995).

The typo-chronological classification into oblique, transverse, tanged double edged, and single edged points (Helskog *et al*. 1976:24–26) has been used in dating Mesolithic sites in Norway. In northern Norway a division is made between Phase I tanged and singled edged points and Phase III transverse points. However, typological dating of simple artefact types, in this case marginally retouched points, is problematic. Excavated and analysed closed contexts with oblique points like Rastklippan and the Mávdnaávži 2 site in northern Finnish Lapland, where one short occupation phase has created the entire lithic assemblage, illustrate the problems well. The variation in point shapes in these assemblages is big and includes the whole range of types from varied tanged points over oblique points to transverse points. What is significant is that these artefacts have been made of one raw material and if not during a single knapping session at least during the same occupation phase (see Manninen & Knutsson *in preparation*). Such examples, of course, must have implications for how we interpret the finds also from other sites with these kinds of points.

For instance, in several discussions of Early Mesolithic sites on the Barents Sea coast, there seem to be points that do not fit typo-chronologically the dating implied by the other finds and the elevation of the site (e.g., Havas 1999:64; Thuestadt 2005:74; see also Tansem 1999:98). This is often explained away as a consequence of several occupations at the same site but, with the above mentioned examples in mind, it could also be interpreted as variation within the artefact type. Whether the points on these sites are Early or Late Mesolithic is of no particular importance here. The situation just goes to show that at sites like Slettnes IVA:1 on the Finnmark coast, where points are considered Preboreal on the basis of typology (Hesjedal *et al*. 1996), but where five radiocarbon dates (**Fig. 10**) and a Holocene transgression shore might rather point towards a Late Mesolithic date, the dating of points on typological grounds can be questioned.

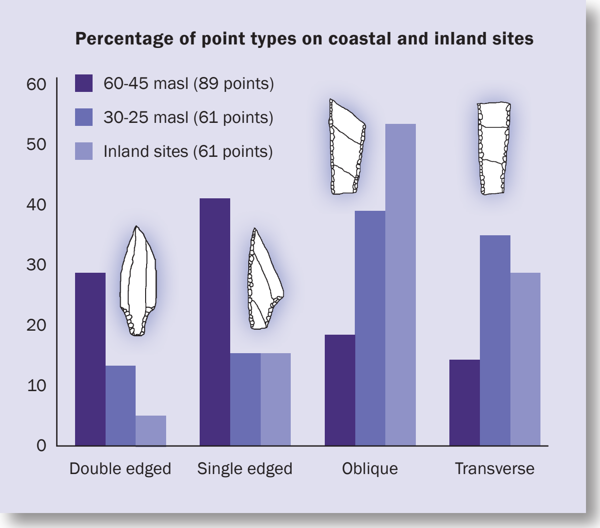


Figure 3. Edge types of points from sites at Varangerfjord divided in two temporal groups (roughly Early and Late Mesolithic) on the basis of altitude above sea level (data from Odner 1966 and Simonsen 1963) and from the inland sites Mávdnaávži 2, Devdis I, Rastklippan and Aksujavri. Point type drawings adapted from Helskog *et al.* 1976.

If one looks through Simonsen's (1961; 1963) and Odner's (1966) descriptions of sites in the Varangerfjord area in eastern Finnmark, variation in point types can in fact be seen. **Figure 3** shows the point types according to Odner's and Simonsen's site descriptions and find classifications in relation to the sites' height above sea level. The diagram gives a rough picture of the typological, chronological and geographical variation.

Although this information should also be set against the technological context of the sites in question, it nevertheless forces a careful approach especially when dealing with stray points found in, for example, the inner parts of Finnmark and northern Finland. It seems obvious that the difference in point types as defined by Helskog *et al*. (1976:24–26) between old sites and younger ones is one of quantity rather than quality. On the older sites there is a higher frequency of double and single edged tanged points, on the younger sites oblique and transverse points dominate. A further problem we are facing here, judging from the contextual analysis of the finds (Manninen & Knutsson *in preparation*) and, assuming that the typo-chronology can be applied to the inland points, is that most of the points we are classifying are actually rejects from the manufacturing process instead of finished products. This makes their classification into point types questionable by definition.

	Site	Lab. No.	Date BP	calBC 2σ	Material	Context
1	**Devdis I**	**T-1343**	6575±150	**5759–5221**	Charcoal	Pit structure 3
2	Devdis I	**T-1453**	1800±220	**357–AD649**	Unburnt bone	Pit structure 2
3	Devdis I	**T-1342**	1020±80	**AD784–1212**	Unburnt bone	Pit structure 1
4	**Garaselet**	**St-5190**	8160±110	**7490–6820**	Charcoal	Feature 22, cooking pit
5	Garaselet	**St-5193**	8040±100	**7300–6660**	Charcoal	Feature 5, hearth
6	Garaselet	**St-5191**	7885±300	**7540–6220**	Burnt bone	Feature 9(u), bone concentration
7	Garaselet	**Ua-2063**	7640±100	**6680–6260**	Charcoal	Feature 27, cooking pit
8	Garaselet	**Ua-2062**	6890±90	**5980–5630**	Charcoal	Feature 24, cooking pit
9	Garaselet	**Ua-2067**	6210±120	**5470–4850**	Charcoal	Feature 35, charcoal layer
10	Garaselet	**Ua-2061**	6190±90	**5350–4860**	Charcoal	Feature 8, hearth
11	Garaselet	**Ua-2066**	5970±110	**5210–4610**	Charcoal	Fearture 34, hearth
12	Garaselet	**Ua-2060**	5920±80	**5000–4590**	Charcoal	Fearture 6, cooking pit
13	Garaselet	**Ua-2064**	4480±80	**3370–2920**	Charcoal	Feature 30, hearth
14	Garaselet	**Ua-2065**	1370±80	**AD540–880**	Charcoal	Fearture 31, hearth
15	**Kjerringneset IV/Inganeset**	**Tua-3025**	5990±55	**5006–4727**	Food crust	Säräisniemi 1 pottery sherd
16	Kjerringneset IV/Inganeset	**Tua-2886**	4815±65	**3712–3377**	Charcoal	Cultural layer
17	**Mávdnaávži 2**	**Hela-963**	6455±45	**5484–5327**	Burnt bone	Bone pit/hearth isnside hut
18	**Museotontti**	**Hel-2563**	7880±140	**7137–6457**	Charcoal	Hearth 119,31/155,42
19	Museotontti	**Hel-2564**	7750±120	**7029–6414**	Charcoal	Refuse pit, 124,5/148,6
20	Museotontti	**Hel-2728**	7640±120	**6770–6232**	Charcoal	Refuse pit, 121,7/176,43
21	Museotontti	**Hel-2565**	7640±110	**6697–6238**	Charcoal	Refuse pit, 122/158
22	Museotontti	**Hel-2559**	7210±120	**6368–5847**	Charcoal	Hearth 120,72/151,83
23	Museotontti	**Hel-2562**	5100±100	**4225–3658**	Charcoal	Hearth 121,75/155,5
24	Museotontti	**Hel-2561**	2150±110	**405–AD71**	Charcoal	Hearth, 123,14/153,21
25	Museotontti	**Hel-2560**	1430±110	**390–AD867**	Charcoal	Hearth, 126,2/146,3
26	**Nellimjoen suu S**	**Hel-2678**	6000±120	**5220–4606**	Charcoal	Cultural layer inside hut
27	**Noatun Neset**	**Beta-131296**	5950±90	**5196–4598**	Food crust	Säräisniemi 1 pottery sherd
28	**Rastklippan**	**Ua-3657**	8055±75	**7287–6695**	Charcoal	Hut floor filling
29	Rastklippan	**Ua-3656**	6540±75	**5626–5363**	Charcoal	Hearth inside hut
30	Rastklippan	**Ua-3655**	6355±75	**5483–5081**	Charcoal	Hearth inside hut
31	Rastklippan	**Ua-3654**	6410±75	**5508–5223**	Charcoal	Hearth inside hut
32	**Supru, Suprunoja**	**Hel-2117**	6650±120	**5782–5365**	Charcoal	Hearth 1034/954
33	Supru, Suprunoja	**Hel-2116**	5830±120	**4997–4403**	Charcoal	Hearth 1036/942
34	Supru, Suprunoja	**Hel-2115**	4230±120	**3319–2476**	Charcoal	Hearth 1030/936
35	Supru, Suprunoja	**Hel-2114**	3680±100	**2434–1772**	Charcoal	Hearth 1030/936
36	**Vuopaja**	**Hel-3584**	7600±90	**6634–6254**	Charcoal	Hearth 121/998
37	Vuopaja	**Hel-3585**	7410±100	**6443–6072**	Charcoal	Hearth 120/1000
38	Vuopaja	**Hel-3582**	7110±140	**6328–5716**	Charcoal	Hearth 116-118/994
39	Vuopaja	**Hel-2628**	5390±120	**4454–3973**	Charcoal	Hearth 3/1987
40	Vuopaja	**Hel-2627**	5340±90	**4341–3984**	Charcoal	Hearth 3/1987
41	Vuopaja	**Hel-2629**	5330±90	**4337–3981**	Charcoal	Hearth 9/1987
42	Vuopaja	**Hel-3581**	5210±140	**4334–3713**	Charcoal	Hearth 102/994C
43	Vuopaja	**Ua-10109**	4955±65	**3942–3640**	Charcoal	Fossil turf layer
44	Vuopaja	**Ua-4364**	4805±85	**3765–3372**	Food crust	Kierikki Ware sherd
45	Vuopaja	**Hel-3583**	4490±90	**3494–2914**	Charcoal	Fossil turf layer
46	Vuopaja	**Hel-2631**	4410±140	**3515–2674**	Charcoal	Hearth 4/1987
47	Vuopaja	**Hel-2626**	4330±90	**3339–2680**	Charcoal	Hearth 3/1987
48	Vuopaja	**Hel-2632**	4140±90	**2902–2488**	Charcoal	Hearth 4/1987
49	Vuopaja	**Hel-2633**	4020±120	**2886–2209**	Charcoal	Hearth 4/1987
50	Vuopaja	**Hel-2630**	3120±90	**1608–1129**	Charcoal	Hearth 7/1987
51	Vuopaja	**Hel-2634**	2530±100	**840–400**	Charcoal	Hearth 106/1004C
52	Vuopaja	**Ua-4365**	2220±80	**406–AD52**	Charcoal	Midden 110/1000A
53	Vuopaja	**Hel-2912**	1770±100	**27–AD532**	Charcoal	Hearth inside hut

Figure 4. Radiocarbon dates from the inland oblique point sites. Data from K. Helskog 1980b; Knutsson 1993; 2005b; *manuscript*; Skandfer 2003; 2005; Manninen 2006; Halinen 2005; Sohlström 1992; Nieminen 1984. See figure 5 for the numbers in the first paragraph.

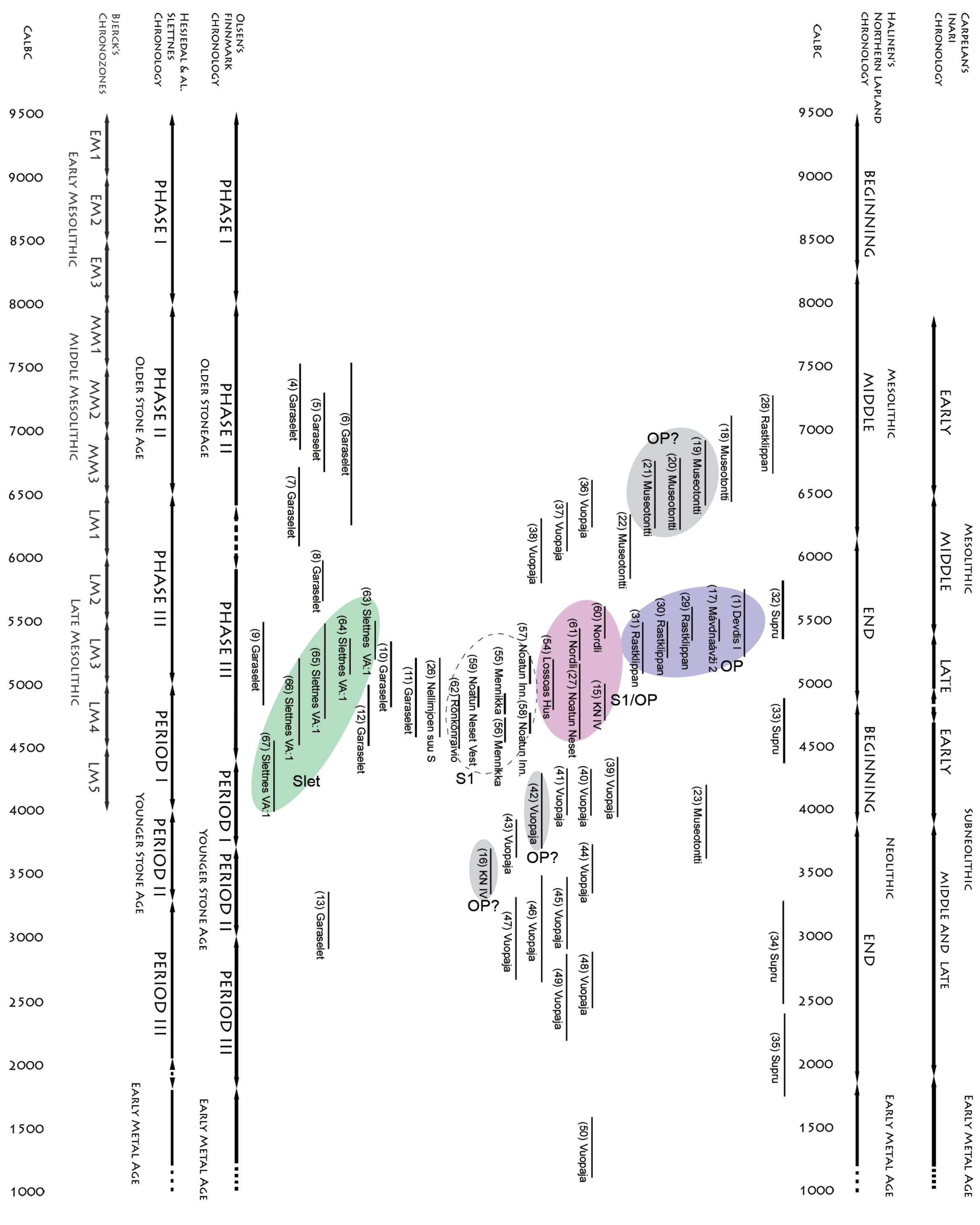


Figure 5. Calibrated radiocarbon dates from inland oblique point sites, Säräisniemi 1 food crust and the coastal site of Slettnes VA:1. Dates from secure inland contexts are marked with purple (OP), dates from Säräisniemi 1 food crust are marked with light red (S1/OP, sites with oblique points) and a grey dashed line (S1, sites without oblique points). Equivocal dates associated with oblique points are marked with grey (OP?). Dates from Slettnes are marked with green (Slet). Site numbers are the same as in Fig. 3. Chronological frameworks by Bjerck 2008; Hesjedal *et al.* 1996; Olsen 1994; Halinen 2005 & Carpelan 2003.

The published radiocarbon dates from the discussed inland oblique point sites cover a time span ranging from *c.* 7300 calBC to *c.* AD 1210 (**Fig. 4**). When discussing the dating of the oblique points some dates can be rejected offhand. These are the two young dates from Devdis I that the excavator deems unreliable (Helskog 1980:98), the old date from Rastklippan that derives from the filling used to level the hut floor (Knutsson 2005:246) and six Iron Age dates from multi-period sites: one from Garaselet, three from the lower terrace of Vuopaja and two from Museotontti. In **Figure 5,** the positions of the remaining radiocarbon dates from the inland oblique point sites are compared with chronological frameworks used in the research area, radiocarbon dates from food crust attached to Säräisniemi 1 pottery, and radiocarbon dates from the coastal site Slettnes VA:1.

Most of the dates derive from sites with multiple occupations from different time periods and are not directly associated with oblique points. Their usefulness in dating the points is therefore questionable at best. Only one charcoal sample from Devdis I, three charcoal samples from Rastklippan and one of burnt bone from Mávdnaávži 2 derive from reliable contexts, in this case camp sites with a limited use period. They are all dated to a short period between 5800 and 5100 calBC. It is noteworthy that also the Aksujavri site in inner Finnmark has recently been dated to this time interval (B. Hood *pers. comm*. 2008).

The representativity of this group of short-term camps can be questioned when it comes to the whole set of inland oblique point sites. Some sites with oblique points have yielded dates of *c.* 6500 calBC or older. Most of these dates have no clear association with the oblique points in these sites. However, at the Museotontti site, some radiocarbon dates falling between *c.* 7000 and 6200 calBC could indicate that oblique points were already in use in the inland area considerably earlier.

The distribution of the seven excavated points at Museotontti can be compared with the general distribution of quartz artefacts, burnt bones, radiocarbon dates, and hearths. During the 1987–1989 excavations finds were registered using an exact system where finds located within a palm sized area in an excavation spit were registered to the same grid. The data have been later used to illustrate find distributions (see, e.g., Halinen 1988; 1995:Appendix 18; 2005:179; Kankaanpää 1988; 1990; Manninen 2006:Fig. 3) that were the basis for the illustrations of combined horizontal distributions shown here (**Fig. 6**). Since there are no radiocarbon dates or reported oblique points from the 1989 area, only the 1987 and 1988 areas are presented in these distributions.

The stone concentrations in the excavated area most probably represent hearths that are more or less disturbed by post-depositional processes such as later human activity and tree roots. Kankaanpää (1988:7–9) identified nine stone hearths in the 1987 area and Halinen (1988:4–6) seven or eight more in the 1988 area. Most of the stones are likely to have been brought to the site that is situated on sandy soil. Judging from the radiocarbon dates at least two stone-packed hearths date to the Iron Age and one hearth has yielded iron slag (Kankaanpää 1988:21). It is difficult to distinguish possible Stone Age hearths from the mixed and disturbed stone concentrations on the map. A clearer picture of Stone Age activity can be achieved by studying the distribution of lithic material versus burnt bones. Although a considerable amount of burnt bone fragments may also be late, concentrations of bone fragments were found in pits filled, besides burnt bone, with sooty soil and charcoal. Some of these pits have been radiocarbon dated to the Mesolithic. These pits correlate with concentrations in the distribution of quartz artefacts that also include most of the oblique points.

The Mesolithic dates, however, derive from pits and hearths dug through the cultural layer, whereas the points were found in the mixed topmost excavation spits (Kankaanpää 1988; Halinen 1988). Although it is tempting to date the points on the basis of the *c.* 6500 calBC dates that coincide with the clearly defined quartz concentrations, it must be borne in mind that the correlation may be a result of post-depositional processes such as the recycling of older lithic waste or the clearing of hut areas. The surface areas of the quartz concentrations are not small, a fact that supports Halinen's assertion that each concentration in fact represents multiple occupations. It is worth noting that the area covered by one of the quartz concentrations has yielded radiocarbon samples with more than two thousand years' minimum difference in age (6700–6240 and 4230–3660 calBC). However, even with these problems in mind, the correlation of the early radiocarbon dates and the distribution of quartz debitage and identified oblique points at Museotontti cannot be bypassed. Until new evidence from more closed contexts is found, however, the dating

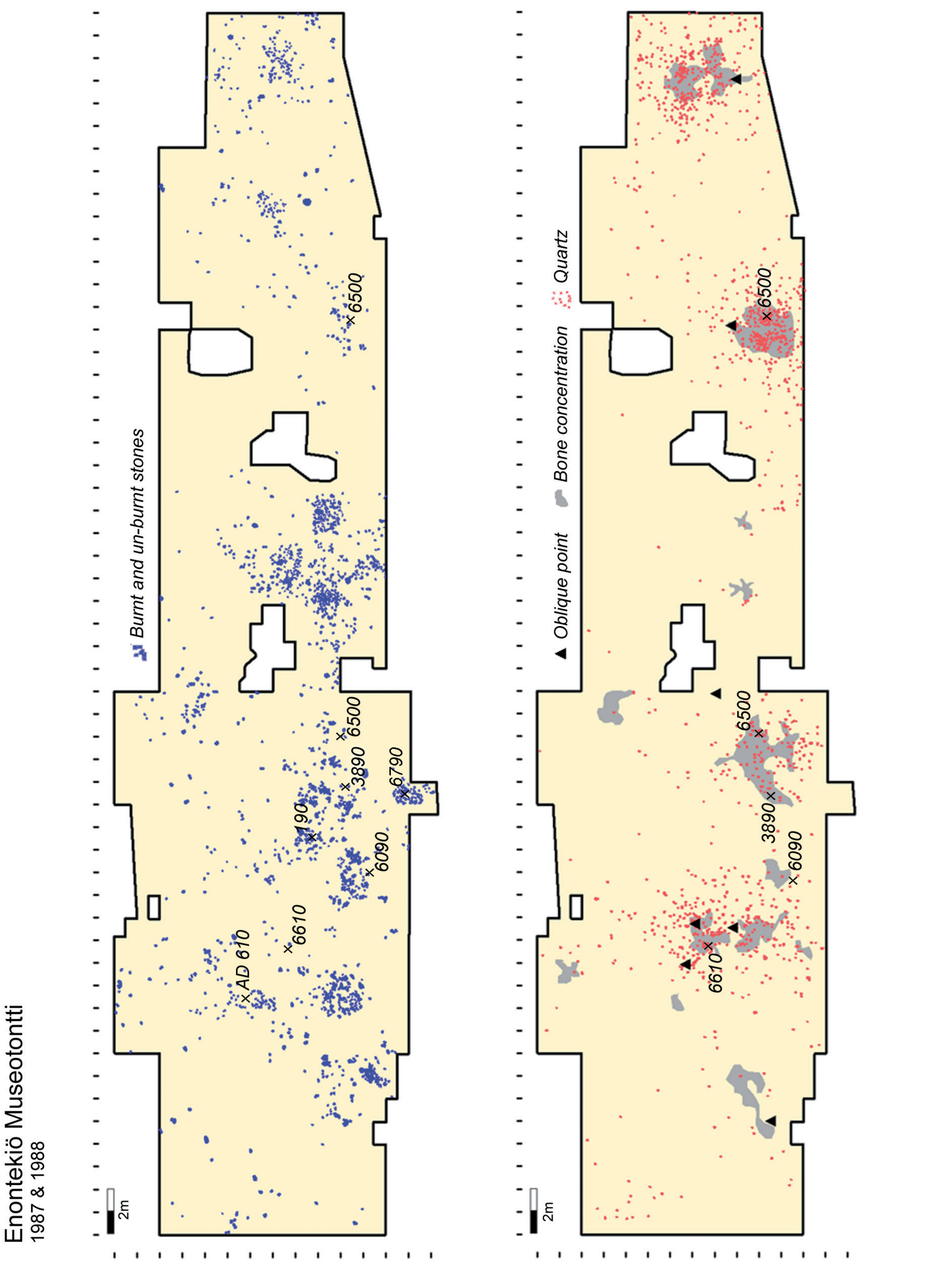


Figure 6. Oblique points, radiocarbon dates and concentrations of stones and finds at the Museotontti site. Dates are marked as calibrated median ages BC. Maps drawn by M. A. Manninen after maps by P. Halinen and M. Koponen in Kankaanpää (1988) and Halinen (1988; 2005).

	Site	Lab. No.	Date BP	calBC 2σ	OP
15	**Kjerringneset IV/Inganeset**	Tua-3025	5990±55	**5006–4727**	x
54	**Lossas Hus**	Tua-3024	6065±55	**5207–4808**	x
55	**Mennikka**	Tua-3027	5975±60	**5002–4720**	
56	Mennikka	Tua-3022	5795±55	**4785–4520**	
57	**Noatun Innmarken**	Tua-3023	6185±65	**5307–4983**	
58	Noatun Innmarken	Tua-3029	5850±55	**4837–4554**	
27	**Noatun Neset**	Beta-131296	5950±90	**5196–4598**	x
59	**Noatun Neset Vest**	Tua-3026	6030±70	**5207–4729**	
60	**Nordli**	TUa-3028	6570±60	**5629–5384**	x
61	Nordli	TUa-3021	6330±50	**5466–5215**	x
62	**Rönkönraivio**	Hela-38	5830±85	**4905–4488**	

Figure 7. Radiocarbon dates from charred food crust adhering to Säräisniemi 1 pottery found in Finnmark and Northern Finnish Lapland. Data from Skandfer (2005) and Carpelan (2004). OP= oblique points found at the same site.

of the oblique points at Museotontti to *c.* 6500 calBC must be considered tentative.

As regards younger sites, an interrelation between oblique points and early Comb Ware of Säräisniemi 1 type has been suggested by several authors (e.g., Engelstad 1989:335; Skandfer 2003:281–283). At a number of the inland sites (Nellimjoen suu S, Vuopaja, Kjerringneset IV/Inganeset and Noatun Neset) as well as at several coastal sites in Varanger (Nordli, Gressbakken Øvre and Lossoas Hus) both oblique points and early Comb Ware of Säräisniemi 1 type have been discovered (Gjessing 1942:174–177; Skandfer 2003:282).

The radiocarbon dates from food crust adhering to Säräisniemi 1 pottery sherds from both inland and coastal sites (**Fig. 7**) indicate that pottery was adopted in the Varanger area and northern Finnish Lapland as early as before 4400 calBC (5600 BP) (see Carpelan 2004:28; Skandfer 2003; 2005), i.e., before the conjectural end of the Mesolithic Phase III in Olsen's Finnmark chronology and during Bjerck's (2008:74) Mesolithic LM4 chronozone (**Fig. 5**). It thus seems clear that oblique points and Säräisniemi 1 pottery are partly coexistent, or at least chronologically close, in the research area even if the earliest dates from Säräisniemi 1 food crust in Finnmark included an error due to the marine reservoir effect (but see Skandfer 2005:5–7). An association between the points and the pottery seems therefore plausible.

It is important to note, however, that although they were found at the same sites, none of the oblique points derive from contexts unequivocally associated with Säräisniemi 1 pottery. Schanche (1988:108), for example, suggests that the points from Nordli could be considerably older than the pottery from the site while Skandfer (2003:283) proposes a post-Säräisniemi 1 dating of *c.* 3500 calBC for the oblique points from Kjerringneset IV/Inganeset.

In sum, the current evidence from the research area speaks in favour of a use period ranging from *c.* 5800 to 4700 calBC for the oblique points in the inland areas of northernmost Fennoscandia with the best contexts dating between *c.* 5800 and 5100 calBC. However, the possibility that oblique points were in use longer, possibly from *c.* 6500 calBC until *c.* 3500 calBC, cannot be completely ignored. It is also important to note that there is no evidence at the moment that would suggest an early Mesolithic (Olsen´s Phase I) date for oblique points from the inland sites.

The Dating of Points Found North and South of the Northern Inland Sites

The *c.* 5800–4700 calBC use period of oblique points on the northern inland sites suggested here is close to the dating of oblique points in southern Finland, as well as to the dating of the late oblique points on the Barents Sea coast. Since the oblique points discussed here seem to fill a gap between these two areas, where similar points are also found, a closer look at the foundations for their dating seems appropriate.

In 1982 Heikki Matiskainen used shore displacement chronology to date the oblique points from the southern part of the east coast of the Gulf of Bothnia and from along the northern shore of the Gulf of Finland to *c.* 6500–4900 calBC (7700–6000 BP) (Matiskainen 1982; 1986; 1989:389; 2002:100).

The fact that oblique points in Finland have not been found in any good context with radiocarbon dates older than 6400 calBC strengthens the result of the shore displacement dating. According to present knowledge, the end of the use of oblique points in southern Finland coincides with the adoption of pottery. The earliest Early Comb Ware dates in mainland Finland, which range from *c.* 5000 to 4800 calBC (Hallgren 2008: 63; Leskinen 2002: Table 1; Schulz 2004), agree with Matiskainen's results. It is also worth noting that only occasional oblique points have been reported from sites that have yielded Early Comb Ware (e.g., Luho 1957:157).

As regards the use period of oblique points in southern Finland, it is important to note that none of the coastal sites have been radiocarbon dated. Therefore, the possibility that the oldest sites according to shore displacement chronology were never close to the shoreline, and are therefore younger than the shoreline dating indicates, cannot be excluded (Matiskainen 1982:66–67).

The Kaaraneskoski 1 site, one of the two oblique point sites in our study area that are located at the former shores of the Gulf of Bothnia, has yielded a radiocarbon date that gives support to this caveat. The distribution of finds at Kaaraneskoski 1 suggests a series of small camps following successive shorelines. The altitude of the site at 83–90 meters above sea level indicates a Late Mesolithic shore displacement dating of approximately 5900–5500 calBC (7000–6500 BP) and suggests an occupation history of some four hundred years. Charcoal collected in the midst of a concentration of burnt bone at approximately 88 m a.s.l. has been dated to 5470–5060 calBC (6310±85 BP, Hela-323). The date gives reason to believe that habitation at the site was well above the actual shoreline. (Kankaanpää 1998; Rankama 2009.)

It must therefore be stressed that the beginning of the use of oblique points in southern and western Finland at *c.* 6500 calBC as indicated by shore displacement chronology, should be seen as a *terminus post quem*. The majority of oblique point sites in Matiskainen's study (1989:Fig.17) are located on shorelines dated to *c.* 5500–4900 calBC (6500–6000 BP).

As mentioned earlier, on the Norwegian Barents Sea coast oblique points are considered typical for two Mesolithic phases. Following Olsen (1994): Phase I, *c.* 9500–8000 calBC (10,000–9000 BP) and Phase III, *c.* 6400/5900–4400 calBC (7500/7000–5600 BP). Olsen's Phases I and III are essentially the same as Woodman's (1993; 1999) Komsa and Trapetze phases. On the basis of the Slettnes excavations, Hesjedal *et al.* (1996:184–186, 190) suggest a slightly differing time span for the third phase (6400–4900 calBC or 7500–6000 BP), but all in all, there seems to be a consensus in recent Norwegian literature about a bimodal typo-chronological dating for oblique points in northernmost Norway (Grydeland 2000:20; Hesjedal *et al.* 1996:184–186; Olsen 1994:29–36).

In his 1966 study Knut Odner, building on relative shore displacement dating of Mesolithic sites in the Varanger area, arrived at a similar conclusion. Odner's Horisont 2, however, possibly due to an assumption of a developmental sequence, included transitional forms between the tanged and single-edged points of Horisont 1 and the transverse points of Horisont 3 (Odner 1966:106). In the more updated radiocarbon based typochronologies, the use of oblique points is said to considerably decrease (Olsen 1994:31, 39) or completely end (Hesjedal *et al.* 1996:184–185, 198) during Phase II. This notion is significant in relation to the inland oblique point sites, as it seems to indicate that oblique points reappeared on the coast in tandem with the appearance of oblique point sites in the inland areas.

The argument that oblique points disappeared at the end of Phase I and later reappeared during Phase III is based on the absence of oblique points from assemblages assigned to Phase II. If we look at the typo-chronological definition of Phase II (Hesjedal *et al.* 1996:184–185; Olsen 1994:39; Woodman 1993:70), it is based on two radiocarbon dated house/tent foundations: Mortensnes, *fornminne* 2, R10 (Schanche 1988:72–75) and Slettnes *Felt* IVA, *Område* 2, *tuft* 45 (Hesjedal *et al.* 1996:65–66), four un-dated house foundations from the site Starehnjunni with a radiocarbon dated outside activity area (Engelstad 1989:334, Woodman 1993:70), and three un-dated house foundations from the multi-period site Sæleneshøgda (Olsen 1994:39; Simonsen 1961:27–42; Woodman 1993:70). More recently one more house pit in the Varanger area has been radiocarbon dated to Phase II (Grydeland 2005:57).

All of the above-mentioned houses have yielded artefacts indicating systematic blade/microblade production, a technological trait considered typical for Phase II (Olsen 1994:31–33; Woodman 1993). Oblique points have been found, depending on the author, in two or three of the houses at Sæleneshøgda (Simonsen 1961:27–37; Woodman 1993:table 2). The authors disagree about the number of houses that have yielded oblique points. Simonsen reports two from House I, three from House II, and three from House III whereas Woodman mentions two from House I, one from House II, and none from House III. Simonsen originally considered the site Neolithic (1961:42) due to polished stone adzes discovered, but this dating was later questioned by K. Helskog (1980a:48), who suggested a Late Mesolithic date. The site's elevation at 56 m a.s.l. (Grydeland 2000:28), however, suggests a *post quem* shoreline dating of *c.* 8700 calBC (9400 BP, see **Fig. 8**). Woodman suggests that the blade production at the site belongs to Phase II, whereas the points found inside the houses, as well as the points found in the dump outside the houses, derive from an earlier occupation at the site (Woodman 1993:71). This explanation for the points is possible but their dating to Phase II seems equally possible. Hence the context of the oblique points remains unclear.

There is an obvious problem in the fact that only assemblages found inside houses are available for

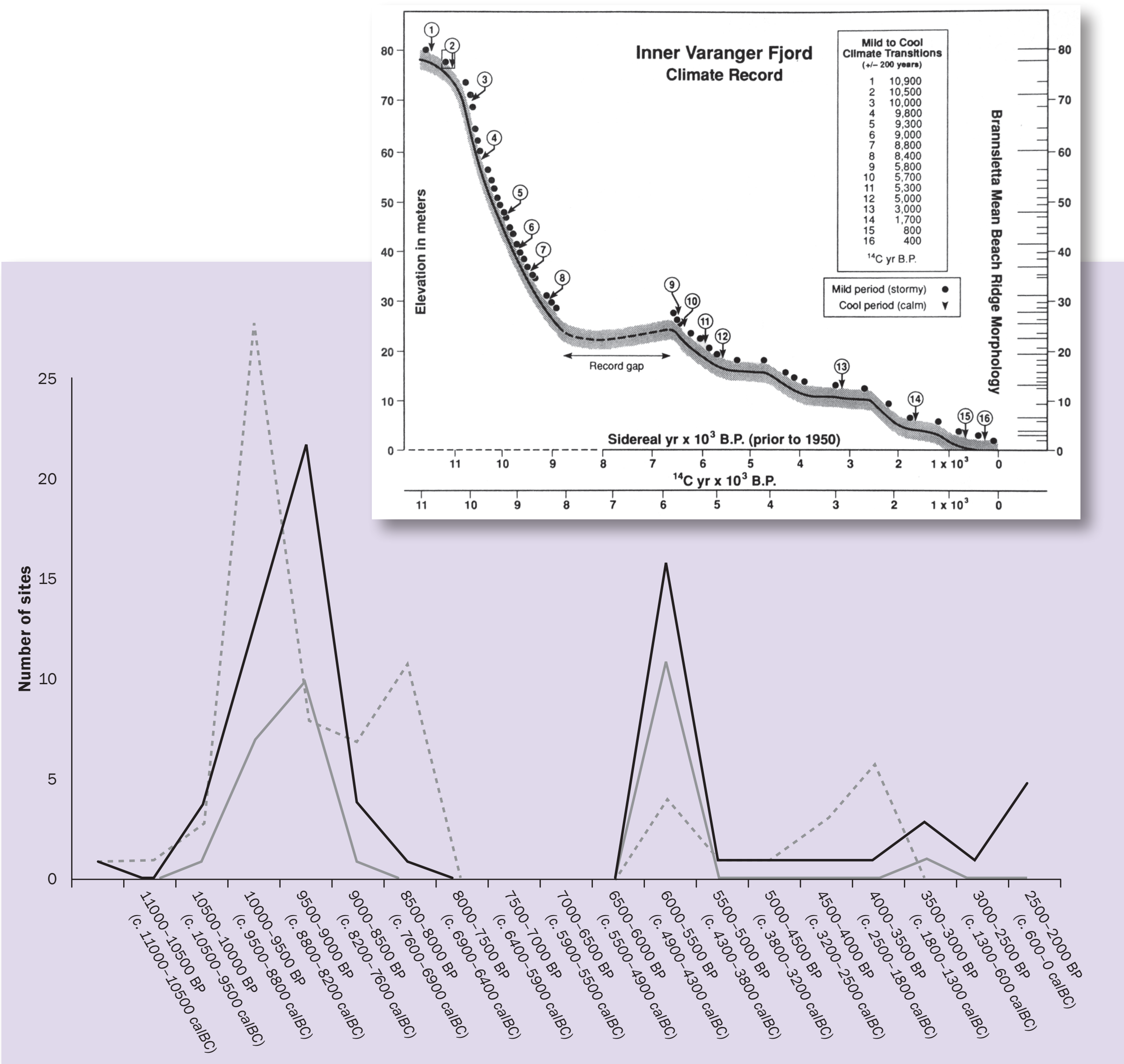


Figure 8. The number of sites in 500 year blocks according to altitude above the sea level on the southern shore of the Varangerfjord. The graphs indicate the total number of sites (solid black line, n=74) and sites with oblique points (solid grey line, n=30) according to the corrected altitude (reduced by 5 metres) and, for comparison, the total number of sites according to uncorrected altidutes (grey dashed line, n=74). The shore levels are dated using the shore displacement curve by Fletcher *et al.* (1993:125) for inner Varanger Fjord (right upper corner). Site and site altitude data from Bøe & Nummedal (1936); Simonsen (1961); Odner (1966).

assessing whether oblique points were in use during Phase II. Artefact types used in other parts of the sites besides houses, or on other kinds of sites, are inevitably underrepresented. Further, due to the mid-Holocene Tapes transgression, shore-bound Phase II assemblages in Finnmark have been largely mixed and destroyed (e.g., Hesjedal *et al*. 1996:134; see also Møller 1987:58) - another factor reducing the available data.

This can be illustrated with data from the Varanger area. According to a simulated shore displacement curve the Tapes transgression should not have affected sites (isobase 28 in Møller & Holmeslet 1998) or at least was less strongly felt than in more westerly Finnmark. A shore displacement diagram for the geological locality Brannsletta, east of Nyelv, based on radiocarbon dated archaeological sites and paleoshoreline indicators (Fletcher *et al*. 1993), shows a record gap at shore levels dating to *c*. 8000–5900 BP (*c*. 6900–4900 calBC). The gap corresponds to the Tapes transgression and indicates that sites dated to this time period were probably affected by the transgression also in the Varanger area (**Fig. 8**). The record gap covers parts of Phases II and III in the Finnmark chronology.

As this curve fits also the more recent radiocarbon dates from the area (e.g., Stuorrasiida-1 in Grydeland (2005) and Nordli in Skandfer (2005)) better than the simulated curve, we have used it to compile a graph representing the number of sites with oblique points at different shore levels in the Varanger area (**Fig. 8**). Møller (1987) has reached the conclusion that Stone Age sites on the Barents Sea coast were located on average 4.8 metres (1.9–9.5 m) above the shoreline. We have therefore lowered the altitude of each site by five meters before comparing it with the shore displacement curve.

The emerging picture seems to indicate that the mid-Holocene transgression may have been a major factor contributing to the absence of points in the archaeological record during Phase II. It is notworthy that during the Mesolithic as a whole the number of sites with oblique points correlates with the overall number of sites.

The diagram is not necessarily accurate enough when it comes to the dating of the peaks and it is probably also affected by old survey and altitude data. However, as regards the number of sites, a similar trend is seen in the more updated data presented by Grydeland (2005:Fig. 5).

	Site	Lab. No.	Date BP	calBC 2σ
	Slettnes IV A:1	CAMS 2684	7320±60	**6361–6056**
	Slettnes IV A:1	Beta 49006	6860±170	**6055–5484**
	Slettnes IV A:1	Beta 49005	6720±120	**5886–5471**
	Slettnes IV A:1	Beta 49004	6200±100	**5373–4851**
	Slettnes IV A:1	T 8101	6160±110	**5356–4807**
63	**Slettnes VA:1**	Beta-49052	6390±80	**5509–5214**
64	Slettnes VA:1	Beta-49057	6390±100	**5551–5078**
65	Slettnes VA:1	Beta-49056	6170±170	**5473–4727**
66	Slettnes VA:1	Beta-49053	5930±110	**5205–4531**
67	Slettnes VA:1	Beta-49054	5470±120	**4547–3996**

Figure 9. Late Mesolithic radiocarbon dates from the Slettnes IVA:1 and VA:1 sites. Data from Hesjedal *et al*. 1996.

All in all, judging from the data presented here, it must be concluded that at the moment the evidence from the Varanger area implies a decline in oblique point use during Phase II but the data cannot be interpreted as indicating that the points were totally absent. It must be stressed, however, that there is a very limited number of published radiocarbon dates and assemblages from Phase II and that since we have not had the opportunity to study the sites and assemblages in the area in detail we may be lacking relevant unpublished information.

It must also be emphasized at this point that published radiocarbon dated coastal contexts from Phase III that include oblique points are not numerous either. At Slettnes there are twenty-five radiocarbon dates from five different areas that fall within Phase III, but Hesjedal *et al.* only date 11 obliques points to this phase. Nine of these points derive from area VA:1 that has yielded five dates falling between 5510 and 4000 calBC (**Figs. 5 & 9**). Two more points have been found in probable secondary contexts in Early Metal Age houses. (Hesjedal *et al.* 1996:167.) The transportation of points to secondary context in soil and turf used in house building is a plausible explanation also for the two points from house 1 at Nyelv nedre vest (Simonsen 1961:410) dated by shore displacement chronology to *c.* 3200–2650 calBC (see Helkog 1980a:Table 1 for radiocarbon dates) and the one point found in the Early Metal Age House 1 at Noatun Neset (Simonsen 1963:77–80).

Besides Slettnes, points have been reported from Mortensnes 8R12 (Schanche 1988:78–80), a midden radiocarbon dated to the interface between the Late Mesolithic and the Early Neolithic, but according to Skandfer (2003:282) these artefacts are not retouched and therefore cannot be regarded as points.

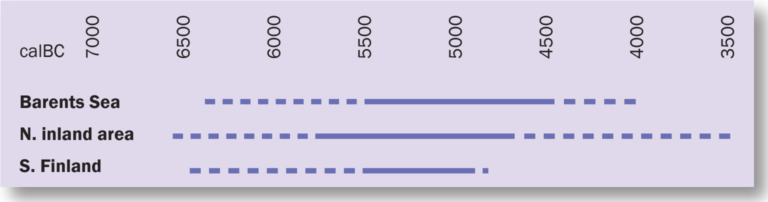


Figure 10. Roughly defined use-periods of late oblique points in Eastern Fennoscandia according to data from radiocarbon dates and shore displacement chronologies with the best evidence marked with a solid line.

The dates from Slettnes VA:1 that fall between 5510 and 4000 calBC are in good agreement with the dates suggested for oblique points on the northern inland sites and within the dating suggested for oblique points further south in Finland (**Fig. 10**).

Allowing for a margin of error of a few hundred years, the main use periods of Late Mesolithic oblique points on the northern inland sites (*c.* 5800–4700 calBC) and the Late Mesolithic oblique point sites on the Barents Sea coast (*c.* 5500–4300 calBC) and in southern Finland (*c.* 5500–4900 calBC) seem the same, and even the dates suggesting possibly older and younger dates for oblique points, if correct, do not change this picture much.

The Extent of the Late Mesolithic Oblique Point Tradition

As has become apparent, the Late Mesolithic oblique points in the inland areas of northern Fennoscandia are not an isolated phenomenon. Although only a few good contexts have been radiocarbon dated, the evidence from shore displacement studies and find contexts supports a rapid expansion of the oblique point technology into most of Eastern Fennoscandia during The Late Mesolithic.

From a technological point of view, there are some shared traits in the Late Mesolithic oblique points that separate them from the Early Mesolithic points of the Barents Sea coast. For instance, the type variation within the lower lying and thus younger group of points in the Varanger area appears similar to the variation on the inlands sites (**Fig. 3**). Besides being an indication of contemporaneity and thus in line with the evidence that the same groups used both the coastal and the inland areas in Eastern Finnmark and northern Finnish Lapland (see Manninen 2009), this also supports the observations about technological differences in blank production.

According to Hesjedal *et al.* (1996:166) and Woodman (1999:301–302), at coastal sites points made from blades in a technological "blade context" seem to be typical of the early stages of the Mesolithic, whereas the Late Mesolithic points are generally made from flakes and related to a more dynamic flake industry (Hesjedal *et al.* 1996:186; Olsen 1994:34). However, the description of tanged points at Slettnes (Hesjedal *et al.* 1996:166) indicates that the blank type (blade vs. flake), the orientation of the blank, and the position and localization of retouch vary also in Early Mesolithic points to some degree.

In the same way as for the late coastal points, the use of flake blanks from platform cores is a common denominator for the technology employed to make points at Rastklippan, Devdis I, Aksujavri and Mávdnaávži 2, as well as the other points from northern inland sites (**Fig. 2**) and the oblique points of more southern Finland (see Manninen & Knutsson *in preparation*; Manninen & Tallavaara *this volume*; Matiskainen 1986).

Grydeland (in Skandfer 2003:270) notes that occasional blades are found at Late Mesolithic sites in the Varangerfjord area and some blades are also known from the Late Mesolithic inland sites (e.g., Manninen 2005:Fig. 6) but they do not seem to derive from systematic blade production.

On the Barents Sea coast some chronological changes in raw material use have also been observed. Schanche (1988:124) has noted, mainly on the basis of shore displacement dates, that at Mortensnes the use of fine grained raw materials grew until *c.* 6400 calBC (7500 BP) but nearly ended towards the end of the Mesolithic. In a similar vein the use of quartz is noted to have increased during the Mesolithic Phase III at Slettnes (Hesjedal *et al.* 1996:159) and in the Varanger area Grydeland (2005:57), also relying on shore displacement dating, has noted a gradual increase in quartz use and in the use of cobbles as a raw material source towards the end of the Mesolithic. These differences can be seen as further indication of the spread of a new flake-based technology which, as a consequence, was less dependent on fine grained raw materials.

All in all, the Late Mesolithic oblique point technology can be characterised as very flexible. The flake blanks do not seem to have been of a standardised shape and the manufacture of points was not dependant on specific raw materials. In addition, the quality of the raw material, as regards workability or the size of raw material pieces, does not seem to have been a major factor, although, when available, cherts and fine grained quartzites were preferred. The studied assemblages include points made, by archaeological definitions, of quartz, quartz crystal, slate, rhyolite and different kinds of cherts and quartzites. This kind of technology facilitates the use of areas with very different raw material situations and enables organizational strategies not tied to specific lithic raw material sources.

The geographical distribution of the technological concept described above covers most of eastern and northern Fennoscandia. In Finland, the southern border of the area with oblique points is the Gulf of Finland. The distribution of sites that have yielded oblique points, as shown in **Figure 11,** is of course biased due to the impact of focused research projects. The large blank areas between the known sites are most probably artefacts of research history (Manninen & Tallavaara *this volume*). To the north and west in northern Norway, the sea forms a natural border, in the east we so far have to accept the fact that the Finnish/Russian border, due to a different research tradition, creates an artificial eastern limit for the area of oblique point sites (but see Halinen *et al*. 2008:250; Nordqvist & Seitsonen 2008:228). Future collaboration with Russian colleagues will surely change this picture.

Oblique points made of quartz flakes have been reported also from a small group of sites in East Middle Sweden dated by shore displacement to *c*. 6500–5300 calBC. Since these points have no clear counterparts in adjacent areas in mainland Sweden and since they predate the Early Neolithic Ertebølle type transverse points, Guinard and Groop have suggested that these points, if correctly classified, are related to the northern Swedish Late Mesolithic oblique point sites. (Guinard & Groop 2007:209.) However, oblique points in this area could also be related to points found east of these sites. It has been suggested that the skerry landscape at the entrance to the Gulf of Bothnia between present day Sweden and Finland was colonised from the east (e.g., Åkerlund 1996; Åkerlund *et al*. 2003).

The use of the area by Late Mesolithic groups from mainland Finland is indicated by the fact that the first permanent settlement on the Åland islands, identified from Early Comb Ware pottery dated to *c*. 5000 calBC (Hallgren 2008:58–63), arrived from this direction. Late Mesolithic oblique points in East Middle Sweden could therefore be seen as a sign of a south-western extension of the oblique point tradition from mainland Finland. One oblique point is also mentioned in passing by the Finnish archaeologist Ville Luho (1967:118) to have been found in Västerbotten in Sweden, from the shore of Lake Malgomaj, approximately 140 km south of Rastklippan.

If we exclude these at the moment unpublished points in East Middle Sweden and the possible point from Västerbotten, the southern border of oblique point sites in Sweden passes through Rastklippan and Lappviken/Garaselet. The large void between these sites and Finnmarksvidda with only the stray finds from Jokkmokk and Överkalix, is most probably a result of low research intensity, or perhaps the fact (see Knutsson 1998) that Swedish archaeologists simply have not had the oblique point in their culturally constructed repertoire of types to be discovered during excavation or surveying in this area.

However, there are indications that oblique points are not necessarily common in the area where the Rastklippan, Lappviken and Garaselet sites are found. In 1969 Hans Christiansson initiated a survey project in central Norrland (Christiansson & Wigenstam 1980). During a period of 10 years 10 000 prehistoric finds at more than 2000 mainly Stone Age sites were found in the *c*. 3000 km^2 area west of Lappviken and Garaselet. In 1998 the material was catalogued by Lennart Falk. One of the present authors (Knutsson) had the opportunity to follow the process of classification of the material.

Despite the fact that every flake in the assemblage was scrutinized, no points of the type discussed here were found. It is, according to our opinion, thus reasonable to assume that the Arvidsjaur area is outside the main distribution of the more North and East Fennoscandian oblique point tradition. However, within and to the south of this area in central and southern Swedish Lapland, there are several sites which contain debitage from another technological tradition – the handle core tradition (Knutsson 1993; Olofsson 1995; 2003).

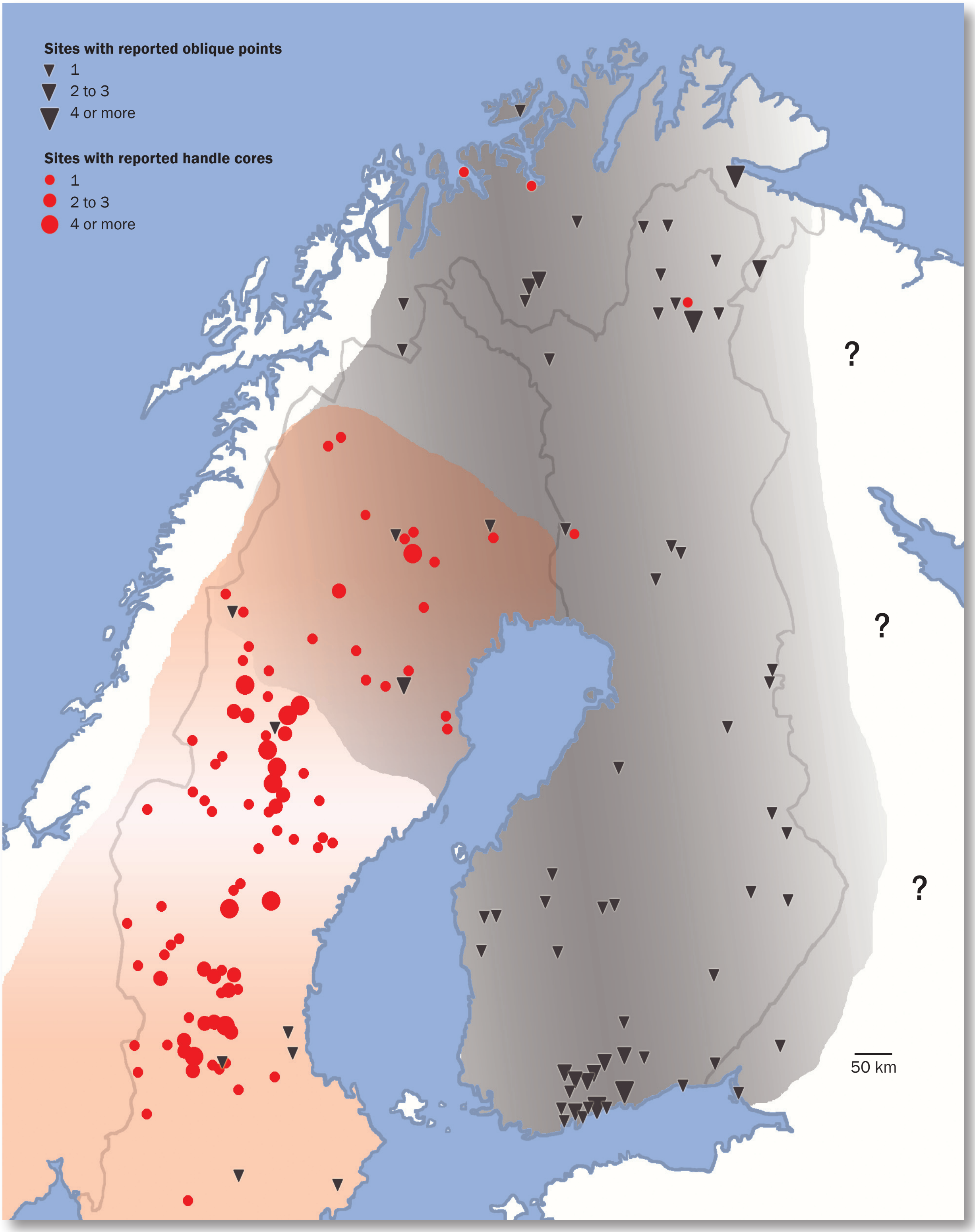


Figure 11. Rough areas of distribution of sites with oblique points (triangles) and handle cores (dots) in Finland, Sweden and northern Norway. In Norway only the two known handle cores from northern Norway, the northern inland oblique point sites, and the unequivocally late oblique point sites on the Barents Sea coast are indicated. Note that artefacts that may not fulfil the defining criteria otherwise used in this paper are also included albeit the artefacts reported by Schulz (1990) as representing boat shaped microblade cores in earlier contexts have been excluded (cf., Knutsson 1993:11–12; Rankama & Kankaanpää *this volume*). Data from Damm *pers. comm.* 2009; Guinard & Groop 2007; Halinen *et al*. 2008; Luho 1967; Manninen & Tallavaara *this volume*; Matiskainen 1986; Nordqvist & Seitsonen 2008:228; Olofsson 1995; Rankama 2009; Siiriäinen 1982).

In 1996 Lars Forsberg presented an analysis of 33 radiocarbon dated Mesolithic sites from Norrland. On the basis of a multivariate matrix and a statistical analysis, he came to the conclusion that the Norrland Mesolithic can be separated into three chronological phases with distinctly different material cultures. According to the analysis, the second of these phases, which includes handle cores, dates to *c.* 6300–4650 calBC (7400–5800 BP) (Forsberg 1996).

Anders Olofsson (1995; 2003) evaluated the handle core tradition in more detail, making also a survey of all handle core sites with radiocarbon dates known at that time in northern Sweden. With a few exceptions, all of the sites are multi-component sites with problematic relations between dating and find material. According to Olofsson (2003:77–79) the earliest dates associated with handle cores are more or less uncertain but there are, however, three stratified sites with handle cores and/or keeled scrapers which give a better context for dating this tradition, or at least a part of it, in the discussed area. One of the sites is Garaselet, where an oblique point has also been found. A one metre thick sealed layer containing handle cores at Garaselet could be dated by four separate dates from hearths and cooking pits (Knutsson 1993) to between *c.* 5450 and 4600 calBC (**Fig. 12**).

	Site	Lab. No.	Date BP	calBC 2σ
	Döudden	St 453	6260±225	**5630–4710**
	Döudden	St 456	6170±100	**5330–4840**
	Döudden	St 548	5200±200	**4450–3640**
	Döudden	St 552	5100±185	**4340–3530**
	Döudden	St 550	5070±125	**4230–3640**
	Döudden	St 551	5050±120	**4230–3640**
9	**Garaselet**	Ua-2067	6210±120	**5470–4850**
10	Garaselet	Ua-2061	6190±90	**5350–4860**
11	Garaselet	Ua-2066	5970±110	**5210–4610**
12	Garaselet	Ua-2060	5920±80	**5000–4590**
	Gressvattnet VI	Birm-654	6990±115	**6070–5660**
	Gressvattnet VI	T-654	6860±120	**5990–5560**
	Gressvattnet VI	T-656	6750±100	**5840–5490**
	Gressvattnet VI	T-655	5980±220	**5370–4370**

Figure 12. Radiocarbon dates from the handle core sites Döudden, Garaselet and Gressvattnet VI. Data from Bergman (1995), Holm (1991) and Knutsson (1993).

The two other sites are also close to the Swedish finds of oblique points: at Döudden in Arjeplog parish in Lappland, Sweden, two stratigraphically secured keeled scrapers/handle cores have been dated to *c.* 5600–3600 calBC by six samples from the find layer (Bergman 1995:91). In addition, the Gressvattnet VI site in Norway, which lies close to the Swedish border and just 40 km east of Rastklippan, yielded handle-cores and/or keeled scrapers in layers dated by four radiocarbon dates (Holm 1991:33) to *c.* 6070–4400 calBC.

The handle core tradition in Norrland thus seems to approximate the handle core chronology in the south (see Andersson & Wigforss 2004; Guinard & Groop 2007; Knutsson 2004; Sjögren 1991), and can be dated to *c.* 6400–4300 calBC (7500–5500 BP) making it contemporaneous with the oblique point tradition. However, only in northern Sweden are oblique points known from the same sites as typical handle cores.

Our hypothesis will thus be that the handle cores and the oblique points are artefact types that represent contemporaneous but spatially exclusive social networks with some distinctly different traits in their material culture. It is probable that even in northern Sweden microblades detached from handle cores were in fact also a part of a projectile technology, namely slotted points (Larsson 2003:xxvii; Liden 1942).

The distribution of handle core sites in Norway (Olofsson 1995:113–118) is otherwise beyond the scope of this paper, but it is worth noting that in northern Norway, in the counties of Finnmark and Troms, only two unambiguous handle cores have so far been found (Damm 2006; *pers. comm.* 2009). The small number of artefacts reported as handle cores in Finnmark and northern Finland in earlier studies (e.g., Odner 1966; Schulz 1990; Siiriäinen 1982; Simonsen 1961) have been questioned in Olofsson's survey (Olofsson 1995:118, 122; see also Kankaanpää & Rankama 2005:139–140; Knutsson 1993:11–12) and it can be stated that although occasional handle cores, or at least microblade cores, are likely to be found also in the Late Mesolithic assemblages here, they are outside the main area of the handle core tradition.

It is, thus, not possible to define exactly the southern border of the oblique point tradition in Sweden and Norway. The contact zone of the spatially exclusive but temporally synchronous distributions of handle cores and oblique points seen in **Figure 11** could, however, indicate an actual "historical" border approximately in the area where the last remnants of the Scandinavian ice sheet melted at the end of the last glacial cycle. The process of human colonisation and the consequent establishment of social networks in northern Sweden during prehistory seem to be closely related to the speed of ice retreat and the extent of the area covered by the ice sheet in the early Holocene (see Knutsson 2004). From this point of view the border between the two Late Mesolithic technological traditions could be seen as reflecting a border deriving from when the first colonisers arriving from the south and from the east met in northern Sweden at the end of the last glacial cycle.

Discussion – the Spread of the Late Mesolithic Oblique Point Technology

The Late Mesolithic oblique points in Finnmark have provoked debate (e.g., Hood 1992:45; Olsen 1994:40; Rankama 2003) stemming from the assumption that the points represent the first colonisers of Finnmarksvidda. The assumption was based on the fact that for a long time no earlier cultural substrata were known in Finnmarksvidda, although finds on the Finnmark coast and in northern Finnish Lapland indicated habitation for millennia before this period.

If, in fact, the inland areas of Finnmarksvidda were not colonised before the Late Mesolithic by oblique point using groups, this could indicate that the spread of the new technology was related to a demographic expansion. This would have further implications for the study of forager groups inhabiting the source area of the expansion and would naturally also raise the question why the area had previously remained uninhabited.

The biotic environment of the late Mesolithic oblique point sites is one parameter that might explain or at least contextualize the events leading to the expansion of this specific technological tradition in northern Fennoscandia, including Finnmarksvidda. In 1993 Olsen (1994:40; 45) suggested that the Late Mesolithic inland sites with oblique points are the first signs of permanent settling of the area and resulted, in addition to social reasons, from environmental changes, namely the expansion of pine forest into this region.

In the study area estimations of the extent of forest cover and temperatures during prehistory are based, besides other sources, on reconstructed prehistoric tree lines. Alpine tree lines can be seen as sensitive bioclimatic monitors and robust proxy paleoclimatic indicators (Kullman 1999:63). More recent studies in this field give a different picture of prehistoric forest cover in Finnmarksvidda than the one prevailing at the time of Olsen's book.

Finds of birch megafossils indicate that the tree line in the northern Scandes was 300–400 meters higher than today almost directly after deglaciation (*c.* 7500 calBC) and until *c.* 3000 calBC (Kullman 1999; Barnekow 2000:416). According to Eronen *et al.* (1999) and Kultti *et al.* (2006) pine forest reached its maximum extent in Finnish Lapland between *c.* 6300 and 2000 calBC, with a peak prior to *c.* 4000 calBC when pine colonised 95% of the currently unforested areas of northern Finnish Lapland. These results are congruent with data from Dividalen in inner Troms (Jensen & Vorren 2008) and can be extrapolated to the inland areas of northern Norway in general (e.g., Hicks & Hyvärinen 1997). It can thus be concluded, that a mixed birch pine forest, with a gradually growing proportion of pine, was present in Finnmarksvidda much earlier than the appearance of oblique point technology in the area.

Hence, the securely dated inland oblique point sites were in a boreal forest environment with a tree-line up to 400 meters higher than today. Both the pollen spectrum from the floor of the Rastklippan hut which was dominated by pollen from pine, birch, alder and hazel as well as various herbs (Robertsson & Hättestrand *manuscript*), and the pine charcoal found in the Mávdnaávži 2 and Rastklippan huts, are in good agreement with this. This knowledge also undermines the explanation that the spread of oblique point technology in the inland areas of northern Norway was a colonisation process related to the spread of the boreal forest.

Evidence from areas surrounding Finnmarksvidda does not support the idea of a Late Mesolithic colonisation of vacant land, either. Finnish Lapland was gradually freed of continental ice starting from the northeast at *c.* 9500 calBC (10,000 BP) and by *c.* 8400 calBC (9100 BP) the edge of the ice sheet crossed the present day border between Finland and Sweden (Johansson & Kujansuu 2005). The earliest known site in northern Finnish Lapland, the Sujala site in Utsjoki, dates to the interface between the Preboreal and the Boreal periods, at *c.* 8300 calBC (Rankama & Kankaanpää 2008).

According to the present general model of deglaciation (Andersson 2000), the northernmost part of Sweden saw opportunities for human occupation from both the north and the south. By *c.* 7500 calBC the last remnants of the Scandinavian ice sheet melted and it was

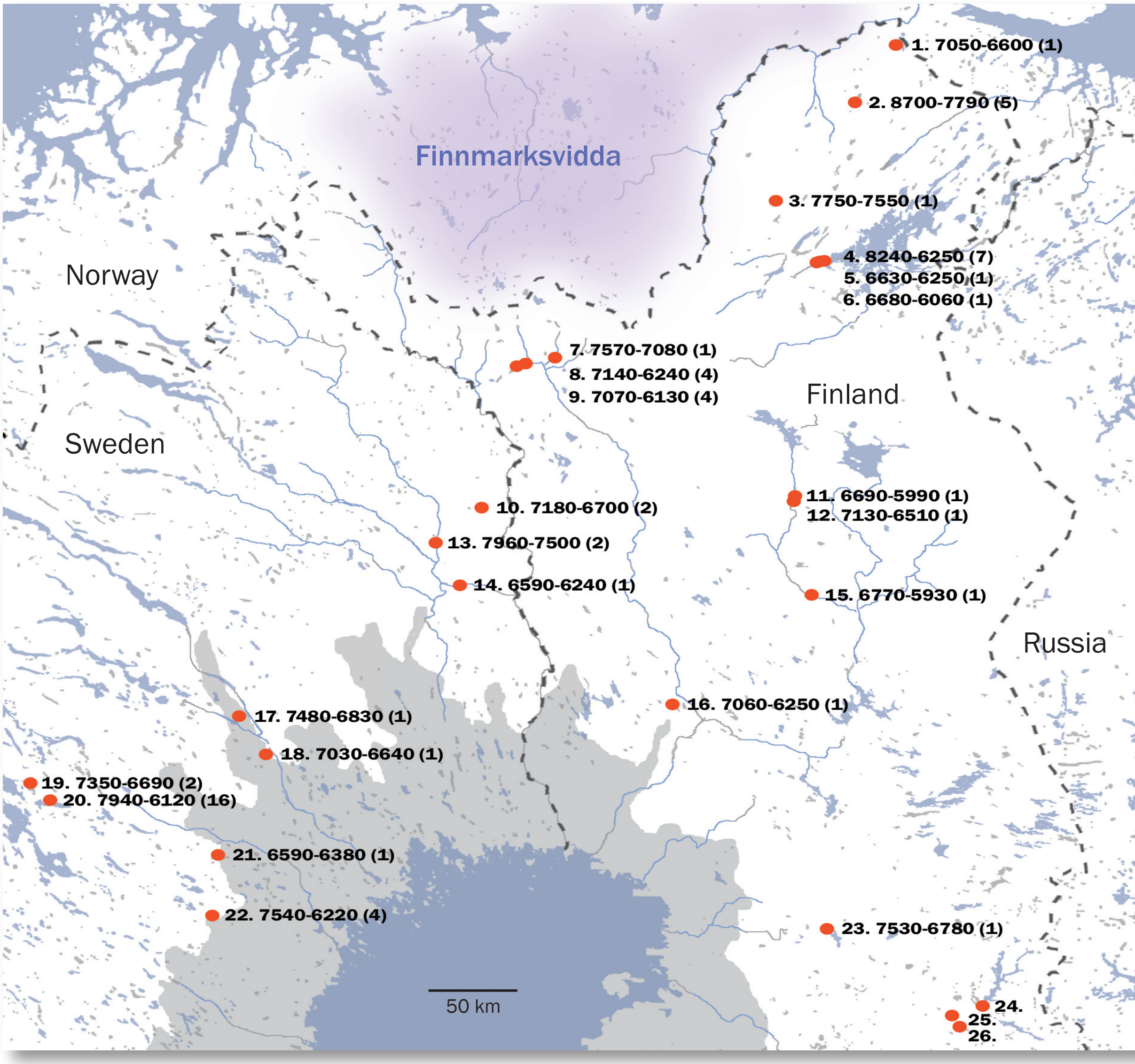


Figure 13. Sites with radiocarbon dates of *c.* 6400 calBC or older from areas around Finnmarksvidda. The extent of the Baltic Sea at approximately 6400 calBC is marked with light grey (following Andersson 2000). The number of dates falling within the given calBC interval is marked in brackets. The sites: 1. Pulmankijärvi, 2. Sujala, 3. Kielajoki, 4. Saamenmuseo, 5. Vuopaja, 6. Vuopaja N, 7. Myllyjärämä, 8. Museotontti, 9. Proksin kenttä, 10. Kitkiöjärvi, 11. Matti-Vainaan palo 2, 12. Autiokenttä II, 13. Kangos, 14. Pajala, 15. Alakangas, 16. Lehtojärvi, 17. Killingsholmen, 18. Tröllomtjärn, 19. Ipmatis, 20. Dumpokjauratj, 21. Skiljesmyren, 22. Garaselet, 23. Varisnokka, 24. Vanha Kirkkosaari, 25. Nuoliharju W, 26. Koppeloniemi. For references and exact dates see Appendix III.

slightly before this time that the first traces of human occupation appeared. Radiocarbon dates from the Dumpokjauratj site close to Arjeplog (Olofsson 2003:19) and the Kangos site in Junosuando (Östlund 2004) push the first settlement of northern Swedish Lapland to as far back as *c.* 7900 calBC. Although scattered and few, the dates from the early sites indicate that the foragers establishing themselves in the area followed closely the shrinking ice from both the north-east and the south. Other sites in Finnish and Swedish Lapland dating from the eight and the seventh millennia BC, indicate a relatively continuous occupation of the area from the colonisation period onwards (**Fig. 13; Appendix III**).

The deglaciation of Finnmarksvidda occurred in parallel with northern Finnish Lapland and by *c.* 8700 calBC (9400 BP) the area was free of ice. The early colonisation of the adjacent inland areas in Finland and Sweden give reason to suspect that the absence of early sites in Finnmarksvidda is a research historical coincidence. In fact, burnt bone samples from two sites in Finnmarksvidda have been recently dated and indicate that both sites have been occupied considerably earlier than 6400 calBC (B. Hood *pers. comm*. 2008). Although only two, these dates add to the indications from surrounding areas in Finland and Sweden and speak in favour of a habitation predating the spread of oblique point technology and even the suggested beginning of Finnmark Phase III at *c.* 6400 calBC.

It thus seems probable that the spread of the oblique point technology in the inland areas of northern Fennoscandia, including Finnmarksvidda, was not the result of the colonisation of pristine land by groups from the north, nor from any other direction, but the result of changes within existing forager groups in the same way as in other parts of eastern Fennoscandia.

The boreal forest environment may not explain the spread of oblique point technology but it gives a context for its adoption. The spread of pine was favourable for species that are adapted to the boreal forest such as the European elk, the beaver, the brown bear, and birds like the capercaillie and the black grouse. The effect of the expanding forest cover on reindeer (*Rangifer tarandus*) is more difficult to assess. Reindeer are present in many of the earliest dated archaeological assemblages in northern Finland (Rankama 1996; Rankama & Ukkonen 2001) and at the early Mesolithic sites Dumpokjauratj close to Arjeplog and Kangos close to Pajala in northern Swedish Lapland (Bergman *et al.* 2004; Olofsson 2003; Östlund 2004).

The present existence of two reindeer subspecies in Fennoscandia, the mountain reindeer (*Rangifer tarandus tarandus*) and the forest reindeer (*Rangifer tarandus fennicus*), has provoked discussion on their importance to prehistoric hunter-gatherers. Since it is hardly ever possible to distinguish between the two subspecies in archaeological assemblages in the area, conclusions about their occurrence are based on the environmental adaptations of the two subspecies today and the context of reindeer bones in archaeological assemblages (e.g., Halinen 2005:43–45; Rankama & Ukkonen 2001). However, the premiss behind this discussion, namely that forest reindeer had a Late Pleistocene refugial origin separate from the mountain reindeer (Banfield 1961), is not supported by research on mitochondrial DNA (Flagstad & Røed 2003). This study suggests a similar diphyletic origin for both subspecies and a relatively recent forest adaptation for the forest reindeer – possibly connected to the postglacial forest expansion.

Oscillations in climate, annual mean temperature and the ensuing changes in forest cover and vegetation in general, suggest that reindeer foraging strategies in northern Fennoscandia during the Holocene have probably changed considerably and not necessarily in a linear fashion – a fact that prevents reliable extrapolation of present reindeer behavior to more distant times.

The reindeer bones from northern oblique point sites, such as Mávdnaávži 2, Aksujavri and Vuopaja, therefore can probably not be connected with either of the present subspecies. Instead, they can be seen as an indication of the adaptation of the original tundra species to boreal forest environment. Whether it had the morphological features of *Rangifer tarandus fennicus* at this point, is of no real importance here. It is known that northern ungulates may have a large variety of foraging strategies to meet the changing needs and circumstances (for a woodland caribou (*Rangifer tarandus caribou*) example see Johnson *et al.* 2001).

Putting the discussion on reindeer subspecies aside, it is clear that the gradual introduction of new fauna to northern Fennoscandia during the Mesolithic is indicated in the archaeological record. After the initial post-glacial reindeer dominance, the refuse fauna at sites becomes more varied. At many sites from the pine forest phase, reindeer only forms a small part of the total recovered faunal assemblages (Rankama 1996; Rankama & Ukkonen 2001).

The availability of specific lithic raw materials is another environmental factor potentially affecting the spread of lithic technology. In large parts of Fennoscandia quartz was the main raw material used to make small lithic artefacts during the Stone Age. These artefacts were mainly simple scrapers and cutting tools on flakes and flake fragments that do not include formal types. For this reason the oblique point stands out in the Mesolithic assemblages in eastern Fennoscandia as the first retouched artefact type since the earliest colonisation phase. The oblique point, albeit a formal artefact type, lends itself to manufacture from many different raw materials, including quartz. This is a quality that most probably facilitated the spread of this technological concept. It is also the reason why this particular lithic technology is archaeologically so readily visible.

The reasons and mechanisms behind the rapid expansion of the oblique point technology are beyond the scope of this paper. Nevertheless, we suggest as one requirement an interconnected network of hunter-fisher-gatherer groups covering large areas of eastern and northern Fennoscandia. The oblique points seem to represent an archaeologically visible change in material culture among already established groups and can be seen as one of the first clear signs in the archaeological record of a relatively tight-knit but dynamic network of groups in the discussed area. A cohesion in material culture, suggested already earlier but especially during later periods by shared traits such as stone tool types and pottery styles (see, e.g., Hallgren 2008:57–64; Knutsson 2004; Manninen *et al*. 2003), speak in favour of a long-term "culture-historical" network system. These kinds of social networks are not stable and change through time (e.g., Whallon 2006). It must be therefore stressed that here a social network does not equal a uniform archaeological culture. Segments of material culture within a social network may well have differing distributions due to different descent histories, *i.e*., differences in the mechanisms of cultural transmission (see, e.g., Jordan & Shennan 2009).

Conclusion

In this paper we have made the first comprehensive survey of oblique point finds known to date in the inland areas of northern Sweden, northern Norway and northern Finland. According to the present data the majority of the points at the inland sites date to *c*. 6400–4700 calBC and the best contexts with oblique points all date to 5800–5100 calBC.

The technology used to manufacture points at the studied inland sites entails the use of flake blanks from a wide spectrum of raw materials, including ones that are usually considered unsuitable for the successful execution of more elaborate lithic technological concepts, such as blade production. This differentiates these points from many of the early Phase I tanged and single edged points of the Barents Sea coast that were manufactured from blade blanks. Together with the absence of evidence of the use of similar points during the coastal Phase II, the technological differences and the available dates thus lead to the conclusion that the oblique points in the inland areas of northern Fennoscandia are mainly a Late Mesolithic phenomenon.

Further, we suggest that the inland points of northern Fennoscandia can be combined with the remaining two of the three possible wider contexts suggested in the introduction, namely the Phase III points of the Finnmark coast and the Late Mesolithic points known from southern Finland. These constitute a chronologically and technologically coherent Late Mesolithic technological tradition that was present, most probably through a network of forager groups, in the whole of Eastern Fennoscandia at roughly 5500 calBC.

The environmental context of the spread of the new technology was a boreal forest. Recent work focussing on vegetation and climate development in northern Finland and along the Scandes in Sweden indicates that the expansion of pine into the already existing birch forest, began already in the early Holocene. It is probable that as species adapted to the boreal forest, such as the European elk, became common also in the northernmost parts of Fennoscandia during the Mesolithic, this contributed to the adoption of the new (hunting) technology in the area. However, as the area covered by the oblique point tradition has experienced relatively quick transmission of technological traditions both before and after the time period discussed here, one should be careful not to make a too simplistic correlation between the new technology and, for instance, the introduction of new prey species.

The point of origin of the Late Mesolithic oblique point tradition within the large area where oblique points are found cannot at this point be distinguished. It is nevertheless clear that Late Mesolithic oblique points appear in the study area and other parts of eastern and northern Fennoscandia before the centuries constituting Bjerck's (2008) LM 4–5 chronozones. These points also predate the Late Mesolithic transverse points in the southern highlands and eastern forest areas in Norway (see also Grydeland 2000:39–40) as well as the transverse points of the South Scandinavian Ertebølle Culture.

Postscript

After the writing of this paper, new radiocarbon dates have become available for several of the discussed sites, as well as three oblique point sites located in more southern parts of Finland (see Manninen & Tallavaara *this volume*). These dates lend support to the *c*. 6400 calBC date for the Museotontti points, push the earliest date of oblique points in the inland areas of northern Fennoscandia possibly as far back as *c*. 6900 calBC, and suggest that the use of oblique points began earlier in northern Finland than in southern Finland.

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Appendix I. The Inland Sites

SWEDEN

Sorsele

1. Rastklippan

The Rastklippan site is located on a small rocky island close to the southern end of Lake Deärnnájávrrie, southern Swedish Lapland. The site was discovered in the 1960s by Ivar Eriksson, one of the Swedish King's rowers, during a fishing trip with King Gustav VI Adolf.

In connection with excavations nearby at Forsavan in 1969 personnel of the Skellefteå museum, Asta Brandt and Ernst Westerlund, took 660 flakes and 14 "microliths" from the site, which consists of a small roundish turf patch on the otherwise rocky surface. Since the collecting caused damage to the site, Peter Gustafsson of the same museum visited the location again the following year and made some basic recording (Gustafsson 1970). After going through the finds Gustafsson concluded that the assemblage did not resemble any of the known archaeological finds from northern Sweden. The recovered lithic assemblage from Rastklippan was kept in the Skellefteå museum collection for over 20 years before it was "rediscovered" by Knutsson (1993) in connection with a research program on the earliest settlement of northern Scandinavia. In order to gain a better understanding of the site an excavation was carried out in 1993.

The turf patch that covered roughly 18 m² was excavated. The lithic assemblage from the site, including the finds retrieved during the 1969 visit, amounts to a total of 974 pieces. The assemblage includes 21 oblique points of quartzite and chert and a large number of other artefacts related to point manufacture. The whole assemblage has been analysed by Knutsson while a comparative analysis was carried out by Manninen in 2005. These artefacts derive mostly from a hut floor with a diameter of approximately three meters, which had been levelled using gravel and sand and lined with stones. Oblique points, a central hearth, and an associated sooty sand layer comprise a closed context that has been dated by three separate pine (*Pinus sylvestris*) charcoal samples. The samples are all dated to the Late Mesolithic (5630–5360 calBC, 5510–5220 calBC, 5480–5080 calBC; see Fig. 4). A piece of charcoal from the layer used to level the hut floor was dated to 7290–6700 calBC. (see Knutsson *manuscript*; 2005a; 2005b; Manninen & Knutsson *in preparation*).

Find numbers with oblique points: 1969:1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17; 1993: 28d, 53, 55, 64, 67 (see Knutsson 1993:Fig. 4; 2005a:Fig. 5; 2005b:Fig. 6).

Skellefteå

2. Lappviken

This site was discovered in 1969 during the excavation of a medieval house foundation by Lappviken at the northern shore of the river Byskeälven in Västerbotten. The excavation was carried out by Lennart Sundqvist of Skellefteå museum (Knutsson 1993; Sundqvist 1983) and covered 80 m². A flaked quartzite and porphyry assemblage was found in two concentrations, including six oblique points made of porphyry (no find numbers). The assemblage is not radiocarbon dated.

For examples of oblique points from Lappviken see Knutsson 1993:Fig. 4.

3. Garaselet

The Garaselet site lies at the southern shore of the river Byskeälven, less than two kilometers from the Lappviken site. The site was found by amateur archaeologist Ivan Ekenstedt in the late 1960s. A test excavation was conducted by Lennart Sundqvist in 1969 and followed by excavations in 1970–1975 (Sundqvist 1978).

The *c.* 600 m² site has a complex stratigraphic sequence consisting of flood layers of silt deposited by the river, and partly mixed cultural layers with hearths and cooking pits from different time periods. Knutsson (1993) and Olofsson (2003:41–42) concur that there are at least two Mesolithic occupation phases at the site, one dating to between *c.* 7500 and 6700 calBC and the other between *c.* 5500 and 4600 calBC. The handle core technology present at the site belongs to the latter of these (Knutsson 1993; Olofsson 2003:42).

The site has also been in use during later periods. For example, a separate layer containing typo-chronologically Neolithic flint axes and another layer containing bifacial points dating typo-chronologically to the Late Neolithic/Early Metal Age can be distinguished. There is also refuse from iron working, a late Iron Age/Early Medieval hut foundation and an Early Medieval knife from the site. (Sundqvist 1978:132–134.) The eleven radiocarbon dates from samples representing human activity at the site (Knutsson 1993:Fig. 11) range between *c.* 7500 calBC and AD 900.

The lithic assemblage consists of 4140 artefacts. The eight handle cores/keeled scrapers and associated artefacts have received the most attention (see Knutsson 1993; Olofsson 1995:92–94). Anders Olofsson has also analysed a small sample of finds deriving from the layers that are with the greatest likelihood associated with the oldest radiocarbon dates from the site. This sample included also an oblique point of quartzite, gone unnoticed in earlier studies (Olofsson 2003:48). Olofsson notes, however, that the dating of the point must be left open due to the absence of a clear context and the fact that the refitting of lithic sequences from Garaselet has shown that there has been considerable vertical, and to some degree also horizontal, post-depositional movement of lithic artefacts (Knutsson 1993:33; Åkvist-Nordlund 1992).

Find numbers with oblique points: no. 495 (see Olofsson 2003:Fig. 3:8).

Jokkmokk

4. Tallholmen

This possible site was found by Kjel Knutsson in a survey carried out on the shores of the Tallhomen island in Lake Burgávrre, directly west of Jokkmokk. An oblique point made of grey quartzite was found in beach sand devoid of any other clear signs indicating a site. However, a few quartz flakes were lying not far from the point.

Find numbers with oblique points: not catalogued yet (see Knutsson 2005a:Fig. 5).

FINLAND

Ranua

5. Kujala/Uutela

The site is located on the shore of Lake Simojärvi, southern Finnish Lapland. The site was inspected by Markku Torvinen in 1978 (Torvinen 1978) and by Hannu Kotivuori during a 1990 survey (no report). Evidence of Stone Age activity at the site is spread over a large area that is nowadays mainly cultivated land. Surface finds from the site include ground stone tools and flakes, fragments and retouched tools of quartz and other, probably local, raw materials (Torvinen 1978). The artefacts retrieved in the 1990 survey are reported to include one oblique point of quartz crystal (Kotivuori 1996:400).

Find numbers with oblique points: KM 26481:4

Kemijärvi

6. Neitilä 4

The site is located on the east shore of the former Neitikoski rapids in the River Kemijoki in southern Finnish Lapland. The site is currently under water due to artificial water level changes. Excavations at the site were conducted by Pekka Sarvas in 1962, 1963 and 1964. A total of approximately 300 m² were excavated. The site yielded finds from many different periods ranging from the Mesolithic to the Iron Age in a more or less stratigraphic sequence, as well as ten or more stone settings. The lithic finds include three oblique points of quartz. (Kehusmaa 1972.) There are no radiocarbon dates from the site. One of the points has been analysed by Manninen and Tallavaara in 2007.

Find numbers with oblique points: KM 16145:1750; KM 16553:794, 1637 (see Kehusmaa 1972:Fig. 68–70).

7. Lautasalmi 1

The site is located on the northern shore of the Reinikansaari island in Lake Kemijärvi in southern Finnish Lapland. The site was found by Christian Carpelan in a survey in 1962 and partly excavated under his supervision the same year. The excavation revealed that the site was mostly destroyed by roadwork, gravel extracting and water level changes in the lake. In the roughly 350 excavated square meters six or seven hearth remains were found, as well as scattered burnt stones, burnt bone and lithic artefacts. The lithics consist mainly of quartz artefacts but fragments of ground slate tools and an oblique point of black chert were also found. (Carpelan 1962) There are no radiocarbon dates from the site. The point was analysed by Manninen and Tallavaara in 2007.

Find numbers with oblique points: KM 15846:78.

Enontekiö

8. Museotontti

The Museotontti site is located on the northern shore of Lake Ounasjärvi. The site was registered in an inspection conducted by Markku Torvinen in 1985. Excavations at the site have been carried out in 1986 and 1988 by Petri Halinen, in 1987 and 1989 by Jarmo Kankaanpää, and in 1994 by Taisto Karjalainen. The 1994 excavation produced no finds. In 1986–1989 an area of 664 m² was excavated and several hearths and find concentrations were registered. These have been divided into 22 camp sites/areas by Halinen (1995:47–62; 2005:51–55). There has also been considerable modern activity at the site (Halinen 1986; Kankaanpää 1988).

Finds from the 1987–1989 excavations include 2881 quartz artefacts, 29 artefacts of different quartzites, 50 artefacts of different cherts, 132 artefacts of different slates or slate-like rocks and 28 artefacts of other rocks/lithic raw materials (Halinen 1988:7–9; Kankaanpää 1988:11–15; 1990:12–15). Some artefacts represent typo-chronologically datable shapes giving the site a coarse use span ranging from the Mesolithic (oblique points) to the Late Neolithic (knife handle of red slate). Iron slag found in one of the hearths indicates later occupation. There are also eight radiocarbon dates from the site (Halinen 2005:Table 19), ranging from the Mesolithic to the Iron Age and clearly indicating that the site in fact has an occupation history of several thousand years.

The lithic material from the Museotontti excavations has been analysed and classified by Petri Halinen (Halinen 1988; 2005; Kankaanpää 1988). Halinen classified five artefacts from the 1987 assemblage and four artefacts from the 1988 assemblage as oblique points. All points are made of quartz. According to Halinen there are no oblique points in the 1989 assemblage. The points and microliths identified by Halinen were re-analysed in 2007 by Manninen and Tallavaara (*this volume*) using more strict criteria. In this analysis seven of the nine points identified by Halinen were classified as oblique points with distinct retouch. One artefact classified as a microlith by Halinen was also re-classified as an oblique point. These eight points include one surface find made outside the excavated area.

Due to the long occupation history and consequent mixing of artefacts from different time periods it was not considered practical to analyse the rest of the quartz assemblage in more detail. The uniformity of quartz, a raw material known to have been used in northern Lapland throughout the Stone Age and also in later periods, prevents the use of methods like nodule analysis or refitting in any useful way on a multi-period site.

Find numbers with oblique points: KM 23877:122, :411, :455, :491, :537, KM 24464:289, :329, :620 (see Knutsson 2005a:Fig. 5).

Inari

9. & 10. Kaunisniemi 2&3

The two sites were found by Aki Arponen in 1990. They are located on the shore of Lake Rááhájävrion the eastern side of the Kaunisniemi peninsula (Kaunisniemi 2) and on a long and narrow, currently submerged, point extending east of the cape (Kaunisniemi 3). The site areas are large and, with natural water levels, stretch over a *c.* 700 meters long strip of the lake shore. Finds were spread into several separate concentrations. At least 68 stone hearths on the two sites were observed by Arponen. The collected finds include artefacts from the Stone Age (slate, chert, quartz, quartzite), but also from more recent times (iron slag, iron strike-a-light). (Arponen 1991.) The finds from the sites were analysed by Manninen and Tallavaara in 2007. Among the lithic artefacts from Kaunisniemi 2 there is one oblique point of white burnt chert and from Kaunisniemi 3 two points of translucent quartz, one of white, probably burnt, chert and one of dark greenish-grey quartzite. There are also a few flakes of the same distinct non-local quartzite as the point, suggesting raw material import and possible on-site manufacture of points.

Find numbers with oblique points: KM 26039:42; KM 26040:2, :5, :35, :53.

11. Satamasaari

The site was found by Aki Arponen in 1988 (Arponen 1989). It lies on the shore of Lake Rááhájävri on a small peninsula pointing towards the north. In the 1990 survey by Arponen a *c.* 150 meters long stretch of the lake shore yielded Stone Age finds in three find areas consisting of several concentrations of lithic debitage and a number of stone-built hearths washed and broken up by water level changes (Arponen 1991:33–36). The finds from the site were analysed by Manninen and Tallavaara in 2007. Besides fragments of ground slate tools and tools and flakes of quartzite, quartz and chert, the finds include an oblique point of white, possibly burnt, chert.

Find numbers with oblique points: KM 26010:4.

12. Kaidanvuono SW

The site was found by Hannu Kotivuori and Markku Heikkinen in a survey in 1986 (Kotivuori 1987a). It is located on the shore of Lake Rááhájävri (partly under water) and is one of six sites found by Kotivuori and Heikkinen on the shore of Kaijanvuono bay. The site includes several stone hearths. The assemblage includes one oblique point made of quartzite, a basal fragment of a straight based bifacial point and other lithic artefacts of quartz and quartzite. (Kotivuori 1987a.)

Find numbers with oblique points: KM 23354:9

13. Kirakkajoen Voimala

The site is located *c.* 20 kilometres south-east of Inari village on the high lying bank of Kaareehjuuhâ River, close to the outflow of the river into the part of Lake Inari called Äijihjävri. The site was found by Aki Arponen in 1990 (Arponen 1990). It was badly disturbed by gravel extraction and a road leading to the power plant located next to it. Flakes and tools of chert and quartzite were found on the road on the verge of the gravel quarry. The site is briefly discussed by Havas (1999:59), who mentions two fragmentary points in the assemblage but in the analysis conducted by Manninen and Tallavaara in 2007 only one broken oblique point of grey chert could be verified.

Find numbers with oblique points: KM 26245:1.

14. Nellimjoen suu S

The Nellimjoen suu S site lies on the south-eastern shore of Lake Inari in Nellim village. The site was found in a survey conducted by Markku Torvinen in 1974 and excavated by Beatrice Sohlström in 1988 (Sohlström 1989; 1992). The excavated area covered a total of 204 m², including test pits. The excavation revealed that later activity had badly disturbed parts of the Stone Age cultural layer (Sohlström 1989).

A circular patch of discoloured soil and a relatively dense concentration of finds (Säräisniemi 1 pottery, lithic tools and debitage, burnt bone) around a hearth have been interpreted as the remains of a circular hut foundation with a diameter of approximately six metres (Halinen 2005:Figs. 40a–I; Sohlström 1992). Only one radiocarbon sample from the site has been dated. A charcoal sample from the cultural layer inside the hut area was dated to 5220–4606 calBC.

The lithic assemblage (1477 artefacts) was analysed by Manninen in 2005. The finds include an oblique point of white (possibly discoloured) chert, as well as flakes of the same raw material, some of which refit into reduction sequences of two to three flakes. The point was found about two metres outside the hut area. Although some flakes of the same or a similar raw material were found inside the hut area, the association of the point or the flakes with the hut is uncertain, especially since the site has been heavily disturbed by later activity.

Find numbers with oblique points: KM 24375:454.

15. Ahkioniemi 1&2

The site was found by Hannu Kotivuori and Markku Heikkinen in a survey in 1986. It is located on the southern shore of Lake Solojävri, *c.* 12 kilometres south-west of Inari village. Stone Age finds, possible prehistoric pit structures, and remains of a World War II military base were registered at the site. The lithic finds include tools and flakes of quartz and quartzite and an oblique point of white, possibly burnt, chert. (Kotivuori 1987b.) The point was analysed by Manninen and Tallavaara in 2007.

Find numbers with oblique points: KM 23363:4.

16. Vuopaja

The Vuopaja site lies at the western end of Lake Inari near the mouth of river Juutuanjoki in the area of the Sámi museum and the Nortern Lapland nature centre Siida (see Seppälä 2007). The earliest survey and consequent excavation at the site took place as early as 1908–1910 (Itkonen 1913). Since then, excavations have been conducted in 1929 by Sakari Pälsi (1929), in 1987–1988 by Aki Arponen (1987; 1988) and in 1993–1994 by Sirkka-Liisa Seppälä (1993; 1994).

A total of 394 m² have been excavated on two terraces with a *c.* 4–5 metres' difference in altitude. Two oblique points of black chert and one of red quartzite have been found on the lower terrace and a concentration of four points made of grey chert in the 44 m² excavated on the higher terrace

The lower terrace has yielded finds from a number of periods, and seventeen radiocarbon dates (Halinen 2005:Table 19) range from 6630 calBC to AD530. The three oblique points were found several metres apart and are therefore not interrelated in any clear manner. One of the points was found in a hearth dated by a charcoal sample to 4330–3710 calBC (Hel-3581). However, since the terrace has been in use throughout prehistory it is quite possible that the point is not contemporaneous with the dated sample. The typo-chronologically datable finds include bifacial points and sherds of Säräisniemi 1 and Vuopaja ware (e.g., Carpelan 2004:26–30) supporting the long use of the lower terrace indicated by the radiocarbon dates (see also Halinen 2005:71; Fig. 36a–i; Seppälä 2007).

The excavated area on the higher terrace does not seem to be as mixed as the one on the lower terrace. It yielded relatively few finds: 84 lithic artefacts of quartz, quartzite and chert, including four points of grey chert (partly burnt white), and fragments of burnt bone. Twenty bone fragments have been identified to the species. Four of these are elk (*Alces alces*) and sixteen are reindeer (*Rangifer tarandus*) (Ukkonen 1994; 1995). There are no radiocarbon dates from the upper terrace. All of the lithics from the upper terrace have been analysed by Manninen in 2005 and the points from both terraces by Manninen and Tallavaara in 2007. For a more detailed analysis of the oblique points and find distribution on the upper terrace see Manninen and Knutsson (*in preparation*).

Find numbers with oblique points: KM 28365:442, :446, :454, :660, :673, :692, :889.

17. Bealdojohnjalbmi 1

The Bealdojohnjalbmi 1 site lies on the northern shore of Lake Bealdojávri in north-western Inari borough. The site was found by Oula Seitsonen, Kerkko Nordqvist, Heidi Pasanen and Sanna Puttonen in 2005 and was partly excavated in 2006. The excavated area covered 20 m² and revealed both Stone Age and later activity at the site. The finds from the survey and excavation include at least three oblique points of chert classified as *trapezoid microliths* by the excavators. (Nordqvist & Seitsonen 2009). The finds from the site have not yet been available for closer analysis.

Find numbers with oblique points: KM 35217:1; KM 36200:115, :120 (see Nordqvist & Seitsonen 2009:Fig. 2).

18. Supru, Suprunoja

The Suprunoja site is located on a narrow strip of land between the lakes Čuárbbeljävri and Kuošnâjävri close to the northern shores of Lake Inari. The site was found by Markku Torvinen in a 1983 survey. Three excavation areas and several test pits covering a total of 202 m² were excavated by Eeva-Liisa Nieminen in 1984 in connection with road improvement work. The results suggest that Stone Age and later activity has taken place all over the neck of land between the lakes. Up to fifteen hearths were located in the excavated areas. (Nieminen 1985.)

The finds were analysed by Manninen in 2005. They include burnt bone and artefacts of quartz and chert. The total number of lithic artefacts is only 55. Among the 42 quartz finds there is one oblique point. Four radiocarbon dates were obtained from charcoal found in hearths in different parts of the site. Two of the dates (2430–1770 calBC and 3320–2480 calBC) derive from the same hearth and belong to the Early Metal Age. One date (5000–4400 calBC) is from the transitional period between the Mesolithic and Neolithic and one date (5780–5380 calBC) is Late Mesolithic. The oblique point cannot be positively tied with any of the dated contexts. Activity at the site during different time periods and the coarse method of recording find locations prevent any reliable interpretations based on find distributions.

Find numbers with oblique points: KM 22685:13.

Utsjoki

19. Mávdnaávži 2

The Mávdnaávži 2 site is located on the bank of the small Mávdnaávžijohka River in the western fell area of Utsjoki borough. The site was found in 1999 by Taarna Valtonen in a survey conducted as a part of a research project concentrating on the Báišduottar – Paistunturi wilderness area (Manninen & Valtonen 2002; 2006; Valtonen 1999). An excavation covering 52 m² was conducted by Manninen in 2004. Most, if not all, of the area containing finds was excavated.

The site was found to be a short-term camp with only one short occupation phase. The excavation revealed a round hut foundation with a diameter of approximately three meters and a central hearth as well as an outside activity area. The hearth inside the hut was surrounded by clearly defined knapping locations, where the finds mainly consisted of grey chert debitage related to oblique point manufacture: a total of 726 artefacts, including 13 intact or slightly broken oblique points. (Manninen 2005; 2006; 2009; Manninen & Knutsson *in preparation*.)

Five burnt bone fragments from the hearth were identified to the species (Lahti 2004). All of them derive from reindeer (*Rangifer tarandus*). The charcoal in the hearth has been identified as pine (*Pinus sylvestris*) (T. Timonen, Finnish Museum of Natural History, Botanical Museum, *pers. comm.* 2004). An AMS dating obtained from burnt bone from a pit located within the hearth area inside the hut dates the site to 5490–5320 calBC.

Find numbers with oblique points: KM 32590:1; KM 34675:7, :147, :164, :199, :225, :261, :317, :335, :13+:214, :222+:104, :223+:234, :5+:21 (see Knutsson 2005a:Fig. 5; Manninen 2005:Fig. 7).

20. Jomppalanjärvi W

The Jomppalanjärvi W site lies on the west shore of Lake Jumbáljávri, a part of the chain of lakes constituting the Utsjoki River. The site was found by Tuija Rankama and Jarmo Kankaanpää in an inspection in 1997. Lithic artefacts (grey chert and quartz), burnt bone, burnt sand, and possible hearths are found on an approximately 150 meters long stretch of sandy soil. (Rankama & Kankaanpää 1997) Among the 1997 finds there is a potential oblique point of quartz, which, however, is excluded here due to insufficient modification. The site was revisited in 2009 by Rankama and Kankaanpää and an oblique point of burnt chert was found.

Find numbers with oblique points: KM 38078:2.

NORWAY

Bardu

21. Leinavatn I

The site was found on the shore of Lake Leinavatn in the county of Troms by Knut Helskog during a survey in 1971. Six flakes of fine grained quartzite and an oblique point were collected from the surface of a 10 m² area. No additional artefacts were found during test pitting. (Helskog 1980b:120–121.)

Find numbers with oblique points: Ts. 11147a

Målselv

22. Devdis I

The Devdis I site is located by a river outlet on the southern shore of Lake Devddesjávri. When found in a 1969 survey by Bjørn Myhre, Devdis I was the first known Mesolithic site in Troms county (Thuestad 2005:13). Contrary to the Rastklippan find, the Devdis I material was familiar to the local researchers, as oblique points had been discovered already for 40 years at Mesolithic sites on the Finnmark coast. Since Devdis I is an inland site, the inland region has, from early on, been integrated in the discussions conserning the Mesolithic of this particular region of northern Norway (see, e.g., Helskog 1974).

An excavation covering 42,5 m² and additional test pitting was carried out by Knut Helskog in 1970 (Helskog 1980b). No artefacts were found outside the excavated area. The site contained four structures: a stone hearth and three pits interpreted as cooking pits, and a pit hearth. The lithic assemblage was discovered both around and inside these features. (Helskog 1980b.)

The site yielded a total of 1475 lithic artefacts, at least 30 of which are oblique points made of different qualities of quartzite and chert. According to an analysis carried out by Knutsson in 1995, a large number of the other artefacts are also related to point manufacture (Manninen & Knutsson *in preparation*).

Three samples from the site have been radiocarbon dated, one from each pit. Two samples were bone and gave Iron Age dates 360 calBC–AD650 and AD780–1210. However, the bone sample sizes were inadequate and these dates cannot be considered reliable. The third date was charcoal and gave the result 5760–5220 calBC, a date supported by the Mesolithic character of the assemblage. (Helskog 1980b; Manninen & Knutsson *in preparation*.)

Find numbers with oblique points: Ts. 5720a ,b, c, e, f, h, i, k, l, n, m, p, t, u, w, x, aa, ab, ac, ad, ae, af, ag, ah, al, an, ap, ar, as, at, aw, lg, om (see Helskog 1980b; Knutsson 2005a:Fig. 5; 2005b:Fig.6).

Kautokeino

23. Aksujavri

The site originally named Kautokeinoelva IX and X, but better known as Aksujavri lies on the western shore of Lake Ákšojávri only some 100 meters from the Kautokeino River. The site was registered by Knut Helskog in 1976 and an excavation of 27,7 m² (including test pits) was carried out by Bryan Hood and Bjørn Helberg in 1986. (Havas 1999:136; Helskog 1976; Hood 1986; 1988.)

The site consists of a series of small lithic scatters, four of which were studied with small excavation trenches. No distinct hearths or other features were observed. Oblique points were found in three trenches. One of the trenches yielded a concentration of 341 pieces of burnt bone. Some of the bone fragments have been identified as reindeer (*Ragnifer tarandus*). (Hood 1986;

1988.) A sample of burnt bone from Aksujavri has been recently dated to *c.* 5500 calBC. (B. Hood *pers. comm*. 2008).

A total of 755 artefacts from the site were analysed by Knutsson in 1995. There are 14 oblique points and point fragments of chert, quartzite and a rhyolite-like raw material in the assemblage, as well as other artefacts indicating point manufacture and intact knapping floors at the site. (Manninen & Knutsson *in preparation*.)

Find numbers with oblique points: Ts. 8479n, å, ø, x, z, ab, ac, ae, ag, bm, bå, bw (see Hood 1988:Fig. 4; Knutsson 2005a:Fig. 5).

24. Kautokeino kirke

The site is located in the vicinity of the Kautokeino church. It is represented in the Tromsø museum collections by three find numbers. These consist of finds collected by an amateur collector in 1971 and material collected by Knut Helskog in 1972 and Ericka Helskog in 1981 (Helskog 1981). A total of six oblique points made of grey fine grained quartzite are included in the finds. The points have been analysed by Knutsson.

Find numbers with oblique points: Ts. 5932a, b, c; Ts. 6956p, q, r (Knutsson 2005a:Fig. 5/Kautokeino 1&2).

25. Guosmmarjavrre 5

The Guosmmarjavrre 5 site lies on the shore of the Lake Guosmmarjávri, approximately six kilometres north-east of Kautokeino church and directly upstream of Lake Njallajávri on the Kautokeino River. The finds, surface collected by Kristian Jansen in 1971, consist of artefacts of white quartz, rock crystal and white and grey quartzite. Included are a point and a point fragment of fine grained grey quartzite. (Tromsø Museum - arkeologisk tilvekstkatalog; B. Hood *pers. comm.* 2010)

Find numbers with oblique points: Ts. 5840a, b.

26. Njallajavvre

The Njallajavvre site lies on the shore of the lake Njallajávri, approximately seven kilometres north-east of the Kautokeino church. It was discovered during surveys in the early seventies and excavated in 1974 by Ericka Helskog. The material contains some asbestos-tempered pottery and lithics of variable raw materials including a polished slate point and fragments of ground stone tools. The only flaked point found during excavation has been analysed by Knutsson.

Find numbers with oblique points: Ts. 5829dæ (see Knutsson 2005a:Fig. 5).

27. Riggajåkka

The site is an area of aeolian sand on the shore of the River Riigájohka, *c.* 22 km kilometres north-east of the Kautokeino church. The site consists of surface finds, two hearths and a burial. In 1974 lithics and asbestos-tempered pottery were found in test pits and from the surface by Ericka Helskog. The assemblage includes a single oblique point made of grey chert (Havas 1999:8–9; E. Helskog 1978).

Find numbers with oblique points: Ts. 5898g (see E. Helskog 1978:Fig. 3.1.1.)

28. Peraddjanjarga

The Peraddjanjarga site is located on the Cape Coagesnjárga on the western shore of the Kautokeino River, slightly south of the Riggajåkka site. Three oblique points of dark and lighter grey chert, alongside other lithic artefacts of the same material, have been surface collected from a sandy terrace in 1971 (Tromsø Museum - arkeologisk tilvekstkatalog; B. Hood *pers. comm.* 2010)

Find numbers with oblique points: Ts. 5880a,b,c.

Karasjok

29. Gasadaknes

The Gasadaknes site lies on the eastern shore of Lake Iešjávri. Finds have been collected by Knut Helskog in a 1973 survey and by Ericka Helskog in 1974 in a 27 m² excavation (Havas 1999:9; E. Helskog 1978:Fig. 3.1.1. b–d). According to Havas (1999:136), the site has yielded also three unpublished Early Metal Age radiocarbon dates. The material consists of debitage of variable raw materials and some sherds of asbestos-tempered pottery. The eight oblique points found during excavation have been analysed by Knutsson. The points are made of white and grey quartzite and grey chert.

Find numbers with oblique points: Ts. 5895ai, an, bæ, cp, dg, di, dk, du (see E. Helskog 1978:Fig. 3.1.1.; Knutsson 2005a:Fig. 5).

Sør-Varanger

30. Noatun Neset

The site is located on a small peninsula in the valley of the Paatsjoki River on the Russian-Norwegian border. The site is relatively large, with 2–3 house pits, and has yielded finds from at least two occupation phases. Excavations at the site were carried out in 1959 by Nils Storå and John Rea-Price, in 1961 by Povl Simonsen, and in 1999 by Marianne Skandfer. More than 100 m² have been excavated. In 1959 an oblique point was found in an excavated house pit (House 1), and a second point in an area interpreted as a refuse heap. Other finds from the site include bifacial and slate points, pottery of the Säräisniemi 1 type and asbestos tempered pottery. According to Simonsen, house 1 presents a later use phase of the site than the Säräisniemi 1 pottery and is associated with the asbestos ware. Charred food crust from a piece of Säräisniemi 1 pottery from the site has been dated to 5196-4598 calBC (Simonsen 1963:74–108, Skandfer 2003:36–38, 231, 233.)

Find numbers with oblique points: Ts. 6116cx; Ts.6120n.

31. Kjerringneset IV/Inganeset

The site is located on the Russian-Norwegian border, on a peninsula in the valley of the Paatsjoki River *c.* 60 kilometres from the coast. It was found in 1959 by Samuel Mathisen and Reidar Wara who also conducted small scale excavations there the same year. Further excavations were conducted in 1961 by Per Hartvig. Simonsen reports two house pits and finds of Säräisniemi 1 pottery, as well as diverse lithic artefacts from the site. The site dubbed Kjerringneset IV by Simonsen was revisited in 1999 by Marianne Skandfer who renamed it Inganeset. Skandfer was unable to locate the house pits and find spots mentioned by Simonsen but a small scale excavation higher up the river bank yielded flint blades and six oblique points of flint. A sample of charcoal (pine) from the excavation was dated to 3710–3380 calBC and according to Skandfer dates the points that consequently would be younger than the Säräisniemi 1 pottery. Charred food crust from a Säräisniemi 1 pottery sherd from the site has been dated to 5010–4730 calBC. (Simonsen 1963:159–161; Skandfer 2003:27–29, 283, 441.)

Find numbers with oblique points: Ts. 11188.

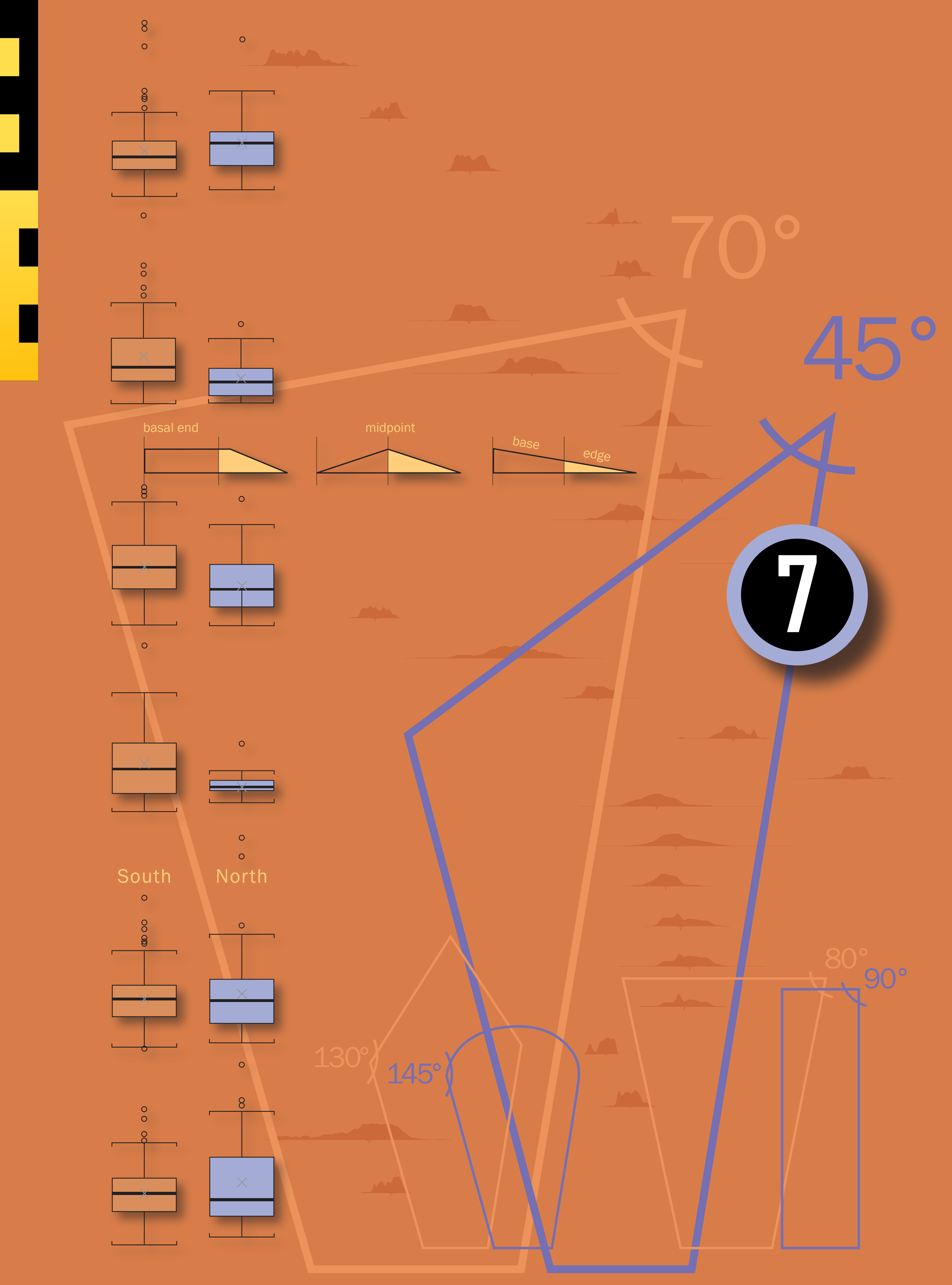
Appendix II. Glossary of place names

Finnish (Fi), Inari Saami (sI), Kven (Kv), Lule Saami (sL), Meänkieli (Mk), Norwegian (No), North Saami (sN), Russian (Ru), Swedish (Sw), Skolt Saami (sSk), South Saami (sS), Ume Saami (sU).

Arjeplog (Sw), Árjepluovvi (sN), Árjjapluovvi (sU)
Arvidsjaur (municipality, Sw), Árviesjávrrie (sU)
Báišduottar (sN), Paistunturi (Fi)
Bardu (municipality, No), Perttula (Kv), Beardu (sN)
Bealdojávri (sN), Peltojärvi (Fi)
Burgávrre (sL), Purkijaur(e) (Sw)
Byskeälven (Sw), Gyöhkahe (sU)
Čuárbbeljävri (sI), Jorvapuolijärvi (Fi)
Devddesjávri (sN), Dødesvatn (No)
Deärnnájávrrie (sU), Tärnasjön (Sw)
Enontekiö (municipality, Fi), Eanodat (sN)), Enontekis (Sw)
Finnmark (county, No), Ruija (Fi, Kv), Finnmárku (Ns)
Finnmarksvidda (area, No), Finnmárkkoduottar (Ns)
Inari (municipality, Fi), Aanaar (sI), Anár (sN), Aanar (sSk), Enare (Sw)
Jokkmokk (municipality, Sw), Jokimukka (Fi), Jokinmukka (Mk), Jåhkåmåhkke (sL), Johkamohkki (sN)
Jumbáljávri (sN), Jomppalanjärvi (Fi)
Junosuando (Sw), Junosuvanto (Fi), Čunusavvon (sN)
Juutuanjoki (Fi), Juvduujuuhâ, Juvduu (sI), Juvdujohka (sN)
Kaijanvuono (Fi), Kaidanvuono (Fi), Skäiđivuonâš (sI)
Karasjok (municipality, No), Kaarasjoki (Fi), Kárášjohka (sN)
Kautokeino (municipality, No), Koutokeino (Fi), Guovdageaidnu (sN)
Kemijoki (Fi), Giemajohka (sN), Kemi älv (Sw)
Kemijärvi (municipality, Fi), Kemijävri (sI), Giemajávri (sN), Kemiträsk (Sw)
Kirakkajoki (Fi), Kaareehjuuhâ (sI), Garitjohka (sN)
Kuošnjâjävri (sI), Kuosnajärvi (Fi), Kuosnajäu'rr (sSk)
Leinavatn (No), Lulit Lenesjávri (sN)
Malgomaj (Sw), Jetneme (sS)
Mávdnaávžijohka (sN), Mávnnaávžijohka (sN)
Mortensnes (No), Ceavccageađgi (sN)
Målselv (municipality, No), Málatvuopmi (sN)
Nellim (Fi), Nellimö (Fi), Njellim (sI), Njeä'llem (sSk)
Norrbotten (county, Sw), Pohjoispohja (Fi), Norrbottena leatna (sN)
Norrland (landsdel, Sw), Norlanti (Fi), Norrlánda (sN)
Ounasjärvi (Fi), Ovnnesjávri (sN)
Paatsjoki (Fi), Paččveijuuhâ (iS), Река Паз (Ru), Báhčaveaijohka (sN), Paččjokk (sSk), Pasvikelva (Sw)
Rahajärvi (Fi), Rááhájävri (iS)
Skellefteå (municipality, Sw), Heletti (Mk), Skielliet (sU)
Solojävri (sI), Solojärvi (Fi)
Sorsele (municipality, Sw), Suorssá (sU), Suorsá (sN)
Sør-Varanger (municipality, No), Etelä-Varanki (Kv), Mátta-Várjjat (sN)
Troms (county, No), Tromssa (Kv), Tromsa, Romsa (sN)
Utsjoki (Fi), Ohcejohka (sN)
Varanger (No), Varanki (Kv), Várjjat (sN)
Varangerfjord (No), Varanginvuono (Fi, Kv), Várjavuotna (sN)
Västerbotten (county, Sw), Länsipohjan lääni (Fi), Västerbottena leatna (sN)
Åland (county, Sw), Ahvenanmaa (Fi)
Äijihjävri (sI), Ukonjärvi (Fi)
Överkalix (municipality, Sw), Ylikainuu (Mk)

Appendix III. C14 dates older than *c.* 6400 calBC from northern Finland and northern Sweden

Site Nr.	Site	Lab Nr.	BP	calBC 2σ	Source
1	**Pulmankijärvi**	Hela-372	7905±85	**7048–6603**	Kotivuori 2007
2	**Sujala**	Hela-1102	9265±65	**8695–8302**	Rankama & Kankaanpää 2008
2	Sujala	Hela-1442	9240±60	**8612–8305**	Rankama & Kankaanpää 2008
2	Sujala	Hela-1441	9140±60	**8541–8256**	Rankama & Kankaanpää 2008
2	Sujala	Hela-1103	8948±80	**8293–7827**	Rankama & Kankaanpää 2008
2	Sujala	Hela-1104	8930±85	**8287–7794**	Rankama & Kankaanpää 2008
3	**Giellájohka 5**	Hela-1610	8615±55	**7751–7545**	Nordqvist & Seitsonen 2009
4	**Saamenmuseo**	Hela-430	8835±90	**8240–7660**	Rankama & Kankaanpää 2005
4	Saamenmuseo	Ua4296	8760±75	**8198–7599**	Rankama & Kankaanpää 2005
4	Saamenmuseo	Ua4363	8380±90	**7584–7187**	Rankama & Kankaanpää 2005
4	Saamenmuseo	Hel-3320	8290±110	**7541–7071**	Rankama & Kankaanpää 2005
4	Saamenmuseo	Hel-2635	8180±110	**7511–6829**	Rankama & Kankaanpää 2005
4	Saamenmuseo	Hel-3319	7940±120	**7174–6510**	Rankama & Kankaanpää 2005
4	Saamenmuseo	Hel-3580	7600±90	**6634–6254**	Rankama & Kankaanpää 2005
5	**Vuopaja**	Hel-3584	7600±90	**6634–6254**	Rankama & Kankaanpää 2005
6	**Vuopaja N**	Hel-3570	7530±150	**6677–6064**	Rankama & Kankaanpää 2005
7	**Myllyjärämä**	Hel-2710	8320±110	**7570–7082**	Rankama & Kankaanpää 2005
8	**Museotontti**	Hel-2563	7880±140	**7137–6457**	Rankama & Kankaanpää 2005
8	Museotontti	Hel-2564	7750±120	**7029–6414**	Rankama & Kankaanpää 2005
8	Museotontti	Hel-2728	7640±120	**6770–6232**	Rankama & Kankaanpää 2005
8	Museotontti	Hel-2565	7640±110	**6697–6238**	Rankama & Kankaanpää 2005
9	**Proksin kenttä**	Hel-2449	7900±110	**7065–6506**	Rankama & Kankaanpää 2005
9	Proksin kenttä	Hel-2454	7760±130	**7036–6417**	Rankama & Kankaanpää 2005
9	Proksin kenttä	Hel-2450	7740±150	**7050–6269**	Rankama & Kankaanpää 2005
9	Proksin kenttä	Hel-2451	7630±140	**7002–6125**	Rankama & Kankaanpää 2005
10	**Kitkiöjärvi**	Ua-24560	8055±55	**7176–6776**	Hedman 2009
10	Kitkiöjärvi	Ua-24559	8010±55	**7072–6700**	Hedman 2009
11	**Mattivainaanpalo 2**	Hel-3322	7470±180	**6690–5985**	Jungner & Sonninen 1998
12	**Autiokenttä II**	Hel-1621	7930±110	**7131–6514**	Jungner & Sonninen 1989
13	**Kangos**	Ua-23818	8720±60	**7956–7596**	Östlund 2004; *pers. comm.* 2009; Hedman 2009
13	Kangos	Ua-23266	8555±65	**7727–7503**	Östlund 2004; *pers. comm.* 2009; Hedman 2009
14	**Pajala**	Ua-33469	7555±80	**6587–6240**	Östlund 2004; *pers. comm.* 2009; Hedman 2009
15	**Alakangas**	Hel-2660	7480±190	**6768–5928**	Jungner & Sonninen 1996
16	**Lehtojärvi**	Hel-168	7740±170	**7063–6254**	Jungner 1979
17	**Killingsholmen**	T-5774	8160±100	**7480–6828**	Olofsson 2003; Bergman et al. 2004
18	**Tröllomtjärn**	Ua-31018	7900±55	**7031–6643**	Hedman 2009
19	**Ipmatis**	Ua-15380	8120±75	**7346–6825**	Olofsson 2003; Bergman *et al.* 2004
19	Ipmatis	Ua-17669	8020±75	**7142–6686**	Olofsson 2003; Bergman *et al.* 2004
20	**Dumpokjauratj**	Ua-19212	8630±80	**7939–7535**	Olofsson 2003; Bergman *et al.* 2004
20	Dumpokjauratj	Ua-17340	8445±90	**7619–7193**	Olofsson 2003; Bergman *et al.* 2004
20	Dumpokjauratj	Ua-17481	8440±90	**7608–7193**	Olofsson 2003; Bergman *et al.* 2004
20	Dumpokjauratj	Ua-18265	8250±85	**7489–7072**	Olofsson 2003; Bergman *et al.* 2004
20	Dumpokjauratj	Ua-17480	8215±100	**7521–7038**	Olofsson 2003; Bergman *et al.* 2004
20	Dumpokjauratj	Ua-17479	8120±80	**7421–6815**	Olofsson 2003; Bergman *et al.* 2004
20	Dumpokjauratj	Ua-18268	8050±85	**7295–6688**	Olofsson 2003; Bergman *et al.* 2004
20	Dumpokjauratj	Ua-14276	8020±80	**7174–6682**	Olofsson 2003; Bergman *et al.* 2004
20	Dumpokjauratj	Ua-17339	8010±75	**7137–6681**	Olofsson 2003; Bergman *et al.* 2004
20	Dumpokjauratj	Ua-18266	8005±85	**7141–6653**	Olofsson 2003; Bergman *et al.* 2004
20	Dumpokjauratj	Ua-17338	8000±80	**7129–6655**	Olofsson 2003; Bergman *et al.* 2004
20	Dumpokjauratj	Ua-18267	7980±80	**7072–6654**	Olofsson 2003; Bergman *et al.* 2004
20	Dumpokjauratj	Ua-14275	7900±80	**7045–6607**	Olofsson 2003; Bergman *et al.* 2004
20	Dumpokjauratj	Ua-17478	7870±80	**7044–6534**	Olofsson 2003; Bergman *et al.* 2004
20	Dumpokjauratj	Ua-4667	7660±70	**6641–6417**	Olofsson 2003; Bergman *et al.* 2004
20	Dumpokjauratj	Ua-14277	7465±75	**6464–6115**	Olofsson 2003; Bergman *et al.* 2004
21	**Skiljesmyren**	Ua-24561	7600±55	**6591–6379**	Hedman 2009
22	**Garaselet**	St-5190	8160±110	**7488–6819**	Knutsson 1993
22	Garaselet	St-5193	8040±100	**7301–6656**	Knutsson 1993
22	Garaselet	St-5191	7885±300	**7543–6222**	Knutsson 1993
22	Garaselet	Ua-2063	7640±100	**6681–6255**	Knutsson 1993
23	**Varisnokka**	Hel-2568	8190±140	**7534–6776**	Pesonen 2005
24	**Vanha Kirkkosaari**	Hel-2313	8950±120	**8430–7683**	Pesonen 2005
24	Vanha Kirkkosaari	Hel-3035	8200±130	**7533–6825**	Pesonen 2005
25	**Nuoliharju W**	Hel-3924	8960±120	**8449–7723**	Korteniemi & Suominen 1998
25	Nuoliharju W	Hel-4045	8890±110	**8287–7681**	Korteniemi & Suominen 1998
26	**Koppeloniemi**	Hel-3033	8440±130	**7742–7084**	Pesonen 2005
26	Koppeloniemi	Hel-1425	8260±120	**7570–7046**	Pesonen 2005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Descent History of Mesolithic Oblique Points in Eastern Fennoscandia – a Technological Comparison Between Two Artefact Populations

Mikael A. Manninen & Miikka Tallavaara

ABSTRACT We analyse a sample of 158 Late Mesolithic margin-retouched points from two geographically separate point populations in Finland to determine whether they represent the same technological tradition with a common descent history or separate developments with possible distant common ancestry. We conduct a technological analysis comparing the points according to geographical source area (i.e., northern Finnish Lapland or southern Finland) and according to raw material. Our analysis shows that the differences between the two point populations are best explained by differences in the raw materials used to manufacture the points and that all of the studied points can be considered to represent the same technological tradition. We also study the spread of the margin-retouched point concept within Finland by using radiocarbon dates. The result of this analysis indicates that the concept spread from the north towards the south. Finally, we suggest that two large-scale environmental changes, the 8.2 ka event and the Holocene Thermal Maximum, triggered the changes leading to the spread of the point concept.

KEYWORDS

Late Mesolithic, Finland, lithics, oblique point, margin-retouched point, quartz, chert, 8.2 ka event, Holocene Thermal Maximum.

Introduction

During the Late Mesolithic, a new arrowhead manufacturing concept, the margin-retouched point, spread throughout the area representing present-day Finland. In addition to Finland, margin-retouched points[1] (e.g., trapezes and transverse points) were contemporaneously used throughout a large part of Europe. In Finland, the points were manufactured from irregular flake blanks with semi-abrupt to abrupt margin-retouch, and the usually unmodified edge of the flake was used as the cutting edge of the point. The resulting point type, *the oblique point*, as well as the manufacturing concept, have no predecessors in the archaeological record in Finland.

However, the known oblique points in Finland have a somewhat bicentric geographical distribution (**Fig. 1**). Broadly speaking, the points are known in the south (including southern Lapland) and in northern Lapland, but they are unknown in a large area in central Lapland. The bicentric distribution is reflected in the archaeological literature as a bicentric research history, and the connection between these point groups has rarely been addressed.

[1] In this paper, the expression *margin-retouched point* encompasses points that are manufactured by retouching the margins of a flake or flake/blade segment by abrupt or semi-abrut retouch, while leaving part of the original blank edge as a cutting edge.

In this paper, we study the descent history of the margin-retouched point concept in Finland and discuss scenarios explaining how the concept of margin retouched points spread in Fennoscandia during the Late Mesolithic. We aim to shed light on whether these points represent the same technological tradition with a common descent history or separate developments with possible distant common ancestry. The paper draws on a technological analysis of measurable characteristics in 158 oblique points from the two geographically separate oblique point populations and on radiocarbon dates from oblique point sites in Finland.

The descent histories of artefact types depend on the social transmission of cultural information. In recent years, cultural transmission theory (e.g., Boyd & Richerson 1985) has gained popularity, especially in explaining formal variation in artefact groups (e.g., Bettinger & Eerkens 1997; 1999; Eerkens & Lipo 2007; Jordan & Shennan 2009). Cultural transmission theory is also instrumental to the orientation of this paper. Following Boyd and Richerson's (1985) definition, we see culture as socially transmitted information that is capable of affecting an individual's behaviour. Central to cultural transmission theory are *decision-making forces*, some of which increase population variation and others of which reduce variation (Bettinger & Eerkens 1997; 1999; Boyd & Richerson 1985; Cavalli-Sforza & Feldman 1981; Eerkens & Lipo 2005; Richerson & Boyd 2005). In Finland, because the margin-retouched point concept spread to areas in which directly preceding lithic arrowhead types are not known, differences or similarities in within-population variation could shed light on the transmission mechanisms behind the spread of the manufacturing concept and, consequently, on the descent history of oblique points.

In their study on the dispersion of bow-and-arrow technology in the Great Basin area in North America, Bettinger and Eerkens (1997; 1999) concluded that the different design characteristics of corner-notched points in central Nevada and eastern California reflect different and contrasting modes of cultural transmission behind the spread of bow-and-arrow technology in these areas. However, Bettinger and Eerkens (1997) acknowledge that their study does not consider certain environmental factors, such as the effects of raw material. Boyd and Richerson's definition of culture nevertheless includes an important distinction between culture and behaviour as well as the products of behaviour (e.g., artefacts) because behaviour is always a product of both cultural and environmental factors. This means that two individuals with an identical cultural repertoire behave differently in different environmental settings (see also Binford 1973). The manner in which these individuals react to different environmental settings depends on culturally acquired information. One environmental factor capable of affecting artefact form is the raw material used to produce it.

It is widely acknowledged that the physical properties of raw materials have a strong impact on lithic assemblage variation (e.g., Amick & Mauldin 1997; Crabtree 1967; Domanski *et al.* 1994). Therefore, depending on the properties of the raw material, individuals who have acquired similar information concerning an artefact manufacturing process can produce formally different versions of the same artefact type. Bearing this fact in mind, we will also study the effects of raw material on the observed differences in within-population variation in the northern and southern oblique point groups as well as on the differences observed between the two groups.

The setting

The first notable oblique point site in Finland was published in 1948 (Luho 1948) and since then the point type has been considered mainly to be pre-pottery Mesolithic in the southern part of Finland (e.g., Luho 1967; Matiskainen 1986:Fig.9; 1989b; Siiriäinen 1984; Äyräpää 1950) with only a few occasional points found in possible association with pottery (e.g., Luho 1957). In more recent research, sites with oblique points in southern Finland have been dated to the Late Mesolithic (to *c.* 6500–4900 calBC) (Matiskainen 1986; 1989b; 2002:100). These points are almost exclusively made of different varieties of macrocrystalline vein quartz.

In northern Finnish Lapland, the discussion on oblique points has pursued a different path. Because the points in this region are often made of cherts and quartzites originating from the Barents Sea coast, Norwegian and Finnish archaeologists tend to discuss these points in relation to the North-Norwegian research tradition and connect them with the Late Mesolithic (Finnmark Phase III, *c.* 6400–4400 calBC) points of northern Norway (e.g., Halinen 2005:32; Hood 1988:30; Huurre 1983:86–87; Manninen 2005; 2009; Olsen 1994:40; Skandfer 2003:295–296).

Figure 1. The points in the southern (left) and northern (right) groups of oblique points in Finland organised according to edge shape. Points in the southern group: Alajärvi Rasi, (a, b, t); Askola Puharonkimaa Järvensuo (c); Hollola Kapatuosia, (g, u); Askola Pappila Perunamaa-Saunapelto (h); Pello Kaaraneskoski 1 (i); Lohja Hossanmäki (m); Kuortane Ylijoki Lahdenkangas (n); Loppi Karhumäki (o, s). Points in the northern group: Utsjoki Mávdnaávži 2 (d, e, r, v); Inari Vuopaja (f, j, w); Inari Kaunisniemi 3 (k); Enontekiö Museotontti (l, p, q); Inari Ahkioniemi 2 (x). See Appendix I for catalogue numbers. National Museum of Finland. Photograph by M. A. Manninen.

Because the margin-retouched oblique points in Finland represent the first formal arrowhead type discovered after the post-Swiderian tanged points of the pioneer colonisation phase and have no predecessors or successors, their appearance in the Late Mesolithic demands an explanation. The explanations put forth follow roughly similar paths: the southern points result from diffusion from countries south of the Baltic Sea (Luho 1948:5; 1967:118–119; Matiskainen 1989a:IX, 63) whereas the northern points are a result of demic diffusion in or colonisation of the inland areas of northern Fennoscandia from the Barents Sea coast (Olsen 1994:40), from the southern oblique point area (Rankama 2003) or from both (Halinen 2005:88–90).

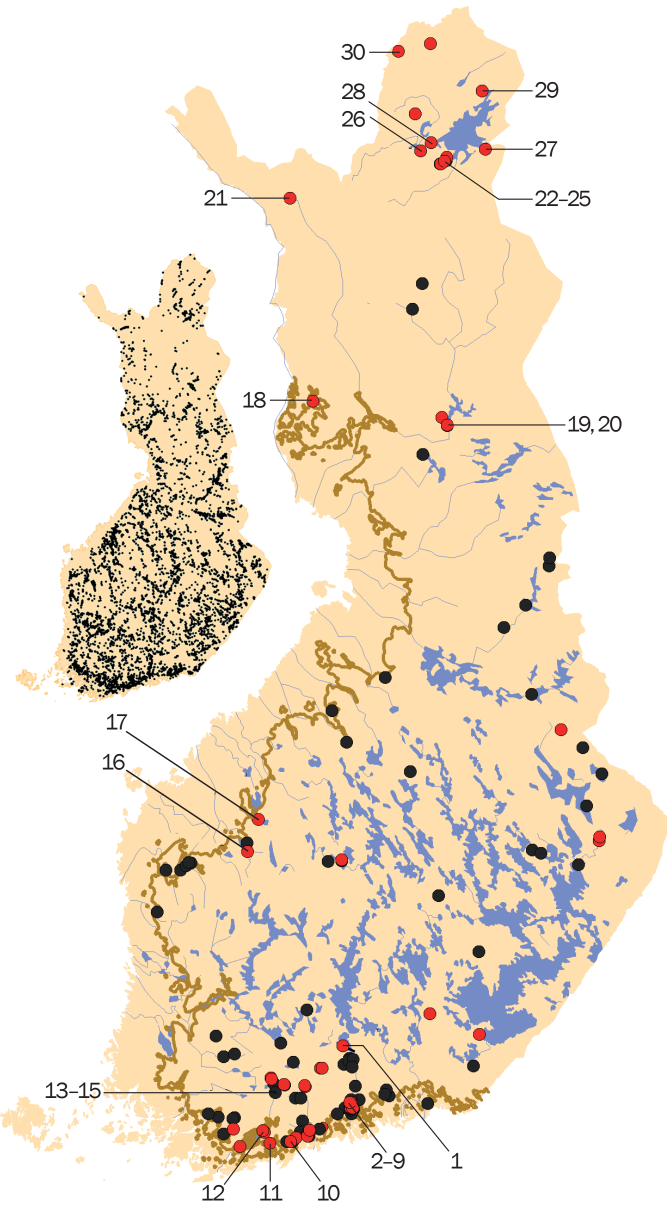

Figure 2. Small map: The distribution of known Stone Age and Early Metal Age dwelling sites in Finland (n= 9188) (MJREK 2008). Large map: The sites with reported oblique points in Finland (see Appendix II). The Litorina Sea shoreline at *c.* 6400 calBC is marked with a brown line. The sites with points confirmed by the present authors are marked with red. The sites included in the technological analysis are numbered as follows: 1. Kapatuosia; 2. Etulinna Ruoksmaa A&B; 3. Rokin Valkamaa; 4. Takalan Ruoksmaa; 5. Pappila Perunamaa-Saunapelto; 6. Siltapellonhaka I; 7. Siltapellonhaka II; 8. Latoniitty Silta-aro; 9. Puharonkimaa Järvensuo; 10. Sperrings Hiekkakuoppa NE; 11. Suitia 1; 12. Hossanmäki, 13. Antinnokka 1; 14. Karhumäki; 15. Lehtimäki; 16. Lahdenkangas 1; 17. Rasi; 18. Kaaraneskoski; 19. Neitilä 4; 20. Lautasalmi; 21. Museotontti; 22. Kaunisniemi 2; 23. Kaunisniemi 3; 24. Satamasaari; 25. Kirakkajoen voimala; 26. Ahkioniemi 1&2; 27. Nellimjoen suu S; 28. Vuopaja; 29. Supru; 30. Mávdnaávži 2.

When oblique points made of quartz, the typical raw material in southern Finland, are found in the north, they are sometimes linked with the southern Finnish points (e.g., Halinen 1995:92; Huurre 1983:86–87; Kehusmaa 1972:76; Kotivuori 1996:58; Rankama 2003). The questions whether the North-Finnish points, let alone the North-Norwegian points, could in fact belong to the same tradition as the points found in southern Finland, and what could explain the virtually simultaneous appearance of the concept of producing margin-retouched points in both areas, however, have not been explicitly addressed.

A survey of the research literature and the archived reports conducted for this study[2] suggests that the number of oblique point finds has increased in relation to the distribution maps published in the 1980s (Huurre 1983:86–87; Matiskainen 1986) and that points have also been reported in the area pointed out by Matiskainen (1986; Koivikko 1999), where lake tilting has submerged sites. However, there is still a gap in the geographical distribution of oblique point finds in central Lapland (**Fig. 2**). The artefacts reported as oblique points in the two sites within the otherwise blank area (Sodankylä Matti-vainaan palo 2 and Sodankylä Poikamella) are single finds that, according to the excavator, may be misclassified (P. Halinen *pers. comm.* 2011). In **Figure 2**, the small map shows a similar distribution of known Stone Age and Early Metal Age dwelling sites in Finland. This distribution suggests that the blank area in the distribution of oblique points may be due to the uneven geographical coverage of field research. Therefore, it may possible to address the vacuum by allocating more survey and excavation efforts to the area. However, we feel that regardless of whether the point populations north and south of the gap belong to the same technological tradition or not, a more rewarding and more warranted approach than simply conducting additional fieldwork is to make a technological comparison between the existing point assemblages from the two areas.

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[2] This survey is not comprehensive. Most of the data was gathered from publications and we studied unpublished reports mostly from areas that are not discussed in the literature. We examined a sample of reported points from those parts of Finland that are not represented by the sites included in the technological analysis to confirm the geographical distribution of the point finds. The sites in which the existence of points could not be verified in the follow-up were omitted from the map. Nevertheless, the site data may include sites in which the artifacts reported as oblique points have not been retouched and, consequently, in our definition, would not be considered to be intentionally manufactured.

The technological analysis

For our analysis, we selected a sample of 196 artefacts that were reported as intact or broken oblique points from 30 sites (**Fig. 2, Appendix III**). Only the artefacts showing clear backing retouch on the margin(s) were considered to be intentionally manufactured points. As a result, we only accepted 158 of the 196 artefacts for further analysis. Most of the points come from sites south of the blank area in central Lapland (i.e., 121 points from 19 sites), whereas the northern group of points is smaller (i.e., 37 points from 11 sites).

The analysis was designed to gather information on point shape and manufacturing process. We inferred the details of the technology behind each point from the points themselves. Debitage resulting from oblique point manufacture is rarely discerned or even discernable in the assemblages, and consequently was not included in the analysis. We studied the point data statistically to analyse patterning in production technology and resulting point shapes. Additionally, we studied the raw material as well as the localisation and position of retouch for each point. When discernable, we also registered the orientation of the point in relation to the blank and the mode of detachment of the blank. To quantify point shape, the studied variables include basic measurements (i.e., weight, maximum length, maximum width, and maximum thickness), the thickness of the arrowhead's longitudinal middle point, and the edge angles.

Because stone arrowheads generally constitute a replaceable part of the arrow and have a typically short use-life (e.g., Cheshier & Kelly 2006; Fischer *et al.* 1984; Odell & Cowan 1986), they are usually somewhat standardised to facilitate the re-use of the arrow shaft. In particular, the contact point between the shaft and the point base is often standardised because a replacement arrowhead must fit the existing hafting mechanism at the end of the shaft. Because the basal part of a point therefore reflects details about the arrow technology beyond the arrowhead (Hughes 1998), we also measured each point's base thickness and width.

It should be noted, that intra-site analyses suggest that oblique points were often produced several at a time and that many of the oblique points found in excavations are actually rejects from the manufacturing process (Manninen & Knutsson *in preparation*). Thus, many of the intact points in the studied assemblage may have been defective in one detail or another. In addition, we consider it likely that practice pieces are included in the assemblage as well. Although these points create some noise in the statistical analysis, we expect their effects to be averaged out because these points still represent acceptable oblique points in most aspects.

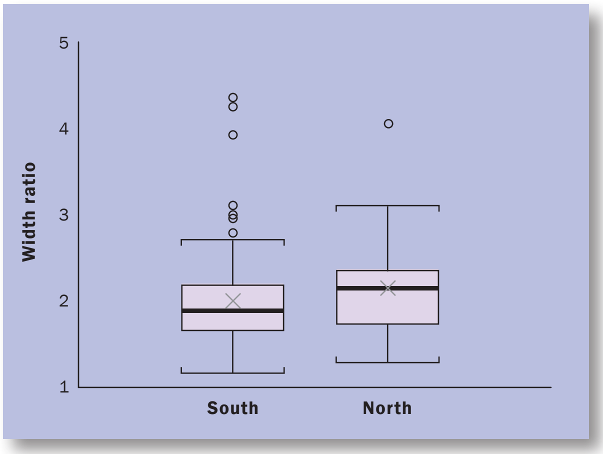

Figure 3. The width ratio (maximum width/basal width) in the studied point groups. South n=103, north n=31. The top and bottom of the box indicate the 25th and 75th percentiles, the black band indicates the data median, and the grey cross indicates the data mean. The ends of the vertical lines indicate the minimum and maximum data values, unless outliers are present. In that case, the whiskers extend to a maximum of 1.5 times the interquartile range. The outliers are marked with circles.

As the studied assemblage consists of finished points, we present the technological details inferred from the point assemblage in reverse order in relation to the manufacturing process. In other words, we start with the finished point and end with primary production and raw material.

Point size and shape

To quantify the overall outline shape of the points (not including the shape of the edge), we first studied the width ratio (i.e., the ratio between the maximum and basal width) (**Fig. 3**). The greater the relative width for a given point, the more triangular or tanged/trumpet-like the point is. A value close to 1 indicates that a point has relatively straight edges (i.e., is nearly as wide at its widest point as it is at its base). As expected, the results show that in both groups, the widest point of the arrowhead is usually not at the base, but also that both the median and mean of the ratio are slightly higher in the northern group. This result indicates that a slightly greater proportion of points in the northern group has a clear basal narrowing.

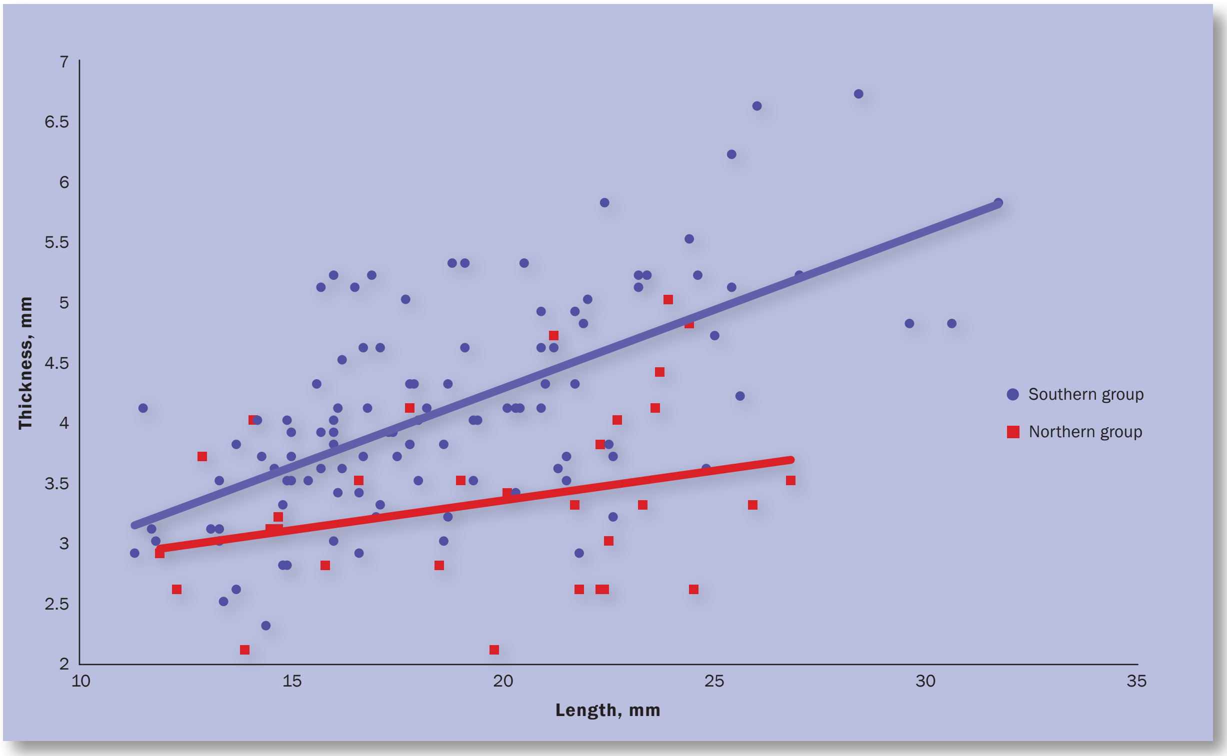

Figure 4. Maximum thickness and length of points in the southern (n=106) and northern (n=32) oblique point populations with linear trendlines of the measured intact points and the points with broken tips (1.5 mm added to length).

We further studied point shape using measurements of point outline dimensions. Here a difference can be clearly seen in the thickness/length ratios (**Fig. 4**). When compared with the southern points, the northern points are thin in relation to length, whereas the southern points are clearly thicker in this regard. There is almost as clear a difference between the groups if thickness is compared with width, but less clear a difference with respect to the length-to-width ratio. Thus, the data indicate that the northern points are generally thinner than their southern counterparts, but the two point populations are equal in terms of length and width. The thinness of the northern points as a group is also the main reason for their generally lower weight (**Fig. 5**).

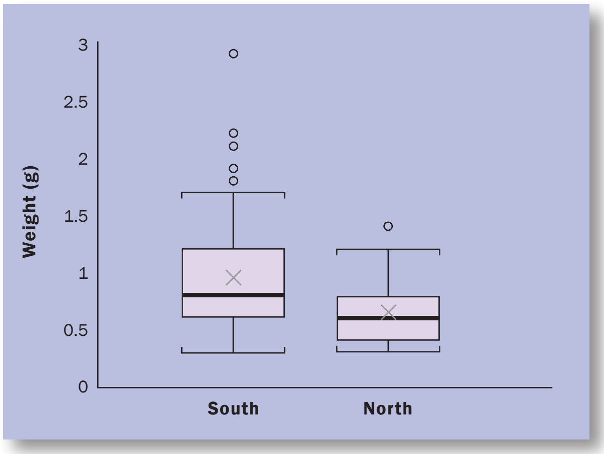

Figure 5. Point weight in the oblique point populations. South n=100, north n=34.

The basal thickness of the points is also generally lower in the northern group than in the southern group. As noted above, the differences in the basal part of the points could indicate differences in arrow technology. As the basal thickness of arrowheads usually correlates with the thickness of the arrow shaft (Hughes 1998), we suspect that basal thickness is one of the variables that determined whether a point was accepted as usable. Evidence supporting this hypothesis can be found in the point data. Specifically, 34 points in the total assemblage show evidence suggesting that the points were thinned by purposeful detachment of small invasive flakes from the dorsal and/or ventral side of the point. This finding indicates that these points were originally considered to be too thick. In 17 points, the thinning is restricted to the base. Judging from the basal thickness of both un-thinned and thinned points, the ideal basal thickness seems to have been approximately 2–3 millimetres (**Fig. 6**).

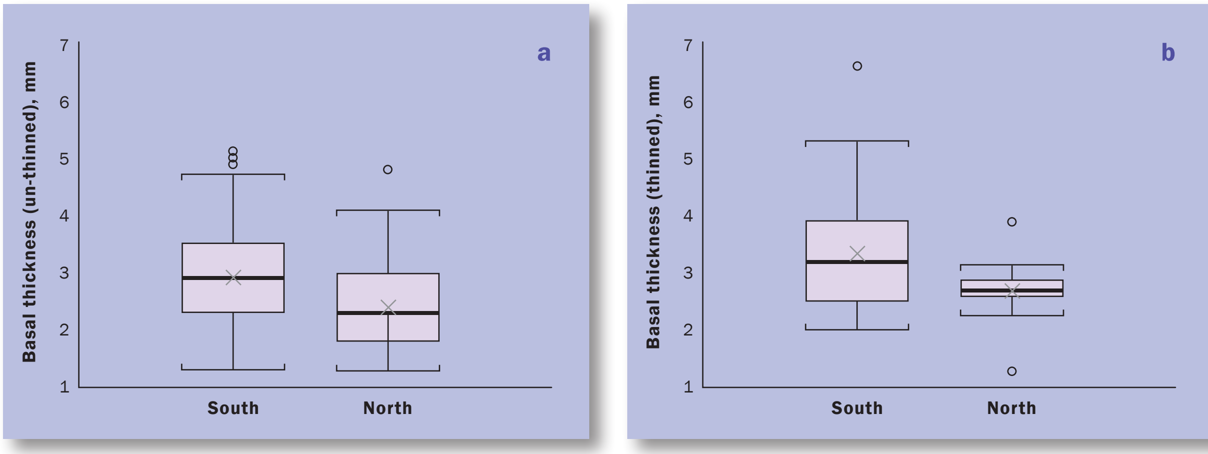

Figure 6. The basal thickness of the un-thinned (a) and thinned (b) points. South, a) n=81, b) n=27. North, a) n=27; b) n=7.

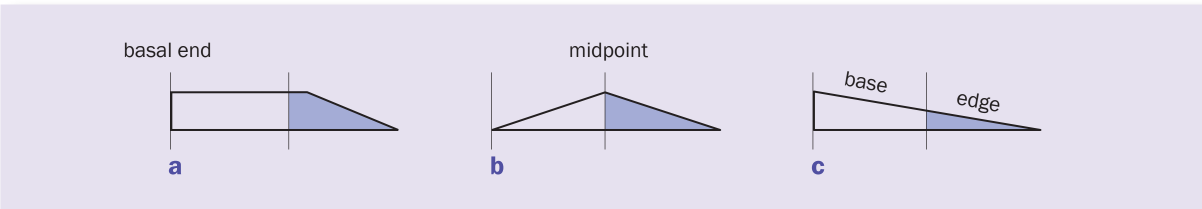

Figure 7. Side view profiles of oblique points: a) point with a base of even thickness , b) point with a tapering base, and c) point with a relatively thick basal end. In addition, the figure shows the variables used to define the midpoint/basal thickness ratio.

We studied the thickness ratio (i.e., the ratio between midpoint and basal thickness) to quantify the side view profiles of the point bases. This value also provides an indication of the overall side view profile, as the point edge usually starts to taper from or close to the midpoint (**Fig. 7**). If the value is close to 1, then the point base is of even thickness for its entire length (**a**). A value over 1 indicates that the thickness tapers toward the basal end (**b**), whereas a value less than 1 indicates that the basal end is thicker than the rest of the point (**c**). The results show that no great difference exists between the two groups in this respect, although slightly more variation exists in the northern group (**Fig. 8**). Points with the thickest point near or at the middle of the point are the most numerous in both groups.

The edge angle measurements also show a slight difference between the two groups. The smaller of the two angles between the point edge and the retouched sides of the point can be used as a proxy for edge angle (**Fig. 9**). An angle of *c.* 70–90 degrees indicates a transverse edge (**b**), an angle below 70 degrees indicates an edge that lies at an acute angle to the longer side of the point (**a**), and an angle above 90 degrees indicates that

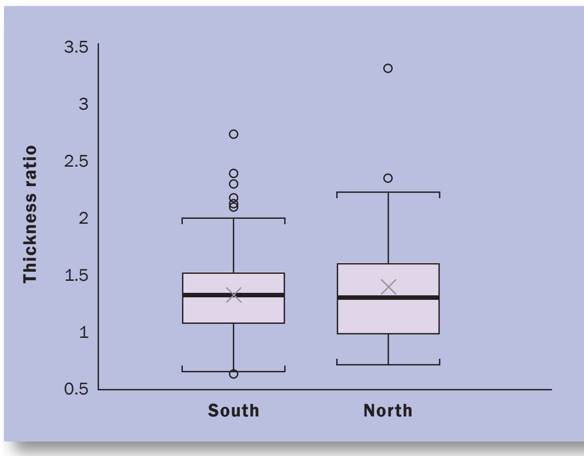

Figure 8. Point midpoint thickness to base thickness ratio. South n=121, north n=37.

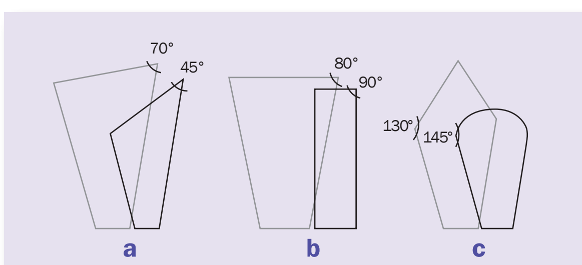

Figure 9. A schematic representation of the smaller edge angles taken from the various point outline shapes. Drawing by M. A. Manninen.

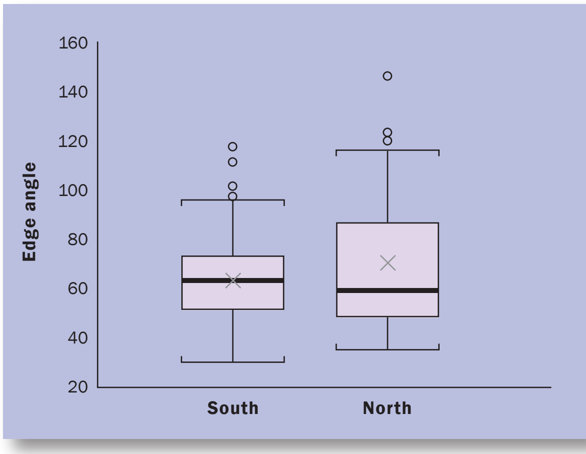

Figure 10. Edge angle variation (smaller edge angle) in the studied point populations. South n=110, north n=31.

both angles between the edge and the retouched sides are obtuse, which means that the edge is pointed or round (**c**). The results (**Fig. 10**) show that the northern points are more heterogeneous in this respect. However, the oblique and transverse edges are most common in both groups.

Retouch

We also studied the modes of blank modification from each point. Because we only accepted artefacts that showed margin modification, in addition to correct general shape, all of the studied artefacts had at least one of four types of margin modification types: 1) semi-abrupt to abrupt backing retouch (n=156), 2) semi-invasive retouch on the margin (n=9), 3) abrasion of point margin (n=13), and 4) snapping of the basal end (n=7). Of these types, types 3 and 4 probably also include examples of alteration caused by use. All four types are present in both the southern and northern groups, except for types 2 and 4, which were observed only in the southern group. However, types 2, 3, and 4 are too rare among the studied points to be used in inter-group comparisons of the two point populations.

The direction of backing retouch varies within both groups (**Fig. 11**). Most of the points show backing done from only one direction (southern group 55% and northern group 69%), but a considerable number of points also show both direct and inverse retouch (southern group 43% and northern group 30%). In general, the data on point margin modification do not seem to indicate any cultural or traditional predetermination or significant inter-group differences.

As mentioned earlier, some points in both groups show evidence of thinning: 27 points (25%) in the southern group and 7 points (21%) in the northern group. Thinning has been done with semi-invasive to invasive retouch and usually consists of less than five detachments. In the analysis, we considered thinning to be clear when the detachments have been made after the final backing retouch has been done. Another 15 points show detachments that may have been made to thin the point but are less clear and sometimes antedate the backing. One of the two slate points in the southern group has a polished dorsal surface, which can also be seen as a sign of deliberate thinning. However, it could also indicate a flake blank detached from a ground slate artefact (see Rankama & Kankaanpää *this volume*).

Blank production and point orientation

We were able to infer the orientation of the point in relation to the blank in 108 of the 158 points. If the flake edge has been used as the cutting edge of the point, then in practice, the points are oriented either perpendicular or parallel to the flake. A comparison of point orientation suggests that a significant difference exists between the two groups (**Fig. 12**). The southern points are almost exclusively oriented perpendicular to the blank (see also Matiskainen 1986; Pesonen & Tallavaara 2006), whereas in the north, over 40% of the points are oriented parallel to the blank.

All of the points in both groups seem to have been produced using flake blanks. During the Stone Age in Finland, flake production has usually followed simple opportunistic methods, especially with quartz (Rankama *et al.* 2006). These methods can be divided into bipolar and platform reduction, and more distinctive technological concepts are seldom encountered. This was the case in this study as well, as the points are made from relatively irregular flakes that do not show any signs of standardisation within the groups or even within the individual sites.

We may reliably infer the mode of primary production (i.e., bipolar or platform reduction) from 42 points (28 south and 14 north) that are all made out of platform flakes. In these points, a part of the bulb of percussion is still visible (19 points), and/or a part of the original platform remnant is one of the sides (19 points) or at the base of the point (4 points). In most of the remaining points the signs of flake initiation have been removed. However, also many of these points have the general appearance of platform flakes. Only one point shows characteristics (i.e., crushing of the flake end) that suggest a flake blank deriving from bipolar production rather than platform reduction. In 78 points (66 south and 12 north), the cutting edge is oriented parallel to a dorsal ridge. There is no evidence suggesting that the microburin technique was used to produce any of the analysed points.

Raw materials

The raw materials used to manufacture points differ between the two groups (**Fig. 13**). Quartz has been used to produce the majority of the points in the southern group, whereas chert is the most common raw material in the north. The other raw materials include rock crystal, quartzite, and slate. All of the raw material categories are based on archaeological definitions of raw materials. No geochemical sourcing or petrologic raw material definitions were available.

Most of the quartz raw material consists of different varieties of opaque white and greyish vein quartz (74 points) as well as greyish translucent quartz (32 points). Only three points from the southern group are made of more colourful varieties of quartz. These varieties include a bluish quartz, a rose quartz, and a striped white/transparent quartz. However, a commonly distinguished sub-category of quartz, the transparent rock crystal, has been used relatively often (21 points). The raw material of one rock crystal point in the southern group has a reddish shade.

Also the chert raw materials vary and include different types of black (3 points) and grey chert (21 points). The grey chert category also includes many points that have turned white because of burning and/or weathering. Many of these points come from sites in which their originally grey colour is clear from conjoining and manufacturing debitage (Manninen & Knutsson *in preparation*), but some points may have originally been a different colour. All of the chert points are in the northern group except for one point of black chert, which was found in Kemijärvi directly south of the blank area in central Lapland. In addition, the northern group includes two points made of fine-grained quartzite (one grey and one red), and the southern group has two points made of black slate.

	South	%	North	%
Left inverse, right inverse	30	24.6	14	38.9
Left direct, right direct	5	4.1	6	16.6
Left inverse, right direct	10	8.2	2	5.6
Left direct, right inverse	6	5.7	3	8.3
Left inverse, right both	10	8.2	3	8.3
Left direct, right both	6	4.9	0	0
Left both, right inverse	5	4.1	1	2.8
Left both, right direct	4	3.3	1	2.8
Left both, right both	6	4.9	1	2.8
Left inverse, right no backing	13	10.7	3	8.3
Left direct, right no backing	6	4.9	1	2.8
Left no backing, right inverse	7	5.7	0	0
Left no backing, right direct	4	3.3	0	0
Left both, right no backing	4	3.3	0	0
Left no backing, right both	1	0.8	0	0
Left no backing, right no backing	2	1.6	0	0
Indiscernible direction	2	1.6	2	2.8
Total	121	99.9	37	100

Figure 11. Direction of backing retouch.

Area	Orientation		Sum
	Perpendicular	Parallel	
North	57.1% (n=16)	42.9% (n=12)	100% (n=28)
South	92.5% (n=74)	7.5% (n=6)	100% (n=80)

Figure 12. Point orientation (perpendicular or parallel) in relation to the flake length axis.

	South	South%	North	North%	Total	Total%
Quartz	99	81.8	9	24.3	108	68.4
Chert	1	0.8	24	64.9	25	15.8
Quartzite	0	0	2	5.4	2	1.3
Rock crystal	19	15.7	2	5.4	21	13.3
Slate	2	1.7	0	0	2	1.3
Total	121	100	37	100	158	100.1

Figure 13. Raw materials.

Summing up the technological profiles

The technological comparison indicates that the two point populations are quite similar. The variables initially considered to possibly reflect differences in overall arrow technology (point weight, basal thickness, and basal width) show only small differences between the populations. For example, all other variables held constant, a weight difference of 10 grains (*c.* 0.6 grams) between arrowheads is said to have no significant effect on modern hunting arrow flight (Schuh 1987:30). The difference in the points' mean

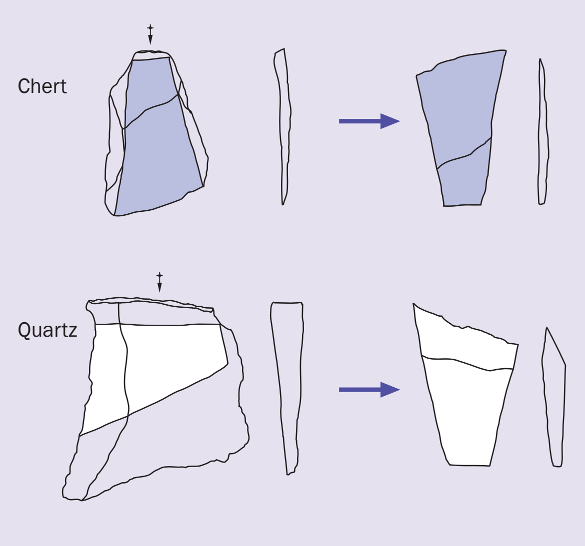

Figure 14. Typical features that distinguish the points in the northern (top) and southern (bottom) group of oblique points. (Note that despite the large number of points oriented parallel to the longitudinal axis of the flake, over half of the northern points were still oriented perpendicularly in relation to the blank). Drawing by M. A. Manninen.

Variable	South	North
Length	23.3	23
Basal width	25.4	24
Max width	16.8	18
Basal thickness	30.8	31.6
Midpoint thickness	21.2	26
Max thickness	21.4	24.2
Weight	51.7	47.9
Thickness ratio (midpoint/base thickness)	27.7	30.7
Edge angle	26.1	41
Relative thickness (thickness/length)	19	28.7
Width ratio (max/basal width)	27.1	26
Mean	26.4	29.2

Figure 15. Comparison of the coefficient of variation ((σ/μ)x100) for the studied measurable variables in the southern and northern groups. Greater values indicate greater variation.

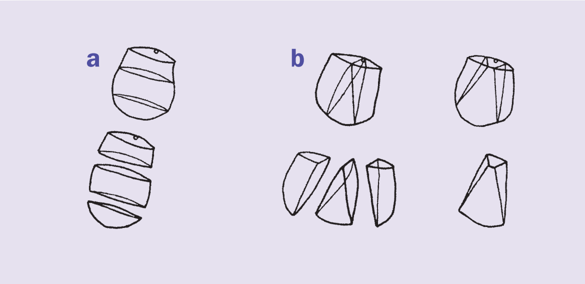

Figure 16. The fragment types most likely to resemble oblique points, from crosswise split flakes (a) and flakes split by radial fractures (b). Based on Knutsson (1998) and Rankama (2002).

weights between the northern and southern point populations is smaller than this value, even though the weights of hunting points made of lithic materials may differ considerably more than 10 grains even when produced by a single skilled person (Shackley 2000:701).

However, some differences between the point groups can be detected, although these differences are not very significant in relation to the overall arrow technology (**Fig. 14**). The clearest differences are seen in the raw materials used, the points' orientations in relation to the blank, and the points' thicknesses and weights. In addition, the northern points are more heterogeneous as a group, as indicated also by the coefficient of variation calculated for the different variables (**Fig. 15**).

The effect of raw material

The fact that the points in the southern group are almost all made of quartz suggests that explanations for the observed differences between the southern and northern oblique points can be found in the differences between quartz and chert. The effect of raw material properties is an environmental factor affecting human behaviour (i.e., a factor independent of cultural choices) and can be tested with the assemblage at hand.

Quartz is known to have a tendency to fragment during flake detachment (Callahan *et al.* 1992), probably as a consequence of its fragility due to low tensile and compressive strengths and the usually high amount of internal flaws. These qualities have affected the design and manufacturing processes of quartz tools when compared with tools made of less fragile raw materials. Quartz artefacts can be manufactured with strategies that to some degree reduce fragmentation and with design criteria that counterbalance the fragility of the raw material (Tallavaara *et al.* 2010a). However, in their ideal form, certain types of flake fragments resemble the typical outline shape of an oblique point (Knutsson 1998). Thus, it could be expected that the proneness to fragmentation of quartz would have been taken advantage of and fragments of these types (**Fig. 16**) would have been selected for point blanks, thereby reducing the amount of necessary retouch.

The effect of these characteristics of quartz on oblique point manufacture and especially on the intergroup differences observed in the technological analysis can

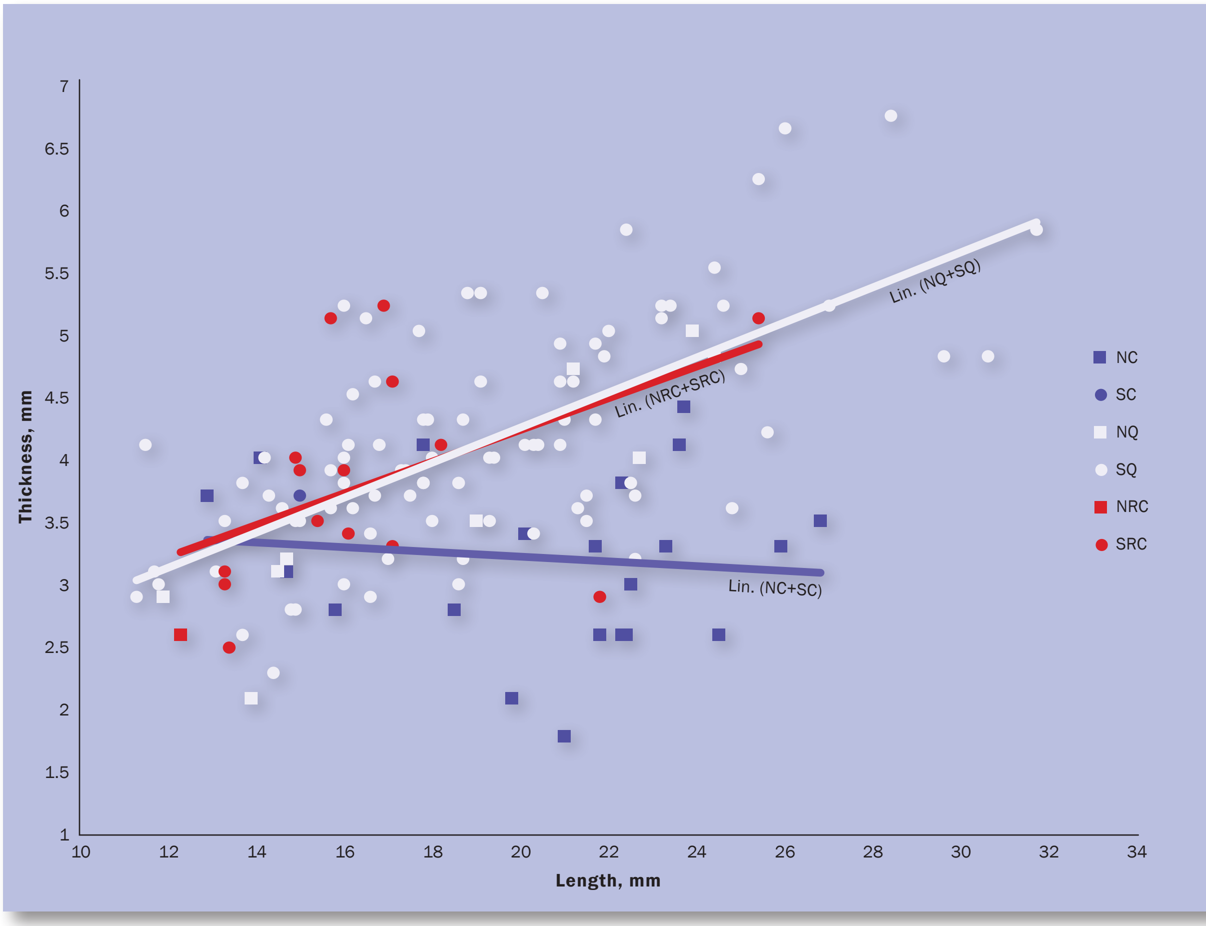

Figure 17. Thickness/length ratios of intact points and points with broken tips (1.5 mm added to length) made of different raw materials in the northern (N) and southern (S) groups of points. Chert (C) n=22, quartz (Q) n=98, rock crystal (RC) n=16.

be studied by dividing the point data by the raw material, and especially by contrasting the quartz point data from the two geographical groups with the chert point data.

Starting with a comparison of the relative thicknesses of quartz and chert points (**Fig. 17**), we find that the difference in point thickness between the two populations appears to be due to the relatively larger number of points in the southern group that are made of quartz. The thickness of chert points does not correlate with their length. However, the thickness of quartz points increases with their length, which makes the quartz points thicker as a group. Experimental work indicates that an increased thickness-to-length ratio makes projectiles more durable (Cheshier & Kelly 2006) and that the fragmentation of quartz flakes during detachment can be reduced to some degree by producing relatively thicker flakes (Tallavaara *et al.* 2010a). The greater thickness of quartz points in comparison to chert points can thus be explained as an attempt to compensate for the fragility of the raw material. This conclusion is in accordance with the results from other studies that compare artefacts made of quartz with counterparts made of less fragile raw materials (e.g., Siiriäinen 1977; Tallavaara 2007; Wadley & Mohapi 2008). Although made of a more homogenous raw material than the vein quartz points, the rock crystal points show similar and only in some cases slightly more "chert-like" trends than the vein quartz points when treated separately. For that reason, we henceforth include the rock crystal points in the same group with the other quartz points. As can be expected, the increased average point thickness of the combined quartz group correlates well with the group's increased basal thickness (**Fig. 18**).

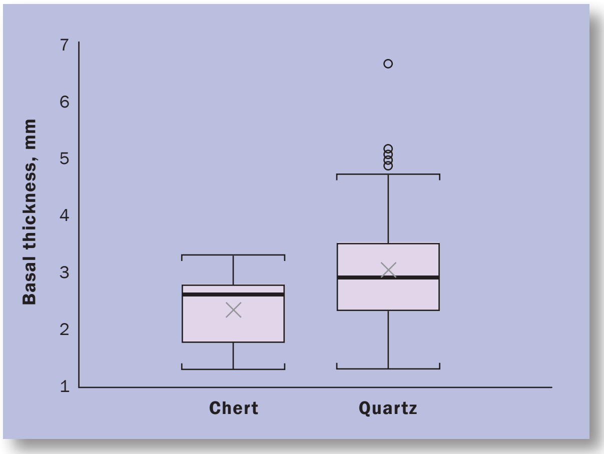

Figure 18. Basal thickness in points from different raw materials. Chert n=25; quartz n=129.

Area	Raw material	Orientation		Sum
		Perpendicular	Parallel	
North	Chert	44.4% (n=8)	55.6% (n=10)	100% (n=18)
	Quartz	87.5% (n=7)	12.5% (n=1)	100% (n=8)
South	Chert	100% (n=1)	0%	100% (n=1)
	Quartz	92.4% (n=73)	7.6% (n=6)	100% (n=79)

Figure 19. Cross-tabulation of point raw material (quartz and chert), and point orientation in the studied groups.

The effect of raw material on point orientation in relation to the blank can be studied by contrasting point population, raw material, and, when discernable, point orientation (**Fig. 19**). The cross-tabulation reveals that quartz points are oriented perpendicularly in relation to the blank regardless of the area of origin, whereas the northern chert points are oriented parallel to the longitudinal axis of the flake as often as they are oriented perpendicularly to the axis. This finding indicates that a quality inherent in the raw material was a major factor in the orientation of the quartz points. We suggest that this quality is the aforementioned fragility of the material. A perpendicular orientation in relation to the blank can be used to create a steeper and more durable edge than the usually gently feathering edge at the distal end of the flake.

The typically perpendicular orientation of the quartz points also reveals that if flake fragments were used to produce quartz points instead of intact flakes, then the fragments from crosswise split flakes were used almost exclusively, whereas the oblique-point-looking middle fragments caused by radial fractures do not seem to have been used. This suggests that fragmentation, at least by radial fractures, was not desired in oblique point blank production.

The correlation amongst variables in the different groups can be studied for the purpose of evaluating the possible effects of different transmission mechanisms *versus* the effects of raw materials on the within-group variation. The logic behind the comparison of paired correlations is that variables acquired as a package by a mechanism akin to indirect bias are more strongly correlated than variables affected by guided variation (Bettinger & Eerkens 1999:237). The data in this study indicate that more interdependence exists among the variables in the southern group than those in the northern group (**Fig. 20:A**). In 33 of the 55 paired correlations, the southern value exceeds the northern value. The correlation in the southern group is significantly larger in five of these cases ($p < 0.05$), but there are no cases in which the northern correlation is significantly larger. This result supports an interpretation that the differences between the southern and northern groups reflect different transmission mechanisms.

However, when the points are divided according to raw material, even though the number of cases in which the quartz value exceeds the chert value is smaller than when comparing the southern and northern points (28 of the 55 paired correlations), a significantly stronger correlation amongst variables is found in nine cases in the quartz group and in two cases in the chert group (**Fig. 20:B**). Thus, more significant correlation exists amongst the variables in the quartz points than amongst those in the southern group of points. Furthermore, in the two cases, where the correlation is significantly stronger in chert points (i.e., relative thickness (thickness/length) to length and relative thickness to maximum width), it is caused by the fact that the thickness of the quartz points increases with increasing length and width. These results indicate that the properties of quartz reduced the degree of variation in the southern group, and therefore the differences in the degree of within-population variation cannot be attributed directly to differing transmission mechanisms.

The fragility and proneness to fragmentation of quartz seems to force a more standardised and robust point shape in comparison with chert. Because of its greater resilience, chert allows for more diverse point orientations and shapes as well as smaller blanks. Moreover, the perpendicular orientation alone renders quartz

A

	Group	Length	Basal width	Maximum width	Basal thickness	Midpoint thickness	Maximum thickness	Weight	Thickness ratio	Edge angle	Relative thickness
Basal width	south	**0.176**									
	north	0.159									
Maximum width	south	0.568	**0.509**								
	north	0.621	0.296								
Basal thickness	south	**0.462**	**0.341**[a]	**0.538**							
	north	0.221	0.061	0.143							
Midpoint thickness	south	**0.587**[a]	**0.220**	**0.463**	**0.451**						
	north	0.303	0.148	0.312	0.431						
Maximum thickness	south	**0.629**[a]	**0.237**[a]	**0.525**	**0.653**	0.900					
	north	0.283	0.118	0.287	0.598	0.964					
Weight	south	**0.865**[a]	**0.354**	**0.710**	**0.576**	**0.768**	**0.809**				
	north	0.670	0.289	0.627	0.438	0.755	0.748				
Thickness ratio	south	**-0.075**	**-0.158**	**-0.224**	**-0.705**	0.207	-0.011	-0.059			
	north	0.057	0.071	0.100	-0.596	0.414	0.254	0.225			
Edge angle	south	**-0.292**	0.025	**-0.084**	**-0.260**	-0.058	-0.126	-0.087	**0.230**		
	north	0.069	-0.057	0.081	0.024	-0.169	-0.149	-0.108	-0.123		
Relative thickness	south	-0.485	**0.110**	-0.091	0.189	0.312	0.351	**-0.123**	0.070	**0.217**	
	north	-0.630	0.025	-0.338	0.303	0.493	0.541	-0.014	0.122	-0.108	
Width ratio	south	0.157	**-0.734**	0.112	0.014	**0.088**	**0.114**	0.071	0.007	-0.041	-0.121
	north	0.271	-0.679	0.465	0.037	0.022	0.032	0.138	-0.045	0.121	-0.277

B

	Raw material	Length	Basal width	Maximum width	Basal thickness	Midpoint thickness	Maximum thickness	Weight	Thickness ratio	Edge angle	Relative thickness
Basal width	quartz	0.171									
	chert	0.229									
Maximum width	quartz	**0.579**	**0.505**								
	chert	0.575	0.228								
Basal thickness	quartz	**0.460**	**0.335**	**0.507**[a]							
	chert	0.225	0.090	0.193							
Midpoint thickness	quartz	**0.620**[a]	**0.245**	**0.519**[a]	0.453						
	chert	-0.155	-0.014	-0.162	0.464						
Maximum thickness	quartz	**0.655**[a]	**0.252**	**0.559**[a]	**0.654**	0.907					
	chert	-0.129	-0.043	-0.133	0.540	0.990					
Weight	quartz	**0.867**[a]	**0.362**	**0.728**[a]	**0.564**	**0.785**[a]	**0.820**[a]				
	chert	0.654	0.252	0.397	0.466	0.473	0.471				
Thickness ratio	quartz	0.003	-0.116	-0.108	**-0.669**	0.263	0.041	0.017			
	chert	-0.356	-0.146	-0.333	-0.612	0.376	0.304	-0.074			
Edge angle	quartz	**-0.312**	0.041	-0.079	-0.269	**-0.097**	**-0.152**	-0.111	0.206[a]		
	chert	0.198	-0.114	0.114	0.349	-0.057	0.002	0.136	-0.259		
Relative thickness	quartz	-0.450	**0.144**	-0.052	0.214	0.313	0.356	-0.096	0.042	**0.218**	
	chert	-0.766[a]	-0.100	-0.518[a]	0.223	0.720	0.710	-0.163	0.396	-0.094	
Width ratio	quartz	**0.183**	**-0.725**	0.136	0.012	0.113	**0.134**	**0.092**	0.038	-0.062	-0.127
	chert	0.133	-0.705	0.490	0.048	-0.172	-0.123	0.001	-0.171	0.180	-0.251

[a] Significantly stronger correlation.

Figure 20. A) Pearson's r Correlation Coefficients for the point variables in the southern and northern groups of oblique points and B) for the oblique points made of quartz (vein quartz + rock crystal) and chert. Thickness ratio = midpoint thickness/ base thickness, relative thickness = thickness/length, and width ratio = maximum width/basal width.

points more standardised, as the number of pointed or round tips is reduced. Chert points are generally thinner, often have relatively thin and/or narrow (**Fig. 21**) bases, and have more diverse edge shapes (**Fig. 22**).

Thus, our evaluation of the effects of raw material properties indicates that, although quartz points differ from chert points, they have similar dimensions and were made in the same manner in both of the studied point groups. The differences in raw material composition and properties appear to explain most of the inter-group differences observed in the point data. Hence, from a technological point of view, there are no differences in the manufacturing processes behind these points that would suggest separate technological traditions or necessitate differing arrow technology. However, that the same or at least very similar technology arrived in the area of present day Finland through different routes remains possible.

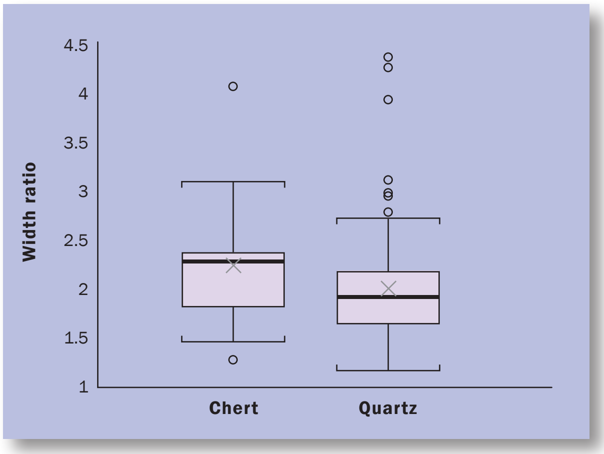

Figure 21. Width ratio (Maximum/basal width). The greater the value, the more triangular or tanged/trumpet-like the point is. A value close to 1 indicates a point with straight edges. Chert n=21, quartz n=111.

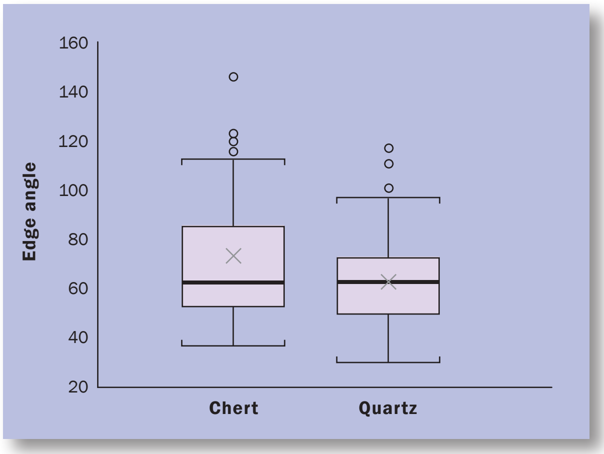

Figure 22. Edge angle variation according to raw material. Chert n=21, quartz n=118.

Origin and dates

To facilitate the evaluation of possible source areas for the oblique point technology in Finland a brief survey of margin-retouched points and related technology in neighbouring areas during the Mesolithic is required. In this study, we do not distinguish between specific types of arrowheads or microliths. Instead, the survey concentrates on the occurrence of the general concept of manufacturing a projectile from a flake, flake fragment or blade segment by shaping most of the points' margins with a backing retouch while leaving part of the sharp margin of the blank as a cutting edge. Thus, the survey includes such generally used classes as transverse and oblique points, trapezoidal microliths (trapezes), and single-edged points. Because indigenous artefact types, such as Mesolithic leaf-shaped slate points and globular mace heads (see Matiskainen 1989a) are known in the study area, the possibility of local innovation cannot be ruled out while discussing new technologies. However, in this case the existence of the margin-retouched point concept in nearby regions prior to its appearance in Finland makes it more reasonable to look for outside influence.

In the areas of present-day Belarus, Lithuania, Poland, and the Central Federal District of Russia, there are margin-retouched points from Upper Paleolithic and Early Mesolithic archaeological cultures, such as Bromme-Lyngby, Ienevo, and Desna (Galimova 2006; Kobusiewicz 2009; Kozłovski 2006:Fig. 2; Sorokin 2006; Zhilin 2005:166–167). Later in the Mesolithic, margin-retouched trapezoidal microliths appear by *c.* 6100 calBC at the latest in the Meso-Neolithic Janislawice and Neman cultures in the south-eastern part of the Baltic region (Kozłovski 2002:Fig.13; Perrin *et al.* 2009:175; Zalinznyak 1997:30–45; Zvelebil 2006:179). However, between this area and Finland, there is a zone consisting of Latvia, Estonia and a large part of north-western Russia from which Mesolithic margin-retouched points or trapezes have not been reported (see, e.g., Kriiska & Tvauri 2002; Oshibkina 2006; Zagorska 1993).

The current understanding of Late Mesolithic point types and chronology on the southern shores of the Baltic Sea is mainly based on materials found in southern Scandinavia (i.e., Denmark and southernmost Sweden), but largely congruent developments are known also from Germany and western Poland (e.g., Hartz *et al.* 2007; Jankowska 1998; Larsson 1993; Schmölcke *et al.* 2006; Vang Petersen 1984; 1999). The research situation is partly due to the geographical changes that have occurred since the Mesolithic. In the southern Baltic area, most of the Stone Age coastal sites are currently some 1–25 meters below the present sea level due to a mainly transgressive shoreline from the Mesolithic onwards (Schmölcke *et al.* 2006:428). However, in parts of Denmark and in most of Sweden, Mesolithic sites are found on dry land (Larsson 1993:261–263).

The typo-chronology of flint points from the Late Paleolithic to Bronze Age in southern Scandinavia is widely known and well established in the literature (e.g., Fischer 1990:38; Vang Petersen 1999). Small margin-retouched oblique and transverse points/trapezes are dominant in the area during the Kongemose and Ertebølle periods at *c*. 6400–3900 calBC (Edinborough 2009; Fischer 1990; Larsson 1993; Sjöström 1997; Vang Petersen 1984; 1999). Similar points are also found in eastern and western Norway at *c*. 5000 calBC (Bjerck 2008:80; Glørstad 2004:53–55). Somewhat similar forms that were retouched from blade segments and flakes are found already among the Late Paleolithic Ahrensburgian points (Prøsch-Danielsen & Høgestøl 1995:Fig. 4; Vang Petersen 1999:77–78), whereas early trapezes are found in the later part of the Maglemose period (Larsson 1993; Sjöström 1997). In eastern Middle Sweden, where transgressions have generally left Mesolithic sites undisturbed (Åkerlund 1996), margin-retouched points from *c*. 5300–4000 calBC have not been reported, and if the earliest known margin-retouched points, dated by shore displacement chronology to *c*. 6500–5300 calBC, are correctly classified and dated, then they have no counterparts in the adjacent areas (Guinard & Groop 2007).

According to current understanding, the first post-glacial colonisation of the Swedish west coast and the Norwegian coast all the way to Varangerfjord in northernmost Norway took place *c*. 9500–8000 calBC by people using margin-retouched points of the Ahrensburgian tradition or other local traditions probably deriving from the Ahrensburgian (i.e., the Hensbacka, Fosna, and Komsa) (e.g., Bjerck 2008; Freundt 1948:14–16; Fuglestvedt 2007; Helskog 1974; Odner 1966; Prøsch-Danielsen & Høgestøl 1995; Schmitt *et al*. 2006; Waraas 2001; Woodman 1993). Later in the Mesolithic, points that were similar and contemporaneous with the Late Mesolithic oblique points in northern Finland were made in a large area consisting of northern Sweden as well as the counties of Finnmark and Troms in northernmost Norway. According to typo-chronologies, the more recent points found in northern Norway belong to the Mesolithic Phase III (*c*. 6400–4400 calBC), while published radiocarbon dates indicate that these points were widely in use in the inland areas of northernmost Fennoscandia in approximately 5500 calBC and later and possibly in use as early as 6500 calBC. (Hesjedal *et al.* 1996:184–185, 198; Knutsson 1993; Manninen & Knutsson *this volume*; Olsen 1994:31, 39; Skandfer 2003:281–283; Woodman 1999:301.)

However, existing typo-chronologies diverge on the question of whether margin-retouched points were in use in Finnmark during the Mesolithic Phase II (*c*. 8000–6400 calBC) (Hesjedal *et al.* 1996; Olsen 1994). It seems certain that the mid-Holocene Tapes transgression that peaked at *c*. 6500 BP (*c*. 5500 calBC) greatly reduced the number of preserved sites on the Barents Sea coast (Fletcher *et al*. 1993; Hesjedal *et al*. 1996:134; Møller *et al*. 2002). As a result, the use of margin-retouched points, especially from *c*. 7000–6000 calBC, is difficult to assess as archaeological fieldwork in the area has concentrated mainly on coastal sites. Nevertheless, there are indications that margin-retouched points could have also been in use during this time period, as suggested by Olsen (1994: 31, 39; Manninen & Knutsson *this volume*). Evidence pointing in this direction has also been recently published from Skarpeneset (Troms) where the use-period of two houses with finds of margin-retouched points has been dated by a large series of radiocarbon dates to 7060–6480 calBC (Henriksen 2010; Nielsen & Skandfer 2010).

Judging from the data presented above, the southern shores of the Baltic Sea and the Norwegian Barents Sea coast (i.e., the two areas suggested by earlier research as the origins of the oblique points in Finland) still remain the most likely candidates. In these areas, there is evidence of use of margin-retouched points that predates or coincides with the *c*. 6500 calBC (7700 BP) date, which marks the introduction of margin-retouched points in the area of present-day Finland (Matiskainen 1982; 1989b Manninen & Knutsson *this volume).* Using this situation as a starting point, we formulate three alternative scenarios for the oblique point technology in the study area: *the south-to-north scenario*, *the north-to-south scenario*, and *the south-and-north scenario* (**Fig. 23**). As the date of the Kongemose trapezes seems too early to be connected with the spread of the Late Mesolithic "Tardenoisien" trapezoidal points (see Perrin *et al*. 2009), these simplified scenarios assume a technological sequence from the Ahrensburgian points to the Kongemose trapezes.

These alternative scenarios can be evaluated to some degree using radiocarbon-dated oblique point contexts in Finland, as it can be expected that the technology in the area with earlier dates does not originate in the area with later dates. For this purpose, we dated seven samples from oblique point contexts in Finland. We selected these samples from contexts that we considered firstly to date the associated oblique points as reli-

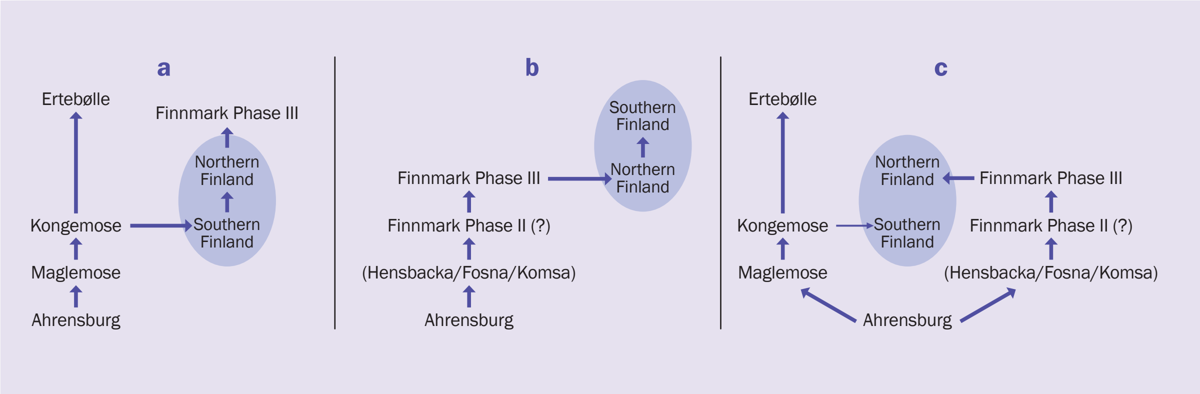

Figure 23. Alternative descent scenarios for the arrival of the margin-retouched point concept in Finland: A) the south-to-north scenario, B) the north-to-south scenario, and C) the south-and-north scenario.

ably as possible and secondly to secure as early a date as possible from both of the studied areas. This series was supplemented with the few published dates from reliable oblique point contexts.

The radiocarbon date data consists of seventeen dates from nine sites (**Fig. 24**). Four of the sites are from the area of the southern group of points (Riihimäki Arolammi 7D Sinivuokkoniemi, Vantaa Hommas, Kuortane Lahdenkangas 1, and Alajärvi Rasi), and the remaining five are from the northern point area (Utsjoki Jomppalanjärvi W, Inari Kaunisniemi 3, Utsjoki Mávdnaávži 2, Enontekiö Museotontti, and Inari Vuopaja). The sample contexts, sample materials, and the calibration curves used for each sample are specified in **Appendix IV**.

Considering the oblique point use-period of 6500–5600 calBC (7700–6700 BP) in southern Ostrobothnia and 6400–4900 calBC (7500—6000 BP) in southernmost Finland suggested by shore-displacement chronology (Matiskainen 1982; 1989b), the dates from Hommas (Koivisto 2010a) and Arolammi 7D Sinivuokkoniemi (Matiskainen 2002) are relatively late (median values 5570–4950 calBC). The dates from Rasi and Lahdenkangas 1 are complementary to these dates. According to the shore displacement chronology, these two sites are among the earliest sites with oblique points, and the samples dated in this study indicate that oblique points were used at these sites at 6230–6060 and 6030–5680 calBC.[3]

[3] There is a *c.* 500 years discrepancy between the *c.* 7700 and 7500 BP (6500 and 6400 calBC) dates suggested by the existing shore displacement curve (Matiskainen 1982; Salomaa & Matiskainen 1983) and the radiocarbon dates from the Rasi and Lahdenkangas 1 sites.

With regard to the northern sites, the choice of the radiocarbon dated sites is determined solely by the reliability of the contexts with oblique points found in surveys and excavations in the area (see Manninen & Knutsson *this volume*). Shore displacement dating is either inapplicable or inaccurate in this part of the study area. For the purposes of this study, we selected and dated samples from two contexts with previously obtained dates (Mávdnaávži 2 and Museotontti, area 11A) as well as samples from three undated contexts with oblique points (Jomppalanjärvi W, Kaunisniemi 3, and area 129–134/977–980 at Vuopaja).

Mávdnaávži 2 and Vuopaja are both dated to *c.* 5500 calBC and, thus, are relatively late compared with the earliest dates from the southern sites. However, the 6220–6050 calBC date from Jomppalanjärvi W is as early as the earliest date in the south, and the dates from Museotontti and Kaunisniemi 3 are even earlier. An earlier date on charcoal (7030–6410 calBC) from Museotontti has been considered tentative by Manninen & Knutsson (*this volume*), but a similar date on burnt bone from the same context rules out the effect of old wood and supports a *c.* 6500 calBC date for the oblique points at the site. The date 7060–6710 calBC from the Kaunisniemi 3 site in Inari is even earlier than this.

Thus, the radiocarbon dates indicate an earlier presence of the technology in northern Finland than in southern Finland. It should be noted, that although there are few radiocarbon dated contexts with oblique points in the southern part of the country, shore displacement chronology indicates that sites containing oblique points earlier than the ones already found are unlikely

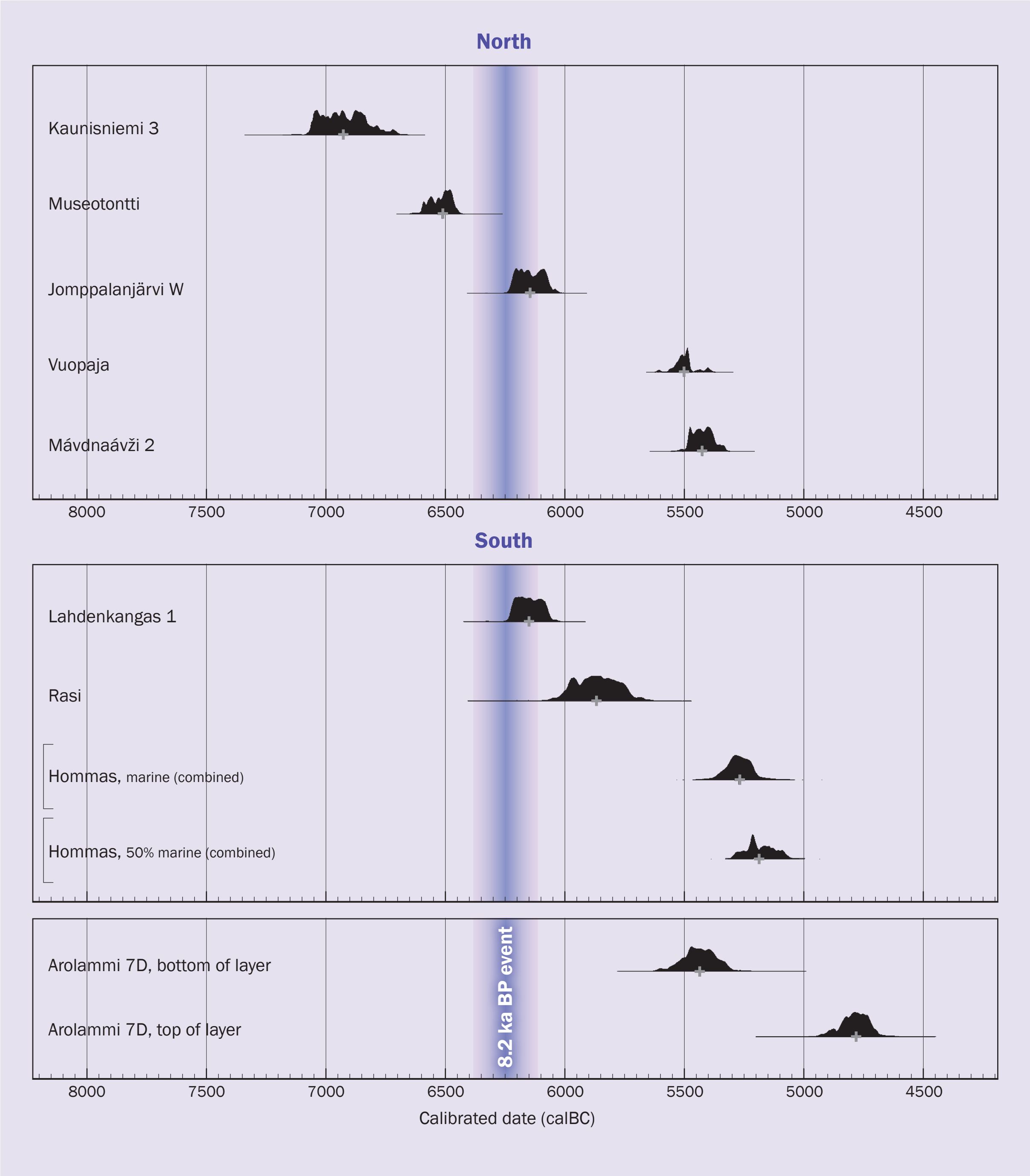

Figure 24. Calibrated dates from oblique point contexts in Finland. Dates on burnt bone are preferred when available. The dates from Arolammi 7D are on charcoal from the find layer with oblique points. See Appendix IV for details and specific dates. Calibrated with OxCal v4.1.7. Atmospheric and marine data from Reimer *et al.* (2009).

to be discovered, at least among the coastal sites. At the same time, the dates from northern Finland are in good agreement with the aforementioned dates from Skarpeneset in Troms (**Fig. 25**). Therefore, it can be concluded that the radiocarbon date dataset does not fit the south-to-north scenario for the introduction of the margin-retouched point concept in Finland, whereas both the north-to-south scenario and the south-and-north scenario remain possible.

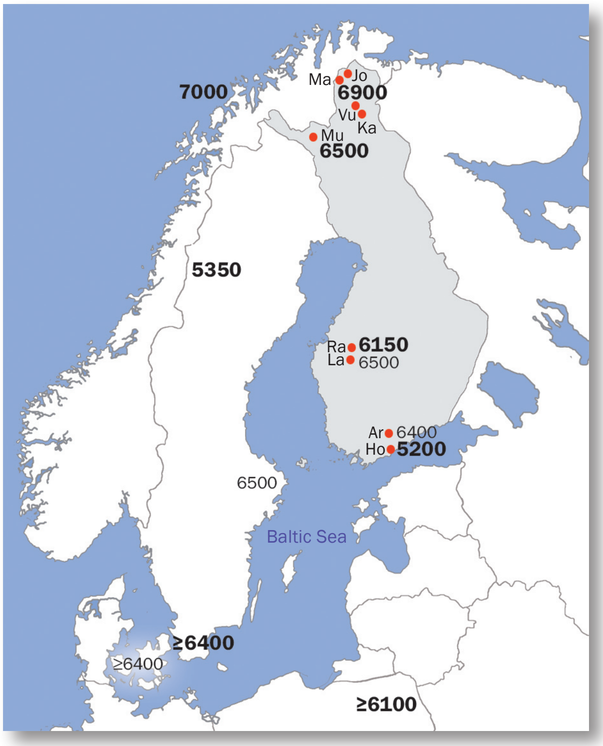

Figure 25. Margin-retouched points around the Baltic Sea, *c.* 7000–5000 calBC. The map shows the earliest shore displacement dates (in italics) and the median values of the earliest radiocarbon dates in the relevant parts of Finland, Sweden, and Norway. The locations of the radiocarbon-dated oblique point contexts in Finland (red dots) are as follows: Utsjoki Jomppalanjärvi W (Jo), Utsjoki Mávdnaávži 2 (Ma), Inari Vuopaja (Vu), Inari Kaunisniemi (Ka), Enontekiö Museotontti (Mu), Alajärvi Rasi (Ra), Kuortane Lahdenkangas 1 (La), Riihimäki Arolammi 7D Sinivuokkoniemi (Ar), and Vantaa Hommas (Ho). The dates in Scania and Denmark indicate the beginning of the Kongemose period according to radiocarbon dates and the date in Poland indicates the earliest dated secure trapeze context in the south-eastern Baltic area. See text for references.

Discussion

To evaluate the outcome of the analyses from the perspective of oblique point descent history in Finland, we must first summarise the main results and discuss their implications.

The technological analysis indicates that, although oblique point finds in Finland form two geographically separate groups, there are only slight differences between these groups and furthermore, that these differences can be explained by the differences in raw material characteristics and composition. Therefore, we conclude that the technological processes behind these points, as far as it is possible to infer from the finished products, are basically identical in both areas if raw material specific differences are not considered.

Since the geological formations in Finland are largely devoid of flint, chert, and other flint-like raw materials, vein quartz from glacial deposits and quarries was by far the most common raw material used to produce small lithic artefacts in the area throughout the Stone Age (e.g., Rankama *et al.* 2006). However, in northernmost Fennoscandia, different types of cherts and fine-grained quartzites are found not far from the border between Finland and Norway, especially near the Barents Sea coast (Halinen 2005:27; Hood 1992). Although quartz has also been utilised to some degree, most of the known northern oblique points are made of cherts. In the area of the southern group, where chert was not available, quartz is the dominant raw material.

Because the use of certain raw materials in the two groups of points correlates with the availability of these materials and because the differences in the raw materials explain the slightly different approaches to manufacturing points, variation-inducing factors observed in earlier studies of variation in arrowheads, such as isochrestic style (e.g., Wiessner 1983) and diverging technological traditions (e.g., Darmark 2007), cannot explain the inter-group differences observed in this study. However, the technological analysis also indicates that there is more variation in the northern points. This observation is not directly explained by the differences in raw materials. Just because the use of quartz forces the production of relatively standardised points does not mean that chert points should be any less standardised. This is true especially in the south-to-north scenario, in which the perpendicular orientation of the southern points could be seen as a trait that was copied from the perpendicular orientation of margin-retouched points in the southern Baltic area and therefore, to a large degree, unrelated to raw material properties. The observation is important if the evidence is considered from the standpoint of cultural transmission theory.

In their study on Great Basin projectile points, Bettinger & Eerkens (1999) hypothesise that differences in intra-group variation within two point populations are explained by different transmission mechanisms: in eastern California, the technology was maintained through a mechanism that caused technological experimentation and, consequently, less correlation between point variables, whereas in central Nevada, point technology was acquired as a package and maintained by copying the successful concept, consequently resulting in less variation.

In the case of the oblique points in Finland, for the south-to-north scenario to hold, the margin-retouched point concept should have been transmitted from the southern Baltic area to southern Finland and then further onwards to northern Finland. As the point concept in Finland spread to areas in which directly preceding lithic arrowhead types are unknown, most likely through copying of a single successful model, one would expect the same transmission mechanism throughout the area and the same perpendicular orientation dominant in both the southern Baltic area and in southern Finland also in the northern points. The greater variation within the northern group of points observed in our study, however, could indicate the intervention of a differing decision-making force if and when the technology spread from southern Finland to the north. In a similar vein, it could be suggested that in the case of the north-and-south scenario, the greater variation in the northern group suggests a different transmission mechanism.

A transverse flint point and two microliths of flint found in excavations at coastal sites in southernmost Finland (Europaeus 1927:Fig. 11; Manninen & Hertell *this volume*) suggest that some contact between southern Finland and the more southern parts of the Baltic Sea shores existed during the Late Mesolithic/Pottery Mesolithic. These artefacts, however, do not derive from radiocarbon-dated contexts The above survey on the usage of margin-retouched points around the Baltic and especially the absence of earlier points in Estonia and Middle Sweden increases the probability that especially the transverse point is later than the spread of the margin-retouched concept to southern Finland and is possibly associated with the spread of margin-retouched points from southern Scandinavia to the Swedish east coast in approximately 4000 calBC (Guinard & Groop 2007). It should also be noted that the so-called Tardenoisien expansion, which has been considered in the past to be the source of oblique point technology in Finland, is too late to be the primary source of the technology according to radiocarbon dates presented here and elsewhere (Perrin *et al*. 2009). Hence, these artefacts do not give much support to the south-to-north or south-and-north scenarios.

Therefore, the north-to-south scenario appears to best fit the available evidence. The radiocarbon data indicate an earlier presence of margin-retouched points in the north, and the technological analysis shows that the quartz points were manufactured in the north in a manner successfully adapted to the specific raw material. This adaptation would have facilitated the transmission of the technology to the south, quite possibly as a package. Although little archaeological evidence exists from the area between the northern and southern regions, the raw material of the single chert point within the southern group (i.e., the point made of black chert found in Kemijärvi, just south of the blank area) resembles chert types found in northern Norway. If the raw material does originate from these sources, it supports the hypothesis that the gap in oblique point distribution between the northern and southern points is artificial and that contact between the areas existed. Earlier contacts between the areas are suggested by, for instance, the similar blade technology and point types in some Early Mesolithic site assemblages in both areas (Rankama & Kankaanpää 2008) and possibly the leaf-shaped slate point from Enontekiö (Erä-Esko 1957), that is similar to southern slate points dated by shore-displacement chronology to *c.* 8300–6900 calBC (9000–8000 BP) (Matiskainen 1989b).

If the north-to-south scenario is accepted as the working hypothesis, then we need to address the reasons behind the spread of the margin-retouched point concept at this point in prehistory. The above discussion leaves open the question of why the new point concept was so readily adopted over a large and ecologically diverse area, although it seems clear that certain design criteria, such as easy replaceability, and the ease of manufacturing from diverse raw materials (including quartz), may have contributed to the proliferation of this concept.

One way of approaching the question of how and why the technology spread from the North-Norwegian coast to southern Finland is to search for marked changes in the natural environment that could have caused changes in subsistence and land-use strategies. Although there is evidence in the archaeological record that culturally transmitted traits, represented by persistent artefact traditions, can survive considerable environmental fluctuation due to cultural inertia (Boyd & Richerson 1985:56–60), there is also increasing evidence suggesting that environmental change has operated as a stimulus for cultural change in many instances in prehistory (e.g., Munoz *et al*. 2010). In the case of Mesolithic northern Fennoscandia, with two groups with differing material culture descending from colonisation waves that originally spread to the area from west and southeast of the Scandinavian Ice Sheet, marked environmental changes could ultimately have led to an increase in inter-group contact. Increased contact, in turn, could have resulted in cultural exchange and horizontal transmission of technology over the likely interface between the two historically distinct populations.

According to recent studies, some major environmental changes coincide with the spread of oblique point technology. Especially the abrupt 8.2 ka cold event caused by the outburst of pro-glacial lakes in North America into the North Atlantic that began at *c*. 6250 calBC (8200 calBP) and lasted roughly 150 years (e.g., Alley & Ágústsdóttir 2005; Barber *et al*. 1999; Kobashi *et al*. 2007; Seppä *et al.* 2007) and the subsequent rapid increase in temperature that marked the beginning of the Holocene Thermal Maximum, are of interest here.

The 8.2 ka event had a major impact on the Barents Sea and caused several interdependent changes. For instance, the freshwater pulse disturbed the thermohaline circulation, reduced the salinity of the North Atlantic surface waters, spiked the wintertime freezing of the Nordic Seas, and caused a major expansion of sea-ice cover in the North Atlantic in general (e.g., Alley & Ágústsdóttir 2005; Renssen *et al*. 2002). For example, the annual duration of sea-ice cover is estimated to have increased by approximately six months in the southeastern Barents Sea during the event (Voronina *et al*. 2001). At the same time, the pollen-based climate records in northern Fennoscandia show less distinctive evidence of the effect of the 8.2 ka event than the records in more southern areas, where a rapid, large-scale temperature cooling was also seen during the summer months. It therefore seems that in the northern Fennoscandian mainland the event primarily caused cooler temperatures during the cold part of the year. (Seppä *et al*. 2007.)

Modelling the effects of environmental changes to ecosystems is not always straightforward, especially at a regional level (e.g., Wookey 2007). Nevertheless, studies on the modern Barents Sea indicate that primary productivity is inversely correlated with ice cover. The influx of warm Atlantic waters keeps the Barents Sea coast free of ice as far east as the Murmansk region throughout the year.[4] In the years during which large amounts of warm Atlantic waters flow into the Barents Sea, primary productivity can be 30% higher than the productivity in years with a low influx of water (Slagstad & Stokke 1994 in Sakshaug 1997). The extent of sea ice cover in the Barents Sea is largely associated with small variations in the seawater temperature, and during recent cold periods, the ice cover has advanced from north-east to the coast of the Kola peninsula, although the drop in seawater temperature has been only in the magnitude of a few degrees Celsius (Vinje 2009). The increased sea ice cover initiates processes that result in a food shortage throughout the marine ecosystem (Cochrane *et al*. 2009; Sakshaug 1997; Sakshaug & Slagstad 1992).

Currently, years with low primary production are followed by crashes in capelin populations (Naustvoll & Kleiven 2009). One such crash was documented from 1988–1989 and was also reflected higher in the food chain as a mass death of capelin-feeding sea birds and a mass migration of harp seals southwards along the Norwegian coast (Sakshaug 1997). Although the Early Holocene ecosystem in the Barents Sea may have differed from the present situation, the general patterns are likely to have been the same. It therefore seems clear that the major cooling caused by the 8.2 ka event markedly reduced primary productivity and probably also pushed the extent of wintertime ice cover to the previously ice-free Barents Sea coast. This type of change would have inflicted a serious disruption in both the marine ecosystem and in the marine hunter-gatherer-fisher subsistence economy.

After the 8.2 ka event, the climate became markedly warmer, and the Holocene Thermal Maximum followed. In the study area, annual mean temperatures reached their Holocene maxima roughly between 6000–4000 calBC (e.g., Heikkilä & Seppä 2003; Korhola *et al*. 2002; Luoto *et al*. 2010). Paleoecological studies conducted in northern Fennoscandia indicate that large, previously (and currently) treeless areas became covered in birch forests, whereas pine forests spread to areas that were previously dominated by birch (e.g., Hyvärinen 1975; Kultti *et al.* 2006; Seppä & Hicks 2006). Corresponding changes in vegetation zones took place also in more southern parts of Fennoscandia, as ecosystems were affected by the warming climate (e.g., Miller *et al.* 2008). For the Barents Sea, a temperature maximum is indicated at *c*. 5900–4800 calBC (Duplessy *et al*. 2001). The warmer climate, as well as a coinciding salinity peak

[4] The situation was the same in the early 20th century (Granö 1918), i.e., already prior to the major warming observed during the past 30 years.

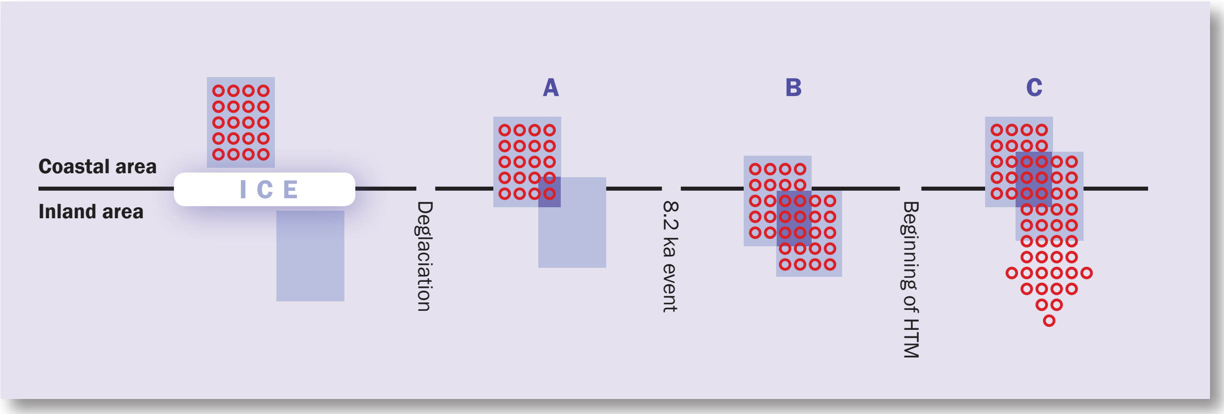

Figure 26. Schematic representation of changes that would have facilitated the transmission of the oblique point technology from the Barents Sea coast to southern Finland across the coast/inland interface between the two historically distinct populations (blue squares). The size of the dark blue areas indicates the amount of contact, and the red circles indicate the margin-retouched point technology. A) Deglaciation and first contact. B) Increased contact and likelihood of horizontal transmission due to the 8.2 ka event. C) The beginning of the Holocene Thermal Maximum and the consequent rapid spread of the new technology to the south due to increasing population size.

in the Baltic Sea, suggests generally increasing environmental productivity especially in the southern parts of the study area after the 8.2 ka event. This increased productivity is also reflected by the gradual growth of human population density starting at *c.* 6200 calBC. (Tallavaara *et al.* 2010b.) It can be assumed that a drop in productivity during the 8.2 ka event led to increased mortality, lower fertility, and reduced human population density, whereas the increasing productivity after the event had an inverse effect.

That ecosystems, the location of most productive areas, and consequently also land-use, hunting, and mobility strategies throughout Fennoscandia were affected by these changes is evident and allows the formulation of a scenario that explains the spread of the oblique point technology to the south (**Fig. 26**). It is generally believed that during the early Holocene, coastal groups of the North-Norwegian coast were maritime hunter-gatherers (e.g., Bjerck 2008). However, examples from south-western Norway indicate that, although they were mainly focused on coastal resources, the Early-Mesolithic groups living in this area also utilised the inland mountain areas (Bang-Anderssen 1996). Indicating a similar pattern, in north-eastern Finnish Lapland non-local lithic raw materials, and in some cases also artefact types, deriving from the Barents Sea coast are repeatedly found in Mesolithic assemblages dated to *c.* 8500–5000 calBC. Regardless of how these artefacts ended up in the inland sites, they indicate that coastal resources were already familiar to the groups that used the area before the earliest known margin-retouched points appeared in the interior (e.g., Grydeland 2005; Halinen 2005; Kankaanpää & Rankama 2005; Rankama & Kankaanpää 2008). As it thus seems probable that contact between the coastal and inland groups occurred already prior to the spread of the oblique point concept in the Late Mesolithic, the transmission of this technology cannot be simply explained as a consequence of contact between these groups (**Fig. 26:A**).

The 8.2 ka event and the subsequent changes in the marine environment, however, would have had a major impact on the subsistence strategies of maritime hunter-gatherers and likely increased, at least at first, the importance of inland resources, especially as the environmental production on dry land during the summer months was not as severely affected by the cold event. Despite its archaeologically short duration, the length of the marine cold period was long enough to force these groups to adapt to the new situation and change their subsistence and mobility strategies accordingly by shifting their foraging focus more to the inland areas. Marked changes towards a less specialised raw material economy, most notably the increased use of quartz, during the Mesolithic Phase III that has been observed on the North-Norwegian coast (Grydeland 2005:57; Hesjedal *et al.* 1996:159) can be linked to this kind of increase in the importance of the inland areas. As the inland areas were also used by groups that had arrived into the area from the south (Manninen & Knutsson *this volume*), the increased use of the interior by groups originating from the coastal areas would have meant increased interaction between individuals and groups (**Fig. 26:B**) and, consequently, facilitated the transmission of the oblique point concept (see also Grydeland 2005:69–71). After the 8.2 ka event, as the climate became gradually warmer and population started to grow especially in the more southern parts of Finland, the technology was rapidly transmitted southwards through established forager networks that likely connected the various hunter-gatherer-fisher groups with shared ancestry residing in the area (**Fig. 26:C**).

Conclusion

In this paper, we have discussed several aspects of Late Mesolithic margin-retouched points and their implications. The study touches upon a number of themes, such as manufacturing technology, dating, geographical distribution, and origin, while focusing on the descent history of the margin-retouched point concept in eastern Fennoscandia. Although much of the reasoning presented here remains to be tested and evaluated in future studies, we can draw the following conclusions from the data:

1. The oblique points in the two geographically separated point groups known in Finland represent the same technological tradition.

2. The differences observed between the northern and southern groups of oblique points are primarily caused by the different properties of the main raw materials used in the north (chert) and the south (quartz).

3. Radiocarbon dates from oblique point contexts are in accordance with the shore displacement dates of the point type in Finland and indicate that the point concept was present in northern Finland during *c.* 6900–5400 calBC and in southern Finland during *c.* 6100–5200 calBC.

4. The present evidence suggests that in Finland the margin-retouched point concept spread from the north to the south.

We suggest that the spread of the margin-retouched point concept in Finland can be explained by changes in hunter-gatherer-fisher organisation triggered by large-scale environmental changes following the 8.2 ka event and the subsequent beginning of the Holocene Thermal Maximum.

These results contribute not only to the study of the Late Mesolithic in eastern Fennoscandia but also to broader fields of study, such as the effect of raw material characteristics on lithic technology, within-population artefact variation, and hunter-gatherer technological organization. In addition, this study contributes to the understanding of the origin and adoption of the margin-retouched point concept throughout all of Europe in the Late Mesolithic. Questions to be answered in future research include the relationship between the margin-retouched points of southern Scandinavia and eastern Fennoscandia and the Late Mesolithic trapezes of southern and western Europe, the processes behind the virtually simultaneous adoption of similar point types in large parts of the European continent and beyond during the Late Mesolithic, and the reasons for the end of margin-retouched point use in eastern Fennoscandia and elsewhere.

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Appendix I. List of catalogue numbers of artefacts shown in Figure 1

a) KM 11771:3	e) KM 34675:147	i) KM 30721:322	m) KM 34856:335	q) KM 24464:289	u) KM 31511:744
b) KM 11771:4	f) KM 28365:660	j) KM 28365:889	n) KM 16856:24	r) KM 34675:199	v) KM 34675:225
c) KM 12159:80	g) KM 31511:816	k) KM 26040:35	o) KM 33461:209	s) KM 33461:160	w) KM 28365:454
d) KM 32590:2	h) KM 12603:90	l) KM 23877:122	p) KM 23877:411	t) KM 11771:17	x) KM 23363:4

Appendix II. Oblique point sites in Finland according to region

	Municipality	Site	Source	Catalogue number
	LAPLAND			
1	Enontekiö	Museotontti	Halinen 2005; Manninen & Knutsson *this volume*	KM 23877:28 +
2	Inari	Ahkioniemi 1&2	Manninen & Knutsson *this volume*	KM 23363:4
3	Inari	Bealdojohnjalbmi (Peltojokisuu) 1	Nordqvist & Seitsonen 2008	KM 35217:1 +
4	Inari	Kaidanvuono SW	Manninen & Knutsson *this volume*	KM 23354:9
5	Inari	Kaunisniemi 2	Manninen & Knutsson *this volume*	KM 26039:42
6	Inari	Kaunisniemi 3	Manninen & Knutsson *this volume*	KM 26040:2
7	Inari	Kirakkajoen voimala	Manninen & Knutsson *this volume*	KM 26245:1-9
8	Inari	Nellimjoen suu S	Halinen 2005; Manninen & Knutsson *this volume*	KM 24376:454
9	Inari	Saamen museo	NBA find catalogue	KM 27808:1058
10	Inari	Satamasaari	Manninen & Knutsson *this volume*	KM 26010:4
11	Inari	Supru	Manninen & Knutsson *this volume*	KM 22685:13
12	Inari	Vuopaja	Manninen & Knutsson *this volume*	KM 28365:442 +
13	Kemijärvi	Lautasalmi	Huurre 1983	KM 15846:78
14	Kemijärvi	Neitilä 4	Kehusmaa 1972	KM 16145:1750 +
15	Kemijärvi	Neitilä 5	NBA find catalogue	KM 29644:89
16	Pello	Kaaraneskoski/Kaarnes 1-2	Rankama 2009	KM 30721:17 +
17	Ranua	Simojärvi Kujala/Uutela	Kotivuori 1996	KM 26481:6
18	Sodankylä	Matti-vainaan palo 2 (Mattivainaanpalot)	NBA find catalogue	KM 27679:878
19	Sodankylä	Poikamella	NBA find catalogue	KM 27674:668 +
20	Utsjoki	Jomppalanjärvi W	Rankama, T. *pers. comm.*	KM 38078:2
21	Utsjoki	Mávdnaávži 2	Manninen & Knutsson *this volume*	KM 32590:1
	NORTHERN OSTROBOTHNIA			
22	Haapajärvi	Hautaperän Allas Tervamäki	Huurre 1983	KM 19030:32
23	Nivala	Järvenpää	Huurre 1983	KM 14536:55
24	Siikalatva	(Kestilä) Päivärinne	Huurre 1983	KM 17062:57
	KAINUU			
25	Hyrynsalmi	Vonkka II	Huurre *et al.* 1988	KM 21466
26	Kuhmo	Vasikkaniemi SW	NBA find catalogue	KM 29136:2591 +
27	Suomussalmi	Kellolaisten Tuli	Huurre 1983	KM 14831:159a
28	Suomussalmi	Tormuan särkkä	Räihälä 1999	KM 18322:696
29	Suomussalmi	Vanha Kirkkosaari	NBA find catalogue	KM 24729:74
	NORTH KARELIA			
30	Joensuu	(Eno) Häihänniemi etelä	Pesonen, P. *pers. comm.*	KM 34119:4
31	Joensuu	(Eno) Sahaniemi	Pesonen, P. *pers. comm.*	KM 34102:4
32	Joensuu	(Pielisensuu) Mutala (Latola)	Pälsi 1937	KM 10640:8
33	Lieksa	Haasiinniemi	NBA find catalogue	KM 28066:30 +
34	Lieksa	Jongunjoki Pälvekoski	Rankama, T. *pers. comm.*	KM -
35	Lieksa	Törisevänvirta 1	Pesonen, P. *pers. comm.*	KM 35398:1
36	Nurmes	Tetrijärvi 1	Hertell, E. *pers. comm.*	KM 37583
37	Outokumpu	Kaalainsalmi	Matiskainen 1986	KM 20019:1
38	Outokumpu	Sätös	NBA find catalogue	KM 17284:409
	NORTHERN SAVONIA			
39	Pielavesi	Kivimäki	NBA find catalogue	KM 24465:570
	CENTRAL FINLAND			
40	Saarijärvi	Kalmukangas	Matiskainen 1986	KM 18092:3
41	Saarijärvi	Rusavierto (Karjalaispirtti/Rusavierto)	NBA find catalogue	KM 29406:489 +
42	Saarijärvi	Summassaari Moilanen	Matiskainen 1986	KM 12234:3 +
	SOUTHERN OSTROBOTHNIA			
43	Alajärvi	Rasi (Heikinkangas ja Rasinmäki)	Luho 1948, Matiskainen 1986	KM 11617:83 +
44	Isojoki	Rimpikangas	Katiskoski 1994	KM 25937:1
45	Kauhajoki	Koivumäki	Matiskainen 1986	KM 16416:4 +
46	Kauhajoki	Toivakka	Katiskoski 1994	KM 26355:5
47	Kuortane	(Mäyry) Haavistonharju 1	Matiskainen 1986	KM 16163: +
48	Kuortane	(Ylijoki) Lahdenkangas 1	Matiskainen 1986	KM 16856:3 +
49	Kurikka	(Myllykylä) Mäki-Venna/Mäkinen	Matiskainen 1986	KM 17077:34
50	Kurikka	(Pitkämö) Mertamäki/Palomäki	Matiskainen 1986	KM 16564:97 +
51	Kurikka	Topee (Myllykylä)	Matiskainen 1986	KM 17486:100
	SOUTHERN SAVONIA			
52	Juva	Päiväranta 1	Schulz 2002	KM 33235:1-52
53	Mäntyharju	Muurhaisniemi	Pesonen, P. *pers. comm.*	KM 36702:1-958
54	Pieksämäki	Kahvikivi	NBA find catalogue	KM 25275:534
	PIRKANMAA			
55	Punkalaidun	Rautionmaa (=Haukuri Rautee) tai Hankuri	Matiskainen 1986	KM 13669:394
56	Pälkäne	(Luopioinen) Hietaniemi Hietasenkärki	Matiskainen 1986	KM 16822:638 +

	Municipality	Site	Source	Catalogue number
	SOUTH KARELIA			
57	Luumäki	Suo-Anttila Reijonkangas	Jussila 2005	KM 36697:249
58	Taipalsaari	Mielakansaari Simolinna	Koivikko 1999	KM 31387:1 +
	KYMENLAAKSO			
59	Kotka	(Kymi) Saksala Saukko	Matiskainen 1986	KM 17541
	PÄIJÄNNE TAVASTIA			
60	Hollola	Hahmajärvi 3	Lahelma 2002	KM 32676:4 +
61	Hollola	Kapatuosia	Poutiainen 2002	KM 31511:341 +
62	Hollola	Luhdanjoki 1	Poutiainen 2002	KM 31220:4
63	Hollola	Luhdanniitty 2	Lahelma 2002	KM 33186:11 +
64	Lahti	Ristola	NBA find catalogue	KM 31452:100 +
65	Orimattila	Mikkola	NBA find catalogue	KM 31240:5
66	Orimattila	Puujoki 3	Poutiainen 2002	KM 32121:13
	TAVASTIA PROPER			
67	Hattula	Torttolanmäki 3	NBA find catalogue	KM 27723: 302 +
68	Hausjärvi	(Haminankylä) Teuronjoensuu S	Matiskainen & Ruohonen 2004	KM 33460:1-7
69	Hausjärvi	(Haminankylä) Teuronjoki	Matiskainen & Ruohonen 2004	KM 32983:117 +
70	Humppila	Järvensuo 3-4	Pesonen, P. *pers. comm.*	KM 35668:4
71	Humppila	Kuusisto	Pesonen, P. *pers. comm.*	KM 35675:2
72	Janakkala	Taurula	MJREK 2008	KM 24745:1-2705
73	Loppi	Antinnokka 1	Pesonen, P. *pers. comm.*	KM 33017:144 +
74	Loppi	Karhumäki	Matiskainen & Ruohonen 2004	KM 33461:16 +
75	Loppi	Lehtimäki	Pesonen, P. *pers. comm.*	KM 33018:48
76	Loppi	Lopenkylä (kirkonkylä) Saukonnokka	Matiskainen & Ruohonen 2004	KM 33462:131
77	Loppi	Salo Pirttiniemi	Matiskainen & Ruohonen 2004	KM 22642:1
78	Loppi	Terväntö	Matiskainen & Ruohonen 2004	KM 32623:5
79	Riihimäki	Arolammi Sinivuokkoniemi	Matiskainen 2002	KM 33457:79 +
80	Riihimäki	Silmäkenevan saari 3	Matiskainen & Ruohonen 2004, MJREK 2008	KM 34031:1-384
	FINLAND PROPER			
81	Salo	(Kisko, Sillanpää) Kuoppanummi	Sinisalo 2004	KM 33881:8
82	Salo	(Muurla) Hossannummi	Sinisalo 2004	KM 29575:20
83	Salo	(Suomusjärvi) Viitamäki	Sinisalo 2004	KM 33579:133
84	Salo	Mustionsuo NE	NBA find catalogue	KM 31082:143
85	Salo	Vuohikallio	NBA find catalogue	KM 29734:218
86	Salo	(Kisko, Kurkela) Siltapyöli	Sinisalo 2004	KM -
	UUSIMAA			
87	Askola	(Korttia) Lepistö	Matiskainen 1986	KM 12789:37
88	Askola	(Monni) Pöökäri Kotopelto (Monninkylä Kotopelto Pääkäri)	Matiskainen 1986	KM 18568:1
89	Askola	(Nalkkila) Kopinkallio	Luho 1957, Matiskainen 1986	KM 12661:350
90	Askola	(Nalkkila) Rokin Valkamaa	Luho 1967, Matiskainen 1986	KM 12260:17 +
91	Askola	(Nalkkila) Rokki Rantapelto	Matiskainen 1986	KM 18599:3
92	Askola	(Nalkkila) Takalan Ruoksmaa/Taka-Piskulan Ruoksmaa	Matiskainen 1986	KM 13067:278 +
93	Askola	(Nietoo Mattila) Tallikäärö	Luho 1957, Matiskainen 1986	KM 12506:11 +
94	Askola	(Vakkola Latoniitty) Silta-aro	Matiskainen 1986	KM 12431:1 +
95	Askola	(Vakkola) Latoniitty Jungfern	Matiskainen 1986	KM 12273:6
96	Askola	Etulinna Ruoksmaa A + B	Luho 1957, Matiskainen 1986	KM 12929:136 +
97	Askola	Juslan Suursuo	Luho 1967, Matiskainen 1986	KM 12605:22 +
98	Askola	Metsola (Pappila Perunamaa)	Matiskainen 1986	KM 12947:5
99	Askola	Pappila (Siltapellonhaka)	Matiskainen 1986	KM 12613:6
100	Askola	Pappila Perunamaa-Saunapelto	Matiskainen 1986	KM 12603:6 +
101	Askola	Pappila Siltapellonhaka II	Matiskainen 1986	KM 12601:25 +
102	Askola	Puharonkimaa Järvensuo	Matiskainen 1986	KM 12159:80 +
103	Askola	Vakkola Siltapellonhaka 1 (Siltapelto Siltapellonhaka)	Matiskainen 1986	KM 12600:6 +
104	Askola	Vakkola Tyyskä	Matiskainen 1986	KM 13138:6
105	Espoo	Bergdal	NBA find catalogue	KM 30601:91
106	Espoo	Fjälldal	NBA find catalogue	KM 29413:1
107	Espoo	Oittaa Kakola	Fast 1995	KM 29411
108	Espoo	Sperrings Hiekkakuoppa NE	Fast 1996	KM 29902:3 +
109	Hyvinkää	Joentaka	Matiskainen & Ruohonen 2004	KM 33456:402 +
110	Hyvinkää	Rantala 1	MJREK 2008	KM 32636:1
111	Kirkkonummi	Kvarntorpsåkern	Luho 1948	KM 5944:22
112	Lapinjärvi	Antasbacken	Matiskainen 1986	KM 9851:27
113	Lapinjärvi	Backmansbacken	Matiskainen 1986	KM 9106:7
114	Lapinjärvi	Gammelby	Matiskainen 1986	KM 9759:58 +
115	Lohja	Harvakkalanlahti	Leskinen 2003	KM 34278:139
116	Lohja	Hossanmäki	Pesonen & Tallavaara 2006	KM 34856:314 +
117	Nurmijärvi	Alitalo	Matiskainen 1986	KM 19787:10
118	Pornainen	Niemelä	Pesonen, P. *pers. comm.*	KM 30518:6
119	Porvoo	Henttala	Matiskainen 1986	KM 11617:83
120	Raasepori	Finnmalmen	Pesonen, P. *pers. comm.*	KM 28741:32
121	Siuntio	Suitia 1	Matiskainen 1986	KM 20873:3 +
122	Vantaa	(Kaivoksela) Gröndal 2	Matiskainen 1986	KM 18959:75
123	Vantaa	Erikas	Matiskainen 1986	KM 19430:25
124	Vantaa	Gårds	Leskinen & Pesonen 2008	KM 31081:312 +
125	Vantaa	Hommas	Koivisto 2010b	KM 37383:675 +
126	Vantaa	Jönsas	Purhonen & Ruonavaara 1994	KM 19274:349 +
127	Vantaa	Asola/Koivukylä 5	Matiskainen 1986	KM 20164:212 +
128	Vantaa	Myyrmäen Urheilupuisto (Raappavuoren urheilukenttä)	Matiskainen 1986	KM 19423:14 +

NBA = National board of antiquities

+ Indicates more than one catalogue numbers with points at the site

Appendix III. Point data

Table key:

MUN: Municipality
NBA Cat.: National Board of Antiquities catalogue number
G: Point group in the study: sth=southern group, nth=northern group
OR: Point orientation; perp=perpendicular, paral=parallel, other=other, undef=undefined
L: Point length (mm)
BAw: Basal width of the point (mm)
MXw: Maximum width of the point (mm)
BAt: Basal thickness of the point (mm)
MIDt: Midpoint thickness of the point (mm)
MXt: Maximum thickness of the point (mm)
WE: Point weight (g)
RAW: Raw material; c=chert, q=qartz, qe=quartzite, rc=rock crystal, rq=rose quartz, s=slate
INT: Intactness of the point; yes=intact, yesx= almost intact (1.5mm added to length); no=broken
THI: Occurrence of thinning; y=yes, n=no, p=possible thinning
Trat: Midpoint thickness to base thickness ratio of the point
EDa: Edge angle (°) of the point
RELt: Relative thickness (thickness/length) of the point
Wrat: Maximum width to basal width ratio of the point
Rdir: Direction of backing retouch: Li=Left inverse, Ld=Left direct, Lb=Left both directions, Ln=Left no retouch, Ri= Right inverse, Ld= Right direct, Rb= Right both directions, Rn=Right no retouch
Omod: Other modifications: LA=Left margin abraded, RA=Right margin abraded, LRA=Both margins abraded, BA=Abraded base, SB= Snapped base, Sib= Semi-invasive backing

MUN	SITE	NBA Cat.	G	OR	L	BAw	MXw	BAt	MIDt	MXt	WE	RAW	INT	THI	Trat	EDa	RELt	Wrat	Rdir	Omod
ALAJÄRVI	Rasi	11771:2	sth	perp	25.4	5.2	13.6	3.6	5.1	6.2	1.6	q	y	y	1.417	43	0.244	2.615	LiRi	LRA
	Rasi	11771:3	sth	perp	29.6	6.4	15.1	4.1	4.6	4.8	2.1	q	y	n	1.122	50	0.162	2.359	LbRb	LRA
	Rasi	11771:4	sth	perp	22.6	6	13.2	3.3	3.7	3.7	1.1	q	y	n	1.121	50	0.164	2.2	LdRd	
	Rasi	11771:6	sth	undef	26	6.8	15	6.6	4.3	6.6	1.9	q	y	y	0.652	52	0.254	2.206	LiRi	
	Rasi	11771:7	sth	perp	24.9	4.8	12.5	3.6	5.2	5.2	1.4	q	yx	n	1.444	53	0.209	2.604	LbRb	
	Rasi	11771:9	sth	undef	16	7.3	12.7	3.3	3.9	3.9	0.7	rc	y	y	1.182	63	0.244	1.74	LbRd	
	Rasi	11771:10	sth	perp	15	6.1	10.1	2.5	3.9	3.9	0.6	rc	y	y	1.56	66	0.26	1.656	LnRi	LA
	Rasi	11771:11	sth	perp	21.9	6.5	14.8	4.4	4.8	4.8	1.5	q	yx	n	1.091	50	0.219	2.277	LdRd	
	Rasi	11771:15	sth	perp	25.4	8.1	11.9	5.1	3.6	5.1	1.6	rc	y	n	0.706	59	0.201	1.469	LiRb	
	Rasi	11771:16	sth	undef	22	5	11.8	5	4	5	1.3	q	y	n	0.8	49	0.227	2.36	LdRi	
	Rasi	11771:17	sth	perp	27	6.5	14.1	3.9	5.2	5.2	2.2	q	y	n	1.333	117	0.193	2.169	LdRd	
	Rasi	11771:18	sth	perp	20.9	6.4	11.7	3.2	4.1	4.1	1	q	y	n	1.281	49	0.196	1.828	LbRb	
	Rasi	11771:25	sth	perp	20	8	13.6	3.7	4.5	4.5	1.3	q	n	n	1.216	36	0.225	1.7	LiRi	
	Rasi	11771:32	sth	perp	14.9	6.3	8.1	2.8	3.5	3.5	0.5	q	y	n	1.25	60	0.235	1.286	LdRi	
	Rasi	11895:2	sth	perp	22.6	6.7	10.9	2.5	3.2	3.2	0.8	q	yx	n	1.28	56	0.142	1.627	LbRi	
	Rasi	11895:26	sth	perp	30.6	7.5	12.7	4.8	4.7	4.8	1.9	q	yx	y	0.979	36	0.157	1.693	LdRb	
	Rasi	11895:51	sth	perp	14.9	5.8	12.7	1.7	2.5	2.8	0.6	q	y	n	1.471	90	0.188	2.19	LnRd	LA
	Rasi	11895:66	sth	paral	16.9	7.4	11.2	3.2	5.2	5.2	1.1	rc	y	n	1.625	66	0.308	1.514	LiRb	
	Rasi	11895:85	sth	undef	22.4	3.4	14.8	4.3	5	5.8	1.5	q	y	n	1.163	65	0.259	4.353	LdRn	RA
	Rasi	11895:91	sth	perp	21.3	4.4	10.9	2.9	3.3	3.6	1	q	y	y	1.138	35	0.169	2.477	LiRi	
	Rasi	11895:116	sth	perp	16.1	4	8.7	2.3	3.4	3.4	0.5	rc	y	n	1.478	74	0.211	2.175	LiRn	
ASKOLA	Etulinna Ruoksmaa A	12929:136	sth	perp	16	5.7	9.2	2.8	4	4	0.5	q	y	n	1.429	51	0.25	1.614	LiRb	
	Etulinna Ruoksmaa A	12929:187	sth	undef	17.4	3.6	9.5	1.8	3.9	3.9	0.6	q	y	p	2.167	97	0.224	2.639	LiRi	BA
	Etulinna Ruoksmaa A	12929:293	sth	undef	11.5	6.4	8.8	3.7	4.1	4.1	0.5	q	y	n	1.108	90	0.357	1.375	LiRd	
	Etulinna Ruoksmaa B	12372:16	sth	undef	17.9	6.5	12.1	4.2	4.3	4.3	0.9	q	y	n	1.024	51	0.24	1.862	LiRn	
	Etulinna Ruoksmaa B	12372:17	sth	perp	16.8	7.1	12.4	2.9	4.1	4.1	0.8	q	y	n	1.414	88	0.244	1.746	LiRd	
	Pappila Perunamaa-saunap.	12603:90	sth	perp	22.5	5.3	9.5	3.1	3.8	3.8	0.8	q	y	n	1.226	30	0.169	1.792	LiRd	
	Pappila Perunamaa-saunap.	13068:146	sth	undef	20.6	3	9.6	1.7	1.9	1.9	0.5	s	n	n	1.118	-	0.092	3.2	LiRd	
	Pappila Perunamaa-saunap.	13068:242	sth	perp	20.9	5	10.5	3.2	4.6	4.6	1.2	q	y	n	1.438	52	0.22	2.1	LiRb	LA
	Puharonkimaa Järvensuo	12159:80	sth	perp	19.3	5.5	12.1	2.4	3.5	3.5	0.8	rq	y	y	1.458	42	0.181	2.2	LdRn	
	Puharonkimaa Järvensuo	12159:81	sth	undef	27.5	5.3	10.8	3.5	5	5	1.7	q	n	n	1.429	55	0.182	2.038	LbRb	
	Puharonkimaa Järvensuo	12788:19	sth	perp	21.5	3.8	9.8	2.4	3.5	3.5	0.7	q	y	n	1.458	41	0.163	2.579	LiRi	
	Puharonkimaa Järvensuo	12940:20	sth	paral	12.8	4.7	8.1	2.3	2	2.3	0.3	q	n	p	0.87	-	0.18	1.723	LiRi	
	Puharonkimaa Järvensuo	12940:20	sth	perp	16	5.3	9.5	2.4	3.8	3.8	0.6	q	y	n	1.583	63	0.237	1.792	LiRn	RA
	Rokin Valkamaa	12260:32	sth	undef	14.9	3.7	11.5	3.5	3.4	3.5	0.5	q	n	n	0.971	-	0.235	3.108	LbRd	
	Rokin Valkamaa	12260:195	sth	perp	12.6	6	9.7	2.7	3.4	3.4	0.5	q	n	n	1.259	-	0.27	1.617	LbRn	
	Rokin Valkamaa	12260:237	sth	undef	18.7	4.9	10.4	2.8	4.3	4.3	0.8	q	y	y	1.536	50	0.23	2.122	LbRd	
	Rokin Valkamaa	12346:17	sth	perp	16.1	6.7	10	1.5	4.1	4.1	0.7	q	y	n	2.733	80	0.255	1.493	LdRi	
	Silatpellonhaka	12601:68	sth	undef	25.5	4.5	12.9	2.8	3.5	3.5	1.1	rc	n	n	1.25	-	0.137	2.867	LiRi	
	Silta-aro	12431:3	sth	paral	25.6	8.2	15.3	5	4.2	4.2	1.8	q	y	p	0.84	46	0.164	1.866	LnRi	
	Siltapellonhaka 1	12600:25	sth	perp	15.7	2.3	9.8	2.7	3.9	3.9	0.6	q	y	n	1.444	73	0.248	4.261	LiRi	
	Siltapellonhaka 1	12600:79	sth	perp	14.8	4.4	7.8	1.5	2.8	2.8	0.4	q	y	n	1.867	76	0.189	1.773	LiRi	
	Siltapellonhaka 1	12600:81	sth	undef	21.7	5.9	11.4	4.3	4	4.3	1.1	q	y	n	0.93	39	0.198	1.932	LnRd	
	Siltapellonhaka 1	12600:95	sth	undef	18.6	3.3	8.6	2.1	3	3	0.4	q	yx	n	1.429	58	0.161	2.606	LiRi	
	Siltapellonhaka 1	12600:126	sth	perp	24.4	3.5	9.7	3.5	5.5	5.5	1.5	q	y	n	1.571	90	0.225	2.771	LiRi	
	Siltapellonhaka 1	12600:187	sth	undef	13.3	4.6	9.5	2.4	2.1	3	0.4	rc	y	y	0.875	70	0.226	2.065	LbRb	LRA
	Siltapellonhaka 1	12933:419	sth	undef	14.4	3.5	8.2	2.1	1.8	2.3	0.3	q	y	n	0.857	67	0.16	2.343	LnRi	
	Siltapellonhaka 1	12933:842	sth	perp	31.7	7	12.3	3.2	5.8	5.8	2.2	q	y	n	1.813	35	0.183	1.757	LnRi	
	Takalan Ruoksmaa	13067:278	sth	undef	18.8	6.6	11	4.1	5.3	5.3	1.2	q	y	y	1.293	55	0.282	1.667	LiRi	
	Takalan Ruoksmaa	13067:302	sth	perp	21.2	5.7	13.1	3.4	4.1	4.6	1.2	q	y	y	1.206	57	0.217	2.298	LbRd	
	Takalan Ruoksmaa	13067:326	sth	perp	15.6	4.2	6.4	3	3.8	3.8	0.5	q	n	n	1.267	86	0.244	1.524	LiRn	
	Takalan Ruoksmaa	13067:358	sth	perp	17.8	2.8	8.3	2.5	3.8	3.8	0.6	q	y	n	1.52	62	0.213	2.964	LiRb	
	Takalan Ruoksmaa	13067:387	sth	paral	15.1	6.2	9	2.9	1.9	2.9	0.4	q	n	p	0.655	64	0.192	1.452	LiRn	
	Takalan Ruoksmaa	13067:445	sth	perp	16.2	4.6	11.4	2.9	4.5	4.5	0.7	q	y	n	1.552	77	0.278	2.478	LiRi	
ENONTEKIÖ	Museotontti	23877:122	nth	perp	23.9	4.9	14.7	2.7	5	5	1.4	q	y	n	1.852	48	0.209	3	LbRi	
	Museotontti	23877:411	nth	undef	14.7	6.6	10.6	3.2	2.8	3.2	0.5	q	y	n	0.875	75	0.218	1.606	Indet	
	Museotontti	23877:455	nth	paral	11.9	5.3	9.2	2.9	2.1	2.9	0.3	q	y	y	0.724	94	0.244	1.736	LiRn	
	Museotontti	23877:491	nth	undef	19	5.6	9.2	2.7	3.5	3.5	0.7	q	yx	y	1.296	40	0.184	1.643	LbRb	
	Museotontti	23877:537	nth	perp	13.9	4.4	8.8	2.1	1.8	2.1	0.3	q	y	n	0.857	58	0.151	2	LdRd	SB
	Museotontti	24464:289	nth	perp	22.7	5.8	12.5	1.7	4	4	1.2	q	y	p	2.353	80	0.176	2.155	LiRi	
	Museotontti	24464:329	nth	perp	14.5	3.9	9	1.8	3.1	3.1	0.3	q	y	n	1.722	101	0.214	2.308	LiRn	
	Museotontti	24464:620	nth	perp	22.2	7	13.6	3.9	4.7	4.7	1.4	q	yx	y	1.205	58	0.212	1.943	LdRd	
ESPOO	Sperrings Hiekkakuoppa NE	29902:3	sth	undef	17.1	7	10.2	3.1	3.9	4.6	0.8	rc	y	y	1.258	38	0.269	1.457	Indet	

MUN	SITE	NBA Cat.	G	OR	L	BAw	MXw	BAt	MIDt	MXt	WE	RAW	INT	THI	Trat	EDa	RELt	Wrat	Rdir	Omod
HOLLOLA	Kapatuosia	31511:95	sth	other	17.1	3.1	12.2	2.7	3.3	3.3	0.6	rc	y	y	1.222	64	0.193	3.935	LiRn	
	Kapatuosia	31511:112	sth	perp	13.3	7.4	13	3.2	2.4	3.1	0.6	rc	y	n	0.75	62	0.233	1.757	LiRi	LA
	Kapatuosia	31511:142	sth	undef	15	8	12.4	3.5	3.1	3.5	0.6	q	yx	n	0.886	64	0.233	1.55	LiRi	
	Kapatuosia	31511:152	sth	undef	19.3	5.5	11.9	3.9	4	4	0.9	q	y	y	1.026	66	0.207	2.164	LdRb	
	Kapatuosia	31511:235	sth	perp	16.5	5.9	11.2	3.5	5.1	5.1	1.1	q	y	y	1.457	90	0.309	1.898	LiRi	
	Kapatuosia	31511:241	sth	undef	20.1	7.2	11	3.2	4.1	4.1	1	q	y	n	1.281	74	0.204	1.528	Indet	
	Kapatuosia	31511:360	sth	perp	20.4	7.5	12.2	2.3	4.1	4.1	1	q	yx	n	1.783	58	0.201	1.627	LdRn	RA
	Kapatuosia	31511:393	sth	perp	24.6	6.9	14.1	3.7	5.2	5.2	2.2	q	y	p	1.405	66	0.211	2.043	LiRb	
	Kapatuosia	31511:396	sth	perp	15.1	7.9	14.7	1.9	3.4	3.4	0.7	q	n	n	1.789	55	0.225	1.861	LiRd	
	Kapatuosia	31511:407	sth	perp	19	6.9	12.9	3.1	5.3	5.3	1.4	q	n	n	1.71	50	0.279	1.87	LbRn	
	Kapatuosia	31511:498	sth	perp	23.2	7.1	13.5	3.1	5.2	5.2	1.6	q	y	p	1.677	75	0.224	1.901	LbRb	
	Kapatuosia	31511:532	sth	perp	15.7	6.7	13.9	2.2	3.6	3.6	0.8	q	y	n	1.636	61	0.229	2.075	LdRi	SB
	Kapatuosia	31511:536	sth	undef	20.6	3.6	8.9	4	4.1	4.1	0.7	q	n	n	1.025	50	0.199	2.472	LiRn	
	Kapatuosia	31511:541	sth	perp	16.7	6.6	13.5	4.8	4.6	4.6	1.1	q	y	y	0.958	49	0.275	2.045	LdRb	
	Kapatuosia	31511:563	sth	perp	21.7	5.7	14	2.9	4.9	4.9	1.8	q	y	y	1.69	68	0.226	2.456	LdRb	
	Kapatuosia	31511:564	sth	perp	16	8.5	14.6	4.3	5.2	5.2	1.3	q	y	n	1.209	68	0.325	1.718	LbRi	SB
	Kapatuosia	31511:572	sth	perp	20.9	5.9	11.8	4.9	3.3	4.9	1	q	y	n	0.673	48	0.234	2	LiRi	
	Kapatuosia	31511:744	sth	perp	21.8	6.7	13.4	2	2.9	2.9	0.8	rc	y	y	1.45	111	0.133	2	LiRd	Sib
	Kapatuosia	31511:753	sth	perp	18.2	5	11.6	2.3	4.1	4.1	0.7	rc	y	n	1.783	42	0.225	2.32	LbRi	
	Kapatuosia	31511:756	sth	paral	24.8	6.2	13.9	2.2	3.6	3.6	1.3	q	y	y	1.636	51	0.145	2.242	LdRi	
	Kapatuosia	31511:763	sth	undef	20.3	8.3	11.5	4.5	4.1	4.1	1.2	q	y	n	0.911	64	0.202	1.386	LnRb	Sib
	Kapatuosia	31511:769	sth	undef	17.8	6.1	11	3.4	3.8	3.8	0.9	q	y	y	1.118	75	0.213	1.803	LdRd	SB
	Kapatuosia	31511:816	sth	perp	19.1	6	9.9	3.2	5.3	5.3	1.1	q	y	n	1.656	55	0.277	1.65	LiRb	
	Kapatuosia	31511:907	sth	perp	13.7	7.1	9	2.3	3.3	3.8	0.6	q	y	n	1.435	86	0.277	1.268	LiRi	
	Kapatuosia	31511:912	sth	perp	16.2	6.2	9.2	2.6	3.6	3.6	0.6	q	y	n	1.385	70	0.222	1.484	LdRd	SB
INARI	Ahkioniemi 1&2	23363:4	nth	paral	19.8	5	10.9	1.3	2.1	2.1	0.4	c	yx	y	1.615	116	0.106	2.18	LiRi	
	Kaunisniemi 2	26039:42	nth	paral	25.9	4.5	10.6	3.3	2.9	3.3	0.6	c	y	n	0.879	146	0.127	2.356	LiRi	
	Kaunisniemi 3	26040:2	nth	perp	14.1	4.2	7.7	2.7	4	4	0.3	c	y	n	1.481	63	0.284	1.833	LdRd	
	Kaunisniemi 3	26040:5	nth	other	17.1	4.9	14.4	1.3	4.3	4.3	1.1	rc	n	n	3.308	-	0.251	2.939	LiRi	
	Kaunisniemi 3	26040:35	nth	perp	16.6	6.8	10.1	1.6	3.5	3.5	0.6	qe	y	p	2.188	61	0.211	1.485	LiRn	
	Kaunisniemi 3	26040:53	nth	perp	12.3	3.4	7.8	2	2.6	2.6	0.3	rc	y	n	1.3	45	0.211	2.294	LdRi	
	Kirakkajoen voimala	26245:1	nth	undef	20.6	4.8	11.1	3.2	5.1	5.1	0.9	c	n	n	1.594	-	0.248	2.313	LiRi	
	Nellimjoen suu S	24375:454	nth	perp	14.7	3.7	8.8	1.5	3.1	3.1	0.4	c	y	n	2.067	101	0.211	2.378	LdRi	
	Satamasaari	26010:4	nth	undef	23.7	5.6	12.9	2.8	4.4	4.4	0.8	c	yx	n	1.571	46	0.186	2.304	LdRd	
	Supru	22685:13	nth	perp	24.4	4	9.7	4.8	4	4.8	1	q	yx	n	0.833	35	0.197	2.425	LdRi	SB, BA
	Vuopaja	28365:442	nth	perp	12.9	7.4	9.5	2.7	3.7	3.7	0.5	c	y	p	1.37	69	0.287	1.284	LiRi	
	Vuopaja	28365:446	nth	paral	21.8	3.5	14.2	2.2	2.4	2.6	0.6	c	y	n	1.091	86	0.119	4.057	LiRi	
	Vuopaja	28365:454	nth	perp	20.1	4.6	12.6	2.6	3.4	3.4	0.7	c	y	y	1.308	76	0.169	2.739	LiRi	
	Vuopaja	28365:660	nth	paral	22.5	3.6	10	2.3	3	3	0.6	c	y	n	1.304	59	0.133	2.778	LbRd	
	Vuopaja	28365:673	nth	perp	23.6	4.6	10.5	2.3	4.1	4.1	0.9	c	yx	n	1.783	48	0.174	2.283	LdRd	
	Vuopaja	28365:692	nth	paral	13.4	4.9	9.6	2.3	3.1	3.1	0.4	qe	n	n	1.348	-	0.231	1.959	LiRd	
	Vuopaja	28365:889	nth	other	21.7	6.4	13.2	1.6	3.3	3.3	0.6	c	y	n	2.063	37	0.152	2.063	LiRi	
KEMIJÄRVI	Lautasalmi	15846:78	sth	perp	15	3.8	8.7	1.6	3.7	3.7	0.5	c	y	n	2.313	78	0.247	2.289	LiRi	SB
	Neitilä 4	16145:1750	sth	perp	15.4	6.6	12.2	3.4	3.5	3.5	0.7	rc	y	n	1.029	60	0.227	1.848	LbRn	
KUORTANE	Lahdenkangas 1	16856:19	sth	perp	18.6	4.2	12.6	2.8	3.8	3.8	0.8	q	y	n	1.357	75	0.204	3	LdRn	
	Lahdenkangas 1	16856:24	sth	undef	14.6	6.7	13.4	3.3	3.6	3.6	0.8	q	y	n	1.091	72	0.247	2	LnRn	Sib
	Lahdenkangas 1	16856:38	sth	perp	17.7	4.1	12.7	4.2	5	5	1.1	q	y	p	1.19	51	0.282	3.098	LdRn	Sib
LOHJA	Hossanmäki	34856:52	sth	other	18.8	4.3	8.4	2.1	3.9	3.9	0.5	q	yx	n	1.857	-	0.207	1.953	LiRb	Sib
	Hossanmäki	34856:314	sth	undef	14.3	5.3	10.2	2.4	3.7	3.7	0.6	q	y	n	1.542	71	0.259	1.925	LbRn	Sib
	Hossanmäki	34856:335	sth	perp	21	7.5	13.9	2.8	4.3	4.3	1.4	q	y	y	1.536	74	0.205	1.853	LnRn	Sib
	Hossanmäki	34856:337	sth	perp	15.7	7.9	13.1	5.1	4.1	5.1	1	rc	y	y	0.804	67	0.325	1.658	LbRi	
	Hossanmäki	34856:366	sth	paral	15.6	11	12.9	4.3	4	4.3	1	q	y	n	0.93	84	0.276	1.173	LiRn	
	Hossanmäki	34856:402	sth	perp	15.2	3.7	7	2	2.6	2.6	0.4	q	n	n	1.3	-	0.171	1.892	LiRi	
	Hossanmäki	34856:460	sth	undef	15	5.3	12.1	2.6	4.4	4.4	0.7	rc	n	n	1.692	-	0.293	2.283	LiRi	
	Hossanmäki	34856:490	sth	perp	13.1	4.1	8.8	2.1	3.1	3.1	0.3	q	y	n	1.476	41	0.237	2.146	LiRi	LRA
LOPPI	Antinnokka 1	33017:144	sth	undef	17.8	5.2	10.4	2.2	4.3	4.3	0.7	q	y	n	1.955	50	0.242	2	LdRi	
	Antinnokka 1	33017:548	sth	perp	18.7	8.1	13	2.3	3.2	3.2	0.9	q	y	n	1.391	72	0.171	1.605	LiRi	
	Karhumäki	33461:16	sth	perp	17	5.9	10.3	2.4	3.2	3.2	0.7	q	y	y	1.333	69	0.188	1.746	LiRi	
	Karhumäki	33461:18	sth	perp	11.8	3.2	6.6	2	3	3	0.3	q	y	p	1.5	88	0.254	2.063	LiRi	
	Karhumäki	33461:145	sth	perp	20.9	6.7	12.1	3.9	4	4	0.8	q	yx	p	1.026	45	0.191	1.806	LiRd	
	Karhumäki	33461:155	sth	undef	13.7	5.7	9.9	1.6	2.6	2.6	0.5	q	y	n	1.625	65	0.19	1.737	LiRd	
	Karhumäki	33461:158	sth	perp	16	5	10	3	2.8	3	0.5	q	y	n	0.933	74	0.188	2	LdRb	
	Karhumäki	33461:160	sth	perp	28.4	7.8	14.3	3.2	6.7	6.7	2.9	q	y	n	2.094	101	0.236	1.833	LnRi	LA
	Karhumäki	33461:161	sth	perp	11.7	7.3	11.5	1.3	3.1	3.1	0.5	q	y	n	2.385	73	0.265	1.575	LdRi	Sib
	Karhumäki	33461:164	sth	undef	18	6.1	11.6	3.2	3.5	3.5	0.8	q	y	y	1.094	69	0.194	1.902	LiRn	
	Karhumäki	33461:165	sth	perp	14.2	6.7	10.7	2.8	4	4	0.7	q	y	n	1.429	86	0.282	1.597	LiRi	
	Karhumäki	33461:169	sth	undef	17.5	7.2	12	3.4	3.7	3.7	0.8	q	y	p	1.088	64	0.211	1.667	LnRd	
	Karhumäki	33461:193	sth	perp	13.4	5.4	8.9	1.5	2.5	2.5	0.3	rc	y	n	1.667	62	0.187	1.648	LiRd	
	Karhumäki	33461:200	sth	perp	26.8	6.8	13.4	3.5	4.7	4.7	1.7	q	yx	n	1.343	61	0.175	1.971	LdRb	
	Karhumäki	33461:208	sth	undef	13.3	5.1	9.3	2.5	3.5	3.5	0.4	q	y	n	1.4	68	0.263	1.824	LbRi	
	Karhumäki	33461:209	sth	perp	11.3	6.1	10	2.1	2.9	2.9	0.3	q	y	y	1.381	86	0.257	1.639	LiRb	Sib
	Lehtimäki	33018:48	sth	perp	23.2	9	13.4	2.4	5.1	5.1	1.4	q	y	p	2.125	35	0.22	1.489	LiRn	RA
PELLO	Kaaraneskoski	30721:322	sth	undef	14.8	3.9	8.4	3.1	3.3	3.3	0.6	s	y	n	1.065	54	0.223	2.154	LiRi	
	Kaaraneskoski	31377:98	sth	undef	7.5	4.8	7.8	2.1	-	-	0.1	q	n	n	-	-	-	1.625	LiRi	
	Kaaraneskoski	31377:146	sth	undef	18.1	2.5	11.7	3.6	3.1	3.6	0.7	rc	n	n	0.861	35	0.199	4.68	LnRd	
SIUNTIO	Suitia 1	20873:3	sth	perp	13.8	7.5	11	1.9	3.4	3.4	0.6	rc	n	n	1.789	-	0.246	1.467	LiRd	
	Suitia 1	20873:110	sth	perp	14.9	8.3	10.8	3.3	4	4	0.6	rc	y	y	1.212	61	0.268	1.301	LnRi	
	Suitia 1	20873:116	sth	undef	20.3	8.7	11.5	3.2	3.4	3.4	1	q	y	n	1.063	69	0.167	1.322	LiRn	
	Suitia 1	20873:122	sth	perp	19.1	6.8	13.9	3.6	4.6	4.6	1.1	q	y	n	1.278	69	0.241	2.044	LiRb	
	Suitia 1	20873:127	sth	perp	21.5	6.2	11.7	2.7	3.7	3.7	0.8	q	y	n	1.37	68	0.172	1.887	LiRn	
	Suitia 1	20873:205	sth	undef	18	5.7	12.3	4	3.4	4	0.9	q	y	y	0.85	60	0.222	2.158	LiRn	
	Suitia 1	20873:207	sth	undef	16.7	5.6	11.2	2.8	3.7	3.7	0.7	q	y	n	1.321	51	0.222	2	LnRi	
	Suitia 1	20873:267	sth	undef	13.6	5.4	9	2.1	3	3	0.4	q	n	n	1.429	-	0.221	1.667	LdRn	
UTSJOKI	Mávdnaávži 2	34675:5+:21	nth	perp	23.9	6.3	10.8	1.6	2.6	2.6	0.6	c	yx	n	1.625	53	0.109	1.714	LiRb	
	Mávdnaávži 2	34675:7	nth	other	21.8	3	13.9	3	2.6	3.3	0.8	c	n	n	0.867	59	0.151	4.633	LiRi	
	Mávdnaávži 2	34675:13+:214	nth	perp	24.4	5.5	12.9	1.5	1.8	1.8	0.5	c	yx	n	1.2	-	0.074	2.345	Indet	
	Mávdnaávži 2	34675:147	nth	paral	22.3	4.2	9	1.8	2.6	2.6	0.6	c	y	n	1.444	49	0.117	2.143	LiRb	
	Mávdnaávži 2	34675:164	nth	paral	23	4.2	9.5	2.6	2.6	2.6	0.6	c	n	n	1	-	0.113	2.262	LdRd	
	Mávdnaávži 2	34675:199	nth	undef	17.3	5.5	8.6	2.6	4.1	4.1	0.8	c	y	y	1.577	71	0.237	1.564	LiRi	
	Mávdnaávži 2	34675:222+:104	nth	paral	28.3	7.1	12.7	3.3	3.5	3.5	1.1	c	yx	n	1.061	123	0.124	1.789	LdRn	
	Mávdnaávži 2	34675:223+:234	nth	undef	22.5	7.4	11.5	1.8	1.7	1.8	0.4	c	yx	n	0.944	53	0.08	1.554	LiRb	
	Mávdnaávži 2	34675:225	nth	paral	21.7	4.6	12.1	2.9	3.8	3.8	0.7	c	y	p	1.31	120	0.175	2.63	LiRd	
	Mávdnaávži 2	34675:261	nth	paral	15.9	6.3	9.2	3	2.6	3	0.4	c	n	n	0.867	-	0.189	1.46	LiRi	
	Mávdnaávži 2	34675:317	nth	perp	18.5	4.7	9	2	2.8	2.8	0.5	c	yx	n	1.4	40	0.151	1.915	LiRi	
	Mávdnaávži 2	34675:335	nth	paral	15.8	4.1	11.6	2.8	2.6	2.8	0.4	c	y	y	0.929	58	0.177	2.829	LiRi	

Appendix IV. Radiocarbon dated contexts with oblique points in Finland

Riihimäki Arolammi 7D Sinivuokkoniemi

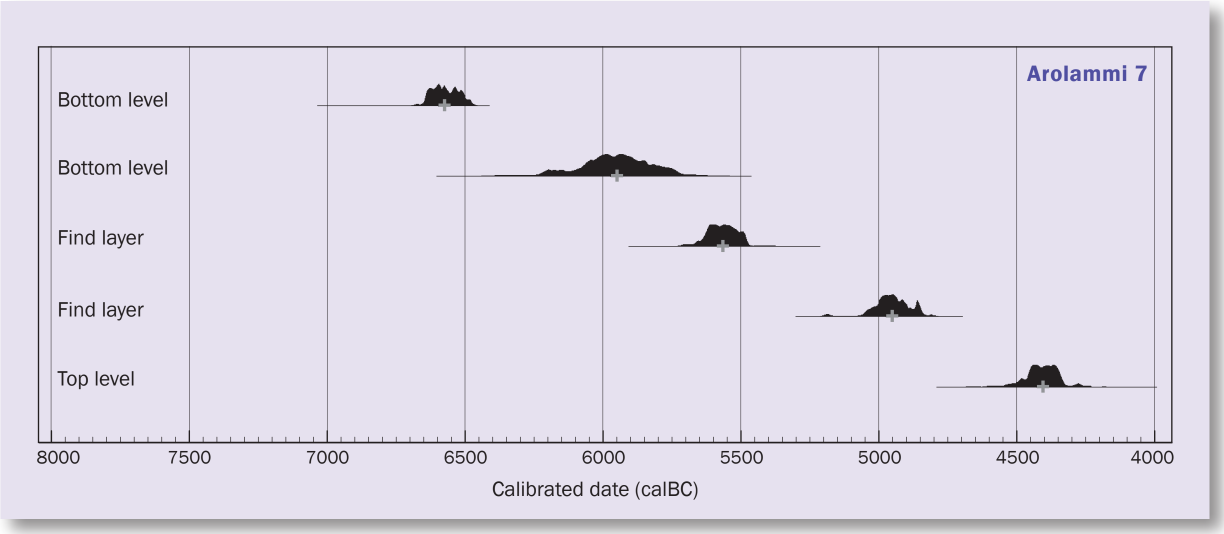
Location (ETRS89): 60° 41' 22.103" N, 24° 46' 53.906" E

General: The Arolammi 7 wetland site has yielded several Late Mesolithic (including pottery-Mesolithic) radiocarbon dates and finds. Excavations have been conducted in different parts of the site. Area 7D has yielded a stratigraphically sealed layer of organic material, Late Mesolithic radiocarbon dates, and lithic artefact types. In total, 45 square metres have been excavated. The lithic artefacts (134 in total) from area 7D include three oblique points (e.g., KM 33457:79). (Matiskainen 2002; Matiskainen & Ruohonen 2004.)

Dated context: Two dates (GIN-11037 & GIN-11042) from area 7D come from the sealed find layer containing the oblique points. These dates are supplemented by three more radiocarbon dates: GIN-11746 and GIN-11039, both of which originate from the bottom level below the find layer, and GIN-11042, which comes from the top level above the find layer. All of the samples except for GIN-11746 come from the same trench with an area of 5 square metres. (Matiskainen 2002.) The dates indicate that oblique points were used at the site sometime around *c.* 5700–4800 calBC.

Lab. number, sample type, and un-calibrated and calibrated (2σ) dates:

1. GIN-11746, charcoal, 7750±40 BP, **6650–6490 calBC**
2. GIN-11039, charcoal, 7080±120 BP, **6210–5730 calBC**
3. GIN-11037, charcoal, 6050±40 BP, **5060–4840 calBC**
4. GIN-11042, charcoal, 6630±70 BP, **5670–5470 calBC**
5. GIN-11038, charcoal, 5560±60 BP, **4530–4270 calBC**



Calibrated in OxCal 4.1.7 (Bronk Ramsey 2010) using the IntCal 09 calibration curve (atmospheric data from Reimer *et al.* (2009)).

Vantaa Hommas

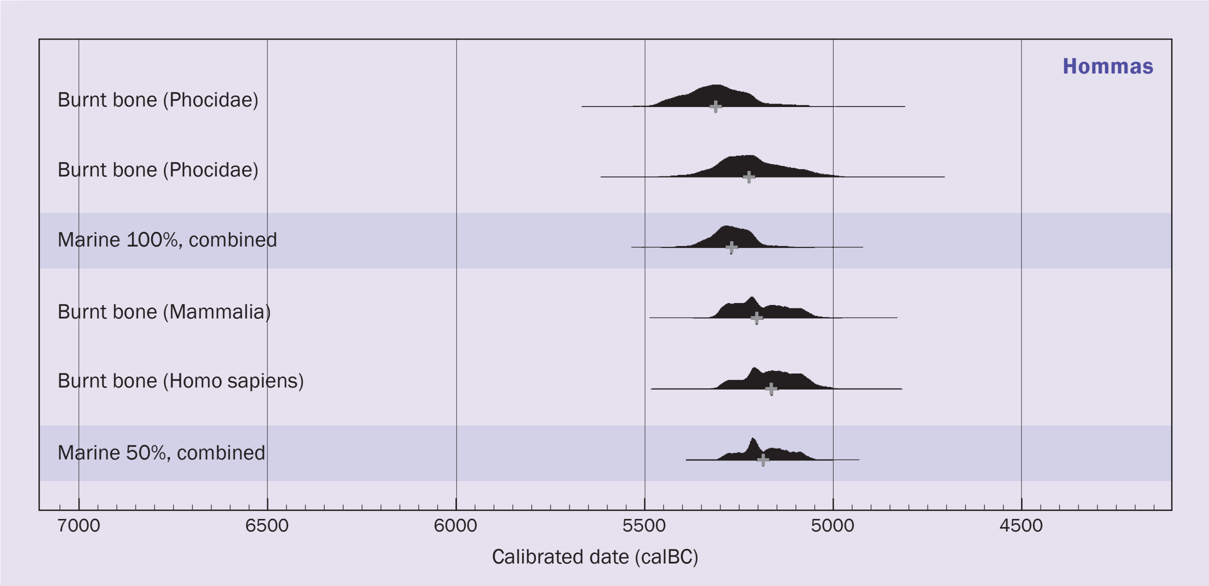
Location (ETRS89): 60° 18' 48.074" N, 24° 53' 21.629" E

General: The site was used in at least two different time periods: a Neolithic occupation mainly located in a lower elevation and a Mesolithic occupation located in a sheltered terrace at *c.* 35 m.a.s.l. Two excavation areas that are roughly 120 square metres in total were excavated in the Mesolithic occupation area. The larger of the two excavated areas (Area 1) yielded a relatively homogenous scatter of quartz artefacts, 19 ground adzes or fragments thereof, and three concentrations of burnt bone. The quartz artefacts include six oblique points and three possible oblique points (KM36869:122; KM 37383:396, :675, :958, :2685, :2884, 2902, :2947, :3103). Four Late Mesolithic radiocarbon dates were obtained from burnt bone in Area 1. A fifth sample from a test pit in the same terrace yielded a Neolithic date, but according to the artefactual evidence, Area 1 was mainly used in the Late Mesolithic and there appears to be only minor later disturbance. The dated samples originate from a 7x7 metres area that included three bone concentrations, a stone hearth, and five oblique points. The dates are in good agreement with the shore displacement date of the site. (Koivisto 2010a, b.)

Dated context: The radiocarbon dates are spread over a *c.* 5 metres long area parallel to the edge of the terrace and can be considered to date the Mesolithic occupation, including the oblique points. Two samples (Hela-2051 and Hela-2054) originate from the same concentration of burnt bone and although only one of the bones has been identified to the species (*Homo sapiens*), the proximity of the samples (*c.* 25 cm apart) and the similarity of the dating results suggest that both samples come from the same individual. Samples Hela-2052 and Hela-2053 originate some five metres north and north-east of the two other samples.

Lab. number, sample type, and un-calibrated and calibrated (2σ) dates:

1. Hela-2052, burnt bone (Phocidae), 6647±41 BP, **5460–5120 calBC**
2. Hela-2053, burnt bone (Phocidae), 6563±41 BP, **5380–5010 calBC**
3. Hela-2051, burnt bone (Mammalia), 6382±41 BP, **5300–5070 calBC**
4. Hela-2054, burnt bone (*Homo sapiens*), 6359±39 BP, **5280–5060 calBC**



Calibrated in OxCal 4.1.7 (Bronk Ramsey 2010). Hela-2052 and Hela-2053 calibrated using Marine09 calibration curve (Reimer *et al.* 2009) with Delta_R LocalMarine -80 (Olsson 1980; Stuiver *et al.* 1986–2010). Hela-2051 and Hela-2054 calibrated using a combination of corrected Marine09 (Delta_R LocalMarine -80) and IntCal 09 curves, with estimated 50% terrestrial and 50% marine diet. Atmospheric and marine data from Reimer *et al.* (2009).

Kuortane Lahdenkangas 1

Location (ETRS89): 62° 42' 34.03" N, 23° 32' 14.39" E

General: The estimated size of the site is 75x10 metres, of which 24 square metres have been excavated. The excavation was conducted and finds were collected in two square metre units. The area included a concentration of burnt bone (*c.* 650 g) extending in four excavation squares. Within these squares also five quartz artefacts reported as oblique points were encountered. No later prehistoric disturbance has been observed on the site. (Luho 1967:84–87.) A fragment of elk bone (KM 16856:23, Mannermaa 2010) from excavation square I:5 within the bone concentration was selected for radiocarbon dating. Three (KM 16856:19, :24, :38) of the five reported points were accepted as oblique points in the analysis conducted in this study.

Dated context: Burnt bone concentration (square I:5). One oblique point made of quartz (KM 16856:19) was found in the same excavation square. Two more points were found in adjacent squares.

Lab. number, sample type, and un-calibrated and calibrated (2σ) date:

1. Ua-40898, burnt bone (*Alces alces*), 7284±42 BP,
6230–6060 calBC

Calibrated in OxCal 4.1.7 (Bronk Ramsey 2010) using the IntCal 09 calibration curve (atmospheric data from Reimer *et al.* (2009)).

Alajärvi Rasi

Location (ETRS89): 62° 59' 38.96" N, 23° 42' 58.791" E

General: The site is part of larger site complex (Heikinkangas ja Rasinmäki/Rasi). Some 217 square metres have been excavated at the Rasi site to date. The excavation was conducted and finds collected in one square metre units. In total, 22 hearths and a pit filled with burnt bones were documented in the excavation. The finds consist of burnt bone and slate and quartz artefacts, including 39 artefacts that were reported as intact or broken points with oblique or transverse cutting edges. No clear later prehistoric disturbance in the find layer was observed during excavation. (Luho 1948; 1967:89–93.) Of the reported points, 25 were included in the analysis conducted for the purpose of this paper, and of these points, 21 were considered to be oblique points. A fragment of burnt bone (KM 11771:134) from a large terrestrial mammal (Mannermaa 2010; *pers. comm.*) was selected for dating. The sample derives from excavation square VI:16 and is part of a concentration of burnt bone covering approximately four square metres. Square VI:16 also yielded two oblique points (KM 11771:6 and :25).

Dated context: Burnt bone concentration in square VI:16.

Lab. number, sample type, and un-calibrated and calibrated (2σ) date:

1. Ua-40894, burnt bone (Mammalia), 6981±92 BP,
6030–5680 calBC

Calibrated in OxCal 4.1.7 (Bronk Ramsey 2010) using the IntCal 09 calibration curve (atmospheric data from Reimer *et al.* (2009)).

Utsjoki Jomppalanjärvi W

Location (ETRS89): 69° 46' 16.661" N, 26° 59' 55.234" E

General: Stretching *c*. 150 metres on sandy soil, this site has yielded lithic artefacts (i.e., grey chert and quartz artefacts) and burnt bones. Among the finds are an oblique point of burnt chert (KM 38078:2) and a potential oblique point made of quartz. However, the quartz point is excluded from this study because of insufficient modification. To date, no later prehistoric disturbance has been observed on the site. (Manninen & Knutsson *this volume*; Rankama & Kankaanpää 1997; T. Rankama *pers. comm*. 2010.) The burnt chert point and 16 fragments of burnt bone (KM 38078:1) were collected in an exposed patch of burnt sand during an inspection of the site in 2009 (T. Rankama *pers. comm*. 2010). The bone fragments (undetermined species, Mannermaa 2010) were dated for the purpose of this study.

Dated context: Exposed patch of burnt sand (probable hearth) with burnt bone and a burnt oblique point.

Lab. number, sample type, and un-calibrated and calibrated (2σ) date:

1. Ua-40899, burnt bone (Mammalia), 7265±40 BP,
6220–6050 calBC

Calibrated in OxCal 4.1.7 (Bronk Ramsey 2010) using the IntCal 09 calibration curve (atmospheric data from Reimer *et al*. (2009)).

Utsjoki Mávdnaávži 2

Location (ETRS89): 69° 42' 3.825" N, 26° 11' 43.692" E

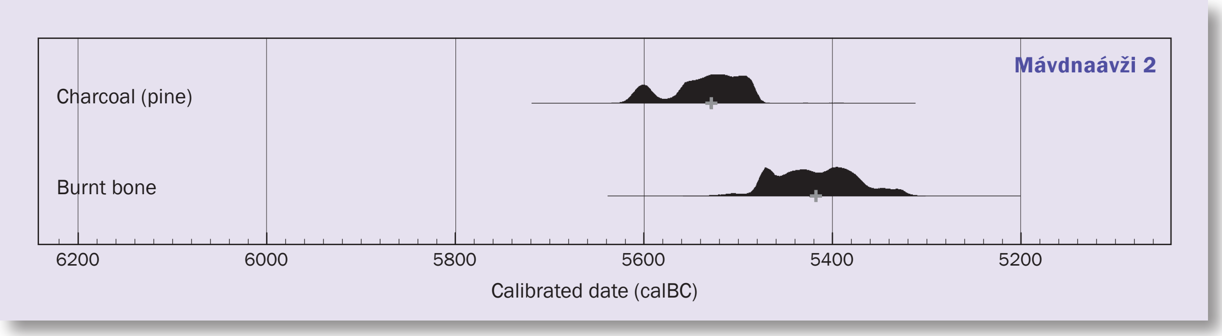
General: The site consists of a small round hut foundation with a *c*. 3 metres diameter and an outside activity area. In total, 52 square metres have been excavated to date. Within the area of the hut foundation, a central hearth surrounded by well-defined lithic concentrations was found. In the hearth and in the concentrations around it, 12 intact and broken oblique points made of grey chert were found (KM 34675:7, :147, :164, :199, :225, :261, :317, :335, :13+:214, :222+:104, :223+:234, :5+:21) along with debitage related to oblique point manufacture. (Manninen 2009; Manninen & Knutsson *this volume, in preparation*.)

A small pit filled with sooty soil, burnt bone, and charcoal was located within the hearth inside the hut foundation. All of the identified bone fragments were reindeer (*Rangifer tarandus*), and the charcoal was pine (*Pinus sylvestris*) (Lahti 2004; T. Timonen *pers. comm*. 2004). Two samples have been dated from the pit. An earlier date on burnt bone (KM 34675:497) from excavation spit 2 (x 111,125/y 504,875) was supplemented in this study with a sample of pine charcoal from spit 3 (x 111,4/y 505,3).

Dated context: A pit filled with sooty soil, burnt bone, charcoal, and burnt lithic artefacts, including oblique points. The difference in age between the samples most likely reflects the own age of the pine sample.

Lab. number, sample type, and un-calibrated and calibrated (2σ) dates:

1. Hela-963, burnt bone, 6455±50 BP, **5490–5320 calBC.**
2. Ua-40900, charcoal (*Pinus sylvestris*), 6580±38 BP,
5620–5480 calBC.



Calibrated in OxCal 4.1.7 (Bronk Ramsey 2010) using the IntCal 09 calibration curve (atmospheric data from Reimer *et al*. (2009)).

Inari Vuopaja

Location (ETRS89): 68° 54' 39.25" N, 27° 0' 56.304" E

General: The site has multiple occupations ranging from the Mesolithic to the Iron Age. Seven oblique points have been found in the 394 square metres that have been excavated. Four of the points (KM 28365:442, :446, :454, :660) derive from excavation squares x129–134/y977–980. The total number of lithics in this area is relatively small, as only 72 artefacts made of quartz, 4 made of quartzite, and 8 made of chert have been found. The chert and quartzite are non-local, and 8 of the 12 artefacts made of these two raw materials originate from an area comprising 3 by 3 metres that also included a small concentration of burnt bone and part of a larger concentration of burnt bone (Manninen & Knutsson *this volume*, *in preparation*; Seppälä 1993; 1994). Fifteen reindeer (*Rangifer tarandus*) bone fragments and one fragment of elk (*Alces alces*) bone have been identified from the 3x3 metre area (Ukkonen 1994; 1995). As the identified elk bone fragments in the 44 square metres excavation area are otherwise found more to the south of the oblique points, a fragment of burnt reindeer bone (KM 28365:448) from square x133/x978 was dated in this study. The finds from this square include 63 fragments of burnt bone (5 reindeer), 1 chert point, and a chert flake. The adjacent squares have yielded 2 more chert points, 2 chert flakes, and a quartzite scraper.

Dated context: Burnt bone concentration in square x133/y978. Sample Ua-40897 from excavation spit 1. Three oblique points made of grey chert have been found within and around the bone concentration.

Lab. number, sample type, and un-calibrated and calibrated (2σ) date:

1. Ua-40897, burnt bone (*Rangifer tarandus),* 6526±39 BP,
5610–5380 calBC.

Calibrated in OxCal 4.1.7 (Bronk Ramsey 2010) using the IntCal 09 calibration curve (atmospheric data from Reimer *et al*. (2009)).

Inari Kaunisniemi 3

Location (ETRS89): 68° 43' 33.133" N, 27° 14' 44.108" E

General: The site and the adjacent site Kaunisniemi 2 constitute a large multi-period occupation area that has yielded finds from several time periods. Among the finds from Kaunisniemi 3 are four oblique points (KM 26040:2, :5, :35, :53). The site has not been excavated and is currently submerged. Finds were surface collected from several smaller concentrations exposed by water level regulation. Area 2W was *c.* 20x15 meters in size and yielded burnt bone and lithic artefacts of several raw materials, as well as some Iron Age artefacts. (Arponen 1991; Manninen & Knutsson *this volume.*) The only chronologically diagnostic lithic artefacts from this area were oblique points. Therefore, this area was considered the most suitable for radiocarbon dating. The burnt reindeer bone fragment KM 26040:47 (Mannermaa 2010) that was dated, derives from a hearth within a concentration of lithic artefacts, including an oblique point made of green non-local quartzite (KM 26040:35) and flakes of the same raw material (KM 26040:44).

Dated context: A hearth containing burnt bone and surrounded by lithic artefacts in area 2W.

Lab. number, sample type, and un-calibrated and calibrated (2σ) date:

1. Ua-40896, burnt bone (*Rangifer tarandus*), 8004±46 BP,
7060–6710 calBC.

Calibrated in OxCal 4.1.7 (Bronk Ramsey 2010) using the IntCal 09 calibration curve (atmospheric data from Reimer et *al.* (2009)).

Enontekiö Museotontti

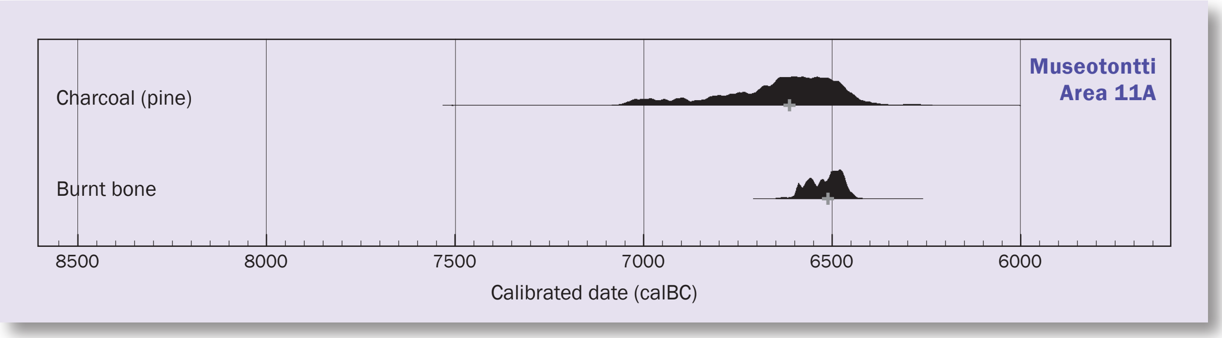
Location (ETRS89): 68° 23' 44.104" N, 23° 41' 53.234" E

General: The site has multiple occupations ranging from the Mesolithic to the Iron Age. A total of 692 square meters have been excavated. Eight oblique points have been identified within the site assemblage. Five of these points (KM 23877:122, :411, :455, :491, :537) originate from find concentrations that have yielded dates of *c*. 6500 calBC. (Halinen 2005; Manninen & Knutsson *this volume.*) The area 11A (Halinen 2005) that included, besides a concentration of lithic artefacts including three oblique points, a pit containing charcoal and burnt bone, can be considered the most suitable for dating the oblique points at the site. Therefore, a sample (2 fragments, KM 23877:492) of burnt reindeer bone (Mannermaa 2010) from the pit was dated in this study to supplement an earlier date on charcoal (undefined species).

Dated context: Bone and charcoal concentration x124.50/y148.60 (Area 11A, refuse pit a). Sample Hel-2564 from excavation spit 5 and sample Ua-40895 from excavation spit 4. The difference in age between the samples most likely reflects the own age of the charcoal sample.

Lab. number, sample type, and un-calibrated and calibrated (2σ) dates:

1. Hel-2564, charcoal, 7750±120 BP,
7030–6410 calBC.
2. Ua-40895, *Rangifer tarandus*, 7668±40 BP,
6590–6450 calBC.



Calibrated in OxCal 4.1.7 (Bronk Ramsey 2010) using the IntCal 09 calibration curve (atmospheric data from Reimer *et al.* (2009)).

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The Kaaraneskoski Site in Pello, South-Western Lapland – at the Interface between the "East" and the "West"

Tuija Rankama & Jarmo Kankaanpää

ABSTRACT **The paper discusses the Late Mesolithic Kaaraneskoski site in Pello, southern Finnish Lapland, focusing on its quartz assemblage. A variety of analysis methods (e.g., technological analysis, fragment recognition, fracture pattern analysis, tool identification, low-power use wear analysis, and spatial analysis) are employed to study the structure of the site, the formation of the quartz assemblage, and the processes of quartz reduction and tool blank selection. The studied assemblages from two separate excavation areas display unusually high tool percentages. The *chaînes opératoires* display five separate production concepts. It is concluded that the site consist of a number of small, consecutive living floors produced by mobile hunter-fisher-gatherers, reflecting intermittent use of a productive locality, and that the quartz assemblages are to a large degree selected from material knapped outside the excavated areas. The assemblages include elements that speak for contacts between the Late Mesolithic south-western (Swedish) handle core area and the eastern (Finnish) oblique point area.**

KEYWORDS
Late Mesolithic, Lapland, quartz, lithic analysis, *chaîne opératoire*, fracture patterns, spatial analysis

Introduction

The Stone Age Kaaraneskoski site in south-western Finnish Lapland (**Fig. 1**) was excavated in 1997–98. The site was named after the neighbouring Kaaraneskoski Rapids, though these themselves no longer exist, having been partly drowned and partly diverted by the building of a small hydroelectric dam in the early 1950s. The earliest stray find from the environs of the rapids, a slate knife, was found as early as 1884, but the existence of a site at the location was first confirmed in 1956 when archaeologist Aarni Erä-Esko found several quartz artefacts near the dam area. Erä-Esko visited the site again in 1964, picking up more quartz and shards of slate from the edges of a small sand quarry. Markku Korteniemi also included it in his survey of the prehistoric sites in Pello Borough (Korteniemi 1984). By the time an excavation was launched in 1997, the expanding sand quarry had destroyed most of the probable central parts of the site and it remained for the archaeologists to work around the surviving edges (**Fig. 2**).

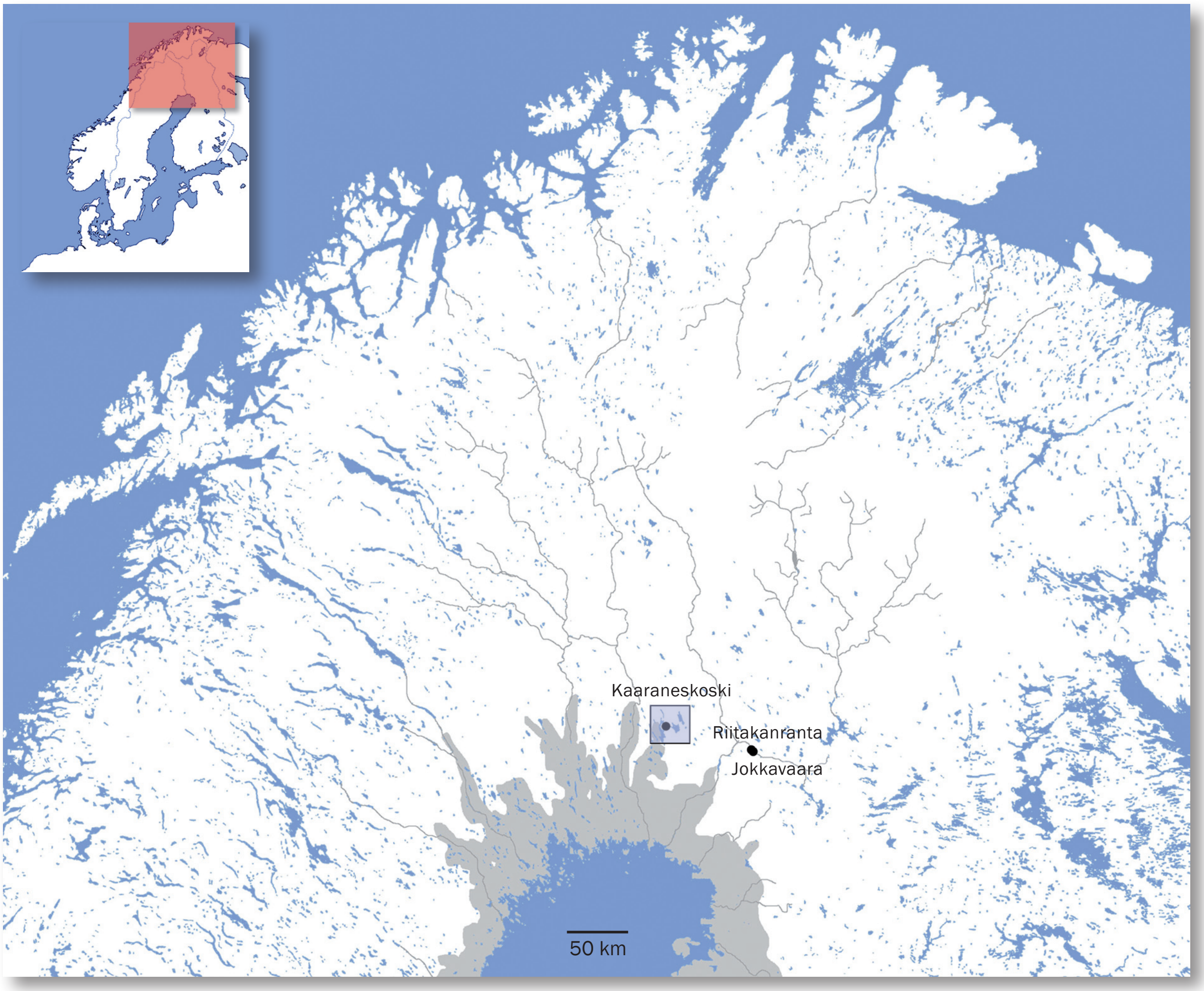


Figure 1. The location of the Kaaraneskoski site in Pello and the Riitakanranta and Jokkavaara sites in Rovaniemi. The grey colour indicates the shoreline of the Litorina Sea at 7100 BP, i.e., slightly before the beginning of the occupation of the site. The box indicates the area covered by **Figures 3** and **4**. Map by M. A. Manninen and J. Kankaanpää.

This paper discusses the locality, the excavations, and the finds, focusing on the quartz assemblage that includes some unusual features. The site is dated to very late Mesolithic, around 5500 calBC (see below). It is located at the interface between the eastern oblique point area and the south-western handle core area (see Manninen & Knutsson *this volume*:Fig. 11). This position is reflected in the assemblage. The aim of the analyses presented in this paper has been to study the structure of the site and the character of the occupation, as well as the character of the lithic assemblage and what it can tell us about the activities that took place at the site. An important objective has also been to show the research potential in quartz assemblages and to provide comparative material for future research. Because of this, the technological characteristics of the assemblage are described in some detail.

The view taken by the authors of this paper is that, instead of concentrating on typologically diagnostic tool forms, lithic analysis should always include all of the various components of the lithic assemblage. While recognisable retouched tools can tell us a variety of things about the activities performed at a site, it is the debitage assemblage that informs us about the *processes* involved in lithic manufacture and use (see, for example, Rankama 2002:80). These processes help us understand the human decision making involved in making and using stone tools. They allow us a unique glimpse of prehistoric human mental processes that are difficult to reconstruct by any other means. They are also a key

Figure 2. The Kaaraneskoski site area from the south-west in 1997. Photograph by J. Kankaanpää.

to understanding the learned, cultural aspects of technology that help us find regional similarities and differences and reconstruct complexes that can be understood as having had a common basis, and thus, perhaps, also sharing other aspects of (material) culture.

Lithic technology is the most reliable key to these reconstructions. Although tool types are often used to identify cultural ties between assemblages and areas, they can be deceptive: individual tools, especially spectacular ones, or ones made of exotic raw materials, can be transferred from area to area as gifts and may not be usable as cultural indicators, even though they may inform us about contacts between groups of people. When studying quartz assemblages, tool types tend to be even less useful. The general pattern in Finnish quartz assemblages is not one of formalised tool types or even of a struggle towards similarities in shape (cf., Rankama 2003b:205). Instead, the emphasis has been on finding or preparing a suitable working edge for each purpose, with less regard on the shape of the piece otherwise. Identified tools display a minimal amount of modification, and the strategy of the quartz user seems to have been to select tools and tool preforms from among the natural fragments produced by quartz reduction. Retouched quartz tools, thus, seldom work as chronological indicators in Stone Age Finland, and the few examples that exist are usually borrowed from outside current Finnish borders. The oblique points discussed by Manninen and Knutsson and Manninen and Tallavaara in this volume may be an exception (but see Manninen & Tallavaara *this volume*). Another exception might be thumb-nail scrapers, which appear, based on experience with several quartz assemblages, to be a Mesolithic tool form. This hypothesis, however, has never been properly studied. Both tool types, in any case, are present in the Kaaraneskoski assemblage (see below).

This study utilises the *chaîne opératoire* concept when interpreting the results of the analyses. Based on Marcel Mauss' anthropology of gestures and body techniques, according to which they are culture-specific (e.g., Mauss 2009:77–95; originally "Les techniques du corps", *Journal de psychologie* 32, 1935), and developed within French archaeology (Leroi-Gourhan 1964), the *chaîne opératoire* approach looks at lithic production as a process of culturally transmitted gestures. A study of *chaîne opératoire* means reconstructing "the organisation of a technological system at a given archaeological site" (Sellet 1993:106) and involves studying lithic manufacture as a process that proceeds from raw material procurement through all the stages of production and use until discard. The *chaîne opératoire,* thus, covers the life cycle of the lithic products and can be used to describe the approach of the prehistoric knapper to the raw material (see, e.g., Sellet 1993 and Sørensen 2006 for an explanation of the meaning of the *chaîne opératoire* concept, its history, and applications).

The intentions of the lithic producer are formulated in his/her mind as conceptual operational schemes, "road maps" to the desired end products, where the process is divided into stages that gradually lead to the goal (Pelegrin 1990:117). According to Pelegrin (1990:118), elaborate knapping activity involves two key concepts: knowledge (*connaissances*) and know-how (*les savoir-faire*). Knowledge means the mental aspect of the process of lithic production: knowing the raw material and the possible modes of dealing with it, knowing the geometry necessary for production, knowing the modalities of production and the required tools on a mental level, and having the mental templates of the desired products. Know-how, on the other hand, involves both the ability to analyse, reflect, and decide on suitable actions in each situation, and the ability to execute the actions successfully (Pelegrin 1990:118–119; see also Sørensen 2006:33, Fig.1).

In the context of quartz reduction, knowledge would, then, involve knowing, for example, the limitations posed by the raw material: which techniques and methods are the most successful, which kinds of quartz are best suited for reduction and which might even be approached with more complex techniques, and which methods would *not* be worth attempting. The mental templates, on the other hand, might require an attempt at production even in a situation of limited raw material possibilities, and learning the limitations of a new raw material environment is one of the key adaptational processes of a colonisation situation. A situation of contact between different social groups, where new modes of production are observed, may also lead to attempts to emulate them in less than ideal raw materials. Evidence of this kind of behaviour can be observed in the Kaaraneskoski assemblage.

Lithic concepts are reproduced within a society through a learning process and tend to remain constant at least to some degree. They can, thus, be considered specific to particular societies (Sørensen 2005:22, Fig. 2; Sørensen 2006:34, Fig. 2) and can be used to study the differences and similarities of lithic manufacture between social groups. An archaeological assemblage can – and usually does – consist of the remains of several *chaînes opératoires*, and several operational schemes or concepts can also exist within one society. These may depend, for example, on the range and quality of available raw materials, but also on social contacts, as well as, naturally, on the desired products. It is for the archaeologists to reconstruct the *chaînes opératoires* and to try to explain the rationale behind the different lithic concepts and the choices behind their use in particular situations.

The Kaaraneskoski site and excavations

The site lies on the sandy western slope of a ridge that separates lakes Vähä-Vietonen (90–93 m above sea level, dam-regulated) and Miekojärvi (76.9 m above sea level; **Fig. 3**). The top of the ridge, down to c. 93 m above sea level, is rocky glacial till and bare bedrock. This is covered at lower elevations by a layer of sand several metres in thickness. The sandy slope terminates at c. 83 m above sea level in a level plateau of agricultural land with a substratum of moist clay, obviously a former lake or sea bottom. The area is covered with mixed forest, primarily Scots pine and birch (see **Fig. 2**). A clear-cut power line corridor passes through the sand quarry from north to south and continues towards the south-east. Most of the upper edge of the remaining sandy area above the sand quarry has been logged some decades ago and is now covered by a dense thicket of pine saplings. The understory consists mainly of heather, lingonberry, and moss.

Due to isostatic uplift, Kaaraneskoski currently lies some 90 km from the coast of the Gulf of Bothnia, but during its occupation the site was coastal and can, thus, be dated through shore displacement chronology (see, e.g., Siiriäinen 1974). The location was at the mouth of a short river draining the Lake Raanujärvi – Lake Iso-Vietonen – Lake Vähä-Vietonen system into a long fjord-like bay of the Litorina Sea (**Fig. 4**). Although some 5 kilometres wide in places, the open expanse of the fjord was broken by a number of islands, including fairly large ones directly west of the site. The site was, thus, reasonably well shel-

Figure 3. Current topography of the Kaaraneskoski area. Topographic map published with the permission of the National Land Survey of Finland.

Figure 4. Late Mesolithic extent of the Litorina Sea with the shoreline at 90 m above the current sea level, and the location of the Kaaraneskoski site. Drawing by J. Kankaanpää.

tered from all but north-western winds. Its location at the mouth of the river would have been profitable for hunting and fishing both in the sea and in the lakes and forests beyond the immediate site area. It is likely that salmon would have entered the river system and the site would have made an excellent salmon fishing location.

Archaeological investigations were carried out at the site in 1997–98 by Jarmo Kankaanpää on behalf of the National Board of Antiquities. The primary goal was to assess the extent and age of the site, since it was deemed to be progressively eroding and largely destroyed. The excavations were financed by a government make-work programme with a set budget. Due to limited funds and time, an excavation of the whole find-bearing area was not possible. The finds, catalogues, maps, photographs, and excavation reports are archived at the National Board of Antiquities in Helsinki.

Figure 5 shows the topography of the site and the excavated areas. The 1997 excavation commenced with surface collecting, during which quartz artefacts were observed in both the upper (eastern) and lower (western) edges of the sand quarry – note that north is to the left of the plan. Test pitting of the upper part of the site was followed by the opening up of two parallel, 1 metre wide test trenches (Areas 1 and 2, 14 m^2 and 12 m^2, respectively) some 10 metres apart in the upper slope between c. 90 and 89 m above sea level. The location of the trenches was decided partly on the basis of productive test pits in the area, partly by the fact that the edge of the sand quarry was eroding and on the verge of destruction. The local tree cover was also a deciding factor, as the placement of the trenches was designed so as not to excessively disturb the growing saplings.

A third trench (Area 3, 36 m^2), perpendicular to the other two, was placed in the power line corridor at approximately the same elevation. As this trench was quite productive, it was widened to three metres over its southern half. A fourth excavation area (Area 4, c. 13.5 m^2) was opened up in the northern part of the site, where a streak of red ochre had been observed in the eroding slope of the sand quarry. The lower (western) part of the quarry edge was deemed stable and left for the following year. The finds from the 1997 excavation are catalogued as KM 30721:1–524.

The 1998 excavation concentrated on two areas: extending the productive Area 3 with perpendicular test trenches and parallel extensions (total = 47.5 m^2), and opening up a new system of trenches (Area 5, 37 m^2) at the lower western edge of the site between c. 86 and 85 m above sea level. The location of Area 5 was decided

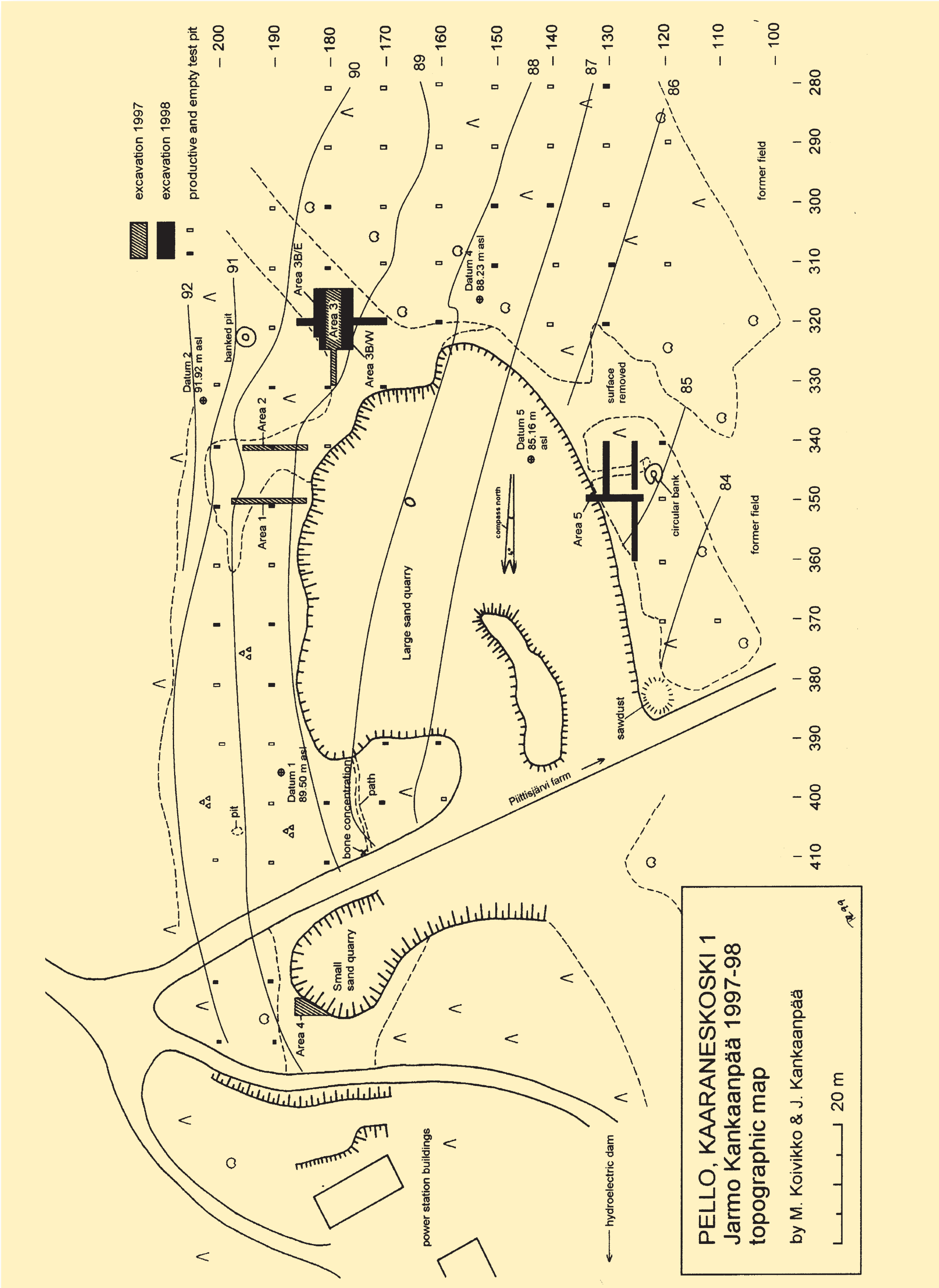


Figure 5.
General plan of the site with areas excavated in 1997 and 1998. Surveyed by M. Koivikko and J. Kankaanpää. Drawing by T. Rankama.

on the basis of abundant surface finds of quartz. Test pitting was also continued along the slope towards the south and along the lower edge. A small concentration of burnt bone eroding out of a road bank in the middle of the area at c. 88 m above sea level, known as "Paula's pit", was excavated as a separate unit and provided the only usable charcoal samples obtained during the excavation (**Fig. 5**). The finds from the 1998 excavation are catalogued as KM 31377:1–1122.

The total excavated area (excluding the test pits) was c. 160 square metres in size. Opening more excavation areas or extending the existing ones was not possible due to limited resources. It is clear from the distribution of productive test pits (**Fig. 5**) that the site area continues to the south and east of the sand quarry and that a considerable portion of the site has been quarried away. The test pits also show that archaeological remains are not contiguously distributed over the site, but occur sporadically over a large area. A substantial part of the site to the north of the quarry has also probably been destroyed by the construction of the hydroelectric power plant. The restricted sizes of the excavation areas, naturally, limit the conclusions that can be drawn from the studied assemblages. Nevertheless, we feel that due to the diffuse structure of the site (see below), we have been able to capture the character of the occupation and analyse coherent, and independent, portions of the occupation area.

The lower edge of documented archaeological remains lies at c. 85 m above sea level, while the upper edge rises to around 91 m above sea level. The elevation range of the site is at least 6 metres, which, at these altitudes, represents a period of some 400 years (see below).

The excavation proceeded in 5 cm artificial spits. Tools noticed during excavation were plotted three-dimensionally. The recovery unit for the rest of the finds was a palm-sized area within the spit, providing for a horizontal and vertical plotting accuracy of ±5 cm. This is sufficient for reliable distribution plans at the scales normally used. In addition, all excavated soil went through a 4 mm mesh sieve. As a result, the larger artefacts not noticed during trowelling were recovered, while the smallest fraction was inevitably lost. The sieve finds were plotted only to the spit and square metre.

Throughout the excavation areas the soil displayed a podsol profile on top of undisturbed sand. Small patches of anthropogenic stained sand were observed only in area 3. The thickness of the excavated layer varied generally between 15 and 30 cm, with only a few small areas reaching a depth of 40 cm or more. The majority of the finds (79 %) were in the top 10 cm, with a further 18 % in the next 10 cm. The bottom 5 excavation spits yielded only 3.3 % of the finds, emphasising the fact that the productive part of the cultural layer was only about 15–20 cm in thickness.

The finds consist primarily of quartz and "slate" (mainly chlorite schist). No pottery was found, though the lowest parts of the site could theoretically date to the Early Neolithic[1]. In Areas 1–3, excavated in the upper part of the site, a band-like concentration of finds was observed following the 89.5 metre contour. This was interpreted as reflecting an occupation phase that closely followed the beach line. Find concentrations were also observed in the Area 5 trenches at the lower edge, but their contexts were less clear. Some of these finds were clearly in a secondary context resulting from recent surface disturbances connected with sand extraction and smoothing the quarry edge. The red ochre notwithstanding, no clear evidence of a burial was observed in Area 4. The area produced a number of finds (mainly quartz and a few fragments of slate), but they did not appear to cluster specifically around the red colour streak.

The date of the site

M. Saarnisto's shore displacement curve for the Rovaniemi–Pello Area (Saarnisto 1981:Fig. 9) dates the site's 91–85 m elevation to c. 7000–6600 BP (**Fig. 6**), but the single radiocarbon date from the bone concentration in "Paula's pit" at 88 m (Hela-323) runs to 6310±85 BP (5473–5061 calBC, 2σ; IntCal09: Reimer *et al*. 2009), suggesting that at least that feature may have been located several metres above the contemporary waterline. In view of this observation, it might be prudent to date the whole site slightly younger than shore displacement would theoretically allow.

The potential occupation period of the site, in any case, covers some 400 years. Because of this, one of the questions addressed by the analyses presented below was whether the occupation was continuous or recurrent, for example within a seasonal round.

[1] In the Finnish chronological system, the beginning of the Neolithic is identified by the appearance of pottery. Agriculture is not present or implied at this stage.

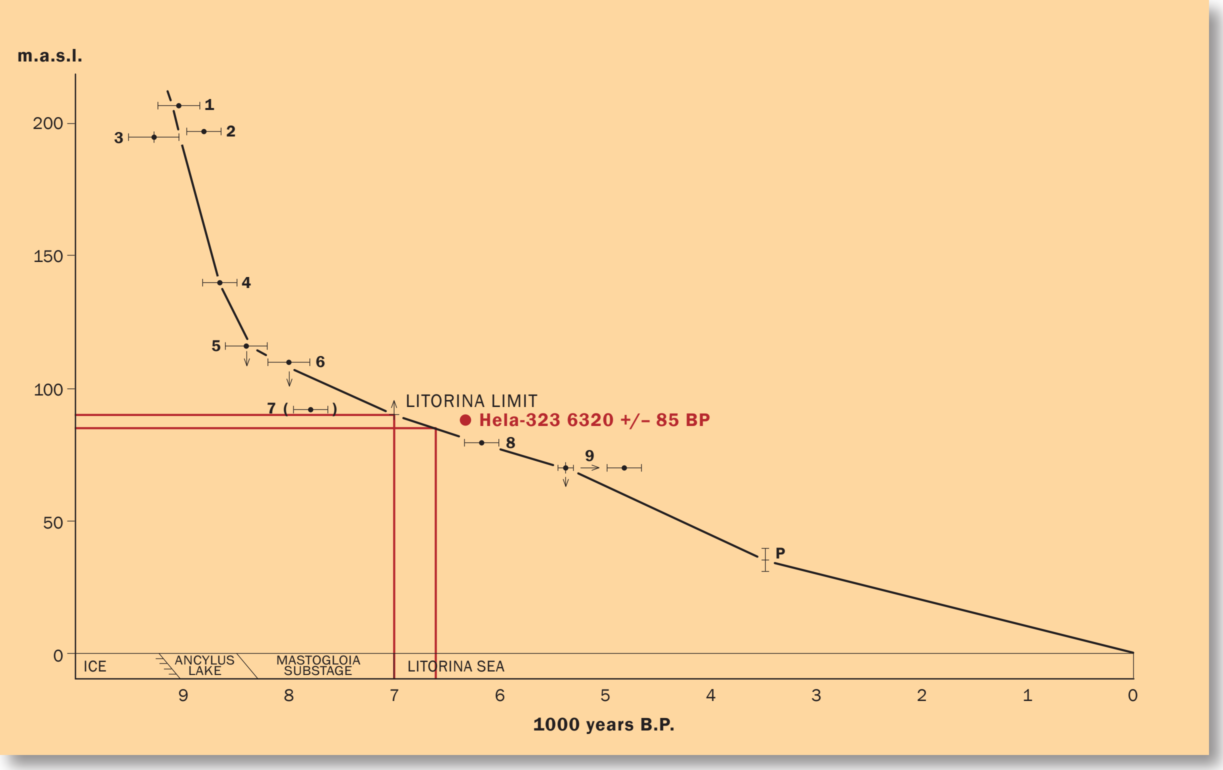


Figure 6. Shore displacement curve for the Rovaniemi–Pello area (Saarnisto 1981:Fig. 9), with the radiocarbon date from "Paula's pit". The elevation of the Kaaraneskoski site is marked with red lines. Edited by J. Kankaanpää.

The lithic assemblage and the structure of the site

The quartz assemblage from Kaaraneskoski consists of 1897 artefacts. In addition, the finds include 305 artefacts of other lithic raw materials, mainly chlorite schist, but also a few pieces of other slate-type rocks and quartzite, as well as 234.6 grams of burnt bone.

The quartz analyses presented in this paper concern the two largest excavation areas (**Fig. 5**): Area 3 to the south-east of the quarry and Area 5 to the west. The quartz assemblages from these areas put together comprise 86% of the recovered quartz artefacts. The number of analysed pieces is 795 from Area 3 and 896 from Area 5. In addition to the quartz, some of the schist implements recovered during the excavation will be commented upon.

In the following analyses, the quartz assemblage from each analysed area is dealt with separately. This is due to the fact that there is a difference of c. 5 metres in the elevation of the areas and they can, thus, be assumed to differ in age. Due to the thin find-bearing layer in each area, the finds have been treated as an undivided whole without an effort to look for vertical differences. Another reason for this is the soil formation that has taken place after the occupation: apart from two small stained patches in Area 3, any anthropogenic discolourations in the soil that might have provided clues to stratigraphy have been destroyed by the podsolisation process (cf., Rankama 2003a:58–60).

Apart from the elevation, the current topography gives few clues to the relationship of the two areas with each other, or indeed to the structure of the site as a whole. The presence of the quarry that seems to have eliminated the central part of the site makes it possible to imagine that most of the archaeology has been lost and what remains are the dregs in the periphery. A closer look at the distribution of the finds in Area 3 (**Fig. 7**) tells a different story, however: there is a distinct fall-off in the finds below the 89.2 metre contour line. The same contour line can be seen as the lower edge of finds also in Areas 1 and 2. This suggests that the occupation reflected in Areas 1–3 has been located at a particular shoreline and that, rather than one large contiguous occupation area, the Kaaraneskoski site as a whole repre-

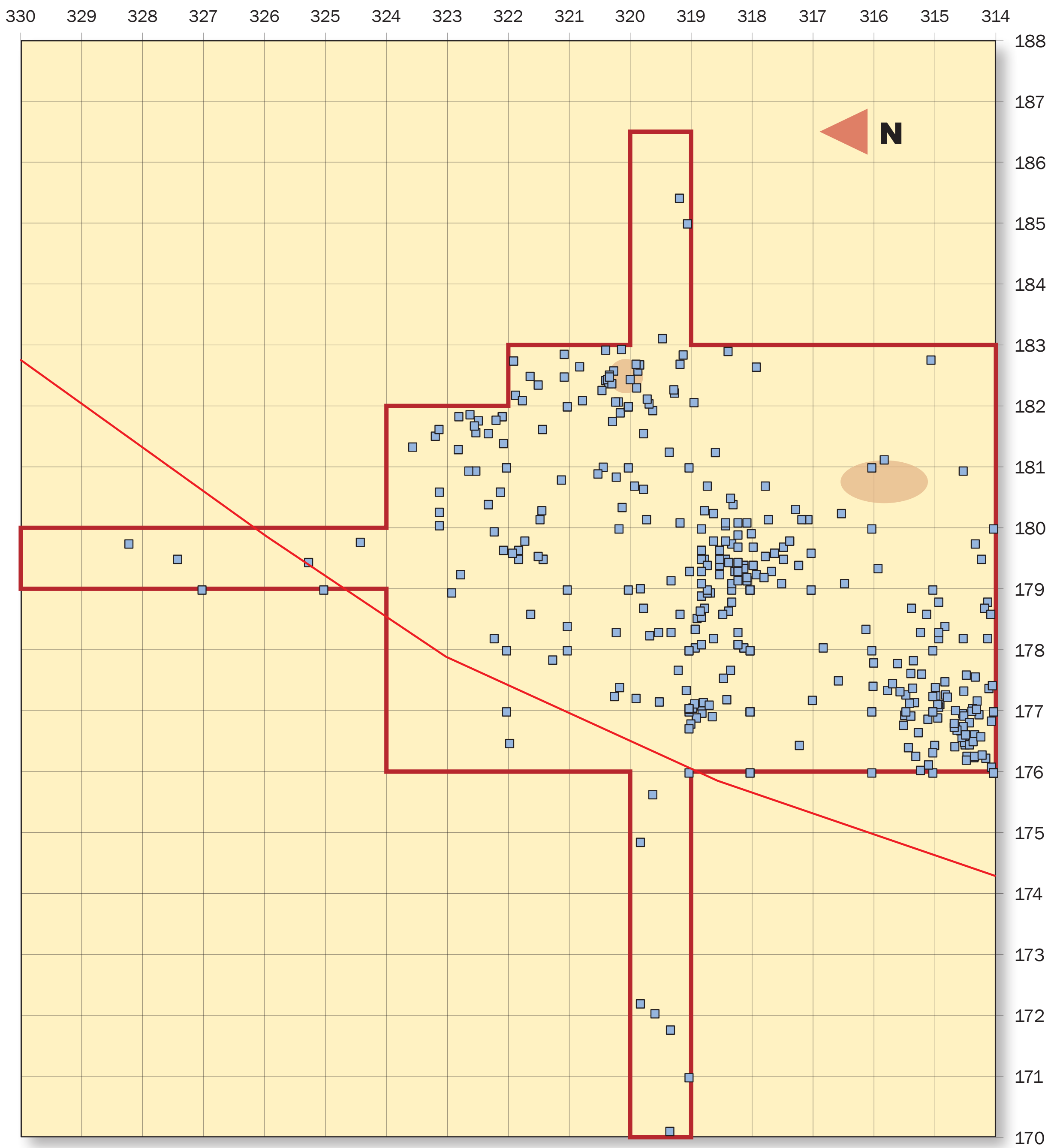


Figure 7. The distribution of all quartz finds in Area 3 at Kaaraneskoski. The ovals show the locations of the stained sand. The red line marks the 89.2 m contour.

sents the remains of a number of individual occupation episodes, each located at or close to the shoreline of their time. Because of the receding shoreline and continuously changing topography, the most profitable site location shifted with time, resulting in the formation of a fairly loose network of living floors of fairly short duration. The finds from each excavation area can, thus, be assumed to constitute samples of separate, coherent wholes.

The distribution of productive and unproductive test pits (**Fig. 5**) tells the same story: productive ones are dispersed as small clusters among unproductive ones. Although the area over which productive test pits occur is wide, the evidence does not support the idea of a large occupation site of long duration, but rather recurring visits by small groups of people over a longer period of time.

The picture that emerges is, thus, not quite as bleak as might be imagined. A large part of the site is definitely gone, but it was not necessarily *the* central part of *the* occupation. Instead, the area that has been quarried away has probably borne the remains of a number of similar separate occupation episodes as the excavated ones. This means that despite the destruction, each of the analysed areas contains clues to one episode of human presence at the site, and these clues need not be considered peripheral to the occupation of that particular episode. As a consequence, it is also safe to assume that the assemblages from excavation areas at different elevations are fairly pristine, i.e., there is no reason to postulate a high degree of mixing of materials from different occupation episodes. As regards settlement structure, the episodic nature of the occupation points towards a mobile way of life, possibly a regularly or irregularly recurring round of which a stay at Kaaraneskoski was just one part. This, of course, is the likeliest lifestyle for Mesolithic hunter-fisher-gatherers in Finland.

The methods of analysis

The classification of the Kaaraneskoski quartz artefacts was done with the help of a low magnification stereo microscope. The standard magnification was 3.6x. In addition, 6x, 12x, and 24x were used to verify the existence of wear marks and very small retouch. All quartz artefacts went through the same analytical procedure.

Several methods were used in the analysis. These included technological analysis, i.e., the identification of the reduction methods employed, the classification of the assemblage into flakes, various categories of tools, and cores, fragment identification and fracture analysis, identifying obvious use wear on the scrapers, and spatial analyses of the various artefact categories.

The technological analysis aimed at identifying the methods used in quartz reduction at Kaaraneskoski. The most common methods employed by the Stone Age quartz users in Finland were platform reduction and bipolar reduction (Hertell & Manninen 2005; Pesonen & Tallavaara 2006; Rankama 2002; Räihälä 1998; 1999; Schulz 1990). Both of these methods were identified among the cores, tools, and flakes in the studied assemblages. In addition to the basic division into bipolar and platform reduction, it was also possible to recognize two separate production concepts within the platform method: flake production and microblade production.

While core classification is usually fairly simple, the reduction method of quartz flakes is not always easy to recognise. Experiments have shown that as much as a fifth of the flakes produced by bipolar reduction may be mistakenly classified as platform flakes, while some platform flakes can also take the appearance of bipolar flakes (Driscoll 2011:739; Knutsson 1988:91–93). These trends, obviously, cancel each other out to some degree in statistical analyses of large assemblages. The “loss” of bipolar flakes to the platform category might also be partly compensated for by the observation (Driscoll 2011:739) that more platform than bipolar debitage tends to remain unclassified as to reduction method. The results of analyses also always depend on the experience of the analyst. Various sources of error, thus, exist and must be borne in mind when assessing analysis results.

The sources of error notwithstanding, technological analysis is a necessary step in the analysis of every quartz assemblage, since it throws light on the technical decisions made by the prehistoric quartz users. The choice of reduction method may be based on practical reasons. Since the bipolar method produces thin flakes with a straight profile, while platform flakes are often slightly bent (Callahan *et al*. 1992:33; Lindgren 2004:174, 176) and fairly thick at least towards the proximal end, it is conceivable that the specific needs of the quartz knapper in each situation played a role in the selection of the reduction method. The method may also be chosen on the basis of the known behaviour of the raw material during reduction. Quartz is known to be difficult to control. The bipolar method, however, produces better results than the platform method: there is, for example, a lower probability of the flakes fragmenting when the bipolar method is used (Callahan *et al.* 1992:34, 38; Driscoll 2011) and this may have played a role in the selection process (Tallavaara *et al.* 2010). It has also been suggested that the choice of reduction method may have depended on the stage of the reduction: analyses of quartz assemblages from Sweden display a *chaîne opératoire* where the reduction was initiated with the platform or platform-on-anvil method, but finished with the bipolar method (Callahan 1987:60–61; Darmark *et al.* 2005; Knutsson 1988:198; Vogel 2006a; 2006b). The same process has been seen as a possibility also for some assemblages in Finland (Pesonen & Tallavaara 2006:16).

On the other hand, the reasons behind the decisions concerning reduction methods may have been culturally or socially determined. In the quartz-using regions of Sweden, for example, analysis results suggest that the bipolar method was a typically Mesolithic mode of quartz reduction, while the proportion of the platform method increased when moving towards the Neolithic. Eventually, the bipolar method all but disappeared (Knutsson & Lindgren 2004; Lindgren 1994:81; Lindgren 2004:38–40, 249–250, 266, Fig. 2.10). This has been interpreted as reflecting a significant change in social structure (Lindgren 2004). Only by analysing a large number of quartz assemblages will it be possible to establish whether culturally or socially based preferences in quartz reduction methods existed also in Finland. According to analyses carried out so far, both the bipolar and the platform method were present in the Mesolithic and there was no notable decrease in the use of the bipolar method in the course of the Stone Age (Pesonen & Tallavaara 2006:16–17; Rankama 2002:83–86, Figs. 3, 5; Räihälä 1998:11; Räihälä 1999:123; Schulz 1990:Fig. 4). Quite the contrary, in the analysed quartz assemblage from one of the youngest published sites, Råvåsen in Kristiinankaupunki, the bipolar method is more dominant than in any of the others (Hertell & Manninen 2005:87, 89–90).

Since the natural breakup of quartz flakes during reduction produces a variety of fragments (Callahan *et al.* 1992; Rankama 2002:Fig. 2; Tallavaara *et al.* 2010) that can, in the absence of appropriate knowledge, be mistakenly interpreted as implements (see Knutsson 1998), strict criteria were employed in tool identification within the Kaaraneskoski assemblage (cf., Rankama 2002:81). These were: 1) presence of secondary modification (retouch) distinguished either with the naked eye or with the microscope, 2) presence of obvious use wear, i.e., rounding or micro-chipping of the edges, even if retouch was absent, or 3) both. The definition of accepted retouch was three consecutive retouch scars. Rounding of the edges was tested by studying the other edges of the supposed tools: if the other edges and ridges were clearly sharper than the proposed working edge, the presence of use wear was accepted. This was based on the assumption that rounding of all edges could be the result of post-depositional processes, such as water rolling, but selective rounding of only one part of the artefact, especially one fit as a working edge, could only have been produced by use.

Defining the exact function of the tools was not attempted, since funds for high-power use wear analysis were not available. Morphologically based functional categories, such as scrapers, were, however, employed in the classification.

Fragment identification was a key part of the analysis. Quartz has an idiosyncratic mode of behaviour during reduction in that the detached pieces more often than not break into smaller fragments. The fragmentation is not random but follows the laws of the behaviour of brittle materials under stress. The most common fracturing types are radial fractures emanating from the point of impact that split the flakes lengthwise, and bending fractures caused by vibrations in the material that result in perpendicular breaks. Both forces act simultaneously (Callahan *et al.* 1992:30–32, 38–38, 50, Fig. 2). The result is a range of fragments (**Fig. 8**), the recognition of which is vital for any quartz analysis. An awareness of natural fragmentation makes it possible to understand quartz assemblages better, and although fragment identification is time-consuming, it is absolutely necessary for avoiding the misclassification of natural fragments as tools (cf., Knutsson 1998).

Since the various fragments have different characteristics as regards, for example, length of thin, sharp edge or sturdiness, fragment classification can be used to study behavioural patterns and the choices made by the prehistoric quartz users, for example the selection of specific fragment types for use or modification as tools (Callahan *et al.* 1992:52–54; see also Darmark *et al.* 2005; Rankama 2002). Combined with spatial analyses, fragment classification may reveal possible activity areas or storage facilities for tool blanks (Rankama 2002:97–106).

Fragment classification was originally used as the basis of fracture analysis, in which the proportions of the various fragments were employed to infer the degree of disturbance – human or otherwise – to a prehistoric quartz assemblage. According to the original publication (Callahan *et al.* 1992), which was based on experimental work, it was possible to put forward the ideal composition of a complete fragment series from which nothing had been removed. In addition, different reduction methods produced distinctly different fracture patterns, i.e., the proportions of whole flakes, lateral fragments, distal fragments, and so on, varied predictably depending on whether the assemblage was produced by platform reduction or bipolar reduction. It was then deemed possible to compare the facture

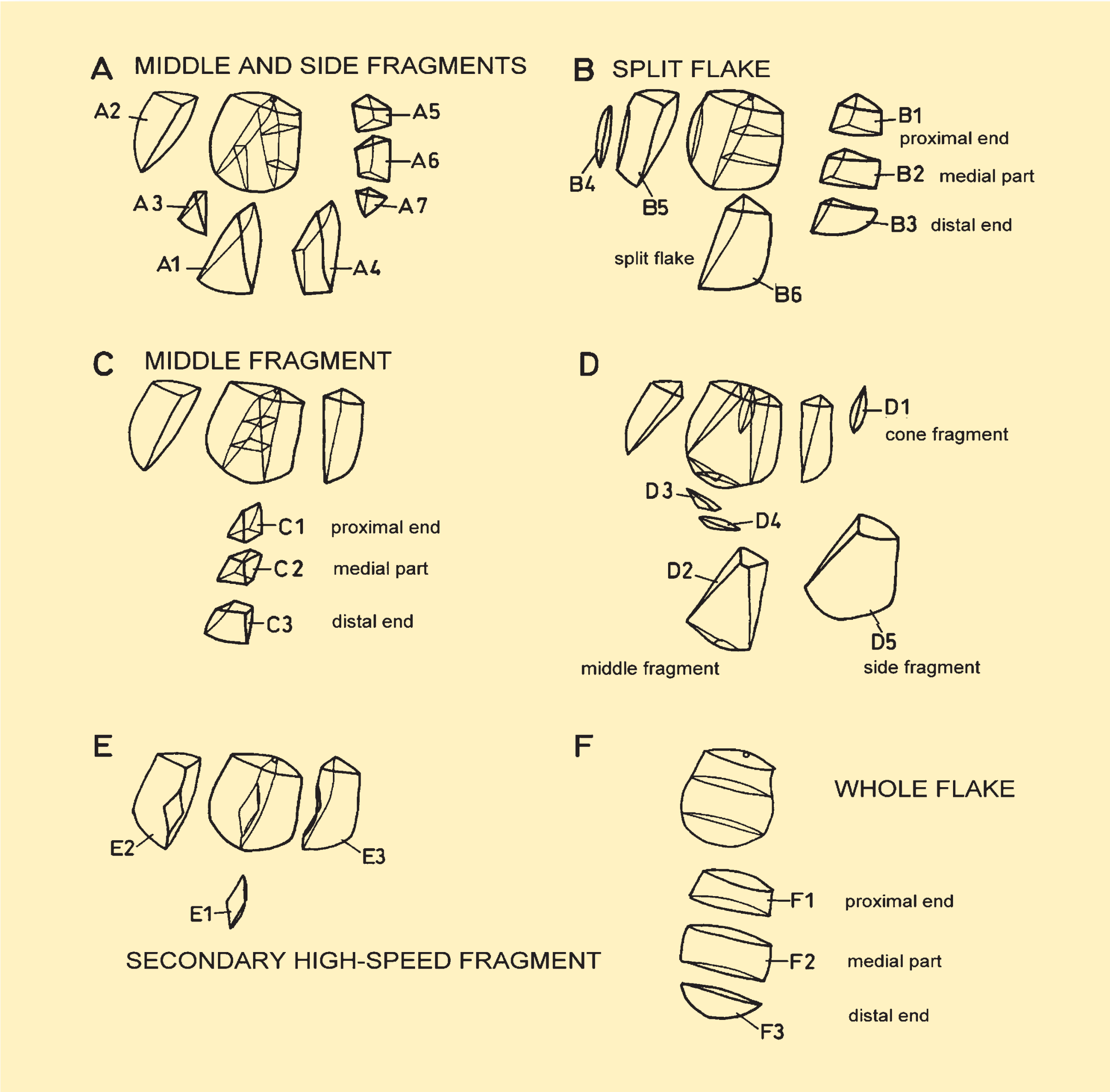


Figure 8. Schematic representation of the different fragment types. Modified from Rankama 2002:Fig. 2. Based on Callahan *et al.* 1992:Fig. 3.

patterns of archaeological assemblages with experimentally produced complete fracture patterns to see to what degree they differed from each other. This was thought to make it possible, for example, to distinguish assemblages representing knapping sites from which the usable fragments had been removed from assemblages representing selected collections of tool blanks (cf., Darmark *et al.* 2005; Rankama 2002; Räihälä 1998; 1999; Vogel 2006a; 2006b).

Recent studies (Tallavaara *et al.*, 2010) have, however, shown that the patterns of fragmentation are not quite as clear-cut as originally proposed. The fracture patterns produced by hand-held direct percussion appear to be affected by "indenter hardness, the relative thickness of the detached flake, and individual knapper-related factors", such as skill, more than allowed for by Callahan *et al.* (1992). As a consequence, comparisons between archaeological and experimental fracture patterns are not as straightforward as originally thought and should, at the very least, be used with caution. This does not, however, reduce the value of fragment identification as a tool for analysing quartz assemblages, or undermine the understanding of quartz behaviour during reduction gained through the experiments by Callahan and his co-workers.

In this study, fracture patterns are not compared with any experimental fragment distributions, but they are used as a basis of conclusions about the formation of the assemblage. The identified fragments are also utilised, for example, in studying the preferences of the fragments used as blanks for a variety of tools, and in combination with the identified tools, in distribution studies that seek to detect activity areas within the site.

Since the whole assemblage went through a low-power microscope analysis, obvious instances of use wear were recorded, and verified by increasing the magnification up to 24x. This paper discusses the patterns of use wear recorded on the scrapers, in which the wear was clearest. The identification follows the guidelines published by Broadbent and Knutsson (1975) and Broadbent (1979). Since they studied quartz deriving from similar geological contexts as in Finland, their experiments and observations were assumed to be valid for the Kaaraneskoski scrapers. The magnifications they used were, however, much higher than was possible in this study. High-power microwear analysis, which would have been necessary for identifying, for example, the exact mode of use of the artefacts, would have required sending the artefacts abroad and was not financially possible.

The wear marks were coarsely divided into "hard" and "soft" wear, "hard" being characterised by crushing and occasionally undercutting of the scraper edge, and "soft" by rounding. No finer distinction of wear types was attempted. According to Broadbent and Knutsson (1975) and Broadbent (1979), hard wear is typically produced by the use of the tool on a hard surface, such as wood, antler, or bone, while soft wear results from working soft materials, such as hide. Due to the low magnifications used, the analysis of the Kaaraneskoski scrapers is necessarily simple and the interpretation should be taken as suggestive only (but see Odell 1990 for a discussion of the potential of low power use wear analysis in interpreting site assemblages). The presence of use wear on several scrapers (and other tools) is, nevertheless, undeniable.

The purpose of the use wear analysis was to study the patterns of scraper use. According to conventional wisdom scrapers are tools that are most commonly used in hide working. Earlier analyses have shown, however, that this is not necessarily the case and that wear associated with working harder materials is more common on scrapers (Broadbent & Knutsson 1975:125–126; Rankama 2002:92–93).

The recording of the finds in small areal units and often individually made it possible to study the spatial distributions of the various artefact categories. An example of the usefulness of distribution studies has already been presented (**Fig. 7**). This paper does not, however, include a full spatial analysis – that would be the topic for a separate publication. A few patterns are, nevertheless, briefly discussed, although the small sizes of the excavation areas and the shape of Area 5 make it difficult to draw definitive conclusions on the basis of the limited distribution analyses included here.

The results of the analyses

Technological analyses

As indicated above, identifying the technique with which a quartz flake has been produced is not always straightforward. Platform reduction sometimes produces flakes that look like bipolar flakes, and vice versa (Driscoll 2011:739; Knutsson 1988:91–93), which means that every analysis will include a certain degree of uncertainty. With this *caveat* in mind, we can look at the results of the technological analyses of the Kaaraneskoski assemblages.

The reduction method was determined in about half of the quartz flakes and tools – 49.3% in Area 3 and 56.6% in Area 5 – and all of the cores. The large proportion of unclassified flakes can be explained by fragmentation: in the Area 5 assemblage, 74.6% of the flakes whose reduction method was not defined were distal or medial fragments which, in the absence of the proximal end or other diagnostic features, cannot be classified (cf., Rankama 2002:Fig. 4), and the same pattern undoubtedly applies to the Area 3 assemblage. Looking at the tools separately, the proportion of artefacts the reduction method of which it was impossible to determine is higher, 65% in both areas. This can be explained by the secondary modification that has in many cases destroyed the evidence of the primary reduction method. Scrapers are a case in point: of the 20 scrapers in the Area 3 assemblage 18, or 90%, could not be classified as to the method of producing the original flake; in Area 5, the percentage was 85, i.e., 33 out of 39.

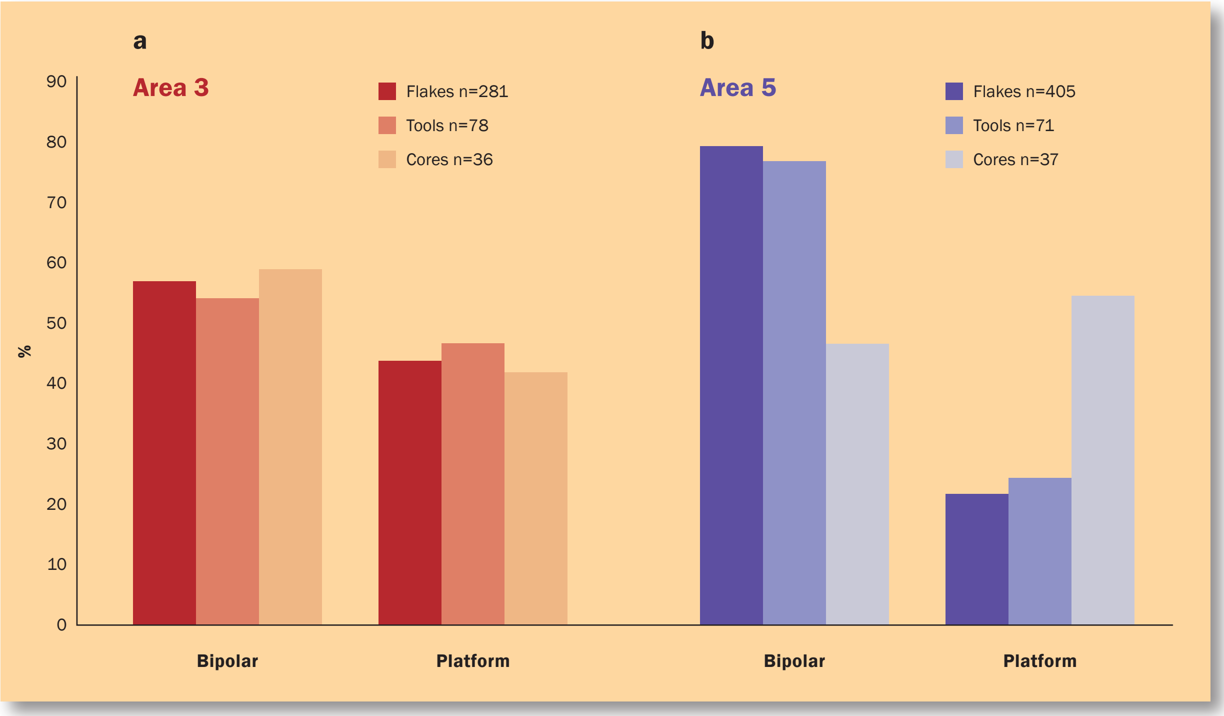


Figure 9. The identified reduction methods in Areas 3 and 5 at Kaaraneskoski.

The technological analysis shows a slight preponderance of the bipolar method in Area 3 (**Fig. 9:a; Appendix I: Table 1**): 54–58% of the flakes, tools, and cores that it has been possible to classify derive from bipolar flaking. In Area 5 (**Fig. 9:b**) the dominance of the bipolar method is more pronounced among the flakes and tools, reaching 76–79%. Among the cores, however, the platform method dominates with 54%.

The pattern in Area 3 suggests that the bipolar and platform methods have been used side by side. There is no discrepancy between the percentages of the different artefact categories, although such discrepancies have previously been observed in several analysed assemblages in Finland and Sweden (see Rankama 2002:84–86 with references for examples and a discussion of this phenomenon). In Central Sweden, it has been suggested that quartz reduction followed a sequence in which the knapper started off with the free-hand platform method, changing to the platform-on-anvil method and finally the bipolar method as the core size diminished (Callahan 1987:60–61, Fig. 97; see also, e.g., Darmark *et al.* 2005; Vogel 2006a; 2006b). This kind of sequence might, for example, result in an overabundance of bipolar cores, as well as platform flakes, as compared with the number of platform cores, since the latter would have changed type during the reduction chain. The Kaaraneskoski Area 3 pattern does not suggest a shift from one method to the other.

To study this theme further, a comparison was made between the sizes of the flakes produced with bipolar and platform reduction. If a sequence from platform through platform-on-anvil to bipolar were present, one should expect to see a pattern where the platform flakes would be systematically larger than the bipolar flakes. Since length measurements of all the flakes were not available, this study was done by comparing the mean weights of the flakes. The results (**Fig. 10; Appendix I: Table 2.**) show that among the unfragmented flakes the bipolar ones are systematically heavier than the platform ones in both excavation areas, although the difference is smaller in Area 5. The pattern is the same when all the flakes are included. This does not support the idea of a sequence from platform to bipolar.

A comparison between the weights of cores of different categories was also carried out (**Fig. 11; Appendix 1: Table 3**). In this study, a more detailed classification of core types was used. The platform cores from both analysed areas at Kaaraneskoski include a few micro-

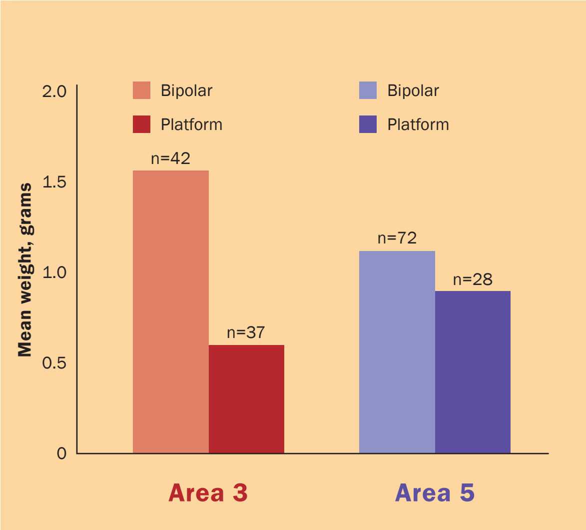


Figure 10. Mean weights of unfragmented flakes from Areas 3 and 5 at Kaaraneskoski.

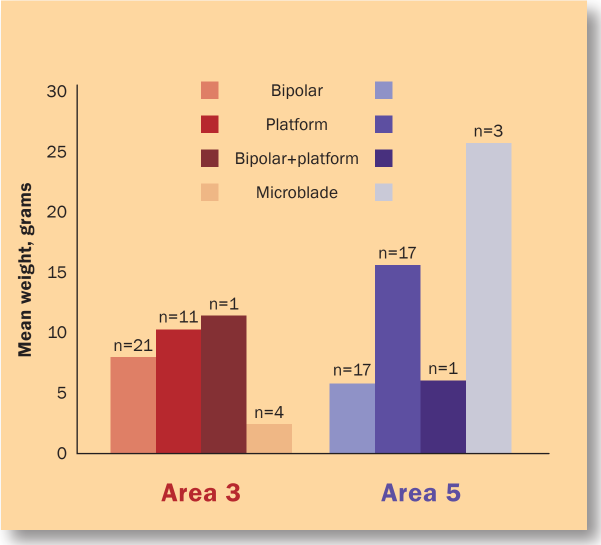


Figure 11. Mean weights of different core categories from Areas 3 and 5 at Kaaraneskoski.

blade cores. One core from each area shows evidence of having been used both in platform and in bipolar reduction. The cores from Area 3 show less variation than the cores from Area 5, but in both areas it is clear that the bipolar cores are smaller and have, thus, been worked further than the platform cores. Combined with the flake weight data this suggests that bipolar reduction started with fairly large nodules, certainly not smaller than platform reduction, and, as is common with the bipolar method, continued until the cores were clearly smaller than the discarded platform cores. The fact that bipolar+platform cores, nevertheless, exist, indicates that, although the two reduction methods as a rule represented separate *chaînes opératoires*, it was not inconceivable to occasionally shift from one method to the other as the situation demanded, or to reuse an old core. There is no evidence, however, of a regularly followed sequence from platform to bipolar in the assemblage.

To return for a moment to the identified reduction methods in Area 5 (**Fig. 9:b**), the number of platform cores seems high as compared with the number of platform flakes. This is difficult to explain, but may have to do with the character of the excavation area, which was basically a set of narrow intersecting trenches (**Fig. 5**). The finds from this area may, thus, not represent a balanced sample of the whole assemblage from this occupation episode.

Tools, cores, and flakes

The analyses revealed an exceptionally high proportion of tools in the Kaaraneskoski quartz assemblages (**Fig. 12; Appendix 1: Table 4**). Although strict criteria were employed in tool identification, in Area 3 as much as 29% of the quartz artefacts were classified as tools, while in Area 5 the percentage reached 23. These percentages are much higher than in other analysed quartz assemblages in Finland. At most analysed sites the percentage is well below 10 (e.g., Pesonen 2001:45; Schulz 1990:10, Fig. 4). Percentages approaching 10 have been recorded at Hossanmäki in Lohja (9.5%; Pesonen & Tallavaara 2006:15, Table 2) and at Kauvonkangas in Tervola (9.8%). In one of the semi-subterranean houses at Kauvonkangas the tool percentage was as high as 13.4 (Rankama 2002:86–88, Fig. 6, Table 1). It is probable that the high tool percentages at Hossanmäki and Kauvonkangas can be explained at least in part through the use of a microscope in the analysis process. This makes it possible to employ use wear to identify tools that have no secondary modification. The existence of tiny retouch can also be verified better with the use of a microscope.

The high proportion of tools in the Kaaraneskoski assemblages may also be associated with the character of the occupation. It has already been observed that the site most probably consists of the remains of a number

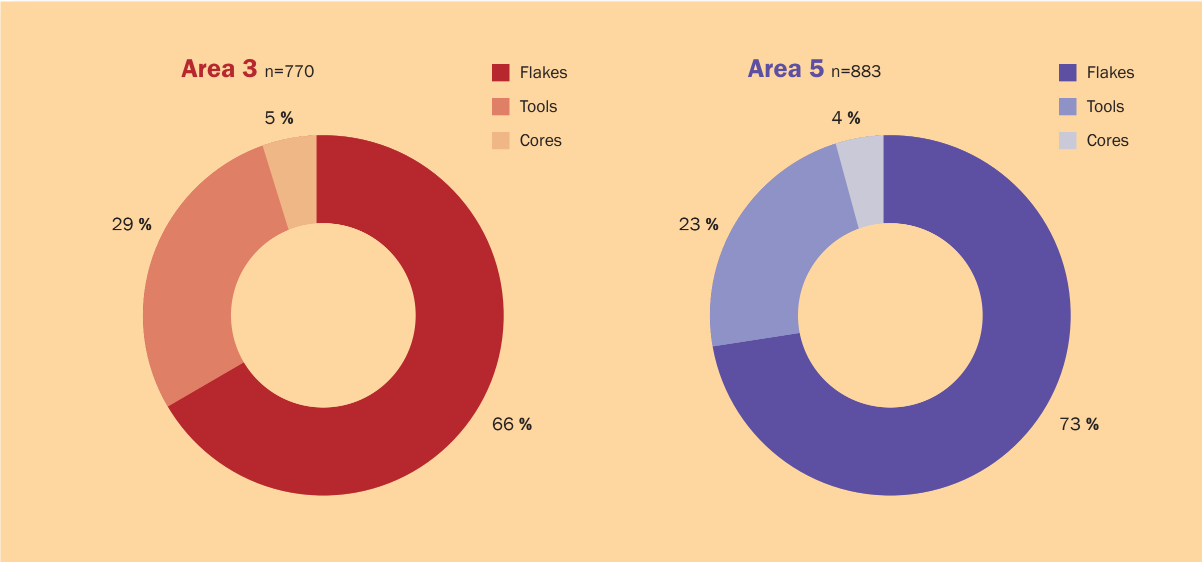


Figure 12. Major artefact classes in the analysed Kaaraneskoski assemblages. The category "Flakes" includes flake fragments.

of individual occupation episodes that took place over a period of some four hundred years. This implies a mobile lifestyle. The groups visiting Kaaraneskoski were using several campsites and transporting lithic material from one site to another within their regular mobility pattern. In this kind of a situation the assemblage of each campsite is hardly pristine, but consists of both artefacts manufactured *in situ* and artefacts brought in from the previous campsite. Since the material brought in is likely to consist mainly of tools, tool blanks, and cores, this will add to the tool percentage, even if some tools will again be taken along to the next site.

The high tool percentage may also be associated with the spatial distribution of activities at the site. Although both analysed assemblages include a large amount of debitage, most of the primary reduction may have taken place away from the actual residential area. The assemblages would, thus, represent highly selected collections of artefacts, which would mean that the artefacts classified as debitage should also show evidence of selection, since they could be expected to consist to a large degree of blanks for tools rather than debitage from primary reduction.

Figure 12 shows also the proportions of cores and flakes in Areas 3 and 5 at Kaaraneskoski. The core percentages – 5% in Area 3 and 4% in Area 5 – are not unusual in Finland. Similar percentages have been published from Hossanmäki in Lohja (3.7%; Pesonen & Tallavaara 2006:15, Table 2) and Kauvonkangas in Tervola (2.6% and 4.5%; Rankama 2002:86–87, Fig. 6). The range of core percentages at archaeological sites appears wide and is subject to a variety of sources of error (see Rankama 2002:86–88 for a further discussion of core and tool percentages in Sweden and Finland). Since there is no standard number of detachments that one core can be expected to produce, it is difficult to know what core percentages as such might reflect. Extremely high or low percentages might evoke arguments about transportation, caching or other special treatment of cores, but with average percentages such discussion is not possible.

Tool categories

Since the various, and numerous, tools are one of the most distinctive features of the Kaaraneskoski assemblage, this chapter discusses implements not only from Areas 3 and 5 but in part also from the other excavation areas, test pits, and surface finds. The quartz tool categories identified can be seen in **Figure 13** (also **Appendix 1: Table 5**), which lists the tools from Areas 3 and 5. Only the most abundant categories will be discussed below in more detail.

As can be seen, both areas have yielded a great variety of tools, indicating that numerous different activities took place in each area. This means that we are

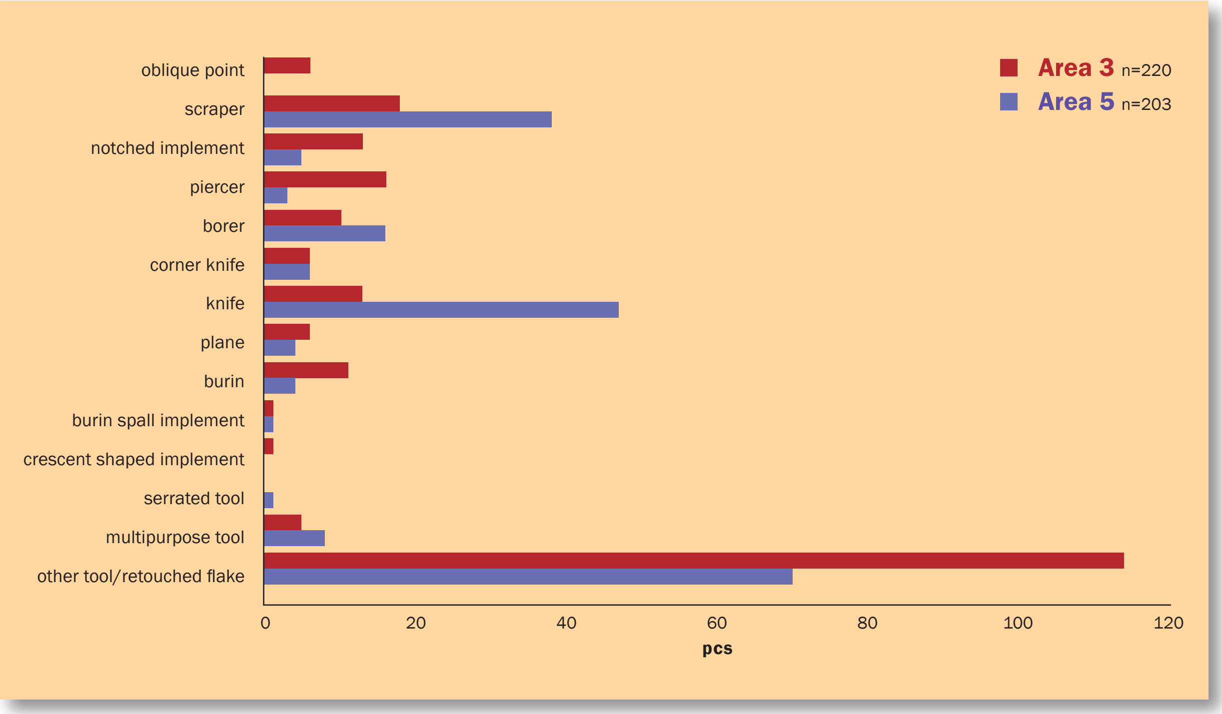


Figure 13. Quartz tool categories from Areas 3 and 5 at Kaaraneskoski.

not dealing with single purpose sites, such as hunting stations.

The most abundant tools are retouched flakes, the exact function of which cannot be determined without microwear analysis. There may be a discrepancy in classification as regards the classes "knife" and "retouched flake". Since Area 5 was excavated in 1998, while Area 3 was excavated partly in 1997 and partly in 1998, the assemblages were analysed at different times. This may be reflected in the number of pieces classified as "knives": in the Area 5 assemblage, analysed later and with more experience, more of the retouched pieces were perhaps classified as "knives", while in the earlier analysis the more general category "retouched flake" was considered safer.

As became evident already in the discussion about tool percentages, tools of almost all categories are more numerous in Area 3 than in Area 5. The most notable exception to this is the scrapers. Borers and multipurpose tools are also slightly more numerous in Area 5. The total numbers are, however, so small that the differences cannot be given statistical significance. The shape of Area 5 also renders it difficult to judge what these discrepancies might mean.

Oblique points

This tool category has been extensively discussed by Manninen and Knutsson (*this volume*) and Manninen and Tallavaara (*this volume*). The oblique quartz point is a Late Mesolithic artefact form that has an eastern and northern distribution in Fennoscandia, i.e., it is found mostly in Finland and northern Norway. Its distribution complements that of the contemporaneous handle cores, which have a more western and southern distribution, but these artefacts seldom occur at the same sites. There is a region in northern Sweden where oblique points, although rare, are found side by side with handle cores (Manninen & Knutsson *this volume*:e.g., Fig. 5, Fig. 11.). The Kaaraneskoski assemblage includes both artefact types and seems, thus, to be the easternmost extension of this region.

Oblique quartz points are characterised by an almost triangular shape, where the narrow base widens towards the tip that is formed by a feathered edge of the flake. The cutting edge is oblique, or sometimes transverse. The base is shaped by backing, usually on both edges (Manninen & Knutsson *this volume*:Fig. 2.). The classification of oblique points is often difficult, since most of

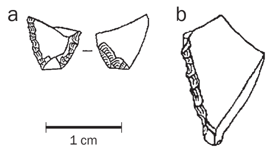


Figure 14. Oblique point fragments of quartz from Area 3 at Kaaraneskoski. Scale in centimetres. Drawings by T. Rankama[2].

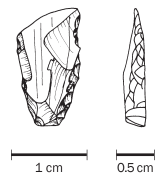


Figure 15. Oblique slate point from Area 2 at Kaaraneskoski. Scales in centimetres. Drawings by T. Rankama.

them are fragmentary. The best identification criterion is the backing, but even this can be at times difficult to ascertain. The presence of backing is, however, essential, since without it, natural fragments can easily be included in the category (Knutsson 1998). The Kaaraneskoski assemblage includes six artefacts classified as oblique point fragments of quartz, all from Area 3. The most compelling fragments are illustrated in **Figure 14**.

In addition to the quartz points, the assemblage includes a unique slate point shaped in the oblique point style (**Fig. 15**). Its edges and base have been shaped first by invasive retouch and then by backing, and the rest of the dorsal surface is polished. It may have been a flake detached from a polished slate adze that was recycled as an oblique point. The implement was found in Area 2, one of the test trenches in the eastern part of the site (**Fig. 5**). Area 2 lies at the same elevation as Area 3 and is probably roughly contemporaneous with it. If most of the quartz oblique points from the site are to some degree suspect, this slate point makes it clear that the oblique point concept was alive among the group(s) that visited Kaaraneskoski.

Scrapers and planes

The assemblage includes 86 artefacts classified as scrapers and 15 artefacts classified as planes. Scrapers and planes are tools that are usually associated with wood, bone, antler, or hide working. In the classification used here, planes differ from scrapers in that they are larger and the working edge is nearly straight and very sturdy. The edge angle is close to 90˚, although precise angle measurements have not been made. Without a microwear analysis the justification of these tools being classified as planes can, of course, be questioned.

The shapes of the scrapers are fairly heterogeneous. As is most often the case in Finnish Stone Age assemblages, the most important feature of the tool seems to have been the working edge, which is usually convex and has been modified with semi-abrupt retouch. The shape of the rest of the implement has apparently been considered less important. **Figure 16** shows a selection of scrapers from the various excavation areas at Kaaraneskoski. Their sizes vary. Some of the scrapers are represented by only a short fragment, barely more than the working edge (**Fig. 16:k, l**). These "slugs" may have been broken – intentionally or unintentionally (cf., Knutsson 1988:150) – or, alternatively, resharpened until only a short piece has remained (cf., Gould 1977:83). In the latter case, they must have been hafted. Some scrapers have two opposing working edges, one with normal, the other with inverse retouch (**Fig. 16:a**). This kind of "propeller" retouch suggests that the pieces were not hafted, or that the hafting method allowed for easy detachment and re-attachment. The recovered pieces are not long enough to have been placed in a hole in the middle of a long shaft with the edges showing from the opposite sides of the shaft, as recorded in some ethnographic examples (e.g.,. Itkonen 1948:313, Fig. 126.)

Despite the generally varied morphology of the scrapers, a couple of more specific scraper types can be distinguished. One is high and almost rectangular, such as the ones shown in **Figure 17**. The other is the circular, or thumb-nail, scraper, which is fairly common in the assemblage (n=12). Scrapers of this type have been found all over the site (**Fig. 18**). Thumb-nail scrapers are often included in Mesolithic assemblages in Finland, but since no quantification of their occurrence at sites of different ages has ever been made, positive statements about their chronological position cannot be made. The implement type would, in any case, be worth a proper study.

As indicated above, only a small proportion – 13 out of 73, or 15% – of the scrapers could be classified as to the method of producing the blank. Five scrapers were made from bipolar flakes, another five from plat-

[2] For the catalogue numbers of this and the subsequent artefact illustrations, see **Appendix II**.

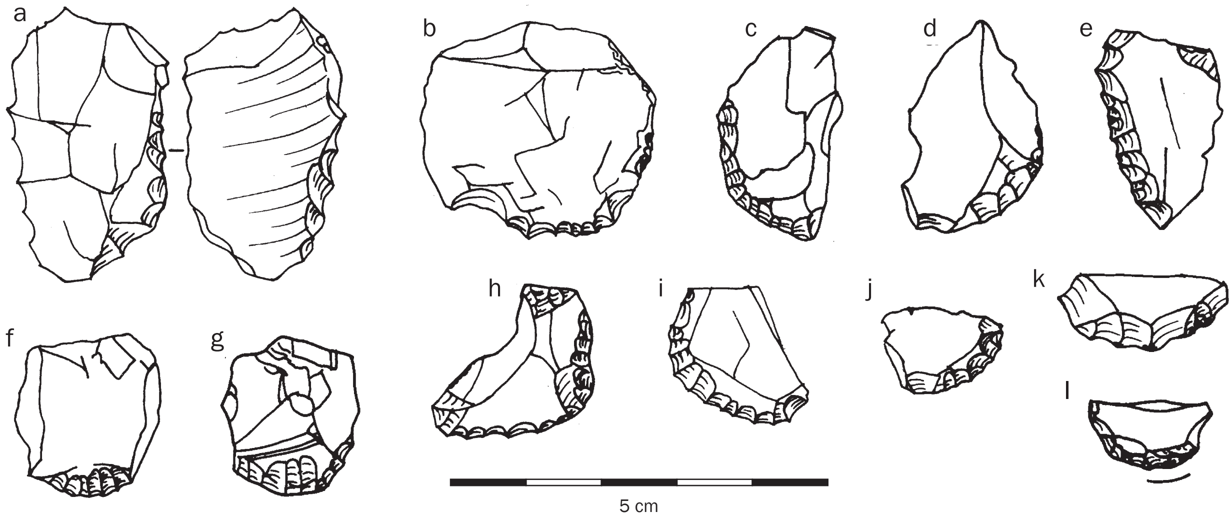


Figure 16. A selection of quartz scrapers from Kaaraneskoski. a–b, g, i, and k from Area 5; d–f, h, and j from Area 3; l from Area 2; c is a stray find. Scale in centimetres. Drawings by T. Rankama.

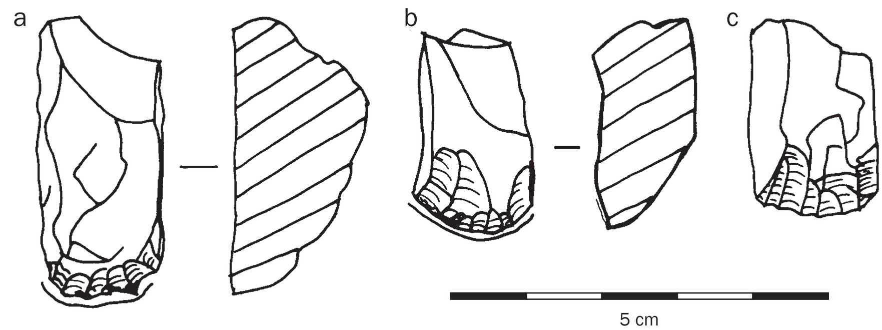


Figure 17. Long, narrow, and high quartz scrapers from Kaaraneskoski. a from Area 2; b–c are stray finds. Scale in centimetres. Drawings by T. Rankama.

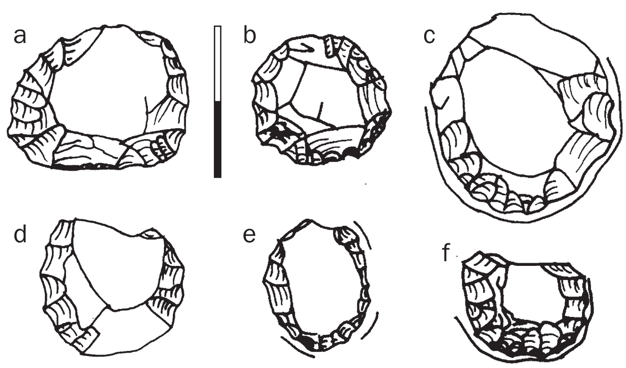


Figure 18. Circular "thumb-nail" quartz scrapers from Kaaraneskoski. a and d from Area 5; b stray find; c from a test pit; e from Area 3; f from "Paula's pit". Scale in centimetres. Drawings by T. Rankama.

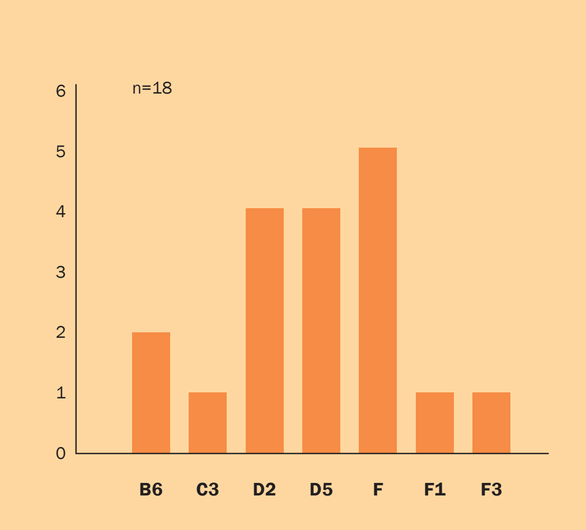


Figure 19. Fragment classification of scrapers from Kaaraneskoski.

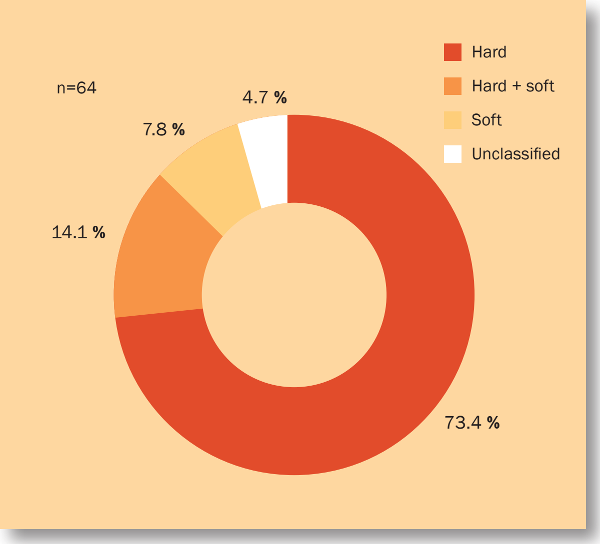


Figure 20. Scraper use wear at Kaaraneskoski.

form flakes, and one from a platform-on-anvil flake. This goes against the expectation that platform flakes would make better blanks for scrapers. The small number of the sample, however, renders the result equivocal. In addition, two scrapers were made from bipolar cores. This mode of behaviour has been observed also in Sweden, where it is considered common (Knutsson 1988:100).

Fragment classification of the scrapers faced the same kind of problem as method classification: due to the extensive secondary modification, the fragment was identified in only 18 scrapers, or 21% of the total. The identified fragments display an interesting, if predictable, pattern (**Fig. 19; Appendix 1: Table 6**). Scrapers are most commonly made from complete flakes (F) and the largest fragment types (cf., **Fig. 8**): side fragments (B6, D5) and middle fragments (D2). The three other fragment types identified (C3, F1, F3) may represent intentional truncation, although evidence of it was not recognised in the analysis (cf., Knutsson 1998:150, Fig. 93). The pattern of blank selection agrees well with what has previously been recorded in Finland (Rankama 2002:95–96, Table 4) and Sweden (Callahan *et al.* 1992:50–54).

Scraper macrowear at Kaaraneskoski shows the same general pattern as at the Kauvonkangas site in Tervola (Rankama 2002:92–93, Fig. 13–14). A total of 88 scrapers from all excavation areas (including stray finds) were analysed. Slightly over a quarter of them (28.1%) displayed no recognisable wear marks at magnifications up to 24x. Of the 64 scrapers with use wear, 73.4% had hard wear, an additional 14.1% both hard and soft wear, and a mere 7.8% soft wear (**Fig 20; Appendix 1: Table 7;** cf., Broadbent & Knutsson 1975). This emphasises again the fact that the use of scrapers was more versatile than generally believed, i.e., that their use was not restricted to soft materials. Seven of the twelve thumb-nail scrapers had hard wear and three had no recognisable wear at all. This seems to suggest that this particular tool form was meant primarily for working hard materials.

Notched implements

Notched implements are a characteristic tool form at Kaaraneskoski and have also been encountered in other assemblages in Finland (e.g., Rankama 2002:90, Fig. 11:1–2). As can be seen in **Figure 21**, they come in various shapes and sizes. The common factor is a notch shaped by retouch. Attempts to quantify the size of the notch to find some patterning have so far failed.

Piercers and borers

Piercers and borers are implements that have a pointed but sturdy shape with either use wear or very small retouch on the point (**Fig. 22**). The retouch, which can be the result of use rather than intentional modification, can often be found on two surfaces indicating use with a twisting motion. **Figure 22:c** is a piercer with a thin and narrow straight edge suitable, e.g., for poking a hole in leather.

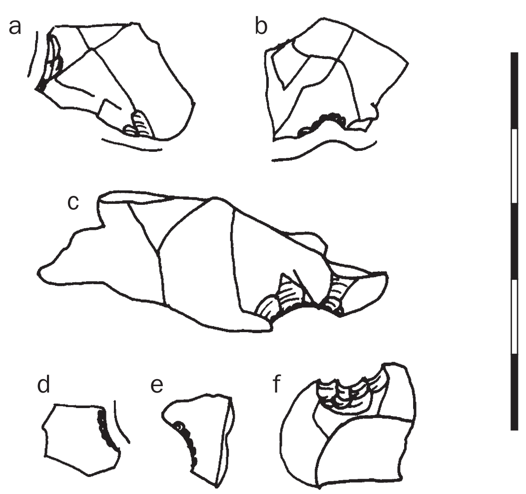


Figure 21. Notched quartz implements from Kaaraneskoski. a from Area 5; b stray find; c–f from Area 3. Scale in centimetres. Drawings by T. Rankama.

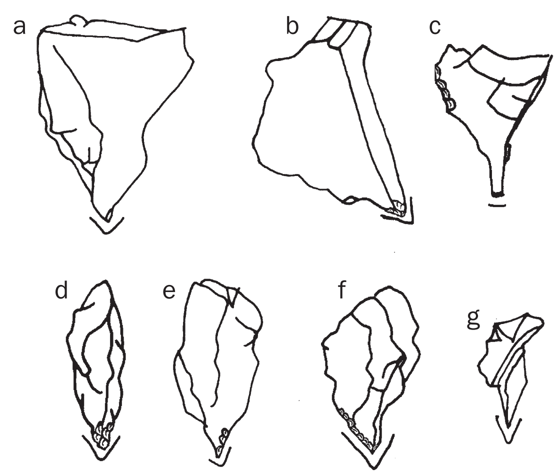


Figure 22. Quartz piercers and borers from Kaaraneskoski. a, b, d, e from Area 5; c, f, g from Area 3. Scale in centimetres. Drawings by T. Rankama.

Knives

Knives are the most numerous tool category in the Kaaraneskoski quartz assemblage (see **Fig. 13**). They come in various sizes and shapes but are always characterized by a thin, sharp edge with small retouch formed either by intentional modification or during use. **Figure 23** shows a selection of knives. Some of the knife edges are straight (**Fig. 23:i**), others convex or even concave (**Fig. 23:m**). The length of the cutting edge varies. Some pieces have evidence of use on more than one side of the flake (**Fig. 23:b**). The shape of most of the pieces suggests that they have not been hafted but held in the hand.

Among the knives, one can distinguish a number of special tools referred to as corner knives (**Fig. 24**). These implements are usually fairly large and wider than

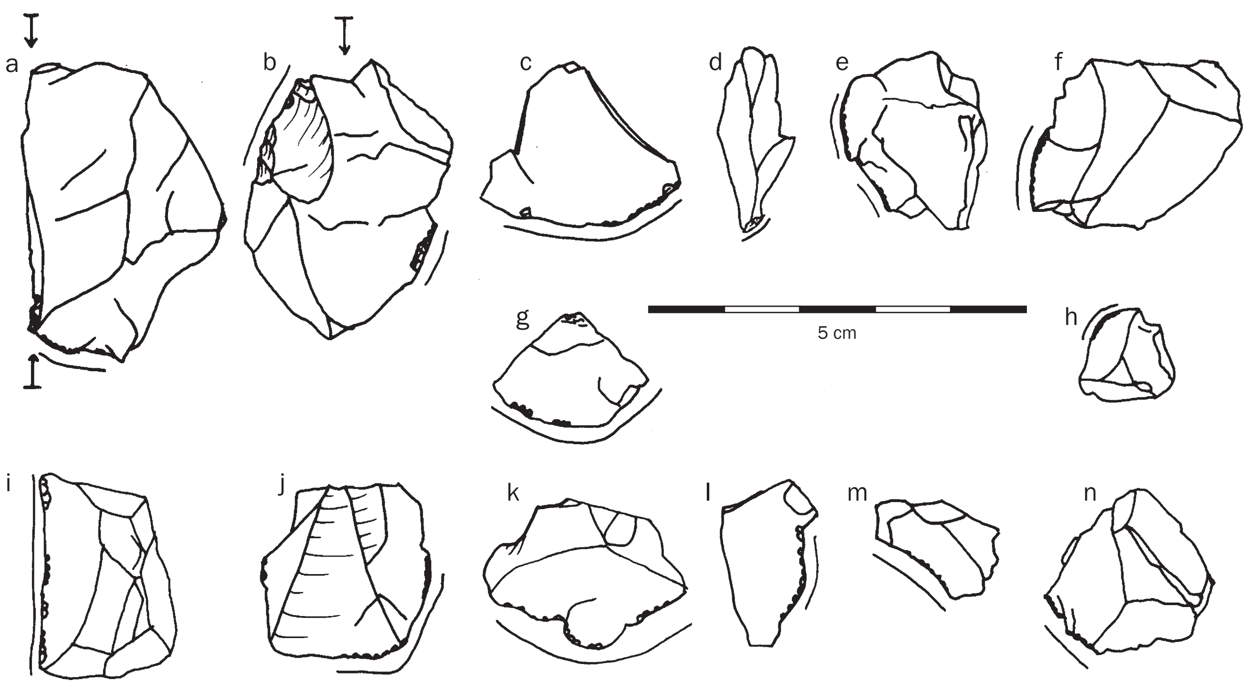


Figure 23. A selection of quartz knives from Kaaraneskoski. a, i from Area 3; b, d, e, k–n from Area 5; c stray find; f from Area 2; g and j from "Paula's pit"; h from Area 4. Scale in centimetres. Scale in centimetres. Drawings by T. Rankama.

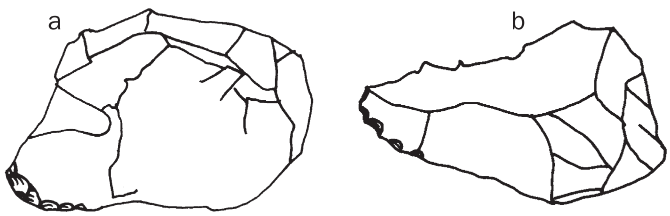


Figure 24. Corner knives of quartz from Area 5 at Kaaraneskoski. Scale in centimetres. Drawings by T. Rankama.

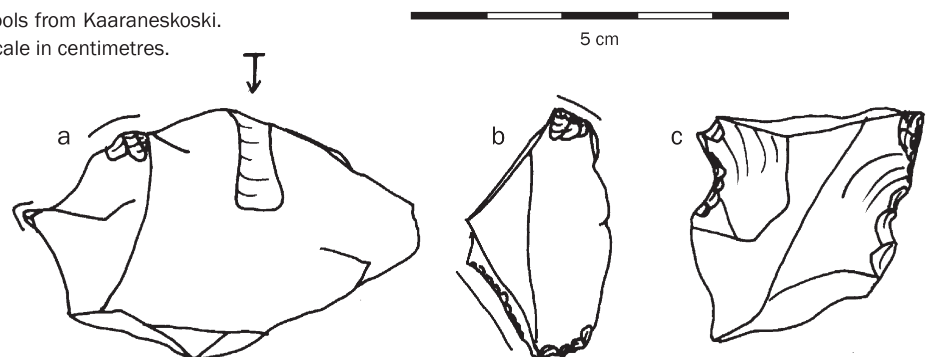


Figure 25. Multipurpose quartz tools from Kaaraneskoski. a–b from Area 5; c from Area 3. Scale in centimetres. Drawings by T. Rankama.

their length; they fit well between the thumb and the first finger, and have retouch around one corner. The tool type was first recognized within the Early Metal Age assemblage from the Ala-Jalve site in Utsjoki (Rankama 1997:14, Fig. 8:9) and is included also in the Kauvonkangas assemblage from Tervola (Rankama 2002:88–89, Fig. 9).

Multipurpose tools

Using a single piece of quartz for several purposes was a typical mode of behaviour at Kaaraneskoski, as indicated by several tools with more than one working edge recognisable through the presence of retouch and/or use wear. Their mode of use depended on the shape of the flake: if it had both a suitable point for perforating and a long thin edge for cutting, it could be used for both purposes. Several multipurpose tools have been recognised. They include, for example, cutting and scraping edges in different combinations with notches, piercers, and so on (**Fig. 25**).

Patterns of quartz tool blank selection

The above drawings have illustrated the great range of variation of shape among the blanks selected for use or secondary modification at Kaaraneskoski. A look at the reduction methods used for producing the tool blanks

Method	bipolar	platform
Area 3		
scraper	2	0
plane	1	1
multipurpose tool	2	0
corner knife	1	1
notched implement	4	1
perforator/piercer	10	2
burin	2	3
knife	2	11
oblique point	0	1
other	16	16
total	**40**	**36**
Area 5		
scraper	3	3
plane	1	0
multipurpose tool	3	2
corner knife	0	2
notched implement	1	0
perforator/piercer	4	1
burin	2	1
knife	21	3
other	19	7
total	**54**	**19**

Figure 26. Reduction methods of tool blanks in Areas 3 and 5 at Kaaraneskoski.

reveals that 36.9% of the tools from Area 3 and 36% of the tools from Area 5 lent themselves to be classified as to blank production method. **Figure 26** shows that out of the 76 classified tool blanks in Area 3, 40 (52.6%) are bipolar flakes and 36 (47.4%) are platform flakes. In Area 5, bipolar flakes dominate more clearly: 54 blanks out of a total of 73 classified (74%) are bipolar, while platform flakes only total 19 (26%). This goes against the assumption that platform flakes would have been sought after as tool blanks because of their sturdiness and better resistance to breakage. The pattern can, however, be at least partly explained by the large general size of bipolar flakes at Kaaraneskoski (**Fig. 10**). In Area 3, the largest number of classified production methods can be found in the "other" category, in which the bipolar and the platform method are tied at 16 pieces each. The other large tool categories are perforators/piercers, among which bipolar flakes dominate 10:2, and knives, where platform flakes dominate 11:2. No clear pattern, thus, emerges in Area 3.

In Area 5, it is specifically the tool categories "knife" and "other" that cause the clear domination of the bipolar method. This is an understandable pattern, since both knives and retouched flakes, many of which were probably used in some kind of a cutting action, can be expected to benefit from the thinness and straightness of a typical bipolar flake. The fact that bipolar flakes remain unfragmented more often than platform flakes (Callahan *et al*. 1992; Driscoll 2011) renders them even more desirable as blanks for cutting implements. The rest of the tool categories are so few in number that no patterns can be detected.

As regards the flake fragments that were selected as tool blanks, in Area 3 it was possible to classify 113, or 61.7% of the tools (**Fig. 27**). In Area 5 the percentage

Fragment	A1	A3	B1	B2	B3	B5	B6	C1	C2	C3	D1	D2	D5	F	F1	F2	F3	total
Area 3																		
scraper														2			1	3
plane												1				1		2
multipurpose tool										1			1		1			3
corner knife							2					2		2				6
notched implement							1					2	4	1			1	9
piercer							1				1		3	3	1		1	10
perforator					1				1		1		1					4
side blade																		0
burin							1						1	2				4
knife		1			4		2							11	1	1	4	24
oblique point												1		1				2
other implement					1		6		1			10	5	13	4		6	46
total		**1**			**6**		**13**		**2**	**1**	**2**	**16**	**15**	**35**	**7**	**2**	**13**	**113**
Area 5																		
scraper							2					2	2		1			7
plane																		0
serrated flake																		0
multipurpose tool														3			1	4
corner knife													1	1				2
notched implement												1					1	2
piercer																		0
perforator							2							4				6
burin								1					1		1			3
knife						1	7			3		2	9	6			2	30
other implement	1		1	2	1	1	3	1	2	1		8	4	6	2	1	5	39
total	**1**		**1**	**2**	**1**	**2**	**14**	**2**	**2**	**4**		**13**	**17**	**20**	**4**	**1**	**9**	**93**

Figure 27. Identified fragments from which tools in Areas 3 and 5 have been manufactured.

was lower, 93 implements or 46.7%. The pattern here is similar to that already detected among the scrapers. Complete flakes (F) dominate as tool blanks in both analysed areas, and the most common fragments used as tools are the largest ones: side fragments (B6, D5) and middle fragments (D2). The large number of distal fragments from complete flakes is also notable.

The patterns of blank selection are very close to those recorded in the assemblage from Kauvonkangas in Tervola (Rankama 2002:91–93, 95–96, Table 3, 4). They also agree well with what has been observed in Sweden (Callahan *et al*. 1992:50–54; Darmark *et al.* 2005; Vogel 2006a; 2006b).

Slate points

The oblique point made of slate has already been discussed above, but it is not the only slate arrowhead from Kaaraneskoski. The assemblage includes three other slate points that seem to form a "type". The points are small, thin, long, and narrow, and although made from slate they are shaped by retouch. Their surfaces have not been ground or polished, and all in all they have the air of being improvised from accidental slate fragments. **Figure 28** shows the points that have been found in different areas around the site: one in Area 1 in the east, one in Area 5, and one as a stray find at the lower edge of the sand quarry.

The authors are not aware of any exact parallels to the Kaaraneskoski slate points in Finland. At the Riitakanranta site close to Lake Sierijärvi in Rovaniemi, some 74 kilometres east-south-east of Kaaraneskoski, ten small coarsely worked slate points, as well as some fragments and roughouts, were encountered in 1990 (Kotivuori 1996:93). These have been assigned to the "Slettnes type" named after the Slettnes site on Sørøya, northern Norway (cf., Hesjedal *et al.* 1996:173–174, Fig. 170), although the association can be questioned. Two slate points more clearly associated with the "Slettnes type" have been found at the nearby Jokkavaara site in Rovaniemi (Torvinen 1999:234, Fig. 15). Both the Riitakanranta and the Jokkavaara site have yielded early pottery of the Sär 1 type and can, thus, be considered slightly younger than Kaaraneskoski. The slate points from these sites differ from the Kaaraneskoski points in being tanged. At least the Jokkavaara points are also more carefully made, while the Kaaraneskoski points are more haphazard in workmanship. It may, nevertheless, be significant that the three sites are located fairly close to each other and are also of fairly similar age.

Cores

Most of the quartz cores from Kaaraneskoski represent the normal bipolar or irregular platform core types (cf., **Fig. 11**). In addition, the assemblage includes a few microblade cores that are worth a closer look. The first one is an almost cubical core from Area 3 (**Fig. 29**). It is made from very high quality quartz with barely any internal flaws, and has been struck from several directions. The first face (on the left in **Fig. 29**) is bi-directional. The striking platforms at each end are flat and the striking angle is c. 90˚. The second face from the left shows a part of the scars of the first face, but also scars in a different direction emanating from the lower right corner. To work the third face the core has been turned 90˚ anti-clockwise and another flat surface has been used as the striking platform. Even here the striking angle is close to 90˚. The width of the last microblades detached from the core is only about 4–5 mm.

The core brings to mind the cubical cores from Zhokov Island in the Siberian High Arctic, dated to c 7800 BP (Giria and Pitul'ko 1994:32, 34–43, Fig, 6–10). That site is, of course, too early and too far away to have had any direct influence on Kaaraneskoski. It is difficult to find any counterparts for the core from less remote areas, however. The core shape may, of course, be purely opportunistic, but the approach of the knapper appears quite purposeful and demonstrates a high degree of determination.

Two other microblade cores, both from Area 5, display features that are not typical of Finnish quartz assemblages. Although irregular due to the quartz raw material, they have an elongated shape with blade detachments only at one narrow end (**Fig. 30**), and the base of the core in **Figure 30:a** has been shaped to a keel with several detachments from below. They can, thus, be assigned to the handle core category typical for Late Mesolithic assemblages in Sweden and the rest of (southern) Scandinavia (Knutsson 1993; Olofsson 1995; Olofsson 2003; Manninen & Knutsson *this volume).*

This core type is not at home in Finnish Mesolithic contexts. Its presence has been claimed in several assemblages in southern Finland (Schulz 1990), but Knutsson

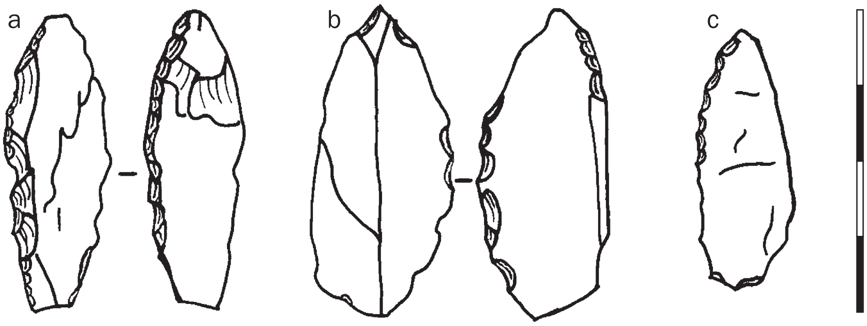
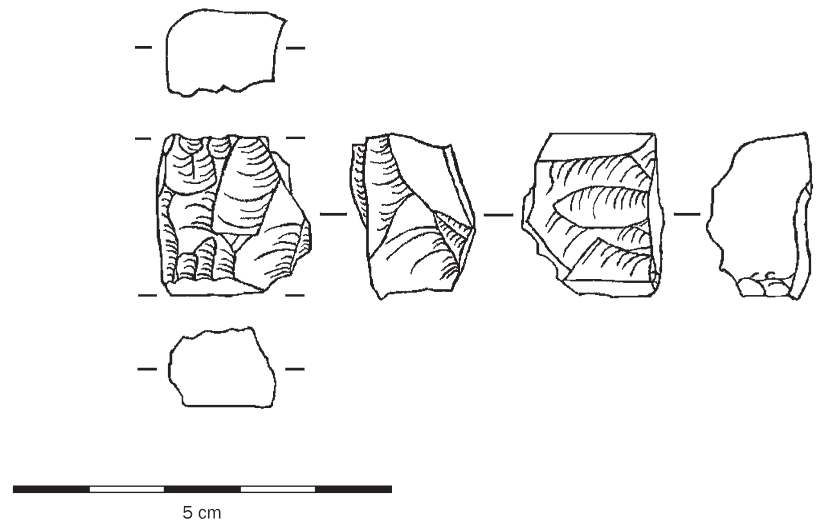
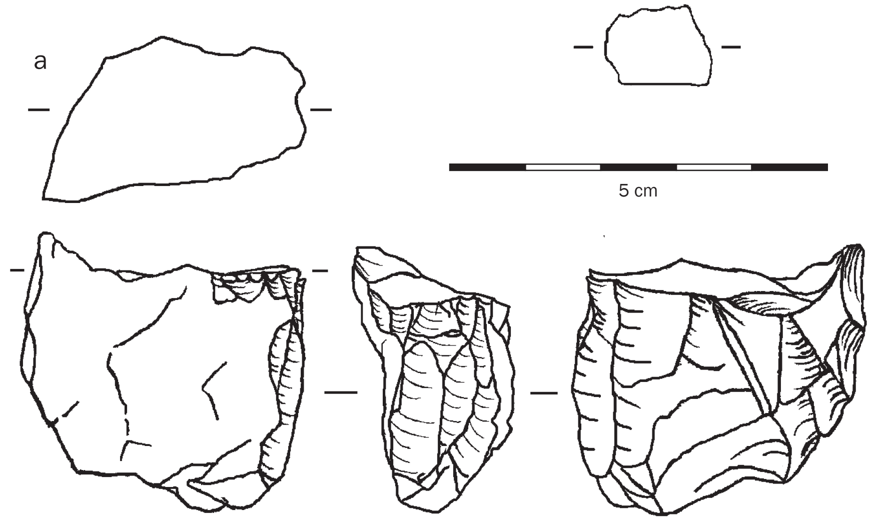


Figure 28. Slate points from Kaaraneskoski. a from Area 5; b stray find; c from Area 1. Scale in centimetres. Drawings by T. Rankama.

Figure 29. Microblade core of quartz from Area 3 at Kaaraneskoski. Scale in centimetres. Drawing by T. Rankama.



a



b

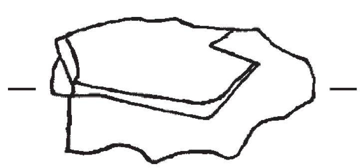
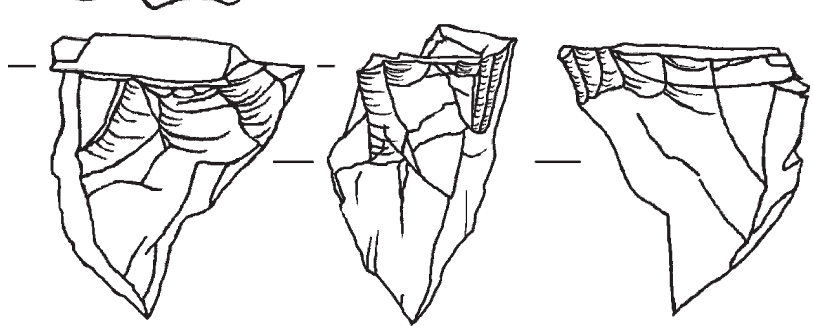


Figure 30. Handle cores of quartz from Area 5 at Kaaraneskoski. Scale in centimetres. Drawings by T. Rankama.



questioned the identification soon after the original publication (Knutsson 1993). According to Knutsson's interpretation, the pieces identified by Schulz as handle cores (or "boatshaped cores" in Schulz's terminology) more probably represent broken bipolar cores that have microblade-like flake scars (Knutsson 1993:12).

Our survey of the cores identified as "boatshaped cores" by Schulz indicates that the group includes no handle cores, and even their classification as platform cores is often questionable. For example, the core from Hopeanpelto in Askola (KM 13064:313; Schulz 1990:Fig. 6g) has a "platform" slanted in two directions, from which detachments would not have been possible – certainly not in the direction of the scars depicted by Schulz. Another core from Koppeloniemi in Hyrynsalmi (KM 20634:114-4; Schulz 1990:Fig. 6e) displays a distinct crushed bipolar saddle where Schulz indicates the striking platform. The edge is so rounded that no platform detachments could have been made. Similar comments can be made about the other "boatshaped cores" identified by Schulz.

Since the Kaaraneskoski site lies so close to the Swedish/Scandinavian "handle core area" (Manninen & Knutsson *this volume*, Fig. 11), it was reasonable to ask whether other Late Mesolithic sites in the vicinity might have yielded handle cores as well, and whether the "handle core area" might in that way be eventually expanded eastwards. There are, however, few excavated Late Mesolithic assemblages in Finland at a reasonable distance from Kaaraneskoski. The closest one is from the above-mentioned Jokkavaara site in Rovaniemi, where both a Late Mesolithic and an Early Neolithic component have been identified. Excavations have been carried out at Jokkavaara several times between 1954 and 1991 (see Torvinen 1999). Because of a theoretical possibility of finding counterparts for the Kaaraneskoski handle cores at Jokkavaara, the Late Mesolithic quartz assemblage was studied in April 2008. No handle cores were identified in the assemblage. Kaaraneskoski, thus, remains the only Finnish site where handle cores of quartz have been encountered.

Microblades

Even though the assemblages include seven quartz cores classified as microblade cores, the number of artefacts that can be classified as microblades is minuscule. Only eleven microblades or "microblade shaped flakes" are included, five from Area 3, three from Area 5, two from Area 4 and one from Area 2. Two of the microblades from Area 5 and one from Area 3 have been retouched; one of them is, in addition, notched. They do not, however, display the characteristics of side blades, as one would expect if they had been used as insets in slotted bone implements. Apparently they have not been used in the typical microblade fashion, or if they have, they have not been retouched (cf., e.g., Olofsson 2002:74).

The small number of microblades would seem to suggest that although microblade cores are definitely present, they were not reduced to a great degree at Kaaraneskoski. They were probably brought to the site ready-shaped, and were for some reason discarded there. One core (KM 31377:27), nevertheless, appears to be exhausted. Another explanation for the scarcity of microblades might be that most of the produced microblades were transported away from the site, or that they were so small and prone to breakage that they have not been preserved or identified in the recovered assemblages.

Fracture patterns

Although the value of fracture analysis in the form presented by Callahan and co-workers (Callahan e*t al.* 1992) has recently been questioned (Tallavaara *et al.* 2010), it may be useful to have a look at the fracture patterns in the Kaaraneskoski assemblage. Even if much benefit cannot be gained by comparing them with experimental fracture patterns, it is still possible to compare them with each other and with other archaeological assemblages.

The fracture patterns for Areas 3 and 5 are presented in **Figure 31** (also **Appendix 1: Table 9;** see **Appendix 1: Table 8** for the grouping of fragment categories). As can be seen, the patterns look very similar – so much so that one might begin to suspect a bias caused by the analyst. However, when the diagrams are compared with the diagram from House 35 at Kauvonkangas in Tervola, analysed by the same person, a clear difference emerges (**Fig. 32**; Rankama 2002:Fig. 17). In the Kauvonkangas diagram whole flakes dominate, while side fragments are much more common at Kaaraneskoski. Since these categories are difficult to confuse, the patterns from Kaaraneskoski must be considered valid.

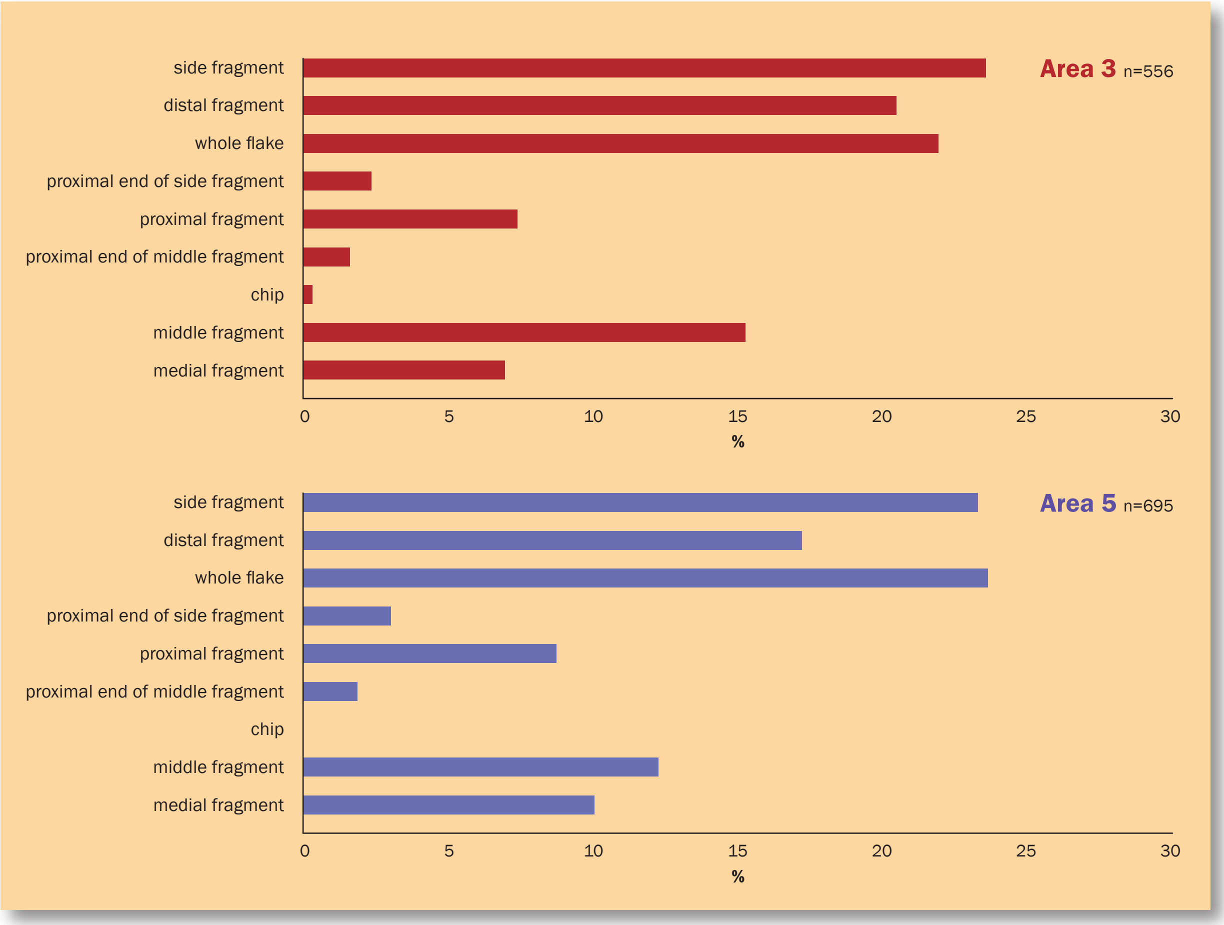


Figure 31. Quartz fracture patterns of Areas 3 and 5 at Kaaraneskoski.

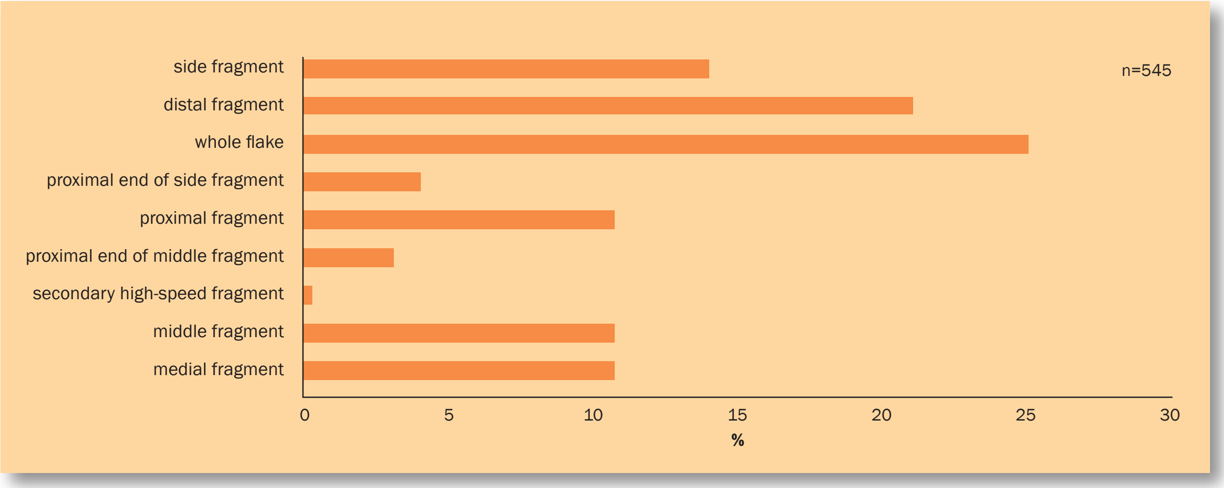


Figure 32. Quartz fracture pattern from House 35 at Kauvonkangas in Tervola.

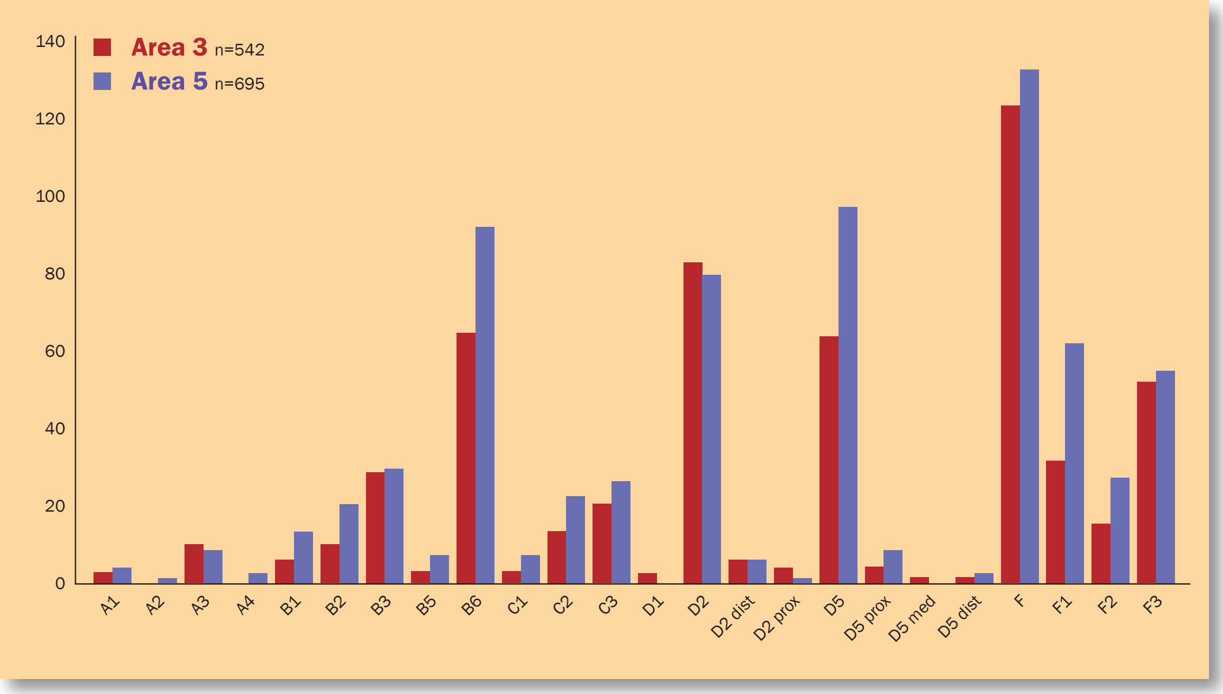


Figure 33. Detailed quartz fracture patterns from Areas 3 and 5 at Kaaraneskoski.

A more detailed look at the fragment distribution at Kaaraneskoski (**Fig. 33; Appendix 1: Table 10**) reveals an interesting pattern. Like all fracture pattern diagrams in this paper, this diagram includes only the unused flakes and fragments – the tools are excluded. In both analysed areas the most common fragments are B6, D2, D5, and F. These are the very same fragments that are most commonly used as tools (cf., **Fig. 27**), i.e., unbroken flakes and the largest side and middle fragments (**Fig. 34**).

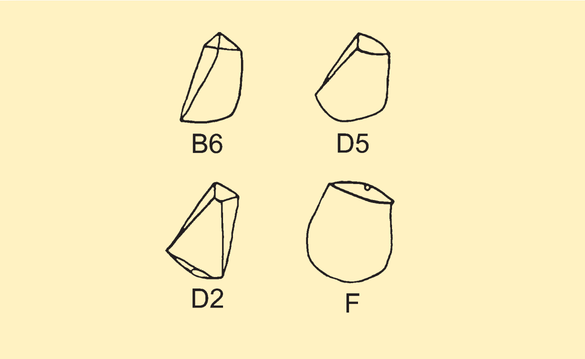


Figure 34. The most common quartz flake fragments at Kaaraneskoski.

The prevalence of these fragments among both the unused flakes and the tools might suggest that the quartz users at Kaaraneskoski have simply taken the fragments that were the most numerous in the knapped assemblage to use. In the absence of valid experimental "ideal fragment distributions" it is difficult to judge whether a pristine knapped assemblage might have had a fragment distribution of the kind present at Kaaraneskoski, and to what degree, for example, the hardness of the hammer might have influenced the fragment distribution. A look at fracture mechanics suggests otherwise, however. As indicated above, quartz fragmentation is caused by two parallel forces. Radial fracturing causes the flakes to split lengthwise, while perpendicular breaks are bending fractures caused by vibrations in the flake after detachment (Callahan *et al.* 1992:30–32, 38–38, 50, Fig. 2). If these forces act in parallel but independently, one would expect the number of bending fractures to remain constant regardless of whether the flakes remained initially whole or fractured radially. In other words, if a flake that splits lengthwise during detachment is also fractured by bending, it should produce twice as many proximal, medial, and distal fragments as a flake that does not split radially. In the Kaaraneskoski assemblages bending fractures of whole flakes (F1, F2, F3) are, however, much more

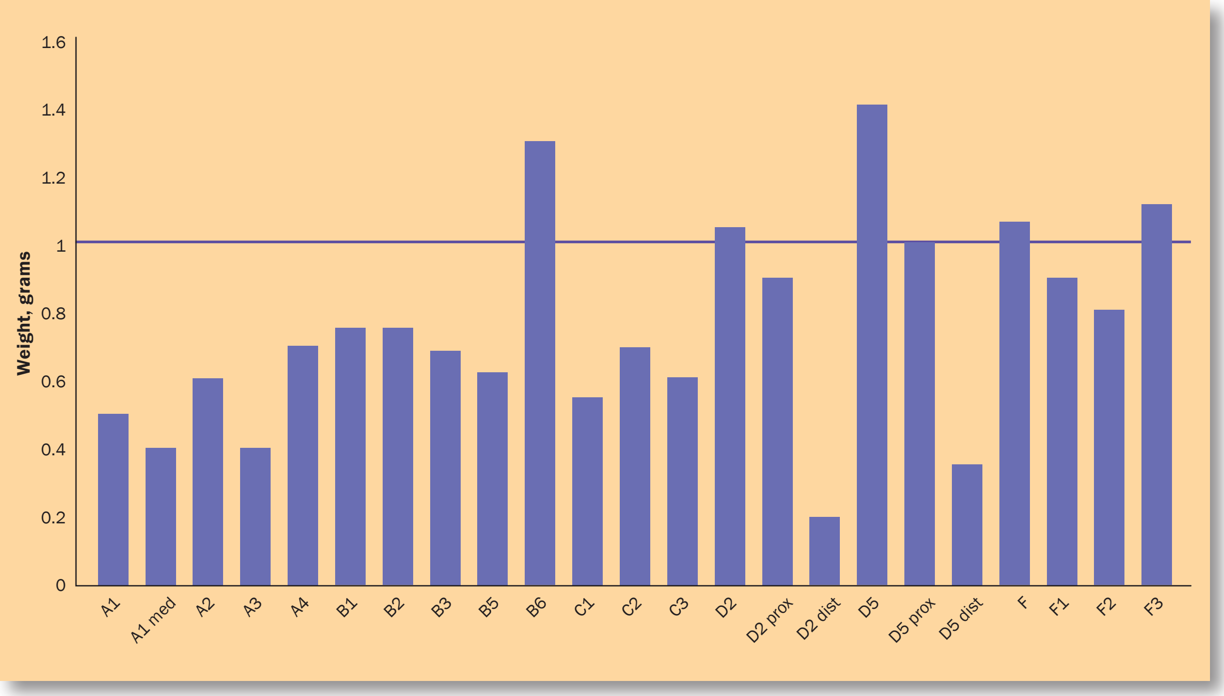


Figure 35. Average weights of different quartz fragment categories in Area 5 at Kaaraneskoski.

common than bending fractures of side or middle fragments (B1, B2, B3, C1, C2, C3, D2 prox/dist, D5 prox/med/dist). This suggests that the Kaaraneskoski assemblages do not consist of material knapped *in situ*, but are selected. In both Area 3 and Area 5 the quartz flake assemblage, thus, seems to consist largely – but not exclusively – of tool blanks that have been brought to the site ready-made from somewhere else.

To study this proposition further, the average weights of the different fragments were calculated in the Area 5 assemblage. The purpose of this was to see if the preferred fragments were indeed larger, and thus, more usable as tools than the rest of the fragments. The fact that these fragments look large in the illustration of fragment types (**Fig. 8**) is misleading, since in reality, for example, side fragments of small flakes may, of course, be much smaller than, say, distal ends or middle fragments of large flakes.

The weight calculations are adjusted. Since the flakes have been weighed by catalogue number, average weights had to be used for those catalogue numbers that included more than one artefact. Nevertheless, the result should be close enough to reality to give an idea of the situation. The average fragment weights in Area 5 can be seen in **Figure 35** (also **Appendix 1: Table 11**). The diagram has been adjusted by removing a few very heavy obvious outliers. As can be seen, the heaviest fragments on average are B6, D2, D5, F, and F3, i.e., the ones that are the most abundant in the assemblage. These are the only fragments with an average weight above 1 gram. This supports the conclusion that the assemblage has been selected in favour of tool blanks.

The excavated areas at Kaaraneskoski, thus, do not appear to be where the primary reduction of cores took place. This is supported by the fact that small chips are practically absent from the analysed assemblages. A primary reduction site should contain a large amount of small chips, which are formed in every stage of quartz reduction. The 4 mm mesh screening will have excluded a part of the potential chip population, but more than a couple of chips would have been recovered during trowelling, had they been abundant in the assemblage.

The fact that the assemblage, nevertheless, contains a fairly large number of cores suggests that other parts of the site may have been used for primary reduction. The assemblages found in the excavated areas could have been selected from the knapping areas. Some ready-made tools were, however, also undoubtedly brought to the site from the mobile groups' previous campsites.

Spatial analyses

Area 3

Figure 36 shows the distribution of all quartz artefacts in Area 3. Two distinct clusters can be detected: one in the south-western corner of the area (Cluster 1) and another practically in the middle (Cluster 2). The north-eastern corner of the area has a less concentrated spread of artefacts. Cluster 1 is separated from the rest of the area by a curving band devoid of finds. Whether this represents the wall line of a circular dwelling, as the pattern might

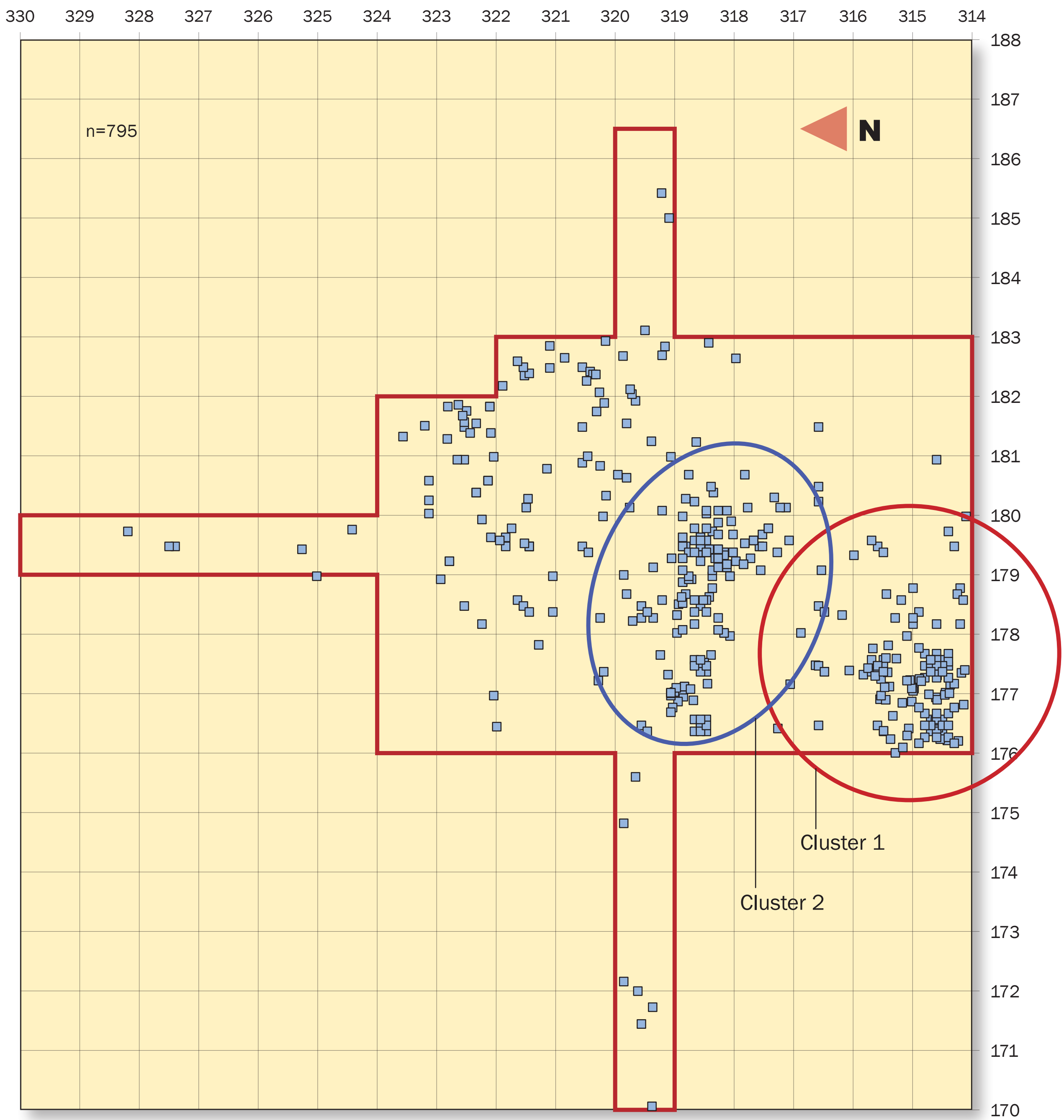


Figure 36. The distribution of all quartz artefacts in Area 3 at Kaaraneskoski.

suggest, is difficult to judge, since in that case only a quarter of the potential dwelling would have been excavated. The topographical survey of the site does not indicate any house pit in this area.

A distribution plan of this kind does not give a full picture of the finds density. Because of this, another plan was made using the Surfer program (**Fig. 37**). This plan includes a third dimension and shows that the highest density of artefacts is actually in Cluster 2. Cluster 1 shows as a much lower peak. The difference between **Figures 36** and **37** is due to the fact that the three-dimensional distribution diagram is able to take into account the fact that several finds may have been found on the same spot (and, consequently, be denoted by a single symbol), which the two-dimensional plan cannot display. The question then is whether there are any differences in the artefact composition between the clusters in Area 3.

Figure 38 shows the distribution of different kinds of tools in Area 3. Most of the tool categories are fairly evenly distributed. A few interesting patterns can, however, be observed. The scrapers and planes, for example, concentrate heavily in Cluster 1 and in the north-eastern corner, but are scarce in Cluster 2. Hardly any piercers and borers have been found outside Clusters 1 and 2. Burins are almost exclusively found in Cluster 2. The numbers of tools in each category are, of course, small and the results, thus, not statistically reliable, but

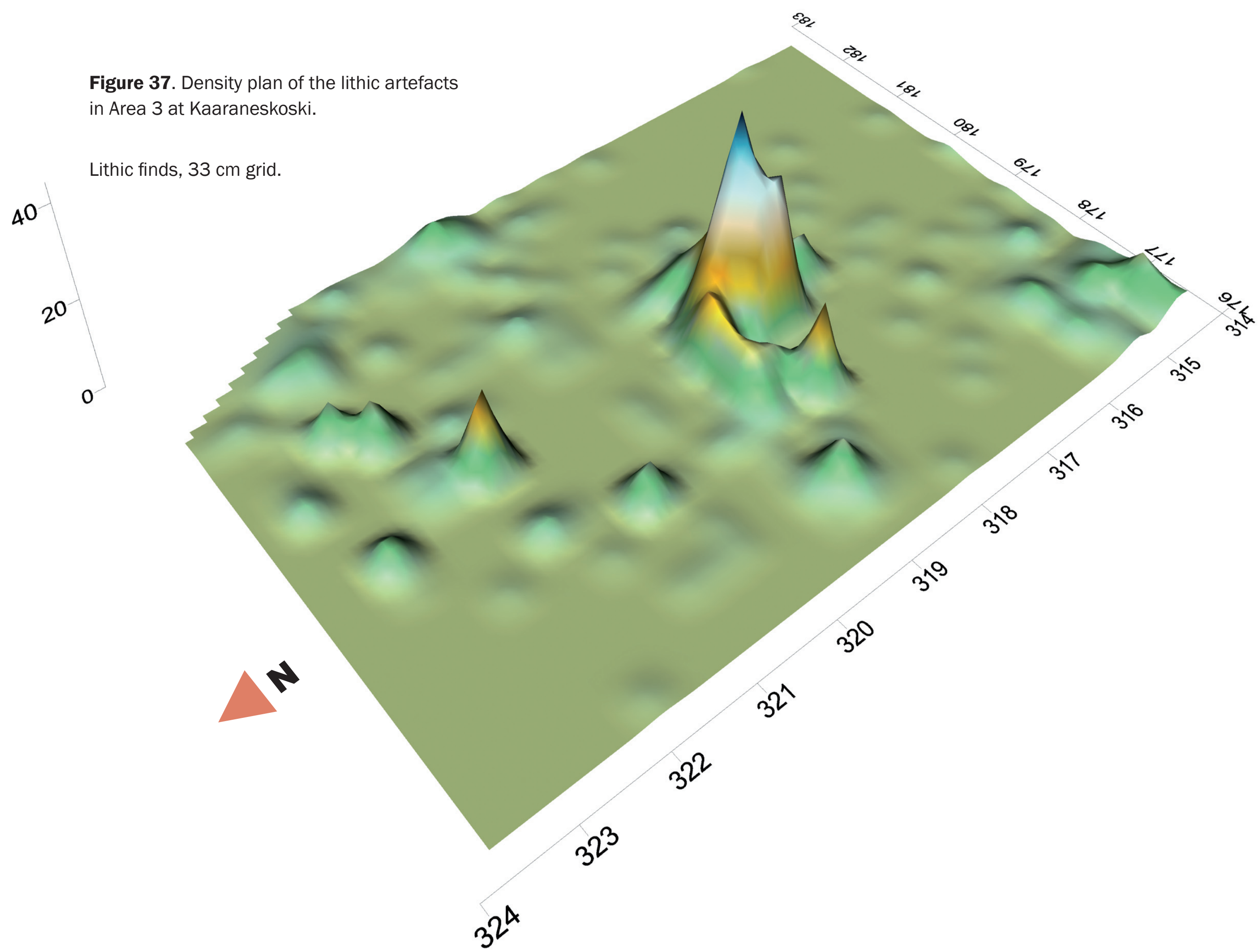


Figure 37. Density plan of the lithic artefacts in Area 3 at Kaaraneskoski.

Lithic finds, 33 cm grid.

the pattern, nevertheless, suggests some kind of differentiation in activities within the area.

The distributions of the most common fragments in Area 3 (**Fig. 39**) show slight variation. All of the fragment types are common in Cluster 2, but in Cluster 1 all except D2 are scarce. Whole flakes (F) are more numerous outside the clusters than any of the fragments. Combined with the tool data this might suggest that D2 fragments were considered particularly suitable for scraper blanks. This result is in agreement with what has

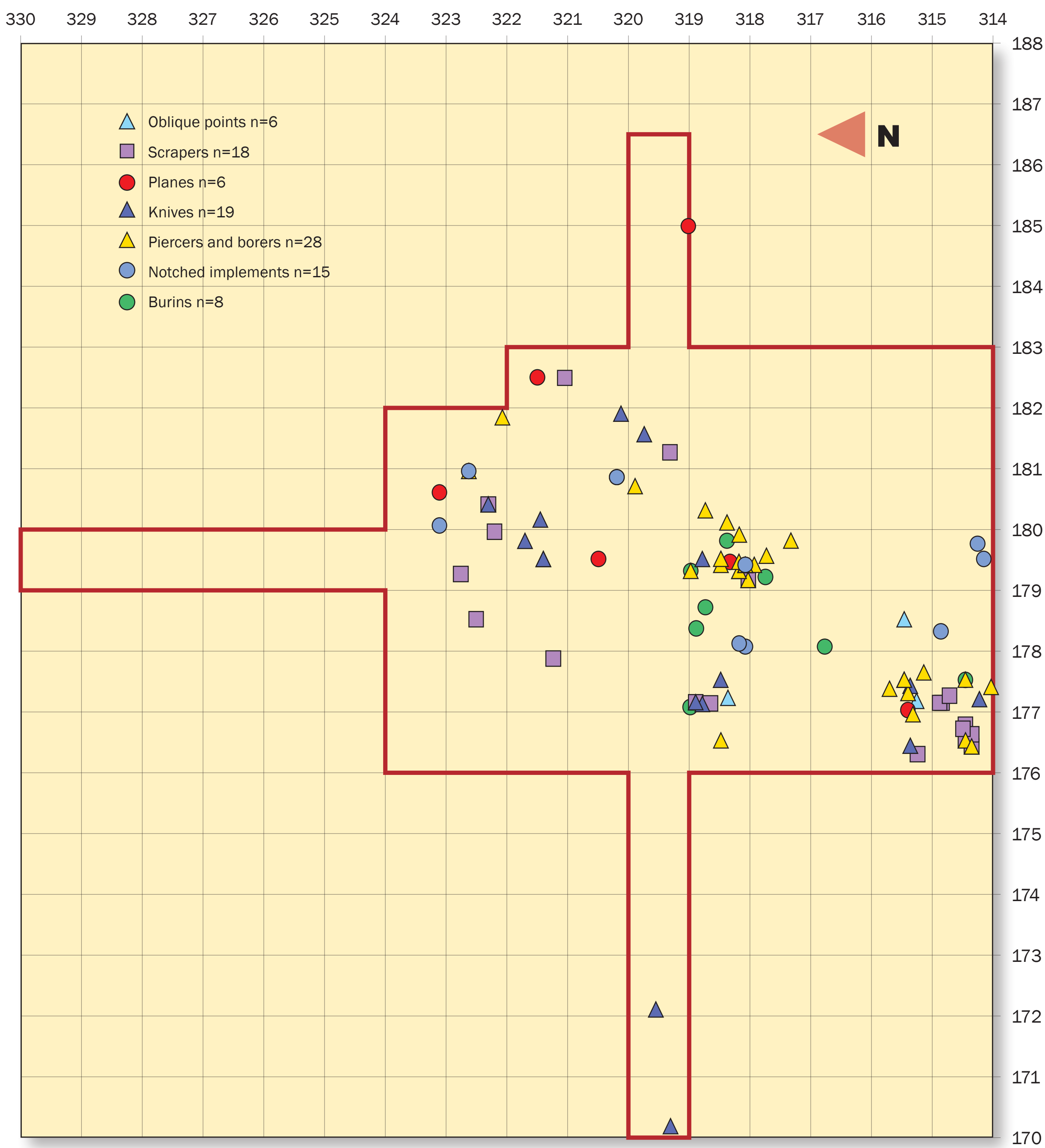


Figure 38. The distribution of tools in Area 3 at Kaaraneskoski.

earlier been found in the analysis of the Kauvonkangas site in Tervola (Rankama 2002:104–106, Fig. 27).

All in all, the distributions of the tools and fragments in Area 3 are so even that definite conclusions based on them are extremely difficult to draw. One way to look at the distribution, nevertheless, is to see a circular tent in Cluster 1, an intense activity area in Cluster 2, and an area of less intense activity in the north-eastern corner. The validity of this interpretation is impossible to test with the current distribution studies.

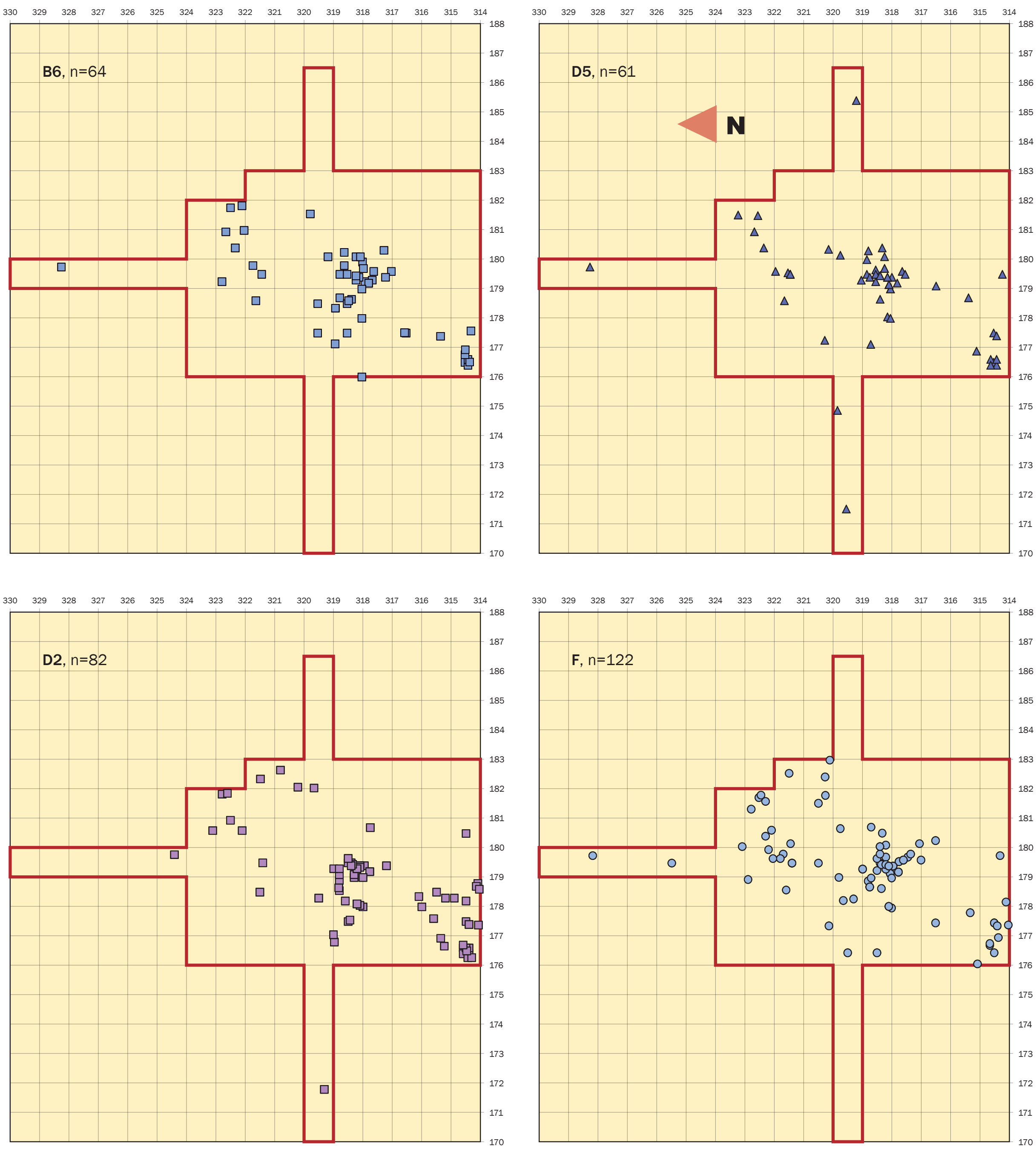


Figure 39. Fragment distributions in Area 3 at Kaaraneskoski.

Area 5

Figure 40 shows the distribution of all quartz artefacts in Area 5. In the eastern N–S trench (interval 130–131) the untouched podsol soil was discovered during excavation to have been covered by a layer of sand that was almost 20 cm thick in places. This was apparently the result of gravel quarrying activities where the top sod and sand from the quarry east of this excavation area was pushed away with a bulldozer before the area was taken into gravel production. The finds from this part of Area 5 are, thus, mixed and consist partly of artefacts

Figure 40. The distribution of all quartz artefacts in Area 5 at Kaaraneskoski.

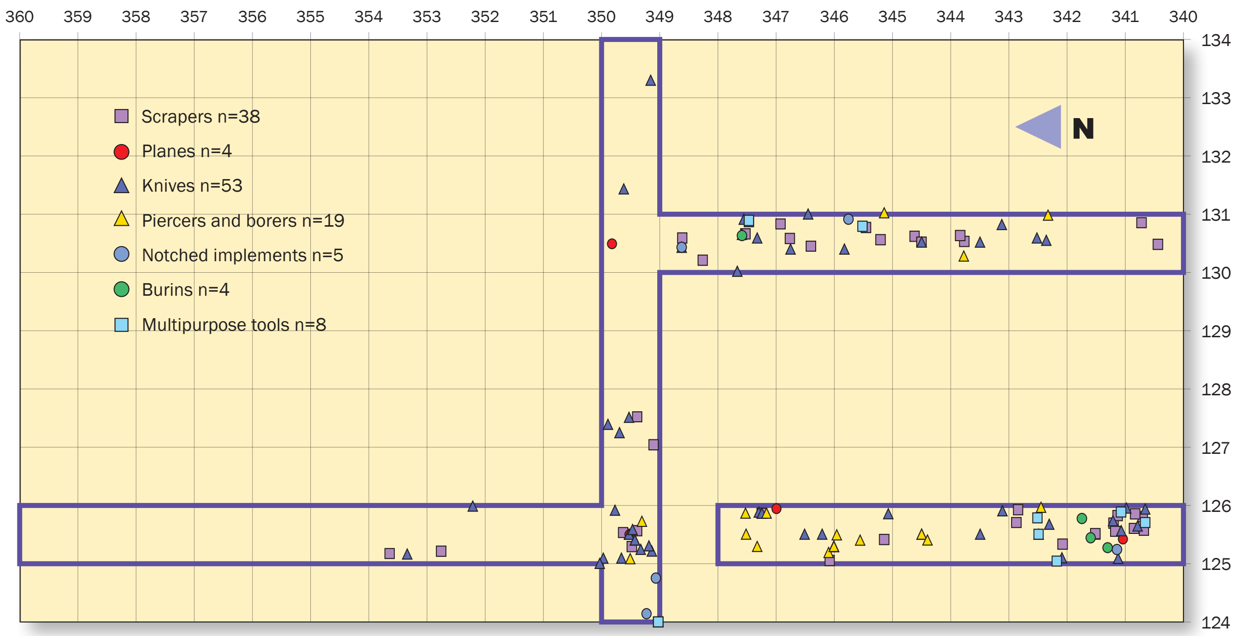


Figure 41. The distribution of tools in Area 5 at Kaaraneskoski.

from the area that has been quarried away. The artefact distributions in this area are, thus, not reliable and will be disregarded.

What remains for study, then, are predominantly the finds in the western N–S trench (interval 125–126). The distribution here appears to consist of five tight, separate clusters. The concentration of the finds in such tight clusters is strange in itself, but can hardly be studied further because of the narrowness of the trenches.

The distribution of different tool types in Area 5 (**Fig. 41**) shows more variation than in Area 3, i.e., the composition of the clusters varies. Scrapers and planes are the most numerous in Cluster 1 but the other clusters only contain one or two of these. Knives are spread somewhat more evenly, but the largest number is found in Cluster 4. Piercers and borers are concentrated in Clusters 2 and 3, and are practically absent elsewhere, whereas notched implements and burins are found almost exclusively in Cluster 1. It appears, thus, that there has been more differentiation between activity areas in Area 5 than in Area 3. The numbers of tools in the main categories are high enough to render the distributions valid.

The distributions of the main fragment types (**Fig. 42**) are also interesting. Cluster 1 contains the highest concentration of D2-fragments, whereas B6-fragments and complete flakes (F) concentrate in Cluster 4 more than anywhere else. The coexistence of scrapers/planes and D2 fragments in Cluster 1 again suggests that D2 fragments were the prime scraper blanks. This is understandable, considering the usually sturdy quality of D2 fragments (see **Fig. 34**). B6 fragments and complete flakes, on the other hand, appear to be associated with knives. This pattern again agrees with what has been found in the analyses of the Kauvonkangas site in Tervola (Rankama 2002:104–106, Fig. 27). Whole flakes and side fragments with long, sharp cutting edges make excellent knives even without secondary modification and have been gathered in the "cutting (tool) area" in Area 5.

The distributions of identified tools and fragments, thus, indicate that activity areas have been differentiated in Area 5. With the long and narrow excavation areas it is difficult, however, to find out what kinds of larger patterns these separate activity clusters might represent. The analysis has, nevertheless, shown that distribution studies of fragments and tools are worth the effort and might produce even more interesting results when applied to larger area excavations. The results also support the interpretation of the Kaaraneskoski assemblages as highly selected collections of tool blanks.

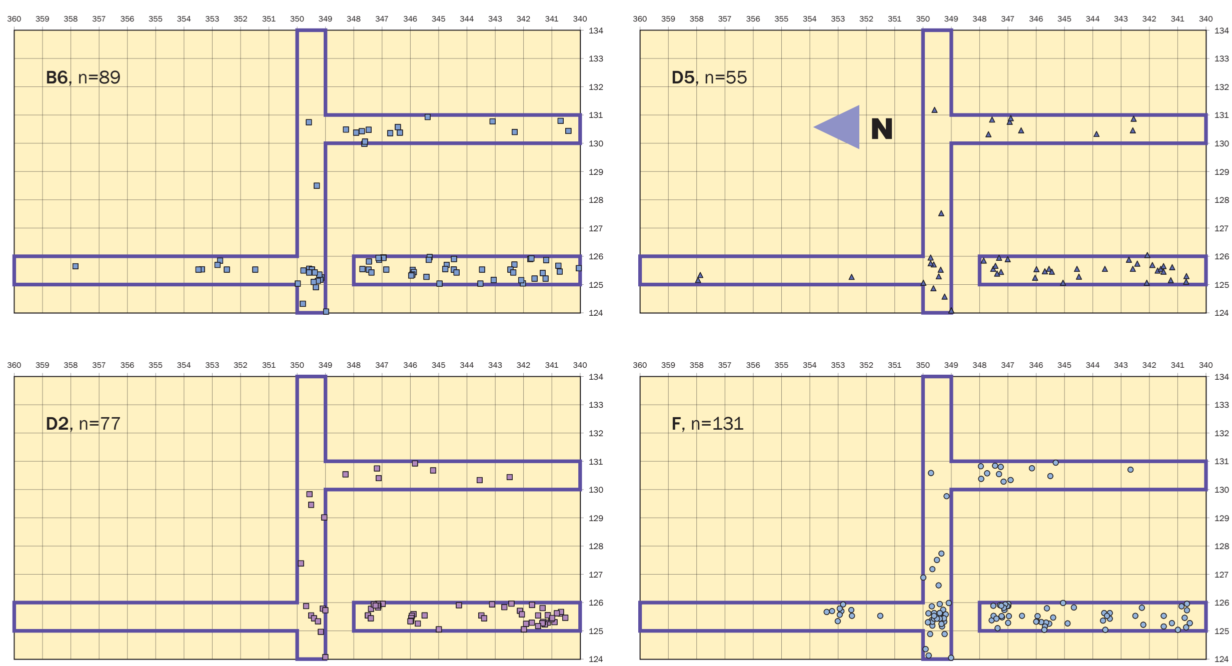


Figure 42. Fragment distributions in Area 5 at Kaaraneskoski.

Discussion

The quartz assemblages from the different excavation areas at Kaaraneskoski show remarkable uniformity in spite of the potentially 400 year age difference between the upper and lower ends of the site. This suggests a continuation of activity patterns throughout the site's occupation span. The analyses of the material suggest that the site was one stop in the migration pattern of mobile hunter-gatherers. The uniformity of the quartz assemblages may be taken to indicate that the residents belonged to the same demographic unit that used the site generation after generation. There is evidence of continuity in activity patterns throughout the history of the site, suggesting culturally reproduced modes of behaviour as regards both lithic reduction and use. This can be seen also in the innovative attitude of the residents towards the use of slate as a tool material, which seems to continue through time.

The large quantity and diversity of tools found in the excavated areas and also around the site as stray finds suggest that Kaaraneskoski was not a single purpose site, such as a hunting station. Instead, a variety of activities took place. The assemblage includes tools for cutting, scraping, piercing, and grooving, as well as for hunting. The wear marks on the scrapers indicate that these tools were not exclusively used in activities associated with the processing of prey. Accordingly, it can be suggested that the groups residing at Kaaraneskoski at different times were demographically varied, probably representing whole family units.

The quartz assemblage as a whole suggests that the primary reduction took place somewhere else than in the excavated areas at Kaaraneskoski. If quartz had been knapped *in situ,* the debitage to tool ratio should have been different. Knapping always produces large amounts of unusable debitage, including small chips that were absent at Kaaraneskoski. Accordingly, the assemblages should have contained much more debitage and fewer tools if they had been produced in the excavated areas. The fragment distribution can also be taken to indicate selection. The assemblages are dominated by whole flakes and large side and middle fragments that can be interpreted as tool blanks carried to the excavated areas from somewhere else. The size of the blanks is deduced not only from the fragment type but also from the average weights of the different fragment categories.

It follows from the above that the *chaîne opératoire* of quartz reduction at Kaaraneskoski is highly incomplete: it begins away from the excavated areas and the recovered artefacts are selected. The results of the analysis, nevertheless, allow a reconstruction of certain features of the chain(s). There is evidence of five different reduction concepts at the site. These are the bipolar method, the platform method, and three different concepts of microblade production: from handle cores, from conical cores, and from a (single) cubical core. It is questionable how much microblade production actually took place. Since one of the conical microblade cores is exhausted, at least some microblades may have been produced. Otherwise one would expect the core to have been discarded at the previous stop of the group residing at Kaaraneskoski.

As regards the bipolar and platform flake production, the analyses indicate that they represent different *chaînes opératoires* in the Kaaraneskoski assemblage. The bipolar flakes are as large as, or larger than, platform flakes, which indicates that bipolar reduction began with large nodules instead of almost exhausted platform cores, as is often suggested to have happened in Sweden. Nor are there discrepancies in the numbers of bipolar and platform cores as compared with the numbers of bipolar and platform flakes. This supports the conclusion that these two methods were used side by side, not as successive parts of a single *chaîne opératoire*.

Tool production was opportunistic in the sense that any blanks with an edge suitable for the purpose the user had in mind could be selected, and there was no effort to produce formal tool types. There were no restrictions about using one blank for several purposes. Most of the tools display a minimal amount of modification. Only the scrapers and the oblique points have more evidence of deliberate shaping. In the other tools, the functional edge or point sufficed.

Nevertheless, the selection of tool blanks from among the fragments was very consistent at Kaaraneskoski throughout its occupation period. The choices seem functionally obvious and have parallels in other assemblages both in Finland and in Sweden. Therefore, it is difficult to judge whether any cultural factors influenced the selection. The fact that bipolar flakes were preferred makes one wonder why platform reduction was employed at all. The picture may be slightly distorted, however, by the fact that the sturdiest implements, viz. scrapers, were in most cases impossible to classify as to reduction method. One might expect platform reduction to have been preferred for scraper blank production, but this cannot be substantiated with actual evidence.

The use of the platform method may have been opportunistic and dependent on the shape of the quartz nodules. On the other hand, it might have been culturally determined. What was certainly culturally determined was the microblade concept and the shape of the handle cores – but not by the Kaaraneskoski residents' own culture. The assemblage as a whole is quite at home with what we know about the Finnish quartz using Stone Age, which is characterised by the prevalence of the bipolar method, the separation of the bipolar and platform methods in the *chaîne opératoire*, and the virtual absence of typologically distinct tool forms. The presence of the oblique point as a concept strong enough to have been applied to slate also supports the conclusion that the Kaaraneskoski population was part of the eastern quartz technocomplex. On the other hand, the facts that the handle cores and other microblade cores appear to have been barely reduced at the site and that no typical microblade objects, such as inserts for bone implements, are included in the assemblage, suggest that the cores might have been acquired through contacts with neighbours in the south-west. This might explain even the presence of the exhausted microblade core: it may have been obtained as a curiosity, not as a functional object.

The use of the tools and blanks and the spatial distribution of activities at the site may also be defined as parts of the *chaîne opératoire*. The evidence for the spatial differentiation of activities is stronger in Area 5, but a case can be made for its presence also in Area 3. Both specific functional tool categories and blanks suitable for these tools are concentrated in particular locations in the excavation areas. In Area 5 these are separated by empty spaces, emphasising the differentiation. The small size of the excavated areas makes further inferences about the spatial distributions difficult, however.

Conclusions

The Kaaraneskoski site in Pello can be interpreted as a locality that has been used by groups of Late Mesolithic mobile hunter-fisher-gatherers as one stop in their regular mobility pattern. The site consists of a number of small, consecutive living floors at different elevations that attest to its recurrent use by people camping close to the shoreline over a period of a few hundred years. The evidence supports the conclusion that whole family units were present and that they belonged to the same population throughout the use period of the site.

The site is located at the interface of two major Late Mesolithic interaction spheres: the south-western handle core area and the eastern oblique point area. The Kaaraneskoski assemblage includes elements derived from both of these spheres. This indicates contacts between the eastern and western groups in this region.

The eastern elements are more strongly represented at Kaaraneskoski than the south-western ones. As a consequence, the site can be regarded as an eastern settlement with contacts towards the west. Whether the groups residing at Kaaraneskoski included areas west of the Tornionjoki River in their regular mobility pattern is difficult to judge. It is possible, however: an overlap in the distributions of handle cores and oblique points in northern Sweden suggests a degree of eastern activity there, and there are also later sites with Finnish pottery types in the region (e.g., Halén 1994). The current national border at the Tornionjoki River would obviously have been of no consequence in the Late Mesolithic.

The Kaaraneskoski quartz assemblage is selected from material knapped somewhere else than in the excavated areas. The selection has been deliberate and consistent throughout the use period of the site. The same applies to the reduction methods employed. This attests to a culturally reproduced way of approaching the quartz raw material. Further evidence of this is found in the mode of tool production.

The analyses of the quartz assemblages at Kaaraneskoski have made it possible to provide answers to the questions about site structure, the character of the occupation, the character of the lithic assemblage, and the activities performed at the site as outlined in the beginning of this paper. The *chaîne opératoire* approach has made it possible to look at the Kaaraneskoski assemblages as parts of a wider whole and throw light on the organisation of lithic production, as well as on contacts between Late Mesolithic societies in the region.

The analyses have also served their purpose in adding to the bulk of comparative material on quartz use in Finland. Much more is needed, however, before conclusions about possible regional or chronological differentiation in quartz technology during the Finnish Stone Age can be drawn.

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Appendix I. Raw data of the quartz analyses of the Kaaraneskoski assemblage 1/2

	Bipolar	Platform	Total
Area 3			
Flakes	159	122	281
Tools	42	36	78
Cores	21	15	36
Area 5			
Flakes	319	86	405
Tools	54	17	71
Cores	17	20	37

Table 1. Quartz reduction methods in Areas 3 and 5 at Kaaraneskoski (cf. Fig. 9).

Whole flakes	
Area 3	grams
Platform, n= 37	0.60
Bipolar, n=42	1.55
Area 5	
Platform, n=28	0.89
Bipolar, n=72	1.11

Table 2. Mean weights of unfragmented quartz flakes in Areas 3 and 5 at Kaaraneskoski (cf. Fig. 10).

Cores	
Area 3	grams
Bipolar, n=21	8.00
Platform, n=11	10.29
Bipolar + platform, n=1	11.40
Microblade, n=4	2.45
Area 5	
Bipolar, n=17	5.82
Platform, n= 17	15.66
Bipolar + platform, n= 1	6.00
Microblde, n= 3	25.70

Table 3. Mean weights of quartz cores in Areas 3 and 5 at Kaaraneskoski (cf. Fig. 11).

Category	Area 3	Area 5
Flakes	512	641
Tools	221	204
Cores	37	38
Total	**770**	**883**

Table 4. Major artefact categories in the analysed quartz assemblages at Kaaraneskoski (cf. Fig. 12).

Tool categories	Area 3	Area 5
Oblique point	6	0
Scraper	18	38
Notched implement	13	5
Piercer	16	3
Borer	10	16
Corner knife	6	6
Knife	13	47
Plane	6	4
Burin	11	4
Burin spall implement	1	1
Crescent shaped implement	1	0
Serrated tool	0	1
Multipurpose tool	5	8
Other tool/ retouched flake	114	70
Total	**220**	**203**

Table 5. Quartz tool categories in Areas 3 and 5 at Kaaraneskoski (cf. Fig. 13).

Fragment	pcs
B6	2
C3	1
D2	4
D5	4
F	5
F1	1
F3	1
Total	**18**

Table 6. Fragment classification of scrapers at Kaaraneskoski (cf. Fig. 19).

Scraper use wear	pcs
Hard	47
Hard + soft	9
Soft	5
Unclassified	3
Total	**64**

Table 7. Use wear on worn scrapers at Kaaraneskoski (cf. Fig. 20).

Grouping by Callahan et al. 1992	All included fragments
side fragment	A2, B5, B6, D5, D5 (-B4), D5+D5, D5+D4, B6/D5, B6+D5
distal fragment	A3, A7, B3, C3, F3, B2+B3, F2+F3, D2/F3, D5/F3
whole flake	F, G1, F (-B4), F (-B4+D4)
proximal end of side fragment	A5, B1, B1+B2, B1/B3, D5/B1, D5/F1, D5/F1/F3
proximal fragment	F1, F1/F3, F1+F2
proximal end of middle fragment	C1, D2/F1, D2/F1/F3, D2/A1/F1, C1/C3
chip	B4, D1, D1/E1, E1
middle fragment	A1, A1/D2, A4, D2, D2+D2, D2+D5, G1-2xG2
medial fragment	A6, B2, C2, D5/F2, F2

Table 8. Fragment grouping in accordance with Callahan *et al.* 1992 (cf., Figs. 31 and 32).

Appendix I. 2/2

Fragments	Area 3	Area 5
side fragment	131	162
distal fragment	114	120
whole flake	122	164
proximal end of side fragment	13	21
proximal fragment	41	61
proximal end of middle fragment	9	13
chip	2	0
middle fragment	85	85
medial fragment	39	69
Total	**556**	**695**

Table 9. Fragment distribution in Areas 3 and 5 at Kaaraneskoski (cf. Fig. 31).

Fragment	Area 3	Area 5
A1	3	4
A2	0	1
A3	10	8
A4	0	2
B1	6	13
B2	10	20
B3	28	29
B5	3	7
B6	64	91
C1	3	7
C2	13	22
C3	20	26
D1	2	0
D2	82	79
D2 prox.	6	6
D2 dist.	4	1
D5	63	96
D5 prox.	4	8
D5 med.	1	0
D5 dist.	1	2
F	122	131
F1	31	61
F2	15	27
F3	51	54
Total	**542**	**695**

Table 10. Raw fragment data for Areas 3 and 5 at Kaaraneskoski (cf. Fig. 33).

Fragment	grams
A1	0.50
A1 med	0.40
A2	0.60
A3	0.40
A4	0.70
B1	0.75
B2	0.75
B3	0.69
B5	0.62
B6	1.29
C1	0.54
C2	0.69
C3	0.61
D2	1.05
D2 prox.	0.90
D2 dist.	0.20
D5	1.39
D5 prox.	1.00
D5 dist.	0.35
F	1.05
F1	0.89
F2	0.80
F3	1.11

Table 11. Average weights of fragments in the Area 5 assemblage at Kaaraneskoski (cf. Fig. 35).

Appendix II. List of catalogue numbers of artefacts shown in the illustrations

Figure 14. a) KM 31377:98
b) KM 31377:146
Figure 15. KM 30721:322
Figure 16. a) KM 31377:359
b) KM 31377:316
c) KM 31377:1106
d) KM 31377:232
e) KM 31377:48
f) KM 31377:1
g) KM 31377:847
h) KM 31377:185
i) KM 31377:940
j) KM 31377:38
k) KM 31377:804
l) KM 30721:282
Figure 17. a) KM 30721:273
b) KM 30721:511
c) KM 31377:1096
Figure 18. a) KM 31377:805
b) KM 31377:1122
c) KM 30721:474
d) KM 31377:520
e) KM 30721:240
f) KM 31377:1069
Figure 21. a) KM 31377:365
b) KM 31377:1117
c) KM 31377:157
d) KM 30721:13
e) KM 30721:115
f) KM 31377:22
Figure 22. a) KM 31377:522
b) KM 31377:663
c) KM 30721:143
d) KM 31377:703
e) KM 31377:890
f) KM 31377:50
g) KM 31377:2
Figure 23. a) KM 31377:161
b) KM 31377:770
c) KM 31377:1120
d) KM 31377:892
e) KM 31377:523
f) KM 30721:278
g) KM 31377:1074
h) KM 30721:439
i) KM 31377:147
j) KM 31377:1072
k) KM 31377:476
l) KM 31377:488
m) KM 31377:507
n) KM 31377:262
Figure 24. a) KM 31377:440
b) KM 31377:718
Figure 25. a) KM 31377:283
b) KM 31377:633
c) KM 31377:178
Figure 28. a) KM 31377:500
b) KM 31377:1110
c) KM 30721:353
Figure 29. KM 31377:77
Figure 30. a) KM 31377:515
b) KM 31377:368