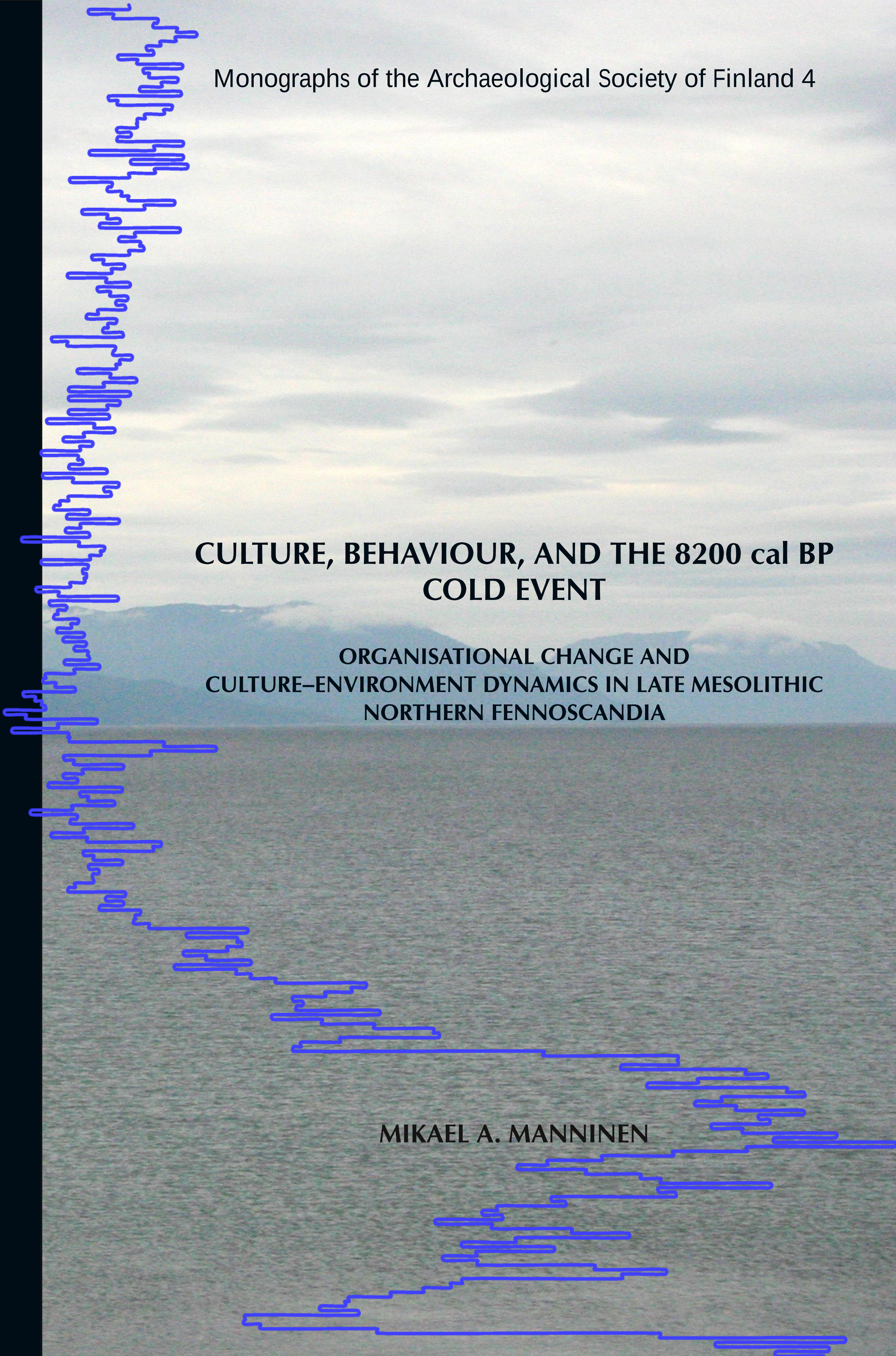

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CULTURE, BEHAVIOUR, AND THE 8200 cal BP COLD EVENT

ORGANISATIONAL CHANGE AND CULTURE–ENVIRONMENT DYNAMICS IN LATE MESOLITHIC NORTHERN FENNOSCANDIA

MIKAEL A. MANNINEN

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Academic dissertation to be publicly discussed, by due permission of the Faculty of Arts at the University of Helsinki in auditorium XII, on the 25th of January, 2014 at 12 o'clock.

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Published by the Archaeological Society of Finland
http://www.sarks.fi/masf/
http://ethesis.helsinki.fi/

Layout & graphic design: Mikael A. Manninen

Cover: Barents Sea coast at Altafjord (Photograph: M. A. Manninen)
and the NGRIP oxygen isotope curve (NGRIP 2004)

ISBN 978-952-67594-5-6 (PDF)
ISBN 978-952-67594-4-9 (paperback)

Monographs of the Archaeological Society of Finland
ISSN-L 1799-8611
ISSN 1799-8611 (online) ISSN 1799-862X (print)

Printed in Finland at Kopio Niini Oy, Helsinki, 2014

MONO GRAPHS OF THE ARCHAEOLOGICAL SOCIETY OF FINLAND

Monographs of the Archaeological Society of Finland is
an international peer-reviewed online open access series.

www.sarks.fi/masf

ABSTRACT

This dissertation focuses on Late Mesolithic (*ca*. 8450–6850 cal BP) lithic technological changes in the northernmost parts of Finland, Norway, and Sweden and on the relationship between these changes and the 8.2 ka climate event that was caused by a disruption in the North Atlantic Thermohaline circulation. The study uses a framework derived from Darwinian evolutionary theory and acknowledges the effects of both environmental constraints and socially transmitted information, i.e., culture, in the way lithic technology was organised in the studied region. The study discusses whether climatic cooling and its effects on the biotic environment could explain the way lithic technology and settlement patterns were reorganised during the Late Mesolithic.

The dissertation takes an organisational approach to the study of past cultural change and seeks to understand changes in prehistoric material culture by studying lithic technology and settlement configuration using lithic technological, statistical, and spatial analyses. The results suggest that Late Mesolithic coastal communities were affected by a marked decrease in marine productivity that resulted from the cooling caused by the 8.2 ka event and a subsequent cold episode at *ca*. 7700 cal BP. It is concluded that the technological changes that occurred during the marine cooling were a result of developments that led to increased use of terrestrial resources and an accompanying long-distance coast/inland residential mobility pattern.

The study contributes to a wider field of research into past climate change as a factor in prehistoric ecological, cultural, and behavioural change and provides reference material for studies on the impacts of future climate change on human communities. The results suggest that in northernmost Fennoscandia, the marine ecosystem is particularly sensitive to disturbances in the North Atlantic oceanographic system. In addition, the study provides new knowledge concerning the relationships between raw material availability, lithic technology, and culture. This new knowledge is widely applicable in research on the way lithic technology was organised in relation to other behavioural and organisational dimensions in past human adaptations.

ACKNOWLEDGEMENTS

Firstly, I would like to thank my supervisors (and friends) docent Tuija Rankama (PhD) and professor Mika Lavento of the University of Helsinki for their patience, encouragement, and advice throughout my PhD project and the interlinked Mesolithic Interfaces in Eastern Fennoscandia project led by Tuija. I would also like to thank my friends and co-authors, professor Kjel Knutsson of Uppsala University and fellow doctoral students Esa Hertell and Miikka Tallavaara of the University of Helsinki, for their support, insights, and knowledge. Completing this thesis would not have been possible without your help.

I am very grateful to my thesis pre-examiners professors Mikael Fortelius and Bryan Hood for their valuable comments on the manuscript. The help of the Mávdnaávži 2 excavation team Esa Hertell (MA), Hanna Suisto (MA), Meri Tallavaara (née Varonen, MA), Miikka Tallavaara (MA), and especially my wife Taarna Valtonen (MA) was invaluable in the work that served as the original stimulus for this dissertation, and I thank them sincerely. Taarna was the one who found the site during a survey of the Báišduottar–Paistunturi project in 1999 and I have always been able to count on her help during this PhD project.

I would also like to express my gratitude to all the archaeologists, who have laid the foundation for my research into the Mesolithic of northern Finnish Lapland, northern Norway, and northern Sweden, especially conservator Aki Arponen, Dr. h.c. Christian Carpelan, professor Charlotte Damm, professor Ericka Engelstad, Sven-Erik Grydeland (MA), docent Petri Halinen (PhD), professor Knut Helskog, Anders Hesjedal (PhD), professor Bryan Hood, Jarmo Kankaanpää (PhD), Taisto Karjalainen (MA), professor Kjel Knutsson, Hannu Kotivuori (Lic. Phil.), the late Knut Odner (PhD), Anders Olofsson (PhD), docent Tuija Rankama (PhD), Kjersti Schanche (PhD), Sirkka Seppälä (Lic. Phil.), the late professor Ari Siiriäinen, the late professor Povl Simonsen, Marianne Skandfer (PhD), the late Markku Torvinen (Lic. Phil.), and professor Peter Woodman.

The students and staff of the University of Helsinki department of Archaeology have helped me in this project in many ways; thanks go especially to Tuija Kirkinen (MA), Satu Koivisto (MA), Antti Lahelma (PhD), Tuovi Laire, Kristiina Mannermaa (PhD), Teemu Mökkönen (PhD), Wesa Perttola (MA), Petro Pesonen (Lic. Phil.), Noora Taipale (MA), Krista Vajanto (MA), and Anna Wessman (PhD) (in addition to those mentioned before). I am also grateful to the staff of the archives of the National Board of Antiquities in Helsinki, especially Leena Ruonavaara (MA) and Päivi Pykälä-aho (MA), for their help in gaining access to a substantial part of the finds and reports used in this study.

The completion of this doctoral dissertation was made possible through funding provided by the Finnish Graduate School in Archaeology, the Finnish Cultural Foundation, the Emil Aaltonen Foundation, the Lapland Regional fund of the Finnish Cultural Foundation, the Niilo Helander Foundation, the Oskar Öflund Foundation, and the University of Helsinki. It goes without saying that I am very grateful for the support.

Last but not least, I would like to thank my parents, children, other family members, and friends for all their support and for reminding me that there are also other things in life than archaeology.

THE THESIS IS BASED ON THE FOLLOWING FIVE PAPERS REFERRED TO IN THE TEXT BY THEIR ROMAN NUMERALS:

I Manninen, M. A. & Knutsson, K. 2011. Northern Inland Oblique Point Sites – a New Look into the Late Mesolithic Oblique Point Tradition in Eastern Fennoscandia. In: T. Rankama (Ed.), *Mesolithic Interfaces – Variability in Lithic Technologies in Eastern Fennoscandia*. Monographs of the Archaeological Society of Finland 1, 143–175. http://www.sarks.fi/masf/masf_1/masf_1.html

II Manninen, M. A. 2009. Evidence of mobility between the coast and the inland region in the Mesolithic of Northern Fennoscandia. In: S. B. McCartan, R. Schulting, G. Warren & P. Woodman (Eds.), *Mesolithic Horizons*, Vol. I. Oxbow books, Oxford, 102–108.

III Tallavaara, M., Manninen, M. A., Hertell, E. & Rankama, T. 2010. How flakes shatter: a critical evaluation of quartz fracture analysis. *Journal of Archaeological Science* 37, 2442–2448. doi:10.1016/j.jas.2010.05.005

IV Manninen, M. A. & Tallavaara, M. 2011. Descent History of Mesolithic Oblique Points in Eastern Fennoscandia – a Technological Comparison Between Two Artefact Populations. In: T. Rankama (Ed.), *Mesolithic Interfaces – Variability in Lithic Technologies in Eastern Fennoscandia*. Monographs of the Archaeological Society of Finland 1, 177–211. http://www.sarks.fi/masf/masf_1/masf_1.html

V Manninen, M. A. & Knutsson, K. 2014. Lithic raw material diversification as an adaptive strategy—Technology, mobility, and site structure in Late Mesolithic northernmost Europe. *Journal of Anthropological Archaeology* 33, 84–98. doi:10.1016/j.jaa.2013.12.001

AUTHOR'S CONTRIBUTION TO THE PAPERS:

I The study was planned, the data were collected, and the archive and literature survey was conducted jointly by both authors. K. Knutsson was responsible for 60% of the lithic analyses and M. A. Manninen for 40%. The other analyses were conducted jointly by both authors. M. A. Manninen wrote the paper with contributions from K. Knutsson.

III The study was planned and the experiments conducted jointly by all authors. The statistical analyses were conducted, the data prepared, and the paper was written by M. Tallavaara with contributions from the other authors in the order indicated by the author list.

IV The study was planned and written by M. A. Manninen with contributions from M. Tallavaara. The data were gathered and the lithic analyses conducted jointly by both authors. The statistical analyses were conducted 60% by M. Tallavaara and 40% by M. A. Manninen. The other analyses were conducted by M. A. Manninen with contributions from M. Tallavaara.

V The study was planned by M. A. Manninen. The lithic data were collected by K. Knutsson (60%) and M. A. Manninen (40%). M. A. Manninen conducted all analyses except for the lithic technological classification, of which K. Knutsson conducted 60% and Manninen 40%. M. A. Manninen interpreted the data and wrote the paper with contributions from K. Knutsson.

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1. INTRODUCTION

The relationship between culture and environment is one of the long-standing themes in studies of prehistoric and present-day hunter–gatherers. The challenges posed by the physical environment in particular and the cultural responses to these challenges were recognised early on and have been recurrent topics in research in this field for decades (e.g., Binford 1973; 2001; Kelly 1995; Mauss 1905; Panter-Brick *et al.* 2001; Pälsi 1916; Siiriäinen 1981a; Steward 1955).

During the last few decades, approaches that relate cultural variability to environmental factors by uniting ecological and evolutionary perspectives have gained a footing in studies of hunter–gatherer culture–environment dynamics (e.g., Binford 2001; Broughton & Cannon 2010a; Kelly 1995; Surovell 2009). In tandem with this trend and with the introduction of high-resolution climate reconstructions from a wide array of biological and physical proxy records, the impact of past climate change as an explanatory factor in prehistoric cultural and behavioural change has also (re)gained importance (e.g., Bonsall *et al.* 2002; Boyd & Richerson 2005; Eren 2012a; Hald 2009; McClure *et al.* 2009; Munoz *et al.* 2010; Riede 2009a; Schmidt *et al.* 2012; van Andel *et al.* 2003; Williams *et al.* 2010). The present study contributes to this discussion.

1.1. A Late Mesolithic change in northern Fennoscandian lithic technology

This dissertation focuses on changes in stone tool production technology that took place in parts of northern Europe during the Late Mesolithic (*ca.* 6500–4900 cal BC or 8450–6850 cal BP). During most of the Mesolithic period, a regional difference existed in stone tool production technology between the Barents Sea coastal sphere in present-day northeastern Norway, that is, the Finnmark coast (Fig. 1), and the adjacent inland areas in present-day Finland and Norway (Grydeland 2005; Hood 2012; Kankaanpää & Rankama 2005; Olsen 1994; Woodman 1999; Papers I and V). However, roughly coinciding with the introduction of a

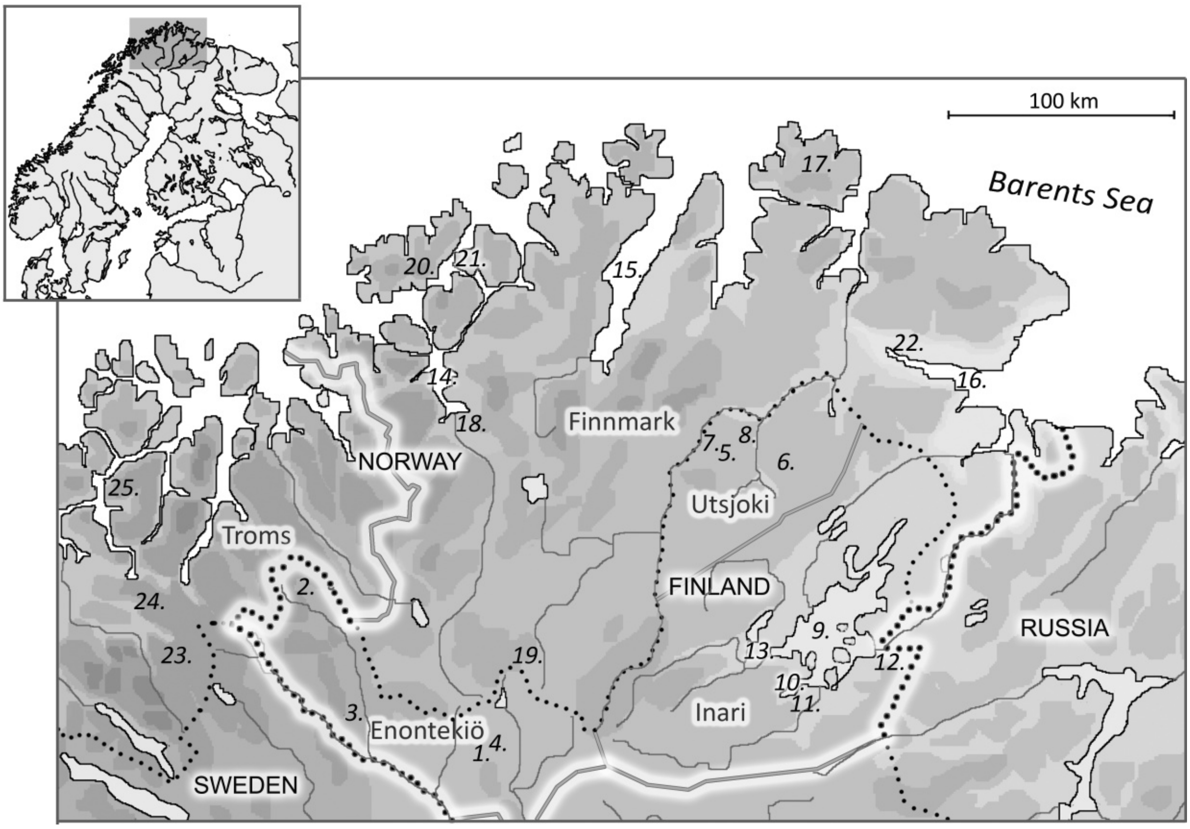
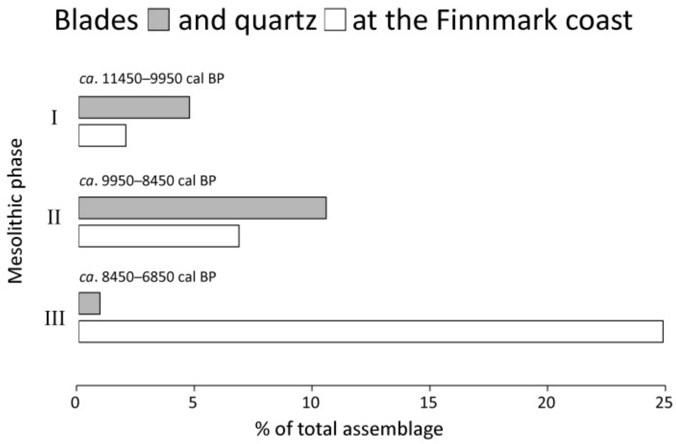


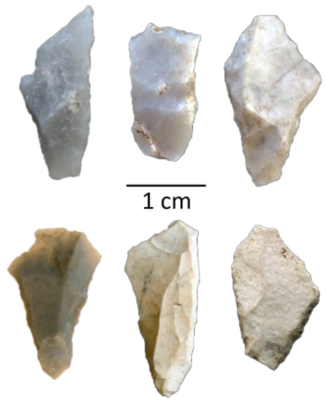
FIGURE 1. Northernmost Fennoscandia and the central study area (white outline), consisting of the county of Finnmark in Norway and the municipalities of Utsjoki, Inari, and Enontekiö in Finland. Important locations and sites mentioned in the text: 1. Ounasjärvi; 2. Toskaljavri; 3. Tsuolbmajavri; 4. Museotontti; 5. Baišduottar/Paistunturit; 6. Sujala; 7. Mávdnaávži 2; 8. Jomppalanjärvi W; 9. Lake Inari; 10. Lake Rahajärvi; 11. Kaunisniemi 3; 12. Nellimjoen suu S; 13. Vuopaja; 14. Altafjord; 15. Porsangerfjord 16. Varangerfjord; 17. Nordkinnhalvøya; 18. Alta; 19. Aksujavri; 20. Slettnes; 21. Melkøya; 22. Mortensnes: 23. Devdis I; 24. Almenningen 1; 25. Skarpeneset. Elevations above sea level are indicated by 100-metre contour intervals. Map by the author.

new point type, namely the margin-retouched "transverse point"[1], and a consequent spread of the margin-retouched point concept, there were marked changes in material culture in the whole region, the most notable of which is the way the new point type was put to use in both coastal and inland settings and in areas in eastern Fennoscandia from where immediately preceding lithic projectile point types are not known.

On the Finnmark coast, the Late Mesolithic period also saw the end of the production of formal blades, as well as changes in raw material economy—above all, an increased use of vein quartz (**Fig**. **2**; Grydeland 2000; 2005:57; Hesjedal *et al.* 1996:159; Schanche 1988:124)—while in the inland region, non-local raw materials are recurrently found in association with margin-retouched points up to 150 kilometres from their coastal sources (**Fig. 3**; Havas 1999; Hood 2012; Manninen 2005; 2006; Nordqvist & Seitsonen 2009; Papers I, II, IV, and V). Although not discussed in more detail in this study, it is worth noting that in the northwestern part of the Norwegian

1 In much of the literature discussing the Late Mesolithic margin-retouched points in northernmost Fennoscandia, these points are called transverse or oblique points to distinguish them from earlier margin-retouched points called tanged single- or double-edged tanged points, even if the shapes of the points is very varied throughout the millennia (Paper I; IV). In this dissertation, the terminology used is defined in the individual papers. It should be noted, however, that in Paper II, the term oblique point is used for Late Mesolithic margin-retouched points, while in Papers I and IV, as well as in this introductory chapter, the term encompasses all Mesolithic margin-retouched points in northern and eastern Fennoscandia, regardless of edge shape or date.





FIGURES 2&3. Left: the relative amounts of blades and quartz in the combined lithic assemblages from three multi-period sites on the Finnmark coast. Data from Hesjedal *et al*. (2009 Melkøya), Hesjedal et al. (1996, Slettnes), and Schanche (1988, Mortensnes). Right: Late Mesolithic margin-retouched points of varying edge shapes from Utsjoki and Inari, Finland. All were made of varieties of non-local (coastal) chert. Modified from Paper IV: Fig. 1. National Museum of Finland. Photograph by M. A. Manninen.

Atlantic coast, there are contemporaneous but differing changes indicated by a shift in blade production technology (Hagen 2011:63–67).

Significantly, a range of contemporaneous changes has also been detected in the archaeological record in many other parts of Europe, North Africa, and the Near East, while there is growing evidence that many of these changes were the result of environmental stress induced by climatic change, or more specifically, the 8200 cal BP cold event (e.g., Budja 2007; Edinborough 2009; Fernández López de Pablo & Jochim 2010; González-Sampáriz *et al.* 2009; Mercuri *et al*. 2011; Robinson *et al.* 2013; Weninger *et al.* 2006). In this dissertation, I study whether and how the above-described changes in lithic technology in northernmost Fennoscandia, and especially the changes in the way technology was organised, could be related to the abrupt climate change.

1.2. The study area

The main area under study in this dissertation covers northernmost Finnish Lapland and the county of Finnmark in Norway. The area is located in a region in which the marine environment in particular can be expected to be directly affected by the sorts of disruptions in North Atlantic oceanic circulation that are considered to be the main causes of most of the abrupt climatic events that occurred in the early Holocene (e.g., Clark *et al.* 2001; Renssen *et al.* 2002).

Depending on the level of analysis and the specific question under discussion, in the individual papers, the geographic focus is at times expanded to include northern Sweden and the county of Troms in Norway (Papers I and V), the more southerly parts of Finland (Papers I and IV) and occasionally even the whole of northern Europe (Paper IV).

1.3. History of research and chronology—a short overview

The area consisting of northern Finnish Lapland and Finnmark is traditionally divided into coastal and inland regions in archaeological research. The border between these regions is, however, in many ways unclear and at least in part follows the present-day national and political border between

FIGURE 4. A sequence of raised shorelines in Roddines, Porsangerfjord. Photograph by the author.

Finland and Norway (*cf.* Havas 1999; Hood 2012; Rankama 1995; 2003). There are nonetheless also differences in the physical environment, such as differences in topography, geology, and habitat distribution, which roughly coincide with the national border. In terms of lithic technology, the most notable difference is in the availability of raw materials: sources of fine-grained lithic material of good workability are found almost exclusively in the area of present-day Norway (see chapter 1.6.1). Together with the national border, these environmental differences, in addition to affecting human adaptations, have contributed to the fact that the Barents Sea coastal strip has in many instances been treated as a detached entity, and therefore, two separate archaeological research traditions, as well as asynchronous chronological frame-works, have long co-existed in the area (Hood 2012; Rankama 1995; 2003; Paper I).

Recently, this divide has started to break down, and prehistoric phenomena are increasingly being studied within the same chronological framework and cutting across the traditional coast/inland division (e.g., Grydeland 2005; Hagen 2011; Halinen 2005; Havas 1999; Hood 2012; Knutsson 2005; Manninen 2005; 2006; Rankama 2003; Rankama & Kankaanpää 2011; Skandfer 2003; 2005). As might have been expected, the widened perspective has revealed changing patterns of land use and coast–inland contacts throughout prehistory, although there still remain clear differences between the areas.

Findings from excavated Mesolithic sites in northern Finnish Lapland suggest that the amount of fine-grained coastal lithic raw material moving into the inland region varied through the millennia, even if, for most time periods, only occasional artefacts have been found (Grydeland 2005; Havas 1999; Hood 2012; Kankaanpää & Rankama 2005; Rankama 1996). Blade production has been detected at only one site in the inland region, where also tools made on blades are rare and mostly undiagnostic flake-based technologies prevailed (Hood 2012; Kankaanpää & Rankama 2005; Manninen & Hertell 2011; Rankama & Kankaanpää 2011). At the same time, typo-chronological sequences constructed using coastal assemblages indicate that blades and blade tools were common in the coastal sphere during the first two phases of the Mesolithic (Hesjedal *et al.* 1996; Olsen 1994; Woodman 1999).

Due to the lack of chronologically diagnostic types at most of the Mesolithic inland sites, in this study, I use a timeline based on the coastal North Norwegian typo-chronologies (Hesjedal *et al.* 1996; Olsen 1994; Woodman 1993; 1999) in which the Mesolithic Stone Age is divided into three phases:

Phase I: *ca*. 11450–9950 cal BP
(*ca*. 9500–8000 cal BC or 10000–9000 BP)

Phase II: *ca*. 9950–8450 cal BP
(*ca*. 8000–6500 cal BC or 9000–7500 BP)

Phase III: *ca*. 8450–6850 cal BP
(*ca*. 6500–4900 cal BC or 7500–6000 BP)

The last of these phases I refer to as the Late Mesolithic. The advantage of a chronological framework based on coastal assemblages is the fact that it can be backed not only by using radiocarbon dated contexts but also by sequences of find locations datable by shore displacement chronology. The isostatic rebound that started after the Scandinavian Ice Sheet retreated from the area (**Fig. 4**) offers the possibility to shoreline date sites and is the reason why the earliest Mesolithic sites at the seashore can be located nearly 100 metres above the current sea level (Bøe & Nummedal 1936; Grydeland 2000; Møller 1987; Tanner 1935). In the study area, where the preservation of organic material is poor, and where, especially before AMS-dating became widely available, the possibilities for radiocarbon dating have been scarce, shore displacement chronology has offered, and still offers, possibilities for detecting typologically and technologically differing phases. However, when studying human activity, shore displacement chronology can in most cases only give *post quem* dates (*cf.* Matiskainen 1982). Therefore, in this dissertation, I use shoreline dates only when needed to supplement the relatively scarce radiocarbon date dataset.

For these reasons, i.e., the nature of shoreline dates and the scarcity of radiocarbon dates, the chronological boundaries in the three-partite chronological division of the Mesolithic in the region are not well established and do not account for regional differences, of which there are many indications (e.g., Carpelan 2003; Grydeland 2005; Hagen 2011; Halinen 2005; Hood 2012; Rankama & Kankaanpää 2011; Skandfer 2005; Paper I). However, using the above-mentioned typo-chronological studies and some of the more recent research (Hagen 2011; Grydeland 2000; 2005; Hesjedal *et al.* 2009; Hood 2012; Kankaanpää & Rankama 2005; Rankama & Kankaanpää 2011; Skandfer 2003), a rough typo-chronological sequence of tools and technology used in the area during the Mesolithic can nevertheless be presented (**Fig. 5**).

This scheme includes the conjecture that simple margin-retouched arrow-

		Phase I *ca* . 11450–9950 cal BP	Phase II *ca* . 9950–8450 cal BP	Phase III *ca* . 8450–6850 cal BP
Raw material	*Coast*	Chert/quartzite + minor use of quartz	Chert/quartzite + minor use of quartz	Decrease in chert/quartzite + clear increase in quartz
	Inland	WMS (1 late site)	Quartz + rare artifacts of coastal chert/quartzite	Mainly quartz, but also production from coastal chert/quartzite
Primary production	*Coast*	Blades & flakes	Blades & flakes	Flakes in East-Finnmark, flakes + bladelets in Troms
	Inland	Blades (1 late site)	Flakes	Flakes
Arrowheads	*Coast*	Margin-retouched	Margin-retouched in Troms and probably Finnmark	Margin-retouched
	Inland	Tanged post-Swiderian	Lack of arrowheads	

wms = weakly metamorphosed sandstone

FIGURE 5. Typo-chronological division of lithic technological trends during the three Mesolithic phases in the study area, based on studies by Hesjedal *et al*. (1996), Hood (2012), Olsen (1994), Rankama & Kankaanpää (2011), and Woodman (1993).

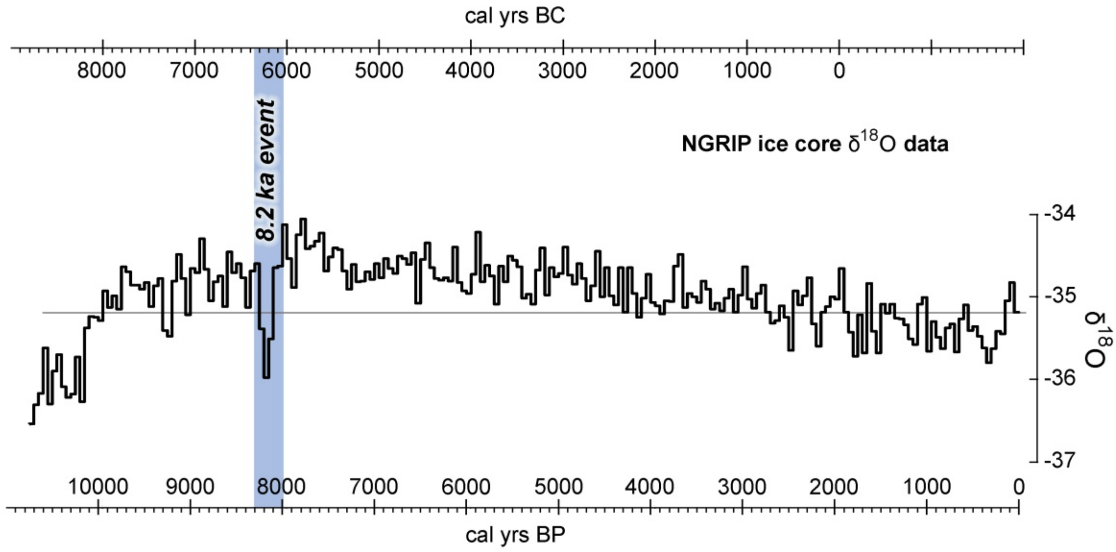


FIGURE 6. North Greenland Ice Core Project Oxygen Isotope Data (NGRIP 2004).

heads were in use at Barents Sea coastal sites throughout the Mesolithic (Odner 1966; Olsen 1994:31, 39). This view was challenged by Hesjedal *et al.* (1996:184–185, 198) who suggested that the use of margin-retouched points ended at the beginning of Phase II and restarted during Phase III. This suggestion was based on the lack of corresponding finds assigned to the intervening period. The absence of margin-retouched points during Phase II may, however, be largely explained by a record gap affecting coastal sites (Paper I) and the fact that the typo-chronological definition of Phase II seems to be largely based on assemblages representing technology associated with a colonisation wave of eastern "post-Swiderian" hunter–gatherers into the area (Rankama & Kankaanpää 2011; Sørensen *et al*. 2013). Finds of margin-retouched points radiocarbon dated to Phase II in recent excavations at Skarpeneset (Tønsnes, Troms County) indicate that such points were present, if not in northeastern Finnmark, at least in its close vicinity, during Phase II (Henriksen 2010; Nilsen & Skandfer 2010).

Only a few studies have explicitly addressed the changes in lithic technology that happened in the area during the Late Mesolithic. Rankama (2003) discussed the increase in quartz use together with the change in blank production and suggested that this could indicate a colonisation of the Finnmark coast by quartz-adapted groups that originated in the inland region, while Grydeland (2005) explained the same change by increased cooperation between coastal and inland groups. Knutsson (2005) related the increased archaeological visibility of margin-retouched points in the area during Phase III (in comparison to Phase II) to a cultural reproduction of the past as a response to a time of crisis. Finally, Hagen (2011) has recently reviewed earlier research on the interface between Phases II and III in the region and discussed how technological changes and trends observed in these studies could be related to environmental factors, most notably the 8200 cal BP climate event.

A substantial amount of research literature also exists in which questions related to the Late Mesolithic changes in the area are discussed and notes on such topics as the origin and chronological position of oblique points in Finland, northern Sweden, and northern Norway are made. However, as this literature is addressed in the individual papers (I, II, IV, and V), it is not discussed in detail here.

1.4. The 8200 cal BP cold event

In general, the early part of the Holocene (before *ca*. 8000 cal BP) was characterised by substantial climatic fluctuation and environmental change, including several abrupt cooling episodes, the effects of which are detectable in multiple proxy records around the Northern Hemisphere (e.g., Blockley *et al.* 2012; Bond *et al.* 1997; Mayewski *et al.* 2004). The most prominent and widely studied of the Holocene cold events is the 8200 cal BP event (henceforth the 8.2 ka event), an abrupt climate change which is clearly detectable in, for example, the high-resolution North Greenland ice core oxygen isotope data as being the strongest climatic signal of the Holocene (**Fig**. **6**).

The event is tought to have been initiated by the final drainage of the pro-glacial lakes Ojibwa and Agassiz into the North Atlantic as a part of the Laurentide Ice Sheet collapse in North America (e.g., Barber *et al.* 1999; Clark *et al.* 2001; Törnqvist & Hijma 2012; Wiersma & Jongma 2010). The fresh-water pulse caused a disruption in the Atlantic Meridional Overturning Circulation, which in itself plays a critical role in the world's climate system (e.g., Alley & Ágústsdóttir 2005; Barber *et al.* 1999; Seppä *et al.* 2007; Wiersma & Renssen 2006). To put the magnitude of the event into perspective, it should be noted that the 8.2 ka event is used as a "worst case scenario" in modelling the effects of future climate change (Schwartz & Randall 2003).

The 8.2 ka event was part of a climatic cooling period spanning *ca.* 8600–8000 cal BP (Rohling & Pälike 2005; Thomas *et al.* 2007; Walker *et al.* 2012:Fig. 3) that interrupted the long-term trend of rising early-Holocene temperatures. The event "proper" lasted approximately 160 years (Daley *et al.* 2011; Kobashi *et al.* 2007). It is detected as a marked cold snap in multiple paleoclimatic records from the Greenland ice cores and a variety of sedimentary records, especially in northern Europe (e.g., Alley & Ágústsdóttir 2005; Seppä *et al.* 2007; Thomas *et al.* 2007; Walker *et al.* 2012), while the climatic changes caused by the event, most notably the cooling in the Northern Hemisphere and an increase in aridity in the lower latitudes, are thought to have affected human populations in many parts of Europe and beyond (**Fig. 7**).

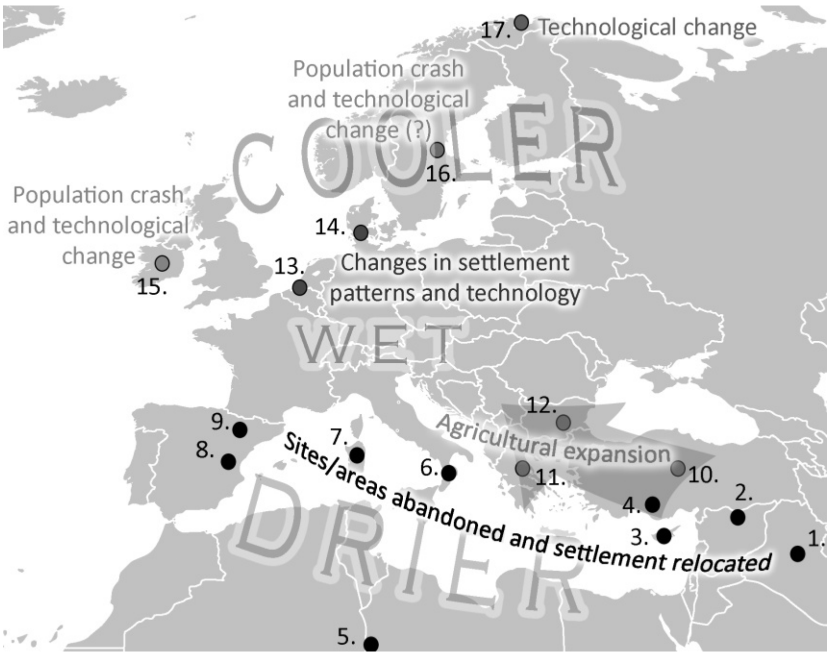


FIGURE 7. Major climatic and hydrological changes in Europe during the 8.2 ka event (Magny *et al*. 2003; Morrill & Jacobsen 2005; Seppä *et al*. 2007) and a sample of regions where the effects of these changes have been observed in the archaeological record (Staubwasser & Weiss 2006 (1.); van der Plicht *et al*. 2011 (2.); Weninger *et a*l. 2006 (3. & 4.); Mercuri *et al*. 2011 (5.); Berger & Guilaine 2009 (6. & 7.); Fernández López de Pablo & Jochim 2010 (8.); González-Sampáriz *et al*. 2009 (9.); Weninger *et al*. 2006; see also Budja 2007 (10.–12.); Robinson *et al*. 2013 (13.); Edinborough 2009 (14.); Riede 2009a (15. & 16.); Hagen 2011; Paper IV (17.)). Map by the author.

1.5. Climate events and hunter-gatherers

Because hunter–gatherers live directly off the natural environment, they are affected by all changes in their respective ecosystems, either directly or indirectly (*cf.* Binford 2001; Dincauze 2000; Kelly 1995). This also means that environmental changes can be expected to be reflected in the archaeological record in various ways that are determined by such things as the severity of the effects of the changes on the ecosystem, the readiness of any given group to adapt, and the riskiness of the group territory. Several case studies show that there are good reasons to assume that in many parts of the world, abrupt climate change has caused population instability and/or demographic collapse, as well as cultural change (e.g., Adger *et al.* 2012; Gronenborn 2009; Munoz *et al.* 2010; Pfister & Brázdil 2006; Riede 2009a; Robinson *et al.* 2013; Tallavaara *et al. in press*.).

Gronenborn (2009; following Pfister & Brázdil 2006) has conceptualised the mechanism behind such changes in communities, such as those of prehistoric hunter–gatherers, which respond on a local level to both non-human and human threats (**Fig. 8**). This generalised scheme offers insights into the catastrophic effects an abrupt climate change can have on hunter–gatherer adaptations and demography as a consequence of large-scale ecosystem turmoil. In risky environments in particular, a negative change in any key variable can lead to malnutrition, lowered fertility, and increased mortality, as well as to various behavioural responses, such as migration, conflict, and technological change. The demographic crashes caused by such crises and the following social and economic reorganisation can therefore be expected to appear as rapid changes in the archaeological record (*cf.* Riede 2009a).

In recent years, the link between climate and human population size has been studied by scrutinising the applicability of radiocarbon dates as a proxy for prehistoric demographic fluctuation (e.g., Gamble *et al.* 2004; Riede 2009a; Surovell *et al.* 2009; Tallavaara *et al.* 2010; Tallavaara & Seppä 2012; van Andel *et al.* 2003; Williams 2012). A prerequisite for such dates-as-data approaches to the study of the impact of climate on human societies is a sufficiently large taphonomically and statistically controlled sample of radiocarbon dates from the studied region (e.g., Williams 2012). This is not the case in northernmost Fennoscandia, where shore-bound sites on the Barents Sea coast from the period under study are likely to have been destroyed by the mid-Holocene Tapes transgression (Møller 1987; Paper I), as well as by the Storegga tsunami (Romundset & Bondevik 2011), and where the number of radiocarbon-dated contexts is still relatively low.

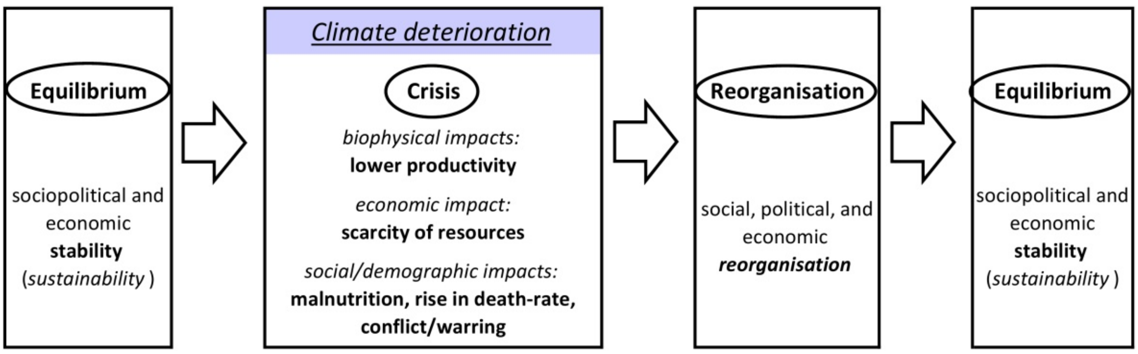


FIGURE 8. Schematic representation of the effects of climate-induced culture change (modified from Gronenborn 2009).

FIGURE 9. Examples showing the geographic and environmental diversity in the study area. Top: Barents Sea coast at Altafjord (a) and Varangerfjord (b). Middle: Inland fell area below (c) and above (d) the treeline in Baišduottar/Paistunturit, Utsjoki. Bottom: Forest shores of Lake Ounasjärvi, Enontekiö (e) and pine forest at Lake Rahajärvi, Inari (f). See Figure 1 for locations. Photographs by the author.

However, a large-scale ecosystem crisis and the economic and social reorganisation that result are likely to also cause changes in material culture and settlement configuration, not only locally but also on a regional level. Therefore, if long time periods of stability and gradual change in the archaeological record are equalled by periods of environmental equilibrium and thus with only minor fluctuation in resource availability, an abrupt large-scale climate event can be expected to cause wide-ranging changes in the archaeological record in areas where the effects of the climate change on ecosystems are severe. Assuming that the 8.2 ka event had such an impact on the environment in northernmost Fennoscandia, its effects can be expected to be visible in settlement organisation and lithic technology.

1.6. Environmental variables in the study area

The geography of the study area in Finnmark and northern Finnish Lapland is varied. The most prominent features, in addition to the Barents Sea, are the mostly barren and uneven terrain of the Barents Sea coast, the rugged fells of the Finnmark Caledonides, with deep river gorges and multiple peaks more than 900 metres high, as well as the undulating plateau to the south of the Caledonides, which is characterised by low rounded fells, lakes and rivers, as well as large areas of peatland (**Fig. 9**).

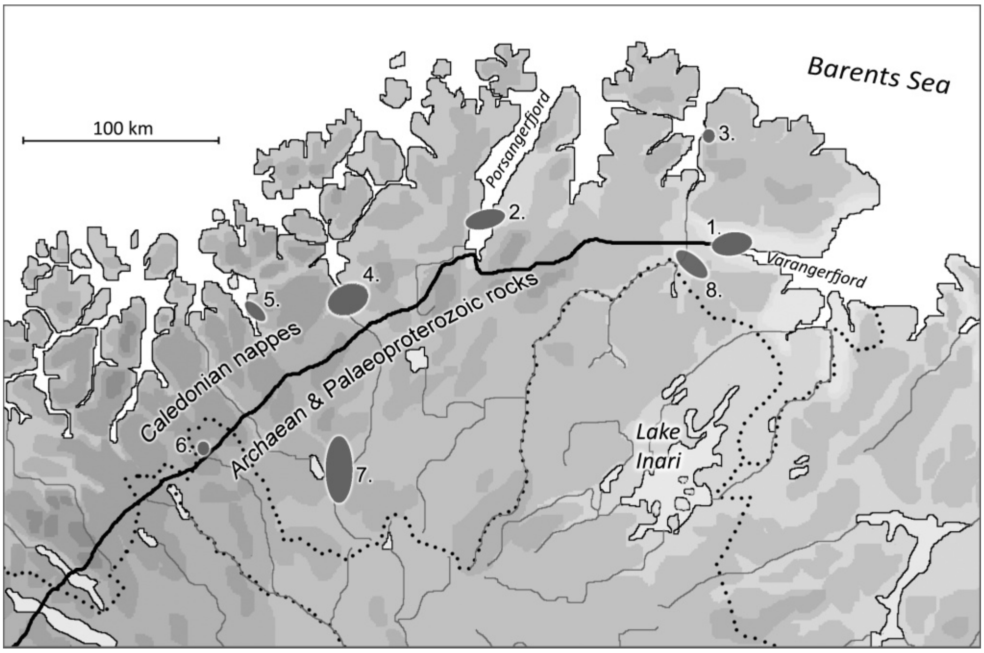


FIGURE 10. Sources of fine-grained lithic raw materials in and near the study area: 1) Chert bearing tillites; 2) Porsanger chert; 3) Oolithic chert; 4) Kvenvik chert; 5) Kvænangen chert sources; 6) Guonjarvárri chert/quartzite; 7) Possible source area for metachert/quartzite; 8) Green quartzite. 1-4), & 7) after Hood (1992b), 5) after Stensrud (2007); 6) after Halinen 2005; 8) after Kleppe (n.d.). The black line marks the geological boundary between the Archaean and Palaeoproterozoic bedrock of the Fennoscandian Shield and the younger sedimentary rocks of the Caledonian nappes (after Lehtinen *et al*. 1998). Elevations above sea level are indicated by 100-metre contour intervals. Map by the author.

The emergence of the area from under the Scandinavian Ice Sheet started from the north, and by *ca.* 10650 cal BP (or 8700 cal BC), Finnmark and northern Finnish Lapland were free of ice (Johansson & Kujansuu 2005).

1.6.1. Availability of lithic raw materials

In Fennoscandia, the occurrence of stone tool raw materials of good flakeability and controllability is largely dictated by a geological division into areas with Archaean and Palaeoproterozoic bedrock on the one hand and younger sedimentary rocks of the Caledonian nappes on the other (**Fig**. **10**; Papers II and V).

Hood (1992a; 1992b; n.d.) has published several sources of chert and other fine-grained raw materials in Finnmark, many of which are known to have been used in prehistory. However, the archaeological material in the area also contains cherts and other raw material types of unknown origin. For example, the sources of the weakly metamorphosed sandstones used to produce large regular blades at the Phase I Sujala site in Utsjoki remain unknown (Rankama & Kankaanpää 2011), although the same, or at least macroscopically similar, material (also known as tuffaceous chert) is found at many sites in the Varanger area (Grydeland 2000; Hood 1992b:91–93).

In a similar manner as might be the case with the Sujala material (Rankama & Kankaanpää 2011), a significant proportion of the raw materials of unknown origin are likely to have come from beach and moraine deposits on the Barents Sea coast and therefore may originally have come from bedrock sources that no longer exist. However, the coverage of archaeological surveys in the region is far from comprehensive, and new lithic raw material sources and source areas are still being found, such as the recently found Guonjarvárri quarries in Kilpisjärvi (Halinen 2005:27–28), the Kvænangen chert sources near

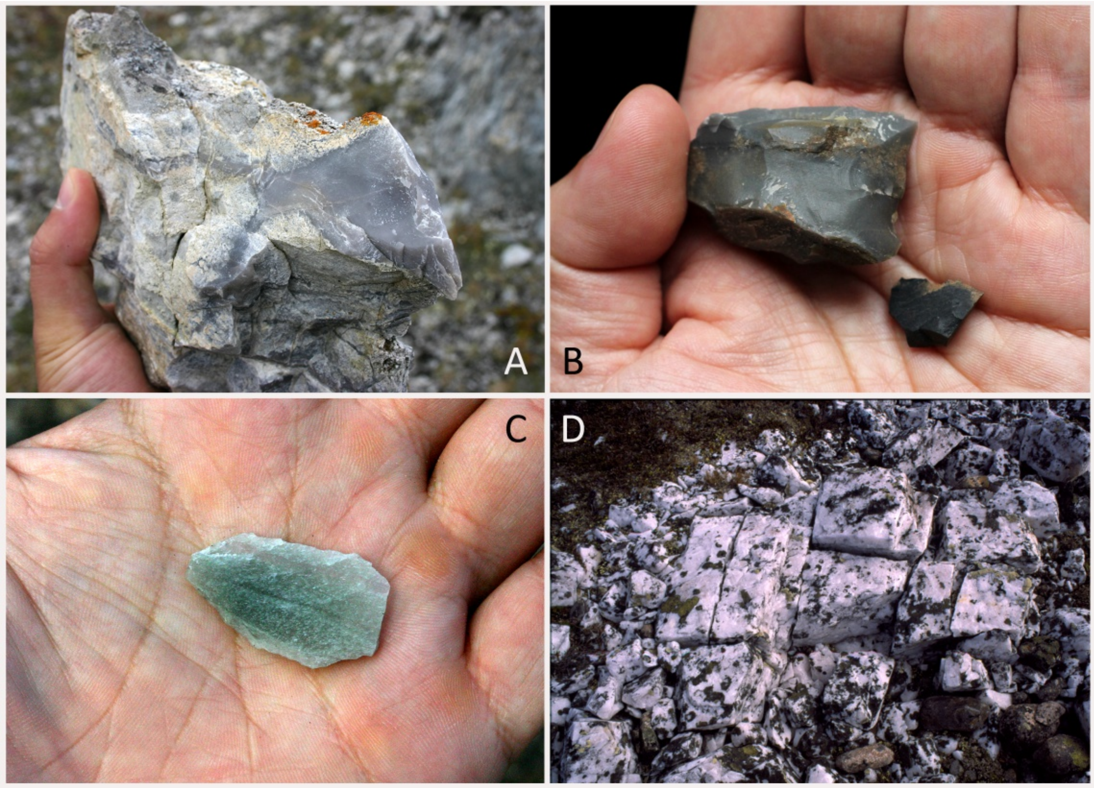


FIGURE 11. Examples of lithic raw material types available in the study area. Porsanger chert (A), Kvenvik chert (B), fine-grained green quartzite (C), vein quartz (D). Photographs by the author.

Troms (Stensrud 2007), the Melsvik chert quarry in Alta (Niemi 2012), and the Piipahta chert source near Børselvnes[2].

What is most important with respect to this study, however, is the differing availability of fine-grained raw materials within the study area (Papers II and V). Sources of raw material of good flakeability and controllability (mostly chert and fine-grained quartzite) are found only in beach and moraine deposits on the Barents Sea coast and as localised sources associated mainly with the Scandinavian Caledonides (Åhman 1967; Hood n.d., 1992a; 1992b; Rosendahl 1936). In contrast, raw materials of lower workability, especially vein quartz, are found throughout the region (**Fig**. **11**).

1.6.2. The early to mid-Holocene climate

Despite regional variations, after *ca.* 10000 cal BP, the period corresponding to the Mesolithic in northernmost Fennoscandia (*ca.* 11450–6850 cal BP or 9500–4900 cal BC), was characterised by an oceanic climate that was generally warm and wet in comparison to present conditions (**Fig. 12**; Allen *et al.* 2007; Seppä & Hammarlund 2000). Paleoclimatic temperature reconstructions indicate an initially high but gradually decreasing influence of Atlantic air masses in the inland areas of northern Fennoscandia (Seppä & Hammarlund 2000), alongside a trend of rising postglacial temperatures that peaked during the Holocene Thermal Maximum (*ca.* 8000–5000 cal BP; Renssen *et al.* 2009) in both the inland region and on the Barents Sea coast (Allen *et al.* 2007; Erästö *et al. submitted*; Seppä *et al.* 2009b).

2 Piipahta is a source of Porsanger chert near Børselv/Pyssyjoki/Bissojohka that was visited by the present author in 2006. The location is marked on the topographic map by the Kven/Finnish name Piipahta, which means literally Flint Cliff. The place name Flintnes, several kilometres south along the same shore, suggests the presence of chert in other unsurveyed localities along the shores of Porsangerfjord.

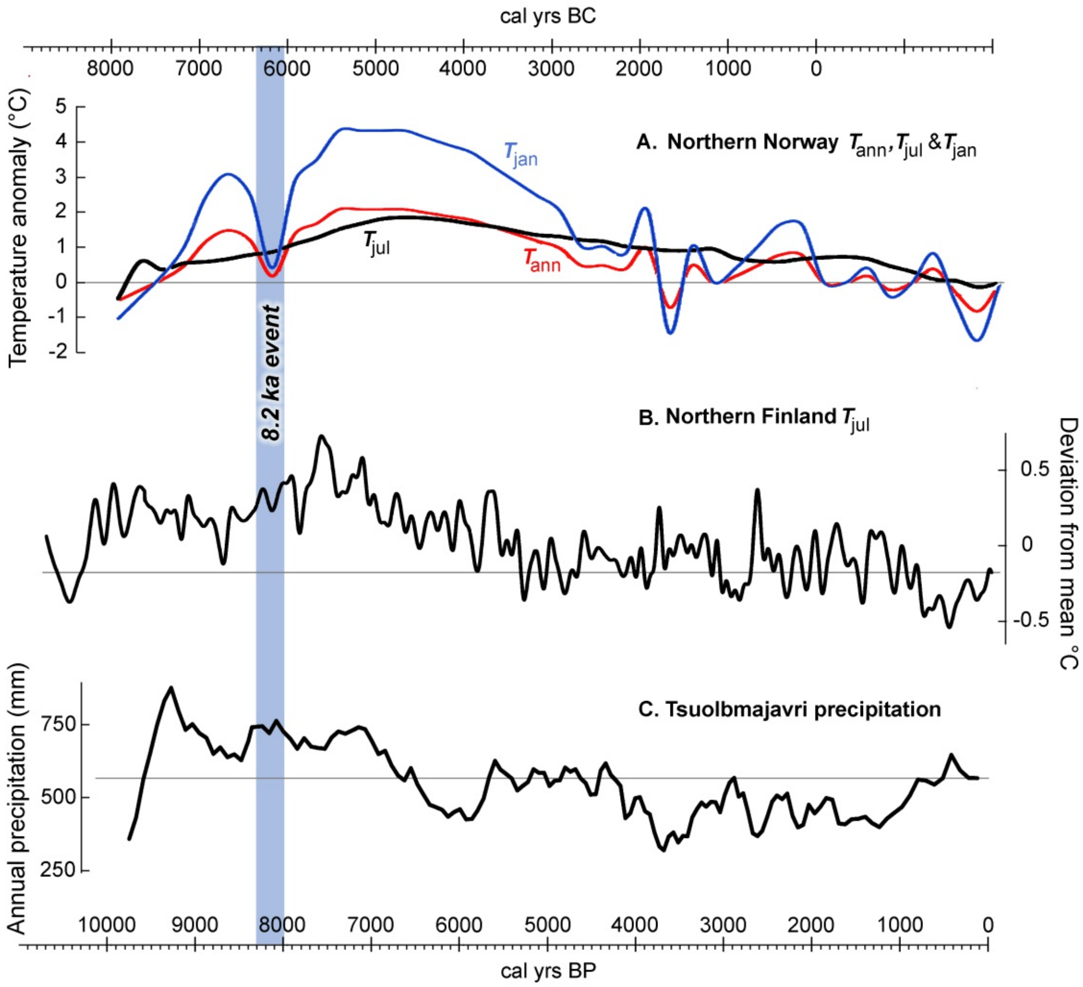


FIGURE 12. Reconstructions of Holocene temperature and precipitation. A) Northern Norway Holocene mean January (blue), mean July (black), and mean annual (red) temperatures (based on a consensus of mean July datasets, speleothem data; GISP2 Greenland Ice Core data and modern temperature relationships) presented as anomalies from modern (1961–1990) temperature (Lilleøren *et a*l. 2012); B) Consensus of six mean July temperature reconstructions (based on pollen, chironomids, and diatoms) from Lakes Toskaljavri and Tsuolbmajavri in northern Finland, computed as averages of cubic spline interpolants of centred reconstructions and presented as deviation from Holocene mean temperature (Erästö *et al. submitted*); C) Annual mean precipitation (mm) inferred from Lake Tsuolbmajavri pollen assemblages (Seppä & Birks 2001; St. Amour 2009:Fig. 5-5). The grey horizontal lines indicate present conditions.

This trend, however, was punctuated by abrupt cooling episodes, most notably the 8.2 ka event (Allen *et al.* 2007; Lauritzen & Lundberg 1999; Lilleøren *et al.* 2012; Seppä *et al*. 2007; for other earlier cooling episodes, see, e.g., Balascio & Bradley 2012; Björck *et al.* 2001; Came *et al.* 2007; Fleitmann *et al.* 2008; Korhola *et al.* 2002; Lauritzen & Lundberg 1999; Rasmussen *et al.* 2007; Rosén *et al.* 2001; Seppä *et al.* 2002).

The relatively short-lived Holocene cold events vary in magnitude in the different temperature reconstructions in northern Fennoscandia, not only because of real differences in their climate effects but also due to differences and problems in the proxy records, such as varying temporal resolutions and degrees of chronological error, the time of year represented by the data (e.g., T_{jul} vs. T_{ann}), the sensitivity of the species/taxa used as biological proxies for temperature changes in a given environment, and the indirect nature of some of the climate effects (e.g., Erästö *et al. submitted*; Nyman *et al.* 2008; Rosén *et al.* 2001; Seppä *et al.* 2007; 2009b; Velle *et al.* 2010).

This is also true in case of the 8.2 ka event, which is the only prominent early Holocene cold event in the modelled mean annual and mean January temperatures for northern Norway (**Fig. 12A**). Nevertheless, this event is hardly visible in many mean July temperature reconstructions in northern Finland, even though it is detected in more southern parts of the country (Seppä *et al.* 2007; 2009b; but see Korhola *et al.* 2002) as well as in the northern Norwegian coastal area (Allen *et al.* 2007). Seppä *et al.* (2007) suggest that during the event increased cooling may have taken place mostly during the winter and early spring, and for this reason, the event is not visible in pollen-based records in northern Finland, where most of the tree taxa flower later in the year.

Based on the present evidence, it thus seems that during the 8.2 ka event, summer temperatures were not greatly affected in northernmost Fennoscandia, whereas the mean annual temperature sum decreased considerably (Allen *et al.* 2007: Fig. 5), which suggests longer and relatively colder winters.

1.6.3. The biotic environment on dry land

During and after deglaciation, the rising early Holocene temperatures brought about rapid shifts in the predominant vegetation regime in northern Fennoscandia, from open tundra vegetation, through a birch (*Betula*) forest phase, to closed forests dominated by birch and pine (*Pinus sylvestris*), especially in the inland region (Hicks & Hyvärinen 1997; Hyvärinen 1975; Rankama 1996; Seppä 1996; Seppä & Hammarlund 2000; Paper I). Accordingly, during most of the Holocene, the terrestrial environment of northernmost Fennoscandia is characterised by dynamic and fluctuating ecotones between the three recurrent types of plant communities, i.e., coniferous forest, mountain birch forest, and tundra (Allen *et al.* 2007; Seppä 1996), which form the basis of both altitudinal and latitudinal vegetation zonation.

Boreal forest reached its maximum extent in northernmost Fennoscandia between *ca.* 8300 and 4000 cal BP, with a peak prior to *ca.* 6000 cal BP when pine colonised 95% of the currently unforested areas and pine stands grew at altitudes 350–400 metres higher than they do today (Eronen *et al.* 1999; Hicks & Hyvärinen 1997; Jensen & Vorren 2008; Kultti *et al.* 2006). Peat bog formation began *ca.* 10200 cal BP at the latest (Mäkilä & Muurinen 2008). Spruce (*Picea abies*) did not arrive in the area *ca.* 4500 cal BP (Seppä *et al.* 2009a).

Currently the pine-dominated Boreal forest transitions northward into Arctic tundra over a relatively short distance (Haapasaari 1988; Seppä & Hammarlund 2000), while during the pine maximum, the distance was even shorter, with grassland and dwarf-shrub tundra present only on the Barents Sea coastal strip and in areas above the mountain birch limit, i.e., some 100 metres higher than the pine limit (Allen *et al.* 2007; Kultti *et al.* 2006).

The post-glacial spread of animal species into the area occurred roughly in tandem with the vegetation development. Reindeer (*Rangifer tarandus*) most likely arrived at the Barents Sea coast during the late glacial period, alongside a set of tundra-adapted species, while European elk (or moose, *Alces alces*) and other Boreal forest species arrived gradually in tandem with the forest development (e.g., Hakala 1997; Rankama 1996; Rankama & Ukkonen 2001). Because of the wide altitudinal and latitudinal range, the variety of biotopes has been large in the area throughout the Holocene. Therefore, most of the species that moved into the area after the last glacial cycle are still present today, and the changes in the predominant vegetation regime can be assumed to have mainly caused fluctuations in their relative abundance and ranges.

The earliest known reindeer bones in the study area are from the Sujala site in Utsjoki and date to *ca.* 10040 cal BP (Rankama & Kankaanpää 2008), while the earliest sign of elk in northern Finland (*ca.* 10030 cal BP) is from Kittilä, some 40 kilometres from the southern border of the main study area (Hildén *et al*. 2010; Sarala & Ojala 2011). From the early Holocene onwards, both species were also present in the refuse faunas of hunter–gatherer sites in the inland areas of Finnmark and northernmost Finnish Lapland (**Fig. 13**). Because of their dominance in the refuse fauna at archaeological sites (e.g., Halinen 2005; Hood 2012; Rankama & Ukkonen 2001) and their potentially high return rates (*cf.* Kelly 1995: Table 3-3; Winterhalder 1981), they can be considered the most important terrestrial species targeted by prehistoric hunter–gatherers in the area.

1.6.4. The aquatic environment

At present, the aquatic environment in the study area is characterised by a large quantity of subarctic low-productivity lakes, large river systems, and the relatively high productivity Barents Sea (Gjøsæter 2009; Rankama 1996; Sorvari 2001). The Barents Sea is a shallow shelf sea divided by the Polar Front and consisting of three main water masses, i.e., coastal, Atlantic, and arctic waters, (**Fig. 14**; Loeng 1991; Loeng & Drinkwater 2007). Warm salty Atlantic water is carried into the southern part of the sea by a branch of the Norwegian Atlantic Current (an extension of the Gulf Stream), whereas low-salinity coastal water of seasonally varying temperature is carried along the coast by the Norwegian Coastal Current (Loeng 1991). The Norwegian Atlantic Current is part of the Atlantic Meridional Overturning Circulation, which consists of a surface flow of warm water from the tropics to the North Atlantic and a southward deep-ocean transport of cold water from the North Atlantic (e.g., Schmittner *et al.* 2007). The flow of warm Atlantic water into the Barents Sea has a marked warming influence on the climate of northern Finnmark (Førland *et al.* 2009).

The Holocene history of the Barents Sea is central to the understanding of hunter–gatherer adaptations in the study area. A presence of maritime-adapted hunter–gatherers on the Barents Sea coast during the early Holocene and onwards has been shown in many studies (e.g., Bjerck 2008; Engelstad 1984; Grydeland 2000; Hesjedal *et al.* 1996; 2009; Niemi 2010; Renouf 1989). The present-day oceanographic pattern was not established in the area until *ca.* 7500

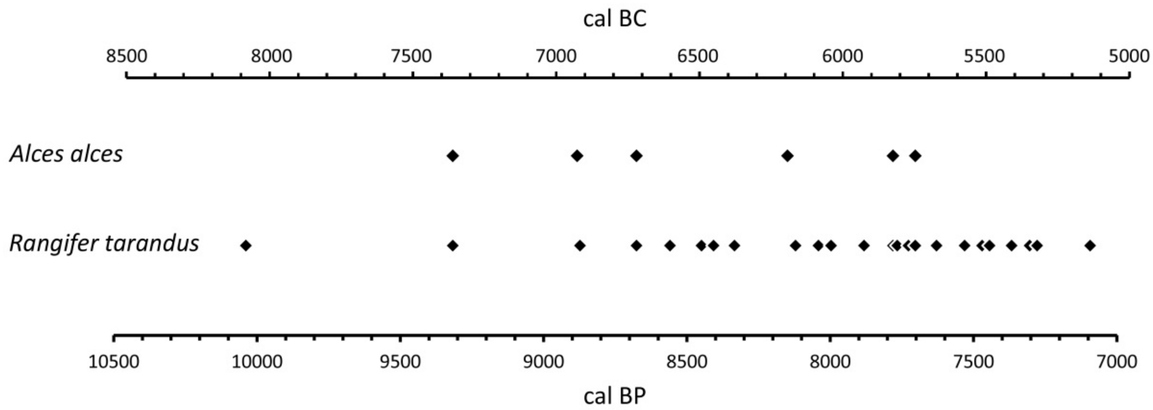


FIGURE 13. Calibrated radiocarbon date median values for European elk (Alces alces) and reindeer (Rangifer tarandus) bones from archaeological sites in Utsjoki, Inari, Enontekiö and Finnmark. Data from Hood (2012); Pesonen *et al*. (n.d.); Rankama & Ukkonen (2001); Paper IV. See Appendix I for data.

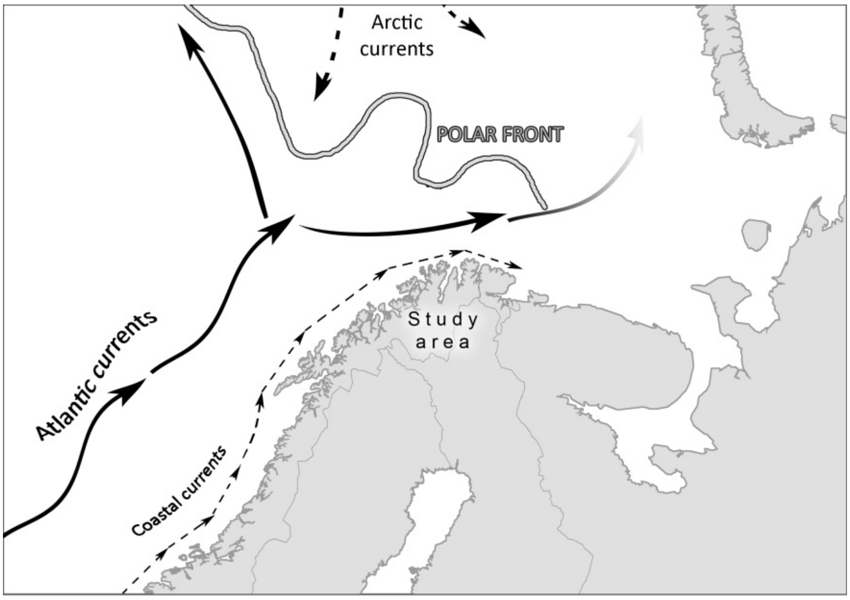


FIGURE 14. The North Atlantic ocean currents in the Barents Sea (Loeng 1991) and the present approximate location of the Polar Front (Risebrobakken *et al*. 2010). Map by the author.

cal BP (Risebrobakken *et al.* 2010), but already prior to this shift, there were gradual changes and rapid events that affected the early Holocene Barents Sea and therefore also the coastal hunter–gatherer communities.

One such event was the Storegga tsunami, which was caused by a major landslide in the Norwegian Sea at *ca.* 8200 cal BP (Hafliðason *et al.* 2005; Romundset & Bondevik 2011). It has been suggested that the tsunami had a catastrophic impact on the Mesolithic coastal societies of the southern North Sea (Weninger *et al.* 2008). Recently, tsunami deposits have been studied in several locations on the Finnmark coast and dated to *ca.* 8200–8100 cal BP, which is consistent with the dating of the Storegga tsunami (Romundset & Bondevik 2011; see also Hagen 2011). According to these studies, an abrupt water run-up of 3–5 metres occurred on the Norwegian Barents Sea coast at the time, causing severe erosion and, among other things, inundating several lakes located close to the shoreline.

The development of the marine biotic environment is less well understood, however. Currently, the Barents Sea has high biological productivity and it supports a wide variety of species, of which especially the fisheries are of particular commercial importance (Gjøsæter 2009). Unfortunately, there are no data that can be used to evaluate directly the early Holocene species composition in the Barents Sea or the abundance or composition of the species sought after by maritime-adapted Mesolithic hunter–gatherers. Currently, the earliest evidence of prey species composition comes from a single midden in the Mortensnes site in east Finnmark, which has yielded radiocarbon dates ranging from the late mid-Holocene to the late Holocene and indicates the consumption of a range of marine fauna (seal, whale, fish, seabirds, molluscs) similar to that usually found at the coastal late Holocene (post 4200 cal BP) sites in the region (e.g., Hodgetts 1999; Schanche 1988).

The rivershore and lakeshore sites dating to the early Holocene have not yielded fish bones either. However, the runs of anadromous fish species in particular, most notably salmon (*Salmo salar*), along the river systems were most likely an important seasonal food resource for prehistoric hunter–gatherers (Rankama 1996). The impact of climate events on these species and indeed their importance to Mesolithic hunter–gatherers is difficult to assess, however, because of riverbank erosion that has destroyed many of the potential river-bound sites

(Rankama 1996) and the poor preservation of Salmonidae bones in the area (Ukkonen 1997).

1.7. Aims of the thesis

Although technological and thus also cultural changes in northern Fennoscandia seem to roughly coincide with the 8200 cal BP event, the mechanism leading to these changes, the effect of the cold event on hunter–gatherer ecosystems in the area, and indeed the possible causality between the climate event and the cultural changes have remained largely unstudied (but see Hagen 2011). In this dissertation, I attempt to shed light on these questions while at the same time providing a more detailed picture of the Late Mesolithic margin-retouched point technology and its relationship to other Mesolithic traditions in Fennoscandia.

Because it is evident that climate does not have a direct impact on lithic technology, the evaluation of constraints in both the physical and social environments that potentially affect human behaviour and the evolution of lithic technology in the studied part of Europe make up an important part of the thesis. Previous research has shown that changes in lithic technology occurred during the Late Mesolithic in northernmost Fennoscandia and that the changes in primary lithic production, as well as in arrowhead technology and distribution, can be considered the most visible and easily recognisable signs of these changes in Finnmark and northern Finnish Lapland.

However, to be able to study whether and how the 8.2 ka cold event might have triggered the chain of events that led to new technology and especially to the spread of the margin-retouched point concept, it is first necessary to know the date, extent, and ecological and technological contexts of the Late Mesolithic margin-retouched point "phenomenon", irrespective of present-day national borders. Such a survey makes it possible to better evaluate how the margin-retouched point sites in the inland areas of Finnmark and in northern Finnish Lapland are connected to the Barents Sea coastal sites and whether causal relationships between the changes that occurred in the two areas can be detected.

The fact that lithic raw materials from the Barents Sea coast have also been found in connection with the new point type in the inland region suggests that there was a change in the organisation of land use and/or in hunter–gatherer social networks (*sensu* Whallon 2006) towards the end of the Mesolithic. The settlement configurations and patterns of lithic raw material movement and use indicated by the Late Mesolithic margin-retouched point sites and technology therefore need to be studied. The underlying assumptions are that the most prominent consequences of the 8.2 ka event in the study area are likely to have been related to the availability and distribution of food resources and that by studying the organisation of technology and land use it is possible to better evaluate whether the changes in lithic technology were linked to changes in resource availability due to the abrupt climate change.

Focusing on the margin-retouched points as an indicator of the new technology, I try to grasp both cultural factors (technological traditions and transmission of culture) and factors in the natural environment (food resource availability, raw material availability and raw material properties) that could explain the development and spread of this arrowhead manufacturing concept during the Late Mesolithic in areas that are often considered to represent separate cultural and technological traditions during much of the earlier Mesolithic period. The interconnected goals of the thesis can thus be summarised as follows:

• To study the date and extent of Late Mesolithic oblique point use in northernmost Fennoscandia and its relation to earlier technological traditions in the area, as well as to the Late-Mesolithic margin-retouched points in more southerly Finland and beyond.

• To study the settlement configuration represented by the Late Mesolithic margin-retouched point sites in northernmost Fennoscandia, as well as the organisation of technology at these sites, while trying to understand the effects of the differing properties and availability of vein quartz *versus* raw materials of better controllability and workability on the technology.

• To evaluate whether the introduction of the margin-retouched point concept to the inland areas of northernmost Fennoscandia and the contemporaneous changes in lithic technology in the study area can be linked to abrupt climate change.

2. THE THEORETICAL AND METHODOLOGICAL FRAMEWORK OF THE STUDY

In terms of theory, the framework of the dissertation can be defined as Darwinian. The study is informed by two complementary approaches, namely *cultural transmission theory*, a segment of dual inheritance (or co-evolutionary) theory (*cf.* Bentley *et al.* 2008; Boyd & Richerson 1985; Collard *et al.* 2008; Eerkens & Lipo 2007; Johnson 2010; Richerson & Boyd 2005) and evolutionary or *behavioural ecology* (*cf.* Barton & Clark 1997; Kelly 1995; Surovell 2009; Winterhalder & Smith 2000). Human behavioural ecology can be defined as the study of evolution and adaptive design in an ecological context (Winterhalder & Smith 1992:3) that is particularly focused on the way natural selection shapes human societies. Cultural transmission theory, on the other hand, seeks to explain the evolution of culture.

In cultural transmission theory, cultural traditions are viewed as products of socially transmitted ways of thinking, while innovation, random choice, selection, and mechanisms of social transmission are considered comparable to the concepts of natural selection, genetic inheritance, mutation, and drift in biological evolution (Boyd & Richerson 1985; Cavalli-Sforza & Feldman 1981; Newson *et al.* 2007; Shennan 2005; 2008). Culture is consequently seen as a means of adaptation that produces non-biological responses to environmental stresses and thus potentially reduces the need for genetic evolution as a response to such stresses (Boyd & Richerson 2005).

The evolutionary framework and the organisational approach (see below) of this dissertation offer the advantage of enabling the use of hypotheses that can be tested using archaeological and ethnographic data and re-tested when new data become available. In addition, ecologically oriented studies in archaeology are beneficial to studies of any and all aspects of human behaviour, regardless of theoretical orientation, as they provide an understanding of environmental constraints on behaviour that acknowledges the inescapable role of humans as a part of the ecosystem. An understanding of the ecological factors that have affected human behaviour thus provides a baseline against which socially governed behaviour can also be studied.

Behavioural ecological studies are

conducted to detect underlying causal variables in human behavioural diversity by designing and testing hypotheses of optimal patterns of behaviour (Broughton & Cannon 2010b; Broughton & O'Connell 1999; Cronk 1991; Winterhalder & Smith 2000). Studies conducted within such a framework usually investigate hunter–gatherer adaptations by modelling optimal solutions to foraging problems for the purpose of identifying those features in the environment that have affected human behaviour and its evolution. In fact, rigorous mathematical formalism can be considered an important quality of evolutionary ecology as a whole (Surovell 2009; Winterhalder & Smith 2000). This quality distinguishes the present study from mathematically oriented evolutionary ecological research because although the goal here is to study evolution and adaptive design in an ecological context, the models in this study, as in much of the research utilising the organisational approach to the study of technology (e.g., Andrefsky 1994; Binford 2002; Johnson & Morrow 1987; Kelly 2001; Kuhn 1994; Nelson 1991; Shott 1986), are informal.

In this dissertation, I therefore try to understand the roles of the physical environment and the evolution of socially transmitted technological traditions in a specific hunter–gatherer context. By doing so, I attempt to avoid explanations that relate all variation in human behaviour to either social causes or rational choice. At the same time, the study contributes to the understanding of the effect of socially transmitted information on the organisation of prehistoric technology (*cf.* Kelly 1995: 58–62; Moore & Newman 2013).

2.1. The organisational approach in hunter–gatherer research

I use an organisational approach to study the settlement configuration represented by the Late Mesolithic inland margin-retouched point sites and its relation to changes in stone tool production technology. This approach has its roots in archaeological studies of human behaviour and especially in the formulation of methods of inference for (Binfordian) middle-range theory (e.g., Binford 1978; 1979; Maschner 1996; Nelson 1991; Schiffer 1976). The approach can be used to identify factors that affect the organisation of sites and activities using behavioural inferences drawn from ethnographic and ethnoarchaeological research by assessing their effect on such archaeologically detectable aspects of past societies as technology, site structure, and settlement configuration. Ethnoarchaeological investigations and ethnographic data suggest that there are several common denominators that characterise mobile camp sites, such as small dwellings and small site sizes, low investment in housing, high feature discreteness, low degrees of debris accumulation, and low preventive site maintenance (e.g., Binford 1990; Chatters 1987; Gamble & Boismier 1991; Gould 1971; Jones 1993; Kelly *et al.* 2005; Kent 1991; Panja 2003; Paper V).

However, when studying aspects of past hunter–gatherer life that are not relevant to the majority of contemporary hunter–gatherers, such as stone tool production and use, inferences about factors that shaped their organisation in the past cannot, in most cases, be tested against ethnographic data. Instead, constraints on human behaviour imposed by such variables as lithic raw material availability (and its relation to settlement configuration) are studied by formulating models that use currencies borrowed from economics, such as utility, efficiency, and risk and by testing the models against archaeological data (e.g., Kelly 2001; Nelson 1991; Surovell 2009; Torrence 1983; 1989). Most studies of lithic technological organisation therefore strive to study the relationship between a constraint and the optimisation of some currency, a fact that indicates obvious rallying points with more formal evolutionary ecological approaches (Jochim 1989; Surovell 2009:10).

Among the reasons that northern Fennoscandia is a study area well suited to the objectives of this study, especially with respect to changes in prehistoric hunter–gatherer lithic technological organisation, are its great variability in stone tool technology throughout prehistory (e.g., Hesjedal *et al.* 1996; Kankaanpää & Rankama 2005; Nummedal 1929; Rankama 1997; Woodman 1999) and the clear-cut division in lithic raw material availability. These qualities facilitate the study of raw material and artefact movement in the area and therefore offer a good platform for studying factors involved in the way lithic technology was organised in relation to raw material availability and properties, especially when combined with knowledge of settlement configuration, economic organisation, and lithic technological traditions.

A central avenue of investigation in studies of lithic technological organisation over the years has been the relationship between the organisation of hunter–gatherer land use and stone tool technology (e.g., Andrefsky 1994; Bamforth 1991; Blades 2001; Carr 1994; Johnson & Morrow 1987). Many studies have considered formal lithic technologies, such as blade production and bifacial flake cores, which are advantageous for mobile groups because of such benefits as low carrying costs and raw material conservation (e.g., Hertell & Tallavaara 2011b; Kelly 1988; Parry & Kelly 1987; Rasic & Andrefsky 2001), particularly when there is a limited supply of raw materials of good workability and controllability (Andrefsky 1994). This has led some researchers to erroneously equate high mobility with formal lithic technology (*cf.* Bamforth 2009; Paper V).

As noted by Kuhn (1994; see also Surovell 2009:142–150), if mobile tool kits are designed to maximise durability and functional versatility while simultaneously minimising weight, the carrying of formal prepared cores is not necessarily more advantageous in terms of transportation costs than is the carrying of small flake blanks and tools. Recently, the superiority of formal prepared cores, in comparison to informal flake cores, in terms of raw material conservation, has also been questioned (Eren *et al.* 2008; Jennings *et al.* 2010; Prasciunas 2007).

This dissertation contributes to this discussion by providing an example from an area where sources of lithic raw materials of good flakeability and predictability are restricted and localised and by studying sites where these raw materials were used in arrowhead production, despite these sites being located at considerable distances from the raw material sources. At the same time, the widely available vein quartz, which is infamous for its poor predictability and controllability (e.g., Callahan 1979:16; Cotterell & Kamminga 1990:127; Siiriäinen 1981b), was commonly utilised at these sites and thus had a role in the way technology was organised by constituting a major factor in the “n-dimensional mesh” of organisational dimensions (*cf.* Chatters 1987; Bamforth 2009).

Knowledge of the movement and use of lithic raw materials has also been employed in earlier studies of land use patterns and settlement configurations in the area (e.g., Grydeland 2000; Halinen 2005; Havas 1999; Hood 1992b; 1994; Rankama & Kankaanpää 2011). However, only Hood (1994) has studied lithic raw material movement in the study area in an organisational framework. It is therefore still largely unknown how raw materials moved in the area and whether the availability of lithic raw materials, stone tool production technology, and the degree of mobility co-vary in the way predicted by models that combine formal lithic production with high mobility and low raw material abundance or whether mobile groups possibly organised their lithic technology otherwise, for instance, by carrying and utilising flake blanks. These questions have obvious relevance when studying the Late Mesolithic changes in the study area, i.e., the changes in raw material use and blank production, as well as the spread of the flake-based margin-retouched point technology.

2.2. The difference between culture and behaviour

Earlier research on the Mesolithic of northernmost Fennoscandia has been conducted within various theoretical frameworks. Nevertheless, most of this research has been interconnected through the use of established typological classifications of lithic artefacts that stem from early culture historical studies and are the basis of defined archaeological cultures. These classifications can be also employed as heuristic devices in current evolutionary approaches (Riede 2006; Riede *et al.* 2012; Roberts & Vander Linden 2011) as they usually succeed in following developments that can be related to the evolution of technological traditions.

However, in large parts of Fennoscandia, classification of lithic artefacts into formal types has not been successful, due to the simple and informal mostly vein quartz-based technology present at Stone Age sites (Knutsson 1998; Rankama *et al.* 2006; Siiriäinen 1981b). Although this situation is most likely more challenging for the researcher than for the prehistoric inhabitants of the area, it nevertheless adds to the importance of studying the impact of differences in the natural environment, not only in lithic technology but also in the transmission of culture. Following the definition used in the framework of cultural transmission theory, in the coceptual framework of this study, culture is understood as socially transmitted information on cultural variants that is capable of affecting an individual's behaviour, and unlike individually learned behaviour, culture is inherited in potentially endless chains (Boyd & Richerson 1985; Richerson & Boyd 1992).

The distinction between culture and behaviour, as well as the products of behaviour, such as artefacts, need to be emphasised when culture is seen as socially transmitted information. Behaviour is considered to be a product of both cultural factors and factors in the physical environment, which means that two individuals sharing the same cultural tradition may act differently in different environmental settings (Boyd & Richerson 1985; see also Binford 1973). Hence, changes and differences in the physical environment, such as raw material properties and availability or changes in the ecosystem may cause differences in behaviour (and artefacts) that are not directly influenced by cultural factors.

However, although social learning is considered to be a transmission mechanism that is in many ways comparable to genetic inheritance in biological evolution, it is acknowledged that there is a clear difference between genetic inheritance and the inheritance of socially transmitted information. The mechanisms operating in the latter are much more diverse and involve, for instance, commonly occurring horizontal transmission (**Fig. 15**), which is very rare for genetic information, as well as decision-making forces, i.e., learning biases, some of which increase the number of cultural variants within populations and others of which reduce variation (Boyd & Richerson 1985; Cavalli-Sforza & Feldman 1981; Newson *et al.* 2007; Richerson & Boyd 1992; 2005; Shennan 2005). In certain situations, the way

	Modes of cultural transmission			
	Vertical or parent-to-child	Horizontal or contagious	One-to-many	Concerted or many-to-one
Transmitter	Parent(s)	Unrelated	Teacher/ leader/ media	Older members of social group
Transmittee	Child	Unrelated	Pupils/ citizens/ audience	Younger members of social group
Acceptance of innovation	Intermediate difficulty	Easy	Easy	Very difficult
Variation between individuals within population	High	Can be high	Low	Lowest
Variation between groups	High	Can be high	Can be high	Smallest
Cultural evolution	Slow	Can be rapid	Most rapid	Most conservative

FIGURE 15. Simple model of cultural transmission. In comparison to biological evolution, cultural evolution is made more complex by the transmission of cultural variants horizontally (between peers) and obliquely (from more experienced non-parents to less experienced individuals). Modified from Cavalli-Sforza & Feldman (1981); Hewlett & Cavalli-Sforza (1986); see also Newson *et al*. (2007).

cultural variants are transmitted can also produce maladaptive results such as loss of technology (Henrich 2004; Riede 2009b).

When discussing material culture, as is the case in most parts of this study, it is important to note that the modes of cultural transmission that affect the frequency of cultural variants within populations, as well as other mechanisms of cultural evolution, can also be expected to influence artefact populations, i.e., the archaeologically visible representations of social learning/cultural transmission and shared traditions (*cf.* Mesoudi & O'Brien 2007). It is assumed that the way information is transmitted has a bearing on the relative amount of variation within artefact groups (Bettinger & Eerkens 1997; 1999; Eerkens & Lipo 2007).

2.3. Technological traditions and cultural inertia

The fact that representatives of groups with different cultural histories often behave differently even when inhabiting similar environments and performing similar tasks, i.e., that a large amount of cultural diversity exists among human societies, is explained by *cultural inertia* in cultural transmission theory. The possibility of horizontal transmission of culture between representatives of the same generation enables potentially rapid culture change in situations in which rapid changes make earlier adaptive solutions useless or impractical, such as during abrupt ecosystem crises (*cf.* Acerbi & Parisi 2006). Nevertheless, it is argued that due to cultural inertia, changes in cultural traditions in response to (gradual) environmental change should usually be slow and that history should explain a significant fraction of present behaviour (Boyd & Richerson 1985:56–60; see also Pagel & Mace 2004; Shennan 2009). The reasons for these phenomena can be found in the way people acquire most of their skills, i.e., by imitation and social interaction, and the way in which language differences and boundaries to movement consequently prompt cultural divergence that is self-reinforcing (Boyd & Richerson 2005:379–396; Pagel & Mace 2004).

3. MATERIAL AND METHODS

3.1. The archaeological sample

The material used to study the Late Mesolithic changes that are the main focus of the dissertation can be divided into four parts. The first part consists of the data concerning the distribution and date of margin-retouched points in Fennoscandia (Papers I and IV). The second part is a dataset on Late Mesolithic margin-retouched point shape, raw material, and technological characteristics in two separate areas in Finland (Paper IV), the third consists of the finds, reports, and documentation from excavations conducted at Mesolithic sites in northernmost Fennoscandia (Papers I, II, IV, and V), and the fourth is an experimentally produced series of quartz fractures (Paper III).

Two sets of sites were selected for analyses of technological organisation, settlement configuration, and cultural evolution. The first set consists of five inland sites, two in northern Finland (Vuopaja and Mávdnaávži 2), two in northern Norway (Devdis I and Aksujavri), and one in northern Sweden (Rastklippan). This set of sites was used for a detailed study of raw material use, site structure, and operational sequences at margin-retouched point sites in the inland areas of northernmost Fennoscandia (**Fig. 16**). The five sites were selected on the basis of the presence of an excavated occupation phase with associated margin-retouched points and reliable radiocarbon dates (Paper V). When compared to sites located on the Barents Sea coast, the inland sites provide clear advantages for the study of Late Mesolithic lithic technology. This is because earlier research has not revealed any indications of margin-retouched point use in the inland region prior to the Late Mesolithic, and because the geological features of the area are such that the use and movement of exotic raw materials is easier to detect and study along a gradient of increasing distance from the Caledonian nappes.

The second set of sites was selected for the purpose of a technological comparison between points found in southern Finland and counterparts found in northern Lapland. The sites selected for the comparison are located south and north of an empty area in the point

FIGURE 16. A view towards Lake Akšojavri and the Kautokeino River from the Aksujavri site in Finnmark, Norway (Hood 1988) (top) and excavations in progress at the Mávdnaávži 2 site, Utsjoki, Finland. From right to left: Hanna Suisto, Meri Varonen, and Esa Hertell. The Aksujavri site has had an important role in discussions concerning the Mesolithic use of interior Finnmark. The Mávdnaávži 2 site, on the other hand, can be considered a key site in the interpretation of artefact distributions and site structure at Late Mesolithic margin-retouched point sites. Photographs by the author.

distribution that lies in southern Lapland (Paper IV). A sample of 30 sites and find locations with a total of 196 artefacts reported as oblique points was analysed for technological details.

3.2. Dating methods and survey of distribution

The data on the distribution and dates of margin-retouched points in Fennoscandia were gathered from research literature as well as from unpublished survey and excavation reports in Finland, Sweden, and Norway (Papers I, II, and IV). To supplement the existing radiocarbon date data, seven samples from oblique point contexts were selected and dated for the purpose of this study (Paper IV). All radiocarbon dates were calibrated using OxCal version 4.1.7 or later (Bronk Ramsey 2010) and the IntCal 09 calibration curve (atmospheric data from Reimer *et al.* 2009), unless otherwise indicated. The calibration procedure used for samples with probable marine reservoir effect (Baltic Sea) is described in Paper IV. Possible cultural boundaries were outlined by comparing the distribution of Late Mesolithic margin-retouched points to those of preceding and contemporary technological traditions (Papers I and IV).

The shore displacement chronology of Mesolithic sites on the Finnish Baltic Sea coast compiled by Matiskainen (1982; 1989) was also utilised, and to a small degree refined, in this study (Papers I and IV). In addition, the find locations of margin-retouched points on the southern shore of Varangerfjord, Norway, were shoreline dated to gain a better understanding of their chronological position on the Finnmark coast. The shoreline dating procedure is described in Paper I. The origin and history of descent of the oblique point was studied by comparing the dates and distributions of margin-retouched points in nearby areas and by using radiocarbon dates to study the most probable direction of spread of the new point type within eastern Fennoscandia. The method is described in more detail in Paper IV.

3.3. Lithic analyses

Details of stone tool production technology and operational sequences used at the studied sites were inferred using basic debitage typological and aggregate analyses and analyses of flake tool attributes (*cf.* Andrefsky 1998; 2001). A special effort was also made to increase the understanding of quartz fracture mechanics and the properties of vein quartz in lithic production and use by experimentally producing data on quartz fragmentation patterns (Paper III). Because of the restrictions on lithic production caused by the high fragmentation tendency of quartz (Callahan *et al.* 1992) the type of effect the use of quartz had on the way technology was organised was also studied (Papers III, IV, and V).

The debitage typological analyses were designed to provide an overview of the nature of the studied site assemblages. The material was classified into flakes, cores, and tools. Following the convention in Fennoscandian quartz studies (e.g., Callahan 1987; Darmark & Sundström 2005; Lindgren 2004; Rankama 2002; Paper III), flakes and cores were divided into *platform vs. bipolar* flakes or cores, depending on the reduction method (platform core of bipolar-on-anvil core reduction). This procedure deviates slightly from the most conventional approach to lithic technological classification, according to which platform reduction is considered the norm, while bipolar flakes and cores are treated as special debitage classes. However, due to the common use of bipolar reduction in quartz flake production in Fennoscandia (and elsewhere; see Paper III), in debitage typological analyses of assemblages, including quartz artefacts, it is better not to consider one of the two reduction methods as the norm.

Flake tool attributes were studied from retouched artefacts and especially margin-retouched points. As it was suspected that differences in within-group variation could indicate differences in transmission mechanisms (*cf.* Bettinger & Eerkens 1997; 1999), the measurable characteristics of point shape and dimensions of two point populations in Finland, one in the north and one in the south, were studied. The measured attributes are described in Paper IV.

The aggregate analyses used in the study include Minimum Analytical Nodule analysis (Larson 1994; Larson & Kornfeld 1997; Tallavaara 2005; Papers II and V) and basic size-graded debitage analysis (Andrefsky 1998:128–131; Paper II). Using a variation of Minimum Analytical Nodule analysis, the movement and utilisation patterns of lithic raw materials were studied by dividing site assemblages into analytical nodules according to visual raw material characteristics. The results of this division were combined with the results of debitage typological analyses to make inferences about future activity planning, adaptive strategies, and mobility patterns at the studied sites.

Due to the generally small size of lithic artefacts in the studied assemblages, as well as the small sizes of the site assemblages, no size cut-off was used in the Minimum Analytical Nodule analysis. The same was also true for the refitting (*cf.* Cziesla 1990) of the Mávdnaávži 2 lithic material, the results of which were used to confirm the picture of on-site activities given by find distributions at the site (Papers II and V).

3.4. Spatial analyses

The site structure and spatial organisation at the Late Mesolithic margin-retouched point sites (Papers I and V) were studied using artefact distributions and their relationship to hearths and other site features. The degree of preventive site maintenance and organisation of on-site activity was inferred from the patterns of find distribution and density and using behavioural inferences of settlement configuration and future activity planning, as well as group size and composition, drawn from ethnographic and ethnoarchaeological research (Paper V).

3.5. Statistical methods

Basic statistics were used in the analyses of the data gathered and used in the different parts of the study. The statistical analyses were conducted in part by Miikka Tallavaara (Papers III and IV) and in part by the author (Papers IV and V). The data treatment procedures and the inferential statistical analyses (comparison of paired correlations and coefficients of variation, correspondence analysis, log-linear modelling, and logistic regression) are described in the individual papers. Descriptive statistics were used to provide simple graphic summaries (box plots, scatter plots, line charts, bar charts, and cross tabulations) of the analysed data (Papers I–V).

4. RESULTS AND DISCUSSION

4.1. Dates, distribution, and descent

The radiocarbon-dated inland contexts in northernmost Fennoscandia, as well as the radiocarbon- and shoreline-dated sites in Sweden and more southerly Finland (Papers I, II, IV, and V), indicate that south of the Barents Sea coastal sphere, the use of margin-retouched points is a Late Mesolithic phenomenon, with the majority of dates falling between 8500 and 7000 calibrated radiocarbon years BP (**Fig. 17**).

The distribution of sites with margin-retouched points in Finland, Sweden, and northern Norway (**Fig. 18**; Papers I and IV) shows that in northern Sweden, the points are rare (4 reported sites) whereas in Finland and northern Norway, Late Mesolithic sites with such points are relatively numerous (over 160 reported sites). The results thus indicate that during the Late Mesolithic, virtually identical arrowheads were in use in both coastal and inland settings in eastern Fennoscandia, from the Barents Sea coast in the north to the Gulf of Finland in the south (Papers I and IV). In both areas, the arrowhead concept fell out of use at approximately 7000 cal BP, after the introduction of Comb Ware pottery, which in eastern Finnmark and in the Lake Inari region has often been found at sites that have yielded also oblique points (Luho 1957; Skandfer 2003; 2005; Papers I, II, and IV).

An evaluation of the most likely scenarios for the descent history of the arrowhead manufacturing concept, in light of the current evidence, suggests a descent from the early post-glacial projectiles of north-central Europe via the Norwegian Atlantic coast (Paper IV). Moreover, although the dates are not numerous, the fact that the earliest dates from oblique point contexts in Finland derive from northern Finnish Lapland suggests that in eastern Fennoscandia, the arrowhead concept spread from the north towards the south (Paper IV).

When discussing change in technological traditions in northern Fennoscandia, it is important to consider the way the earliest pioneer colonisation of the area followed relatively closely the retreating Scandinavian Ice Sheet. Both archaeological finds and the dynamics of ice sheet retreat suggest that at least

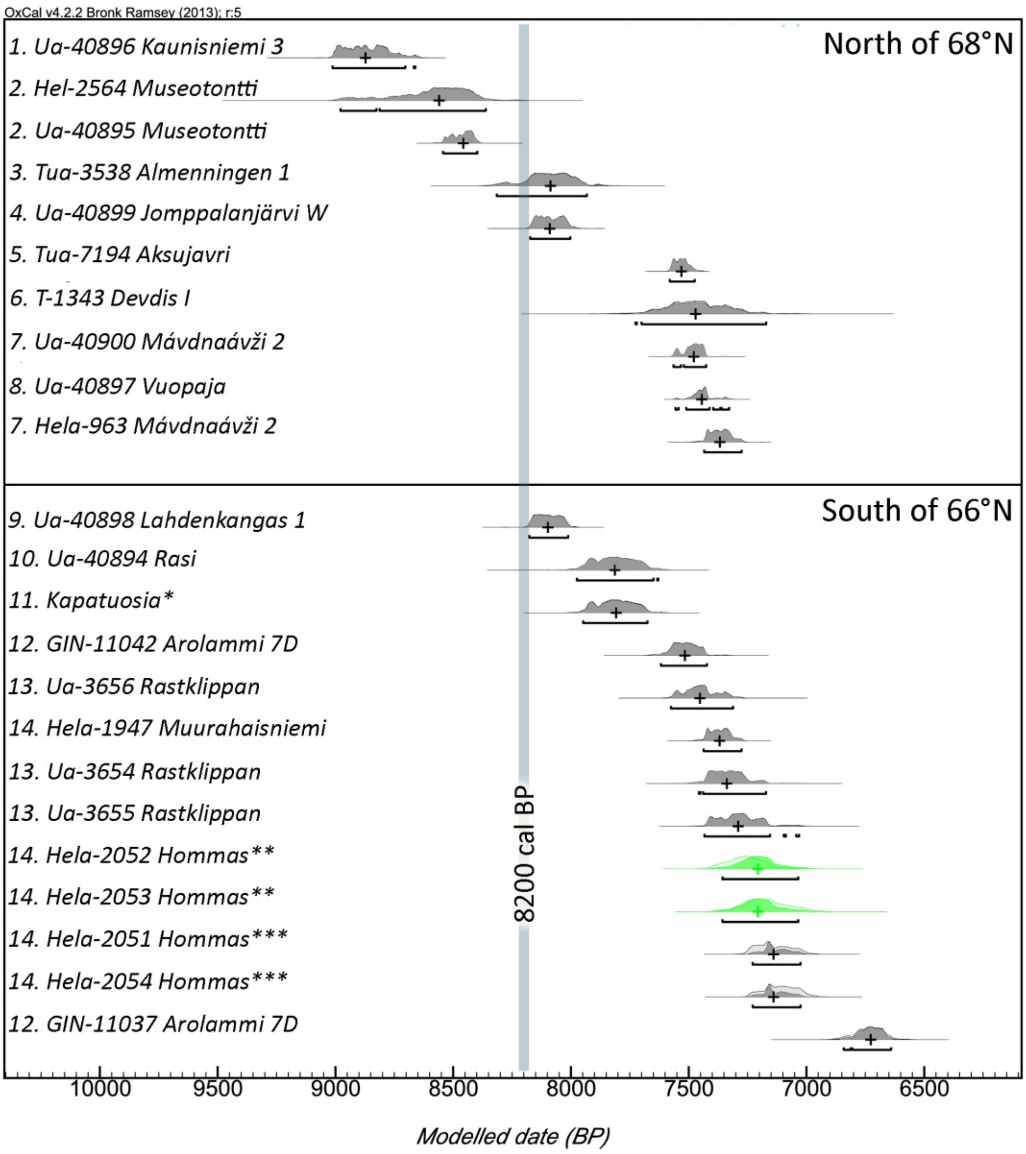


FIGURE 17. Radiocarbon dates of margin-retouched point contexts from inland sites in northernmost Fennoscandia and sites in more southerly Finland and Sweden (there are no radiocarbon-dated point contexts between 66–68°N; see Figure 18 for site locations). See Papers I, IV, and V for references, except for Almanningen 1 (Blankholm 2008), Muurahaisniemi (P. Pesonen pers. comm.) and Kapatuosia (MJrek 2013). *Lab code unpublished. **Hela-2052 and Hela-2053 calibrated using the 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).

two pioneer populations with substantially different adaptations and lithic technological traditions moved into northern Fennoscandia at the end of the last glacial cycle (**Fig. 19**; see also Knutsson 2004; Kosheleva & Subetto 2011; Rankama & Kankaanpää 2008; 2011; Tallavaara *et al. in press*). The first of these populations consists of groups using margin-retouched points that colonised the Norwegian Atlantic coast and most likely descended from the Upper Palaeolithic groups of north-central Europe (Bjerck 2008; Fuglestvedt 2007; Waraas 2001; Paper IV), while the second represents groups belonging to the so-called post-Swiderian tanged-point cultures that entered the area from the southeast (Rankama & Kankaanpää 2011; Tallavaara *et al. in press*) and probably as a consequence

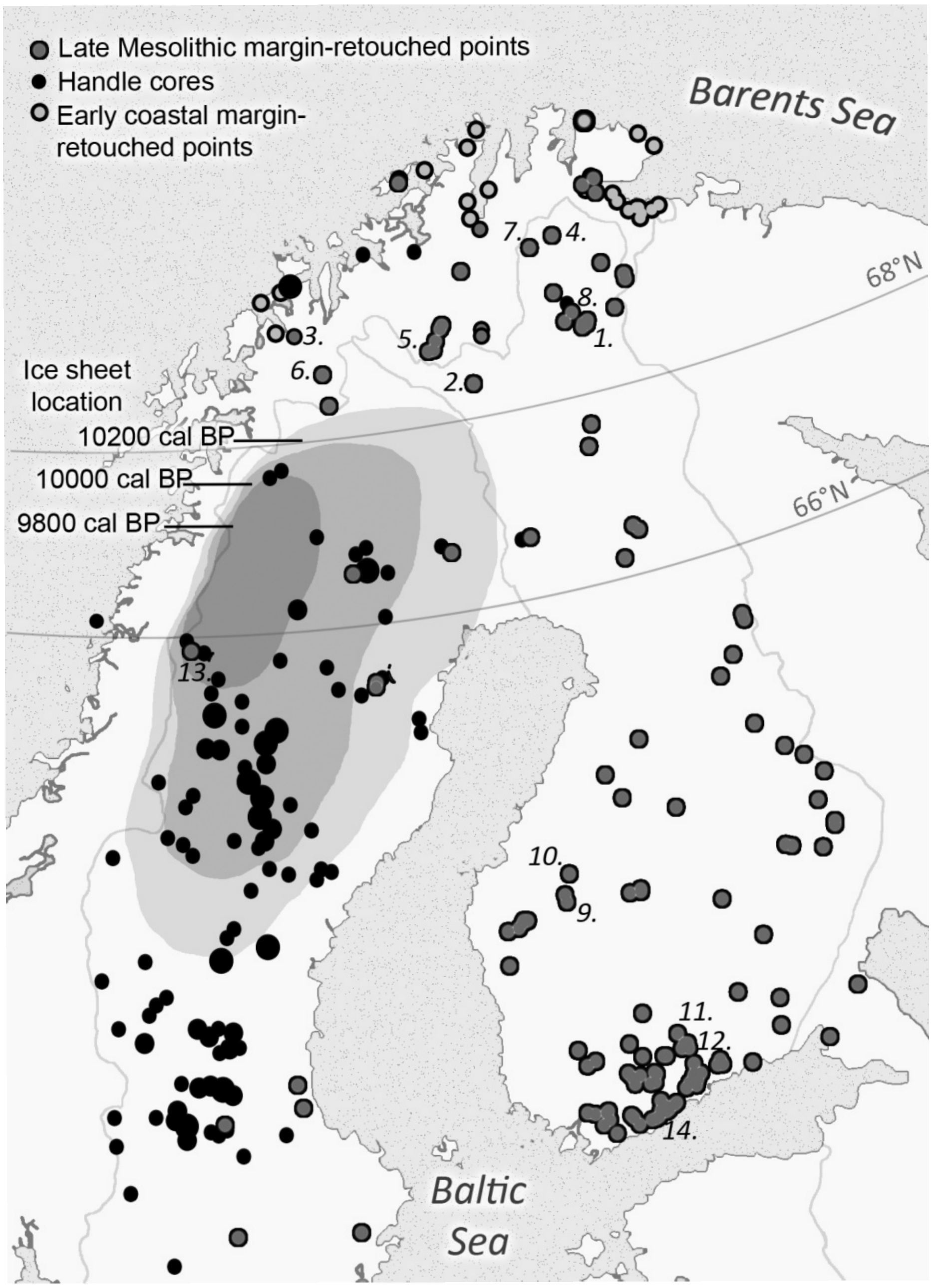


FIGURE 18. The distributions of margin-retouched points and handle-cores. The point distributions are based on Papers I and IV. The distribution of handle core sites is based on Olofsson (1995) and Paper I. Added to the earlier maps are additional finds published by Hood (2012) and the last stages of the retreat of the Scandinavian Ice Sheet (after Daniels 2010; Påsse & Daniels 2011; see also Knutsson 2004:Fig. 6). See Figure 17 for the names and dates of sites 1–14. Map by the author.

of the raw material situation quickly abandoned the formal blade-based technology typical of these groups (Tallavaara *et al. in press*; Paper V). A probable third colonisation front entered the area slightly later from the south, along the Scandinavian Peninsula (Forsberg & Knutsson 1999; Knutsson 2004).

The way the pioneer colonisation of the area took place, due to the barrier formed by the Scandinavian Ice Sheet, thus suggests that the differences in lithic technology between the Barents Sea coastal strip and the inland region of northern Fennoscandia during the early phases of the Mesolithic, in addition to environmental differences, represent a boundary between groups with different descent histories and traditions. It seems plausible that in addition to the self-reinforcing effect of cultural inertia, this boundary was also

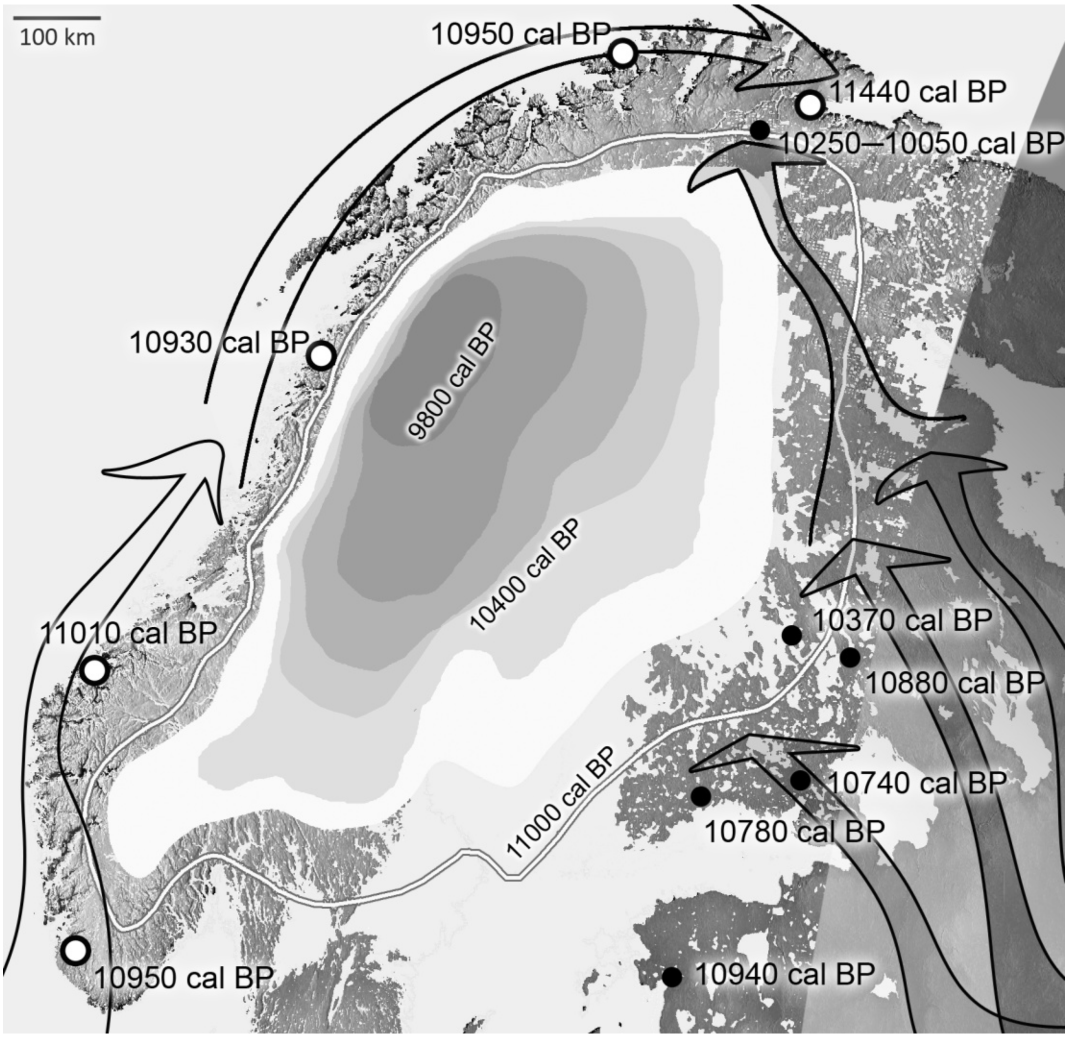


FIGURE 19. Paleomap depicting the retreat of the Scandinavian Ice Sheet and the *ca*. 10800 cal BP shoreline in Fennoscandia (Daniels 2010; Påsse & Daniels 2011), with some of the earliest known sites representing the southwestern (marine) and southeastern (terrestrial) colonisation fronts. The arrows indicate the two directions of pioneer colonisation. Dates and site locations from Bang-Andersen (2012), Bjerck (2008), Jussila *et al*. (2012), Rankama & Kankaanpää (2011), Veski *et al*. (2005) and Tallavaara *et al*. *(in press)*. Map by the author.

later reinforced by the Scandinavian Caledonides (*cf.* Damm 2006).

The current evidence suggests that the margin-retouched point concept was maintained in the Barents Sea coastal sphere for millennia but that only during the Late Mesolithic, at some point in time around the 8.2 ka event, did it cross the cultural and most likely also territorial and linguistic border that the archaeological material suggests existed between groups descending from the early post-glacial coastal pioneers on the one hand and groups descending from the pioneer colonisers that followed the retreating Scandinavian Ice Sheet from the southeast on the other (Paper IV). It seems reasonable to assume that the spread of the technological concept towards the south was triggered by the 8.2 ka event and was accelerated by the Holocene Thermal Maximum and the existence of an established hunter–gatherer network consisting of groups with shared cultural and most likely also linguistic origins that descended from the southeastern pioneer colonisation wave (Papers I, IV, and V).

It must be emphasised that the material culture divide between the interior and the coast in northernmost Fennoscandia was not geographically static during the

Mesolithic. There are also indications that at least one technological concept, namely the post-Swiderian blade-core treatment practises, crossed the border in eastern Finnmark at the end of Mesolithic Phase I and was afterwards gradually transmitted west along the Barents Sea coast (Rankama & Kankaanpää 2011; Sørensen *et al.* 2013).

The existence of long-standing borders between hunter–gatherer networks derived from the period of pioneer colonisation gained support from the distribution of material culture traits in the Late Mesolithic in northern Sweden. Here, the distribution of oblique points can be compared to the distribution of the practically contemporaneous handle cores (*ca*. 8350–6250 cal BP or 6400–4300 cal BC) common in Late Mesolithic Sweden (Knutsson 2004; Olofsson 1995; 2003; Paper I). Only a small overlap in the distributions of the two artefact types exists (**Fig. 18**), and the border zone between the spatially exclusive but temporally synchronous distributions is located in the area where the tail end of the Scandinavian Ice Sheet retreated and fell away at the end of the last glacial cycle (Paper I) and where a long-standing material culture border existed (Knutsson 2004).

The only data available for estimates concerning the temporal relationship between the 8.2 ka event and the Late Mesolithic changes in the inland areas, although still few in number, are the radiocarbon dates from oblique point contexts in Finnmark, Troms, and northernmost Finnish Lapland. There are two radiocarbon-dated oblique point contexts in the interior that predate the event by several hundred years, while the rest of the dated contexts postdate the event. However, if it is accepted that the margin-retouched point concept was present in the coastal sphere from the early pioneer colonisation onwards, it follows that there is no reason to expect that all margin-retouched points in the inland region postdate the 8.2 ka event—even if this seems to be mostly the case. However, the analysed margin-retouched point sites in the interior that postdate the event show that an organisational pattern that suggests a profound reorganisation of technology, land use, and subsistence economy took place across the earlier cultural divide during the Mesolithic Phase III.

4.2. Settlement organisation and site structure

The site structure and patterns of on-site activity at the studied Late Mesolithic inland sites were fairly uniform and suggest short occupation spans. High anticipated mobility is indicated by small dwellings and site sizes, low investment in housing, and high feature discreteness, as well as by low degree of debris accumulation and preventive site maintenance (Papers I, IV, and V). The clearest evidence of this type of behaviour, commonly encountered in association with short-term camps and high residential mobility (*cf.* Binford 2002; Chatters 1987; Gamble & Boismier 1991; Gifford 1980; Jones 1993; Kelly *et al.* 2005; Kent 1991; Panja 2003), is found at the Mávdnaávži 2 site. At this site, feature discreteness is well evidenced in find distribution and low accumulation of lithic debris, as well as in conjoins between burnt and unburnt arrowhead fragments in and around the inside hearth (**Fig. 20**).

The conjoins are clear evidence of lithic production that took place inside the small hut and next to a burning fire. Except for the arrowhead bases thrown into the fire, lithic waste was left where it fell. The most plausible explanation for the clearly low site maintenance is that the site was intended to be abandoned after a short occupation. Although less well preserved, the other studied sites seem to represent almost identical behavioural and organisational

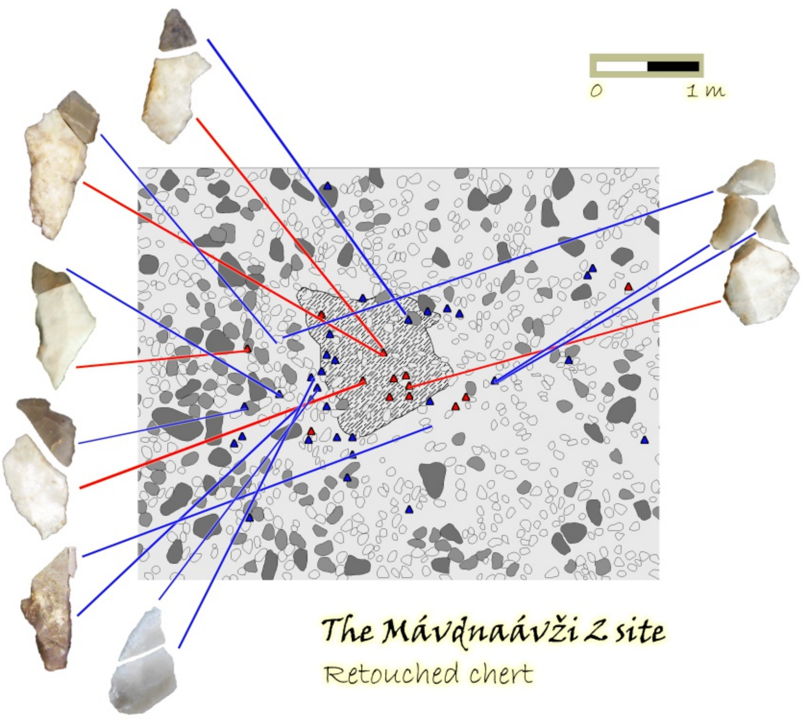


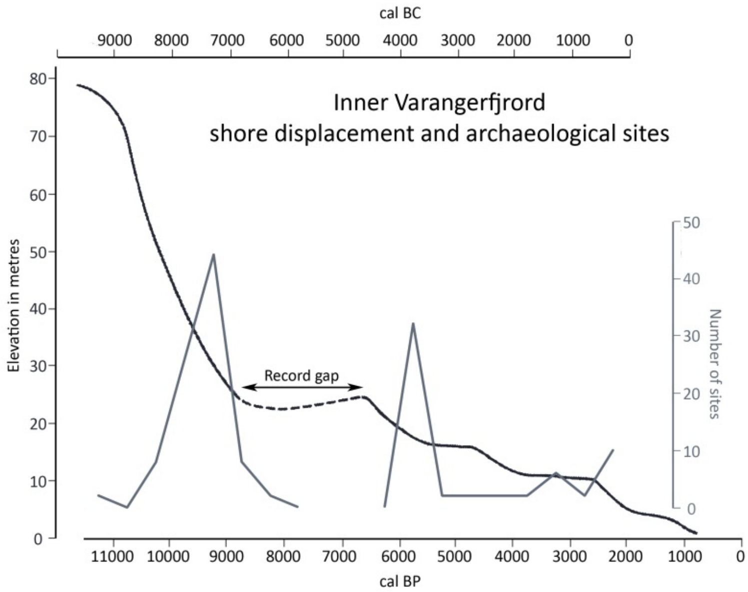
FIGURE 20. Distribution of burnt (red triangle) and unburnt (blue triangle) chert artefacts inside the Mávdnaávži 2 hut. Broken tips of unfinished points and other production waste indicate that arrowhead manufacture took place left of the hearth area (marked with dark grey). The refits and conjoins show a pattern in which the bases of arrowheads broken during manufacture were thrown into the fire. Map, conjoins, and photographs by the author.

patterns (Papers I, II, and V).

The size of dwellings at the studied Late Mesolithic margin-retouched point sites (Paper I and V; see also Grydeland 2000; Odner 1966:75–77) suggests, in addition to high anticipated mobility, that the groups occupying them were small, most likely consisting of only 4–10 individuals (Paper V). Furthermore, the organisation of space inside the dwellings suggests gendered division of labour (*cf.* Grøn 1989; 2003; Paper V) and therefore the presence of both sexes at the sites, which in turn suggests that mobility was in these cases most likely residential.

Significantly, Grydeland (2000: 26, 36, 44) observed a decrease in the number of pit-houses on the southern shore of Varangerfjord in eastern Finnmark at altitudes that are dated to *ca*. 9300 cal BP and later, which can be taken as a sign of increased mobility, smaller groups, and short site occupation spans. The dating, however, is based on a simulated shore displacement curve that suggests that there were no transgressive phases (Møller & Holmeslet 1998). If the altitude data are compared to a shore displacement curve that is based on radiocarbon-dated beach formations (Fletcher *et al.* 1993) and shows a record gap and a plateau at approximately 25 metres above sea level (**Fig. 21**), it becomes clear that the dating of the sites and phenomena in the area on the basis of altitude is not without problems. Radiocarbon-dated sites in the area indicate that during occupation, sites were often located 5 to 20 metres above the contemporary shoreline (Møller 1987; Rankama & Kankaanpää 2011:202). This fact, together with the plateau dating to *ca*. 9300–6600 cal BP caused by a transgressive shoreline, seems to have caused packing of sites at suitable locations between approximately 25 and 37 metres above sea level. Radiocarbon-dated house-pits from Varangerfjord and other locations in Finnmark nevertheless show a pattern of the number of house-pits decreasing towards the end of the Mesolithic (**Fig. 29**), which is in general agreement with the trend observable in many localities in Finnmark where house-pits became smaller and less numerous during Phase III (Grydeland 2000:25–26). After the Late Mesolithic drop, the

FIGURE 21. The number of sites in 500-year blocks according to corrected altitude (reduced by 5 metres) above sea level on the southern shore of the Varangerfjord, n=74 (Paper I) and the Inner Varangerfjord shore displacement curve (Fletcher *et al.* 1993). Site and site altitude data from Bøe & Nummedal (1936); Simonsen (1961); Odner (1966).



number of house-pits starts to increase again approximately 7000–6000 cal BP (Skandfer 2009).

4.3. Lithic technology at the studied sites

The analyses and finds reported in this study (Papers I, II, IV, and V) are consistent with earlier research that suggests that stone tool production technology at sites dating to Phase III in northernmost Finnish Lapland and northernmost Norway was based largely on flake cores and simple tools made on flake blanks (Grydeland 2005; Halinen 2005; Hesjedal *et al.* 1996:186; Olsen 1994:34; Kankaanpää & Rankama 2005).

In the analysed site assemblages, platform flakes were produced using relatively informal cores that give the impression that their treatment was dictated by the initial shape of the objective piece (Paper V). The platform cores are single-platform cores of varied morphology. In many cases, large platform flakes were used as cores in the production of smaller flakes (**Fig. 22**). The cores in the assemblages are small (with maximum dimensions less than 50 mm), which suggests that the shortest acceptable flakes were less than 20 mm in length (e.g., Helskog 1980b: Figs. 26, 27). The lengths of the flakes rarely exceed 40 mm. In addition, the material from Aksujavri, Mávdnaávži 2, and Vuopaja include bipolar-on-anvil cores of quartz.

The majority of tools in the studied site assemblages are thumbnail scrapers and margin-retouched arrowheads made of platform flakes (**Fig. 22a–j, p–s**). In addition, there is a heterogeneous group of flakes and fragments retouched with varying intensity that can be classified as arrowhead preforms, microliths, flake knives, and other indeterminate tools and rejected or discarded pieces (**Fig. 22m–o**).

4.3.1. The arrowhead manufacturing sequence

None of the 246 points included in the analyses conducted in connection with this study (Papers I, IV, and V) show any clear signs of having been produced in another manner than from platform flakes. Maximum arrowhead thickness can be used as an indication of the thickness of flakes used as blanks in point production. In points oriented perpendicular to the blank, point length also gives some indication of the blank width because the points usually have a

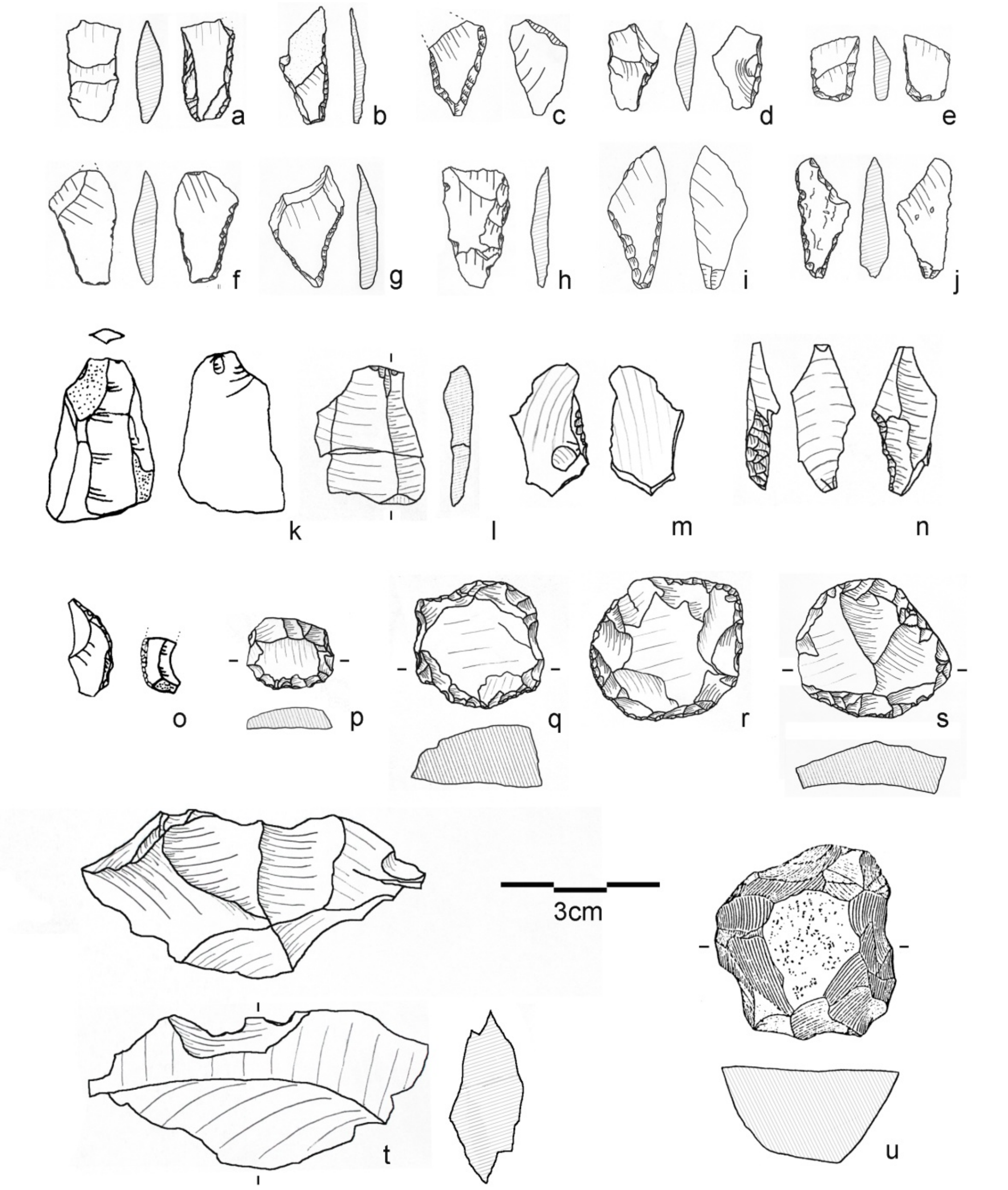


FIGURE 22. Examples of lithic artefacts from the Late Mesolithic margin-retouched point sites. A–i) arrowheads, k–n) flake blanks and arrowhead preforms; o) microliths; p–s) scrapers; t–u) cores. See Papers I and V for site information. The microliths derive from the Mávdnaávži 2 site (Manninen 2005: Fig. 8). All drawings by the author, u) after Helskog (1980b) and c), i), l–n) & t) after sketches by K. Knutsson.

side-view profile with the thickest point near the centre and the cutting edge parallel to a dorsal ridge (Paper IV). For the 158 points analysed in Paper IV, these measurements suggest that the maximum thickness of the blanks was raw material dependent but rarely exceeded 5 mm, while the width of the flake blanks was usually clearly less than 30 mm (the average length of points with perpendicular orientation is 19.2 mm, with a standard deviation of 4.7 mm).

Analyses of edge shapes and angles (Papers I and IV) show that the overall shape of the points varies from transverse points to points with one acute edge angle (between the cutting edge

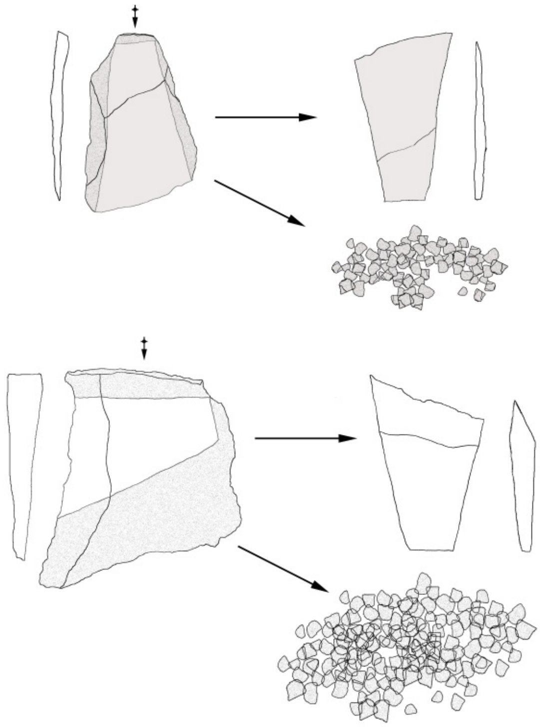


FIGURE 23. Schematic representation of typical blanks, finished products, and waste from Late Mesolithic margin-retouched point production from resilient high-workability raw material (top) and fragile low-workability raw material. Drawing by the author.

and a retouched side) to points with pointed tips. This fact makes the point type variable in form and further indicates that the blanks were of non-standardised shape.

Based on the results presented in the papers, the operational chain of Late Mesolithic margin-retouched point production can thus be summarised as a fairly simple and straightforward sequence in comparison to, for example, arrowhead production utilising formal blades. After relatively thin flake blanks were produced from single-platform cores, the part of the flake-edge considered to be best for the cutting edge of the arrowhead was determined, and finally, the point was shaped by removing the excess part of the blank with semi-abrupt to abrupt margin retouch, thus producing large quantities of small short retouch flakes (**Fig. 23**). The majority of points were oriented perpendicular to the blank, but points made of chert were almost as often oriented parallel to the blank. If the base of the arrowhead was considered too thick, it was thinned with small semi-invasive to invasive detachments, usually after the point had been otherwise shaped. Only a few slightly deviations from this procedure exist in the studied material (see Paper IV for further discussion).

The comparison of points from northernmost Finnish Lapland and southern Finland reported in Paper IV further indicates that although there are differences between the areas and more variation in the northern group of points, these differences are best explained by the differences in raw material use in the two areas and especially by the properties of vein quartz, i.e., the raw material that was almost exclusively used in the southern points. On the other hand, in comparison to coastal Phase I margin-retouched arrowheads, some clear differences can be detected in the late points. Phase III points tend to be transverse or oblique, whereas the earlier points tend to be tanged single-edged or double-edged (Paper I). The early points also tend to be made on blades (Hesjedal *et al.* 1996:166), whereas the late points are practically always made on flakes.

4.3.2. Patterns of raw material movement and use

A large variety of raw materials is found among the margin-retouched points in northernmost Fennoscandia. In northernmost Finnish Lapland and in northernmost Norway, the arrowheads were made of different varieties of chert and quartzite, as well as from vein quartz and rock crystal (**Table 1**). Of these raw materials, practically all of the varieties of chert and most likely most of the quartzite as well came from sources outside the borders of present-day Finland.

The fact that a relatively large quantity of sites in the Lake Inari region has nevertheless yielded margin-retouched arrowheads made of varieties of chert that originate in the Barents Sea coast indicates that in this technological context, it was not uncommon for lithic raw materials to be carried over 150 kilometres from their sources (Papers I, II, IV, and V). The material from the sites studied in Paper V indicates that arrowheads in particular were produced from chert and other raw materials of good flakeability and predictability, even though the proportion of quartz in site assemblages clearly increases with increasing distance to sources of these types of raw materials (**Fig. 24A**). This suggests that the margin-retouched points of vein quartz, known from three sites in the Lake Inari region and elsewhere (Papers I, II, and IV), were produced only after raw materials of better working qualities were depleted. The distance-decay pattern observable in arrowhead length (**Fig. 24B**) further suggests that the raw materials of good predictability and flakeability were used up gradually, a pattern that points to a growing total of re-tooling episodes with increasing distance from the raw material source (Paper V).

The results of the Minimum Analytical Nodule analysis (Papers II and V) show that each of the studied sites has one or two relatively large analytical nodules and a group of small nodules that in most cases contain less than 10 artefacts and often consist of only retouched pieces. A plausible explanation for this pattern is that large nodules represent on-site manufacture, while small nodules consist of tools and blanks produced elsewhere and brought to the sites as parts of portable tool kits (Paper V). The large variety of raw materials and the types of raw materials found in, for example, the assemblages from Utsjoki and Inari (Papers I and IV), suggests that tool-stone was

Margin-retouched point raw materials in the interior

	Troms	*Finnmark*	*Utsjoki*	*Inari*	*Enontekiö*
Chert/quartzite	35	2			
Chert*		37	14	15	
Quartzite		12		3	
Quartz		1		4	8
Other		1			
Unknown	1				

TABLE 1. Number of points per raw material found in inland sites located in northernmost Finnish Lapland, Finnmark, and Troms, n=134 (Hood 2012; Papers I, II, IV, and V). *Chert includes flint, “dolomite”, Porsanger chert, Kvenvik chert, and other undefined cherts. Chert/quartzite includes points made of raw materials that can be classified as chert or quartzite, often depending on the piece. Rock crystal points are included in the quartz points (*cf*. Paper IV).

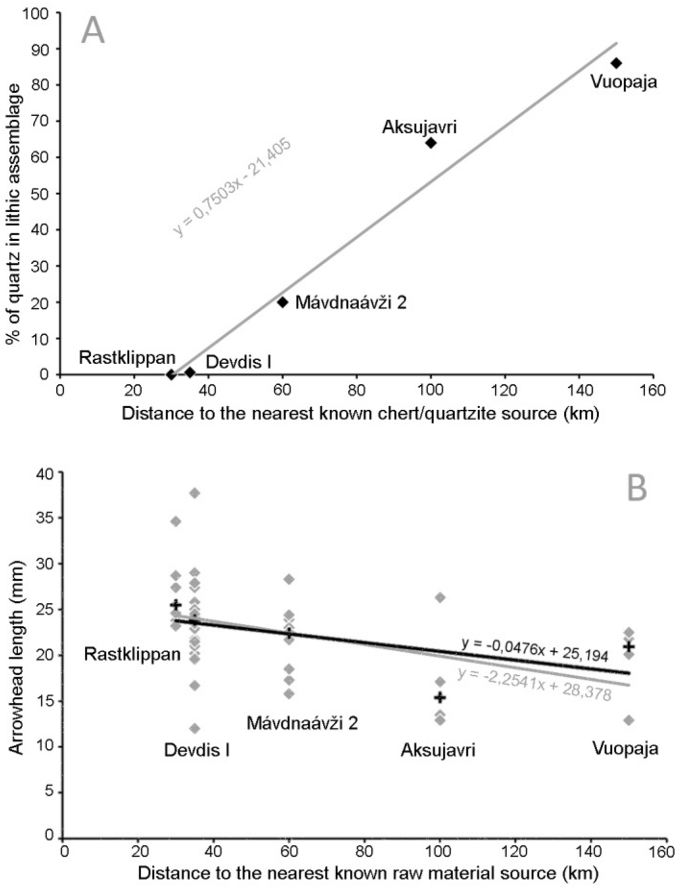


FIGURE 24. A) The relationship between the percentage of quartz in a site inventory and the distance to the closest known source of high-quality raw material (the correlation coefficient of the linear trendline r = 0.99). B) The lengths of arrowheads (gray diamonds) and the median lengths of arrowheads (black crosses) by site in relation to the distance to a known source of arrowhead raw material, with linear trendlines (lengths of arrowheads, r = -0.43; median lengths of arrowheads, r = -0.62). Only the arrowheads of raw materials from known source areas are included in the graph. Material from five inland sites (Paper V). Note that at Aksujavri, a geological formation with possible chert sources is also found closer to the site. However, the presence of chert in the formation has not been confirmed (Hood 1992: 96).

acquired from several sources and that it was possible for a group to use a variety of coastal raw materials during a single short occupation of a site located at a considerable distance from the coast. These patterns are consistent with the other results suggesting high residential long-distance mobility.

The studied material also reveals that in addition to the finished tools, which in most cases can be called microlithic in terms of size, lithic raw materials were often also carried along in small-sized packages, often in the form of flakes, and that during on-site activities and/or re-tooling, these raw materials were either turned into tools or used as cores for the production of smaller flakes (Paper V). The size-graded debitage analysis of quartz artefacts from the Mávdnaávži 2 site further suggests that in addition to raw materials of low and localised availability, the widely available vein quartz was also transported as flake blanks rather than as cores or raw material chunks (Paper II).

4.4. Technological organisation, mobility, and the properties of quartz

The way technology was organised at the Late Mesolithic margin-retouched point sites thus has some features that indicate conservation of high-quality raw material of restricted availability. At the same time, however, there are indications that the technology was designed to facilitate an efficient use of vein quartz (Paper V).

Because it is prone to fragmentation and commonly contains many internal flaws, quartz is a raw material that can be considered unfavourable for the execution of blank-production technologies that are demanding in terms of raw material controllability. However, our results indicate that the fragmentation typical of quartz flakes (Callahan *et al.* 1992; Huang & Knutsson 1995;

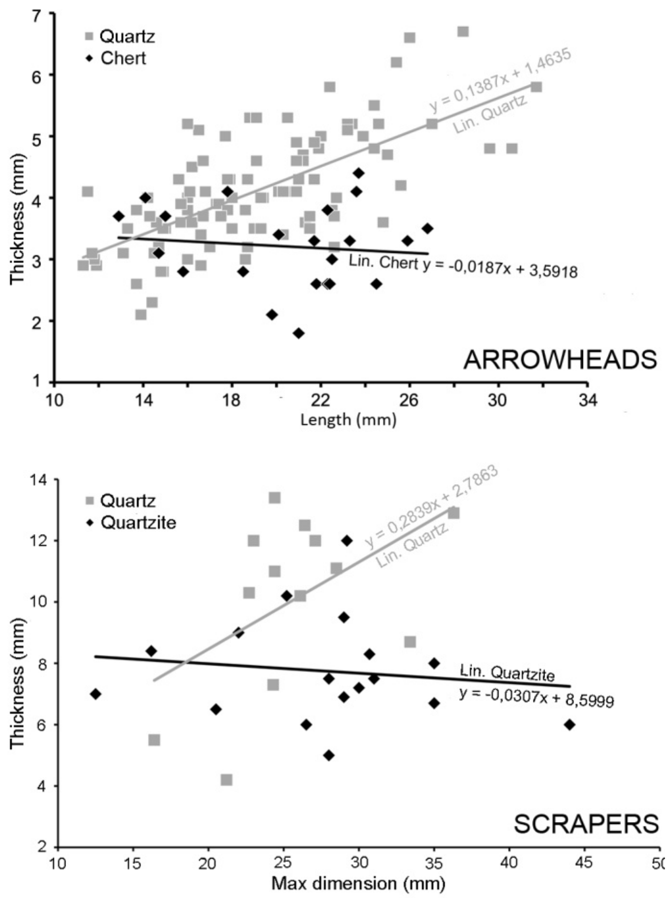


FIGURE 25. Thickness/length ratios of intact margin-retouched arrowheads and arrowheads with broken tips (1.5 mm added to length) made of quartz (n=98) and chert (n=22) studied in Paper IV (with linear trendlines). The relationship between scraper thickness and maximum outline dimension in quartz (n=13) and quartzite (n=17) scrapers studied in Paper V (with linear trendlines).

Knutsson 1998) can be reduced by producing relatively thicker platform flakes (Paper III) and the results of Callahan *et al.* (1992) indicate that flake fragmentation can be reduced by the use of bipolar-on-anvil reduction.

In fact, from the perspective of the issues discussed in this study, the most important results from the experimental research on the properties of vein quartz are related to the constraints the fragility of the raw material imposes on core reduction and the ways of minimising the fragmentation of quartz flakes in lithic production and use. The comparisons made in Papers IV and V between implements made of quartz and counterparts made of less fragile raw materials suggest that the production of relatively thicker flakes from quartz than from other, more resilient raw materials was common in the studied technology and that the fragility of quartz was compensated for by using design criteria that reduced the risk of failure. This is demonstrated by arrowheads made of vein quartz being thicker than ones made of chert and by the thickness of quartz points increasing with increasing length, while the thickness of chert points tends to remain the same irrespective of point length (Paper IV). The same principle of increasing thickness is also observed in quartz scrapers, in comparison to counterparts made of fine-grained quartzite (**Fig. 25**; Paper V).

Other features in the studied assemblages that can be readily interpreted as ways to reduce or cope with quartz fragmentation and/or the risk of raw material failure when using quartz are the selection and transportation of flakes (Papers II and V). A quartz core contains less usable tool edge than a comparable amount of raw material of better working qualities (Paper III), but this is not as much the case with flakes. The perpendicular orientation of quartz points with respect to the blank (Paper IV), the use of bipolar reduction specifically on quartz (Paper V), and when available, the preference for more resilient raw materials for the most critical tasks (Paper V) are also indicative of technological and organisational choices made to maximise the utility of the available raw materials, of which quartz comprised a major part, when moving over large stretches of land with very few areas where raw material of good workability could be found.

Flake-based production represents a marked informalisation of stone tool technology in the coastal area in comparison to the formal blade production known from the earlier phases (Hesjedal *et al.* 1996:186; Olsen 1994:34; Papers I, IV, and V), while in the inland region, despite being a simple artefact type, the oblique point is exceptionally formal in comparison to the simple informal tools found at Phase II sites. The results nonetheless suggest that in the context of Late Mesolithic margin-retouched points in northernmost Fennoscandia, the way technology was organised was not determined only on the basis of transport cost. Although the availability of raw materials of better workability than quartz was low and localised, the technology was not formal in the way that Andrefsky's (1994) results would lead one to expect. The fact that high residential mobility was linked to a technology that utilised small flake blanks and tools is probably partly explained by low carrying costs (*cf.* Kuhn 1994; Surovell 2009:142–150), but it seems likely that it was also determined by the good availability of the low-workability quartz in the area of Archaean and Palaeoproterozoic bedrock. The end of blade production on the Finnmark coast can therefore be linked to prolonged stays in the interior.

In addition to reducing carrying costs, flake-based technology enabled the use of practically the same lithic operational sequences, as well as the same hafting technology, regardless of the geological setting, when moving into the inland region, thus minimising the risk of ending up without suitable raw material (Paper V). The area between the Lake Inari region and the Finnmark coast is a case in point, as the area there with sources of chert and fine-grained quartzite is strictly restricted to the coastal strip. From an organisational point of view, the studied technology can therefore be seen as a solution where several organisational dimensions and design criteria intersect and that provided a tool kit well adapted to high residential mobility in the specific raw material setting. The organisational advantages of the technology include good durability and functional versatility, low carrying cost, and decreased raw material cost (Paper V). It can be concluded that the results of the analyses on settlement configuration and organisation of technology support the model presented in Paper II and speak in favour of a long-distance coast–inland residential mobility pattern in the main study area adjacent to the Barents Sea during Phase III (**Fig. 26**).

4.5. Why the high mobility?

The refuse faunas of the inland oblique point sites include European elk and reindeer (**Table 2**; Hood 2012; Paper I; V). According to vegetation reconstructions, at the time of their use, these sites would have been located in birch–pine or pine forest environments (Paper I). The Phase II to III changes in lithic technology thus seem to be connected to an organisational shift towards increased residential mobility of small groups within large ranges of land and hunting of large terrestrial mammals.

Among ethnographically documented hunter–gatherers, high mobility is usually linked to low utilisation of aquatic resources, whereas a decrease in effective temperature tends to result in

FIGURE 26. Variability in raw material use in the coast–inland long-distance residential mobility pattern with respect to the relative distance between the site and the coastal chert sources.

an increase in the average distance moved between residential locations, unless aquatic resources are heavily utilised or the resource base is exceptionally varied (Binford 2001; Blades 2001:9–10; Kelly 1995:120–131). It thus seems reasonable to look for evidence of a marked decrease in the Barents Sea aquatic resources, possibly linked to the 8.2 ka cold event, that could explain the development and continuation of the long-distance coast–inland mobility pattern.

4.5.1. The Barents Sea and early Holocene environmental change

The contemporary oceanographic conditions and the interrelated changes in the North Atlantic water circulation and climate during the early Holocene are central to the overall understanding of Mesolithic hunter–gatherer exploitation of Barents Sea aquatic resources. The surface waters of the Barents Sea were relatively warm during most of the period, while the salinity was lower than at present (**Fig**. **27D&E**). The Polar Front was located by the Finnmark coast (**Fig. 28)**, several hundreds of kilometres southwest of its present position, to where it moved approximately 7500 cal BP (5550 cal BC) (Risebrobakken *et al.* 2010). It is difficult to model the effects these conditions had on the marine ecosystem in comparison to the present situation, but it can be noted that in general, an increase in sea surface temperature has a positive effect on primary productivity (e.g., Sakshaug 1997), while a decrease in productivity eventually leads to lowered environmental carrying capacity, which in turn means lower human population density (Boone 2002; Kelly 1995; Riede 2009a).

It is generally accepted that most of the abrupt cold events that occurred during the Holocene, most notably the 8.2 ka event, were largely driven by

Lab. No.	**Site**	Dated sample	BP	**cal BP (2σ)**	cal BC (2σ)	**Refuse fauna**
Ua-40896	**Kaunisniemi 3**	Burnt bone, *Rangifer tarandus*	8004±46	**8899–8780**	7060–6710	***Rangifer tarandus***
Hel-2564	**Museotontti**	Charcoal	7750±120	**8587–8476**	7030–6410	***Rangifer tarandus***
Ua-40895	**Museotontti**	Burnt bone, *Rangifer tarandus*	7668±40	**8475–8412**	6590–6450	***Rangifer tarandus***
Tua-7194	**Aksujavri**	Burnt bone	6650±30	**7571–7507**	5631–5526	***Rangifer tarandus***
Ua-40900	**Mávdnaávži 2**	Charcoal, *Pinus sylvestris*	6580±38	**7502–7435**	5616–5478	***Rangifer tarandus***
Hela-963	**Mávdnaávži 2**	Burnt bone	6455±45	**7425–7327**	5484–5327	***Rangifer tarandus***
Ua-40897	**Vuopaja**	Burnt bone, *Rangifer tarandus*	6526±39	**7556–7329**	5607–5380	***Rangifer tarandus, Alces alces***

TABLE 2. Radiocarbon-dated refuse fauna found in association with margin-retouched points (Papers I and V). See Appendix I for references.

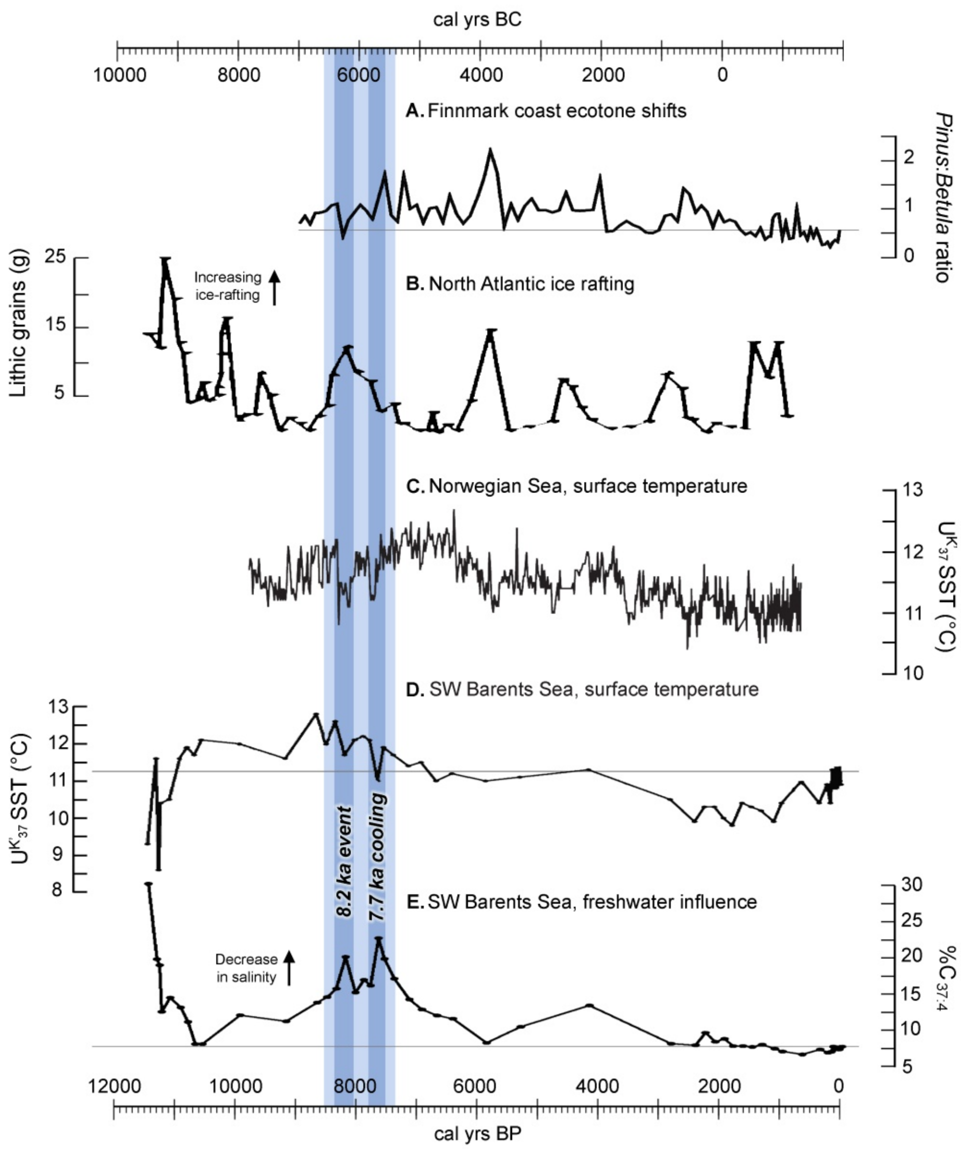


FIGURE 27. Reconstructions of Holocene coastal and marine conditions. A) Shifts in the pine–birch ecotone during the Holocene, as indicated by the *Pinus:Betula* pollen ratio in Nordkinnhalvøya, Finnmark (Allen *et al*. 2007); B) Amount of debris-bearing drift ice in the North Atlantic (Bond *et al*. 1997); C) Alkenone-derived high-resolution sea surface temperature reconstruction for the Norwegian Sea (Andersson *et al*. 2010; Calvo *et al*. 2002); D) Alkenone-derived sea surface summer temperatures for the southwestern Barents Sea (Chistyakova *et al*. 2010; Risebrobakken *et al*. 2010); E) Freshwater influence in the southwestern Barents Sea (Risebrobakken *et al*. 2010). The second vertical blue line indicates the *ca*. 7800–7500 cal BP cooling, while the grey horizontal lines indicate present conditions.

catastrophic outbursts of meltwater from pro-glacial lakes in North America. As noted earlier, the meltwater outbursts lowered North Atlantic sea surface temperatures and consequently affected the Atlantic Meridional Overturning Circulation by weakening the North Atlantic Thermohaline Circulation (Alley & Ágústsdóttir 2005; Daley *et al.* 2011; Delworth *et al.* 2008; Hoffman *et al.* 2012).

As a consequence of the outbursts, the flow of warm Atlantic waters in the Barents Sea also appears to have decreased, and accordingly, during the 8.2 ka event, for example, the salinity and the summer temperatures of the North Atlantic surface waters, as well as those of the Barents Sea, were reduced, the wintertime freezing of the Nordic Seas increased, and the sea ice cover in the North Atlantic expanded (**Fig. 27 & 28**; Alley & Ágústsdóttir 2005; Renssen *et al.* 2002; Risebrobakken *et al.* 2010). These developments are consistent with

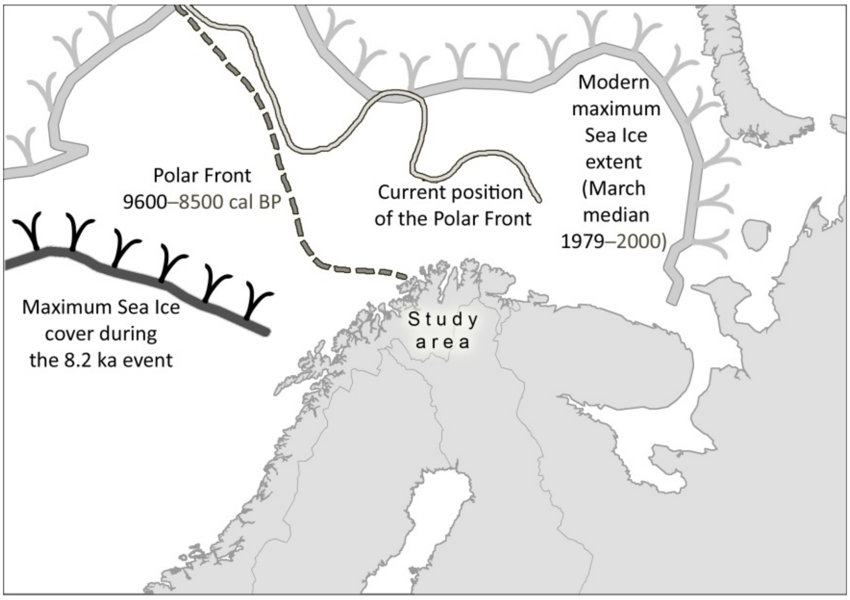


FIGURE 28. Modelled maximum extent of sea ice cover during the 8.2 event (Renssen *et al.* 2001) and the location of the Polar Front between 9600 and 8500 cal BP in comparison to the present seasonal maximum sea ice extent (March median 1979–2000; Polyak *et al.* 2010) and the current position of the Polar Front (*ca.* 7500 cal BP–present). Polar front locations according to Risebrobakken *et al.* (2010). Map by the author.

the expected effects of a weakening of the North Atlantic Thermohaline Circulation due to reduced salinity (Allen *et al.* 2007). 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 8.2 ka event (Voronina *et al.* 2001).

In addition to the 8.2 ka event, several proxy records show a cold episode in the North Atlantic at *ca.* 7800–7500 cal BP (**Fig**. **27**; Aagaard-Sørensen *et al.* 2011), i.e., closely following the 8.2 ka event. This cooling episode is less well known than the preceding event and was most likely more local. However, both cold episodes coincided with periods of especially low solar radiative output (Vieira *et al.* 2011; Wanner *et al.* 2011), and a rapid climatic cooling coinciding with the latter episode is recorded in the combined mean July temperature reconstructions for northern Finnish Lapland (**Fig**. **12**; Erästö *et al. submitted*) as well as in a chironomid-based temperature reconstruction from Lake Sjuodjijaure in northern Sweden (Rosén *et al.* 2001). It is also worth noting that in regard to the 9300 cal BP cold event (*cf.* e.g., Yu *et al.* 2010), the Barents Sea marine proxies do not show any marked changes in salinity or surface temperature.

At present, physical conditions strongly determine the biological production processes of the Barents Sea, and climatic changes during modern times have led to significant fluctuations in the marine ecosystem, due to its sensitivity to temperature changes (Hjermann *et al.* 2004; Loeng & Drinkwater 2007). Primary productivity is highest in the area south of the Polar Front, where the warming influence of the Atlantic waters is more substantial and where the main part of the commercially exploited fish stocks are located, while productivity north of the Polar Front is markedly lower (Sakshaug 1997).

When sea ice cover in the Barents Sea increases, it initiates processes that result in food shortages throughout the ecosystem (Cochrane *et al.* 2009; Sakshaug 1997; Sakshaug & Slagstad 1992). In the years during which large amounts of warm Atlantic water flow into the Barents Sea, primary productivity can be 30% higher than the productivity in years with low Atlantic influx (Slagstad & Stokke 1994 in Sakshaug 1997). Moreover, interconnected developments, such as a crash in capelin population (Naustvoll & Kleiven 2009), a mass death of capelin-feeding sea birds, and a mass migration of harp seals southwards along the Norwegian coast (Sakshaug 1997) have been documented following years with low primary productivity.

Due to the difference in the location of the Polar Front, the generally lower salinity, and warmer surface waters, it is evident that the early Holocene ecosystem in the Barents Sea differed from the present situation, and therefore, it is not possible to draw direct analogies between the two. Nonetheless, temperature and solar radiation are considered to be the main factors limiting the productivity of ecosystems (e.g., Begon *et al.* 1996: 711–745), and it therefore also seems evident that the major coinciding changes in the physical conditions of the sea during the cold events mentioned, i.e., decreased surface temperatures, abrupt reductions in salinity, and increased ice cover, must have caused intense ecosystem responses following major decreases in primary productivity (see also Hood 1992b:77–79).

It is thus safe to say that the major cooling that lasted well over a hundred years, as well as the drop in solar radiation during both the 8.2 ka event and the cold episode that occurred *ca.* 7800–7500 cal BP, had severe if not disastrous consequences for the marine ecosystem in the Barents Sea and that there were also direct and severe food shortages higher up in the food web. It is reasonable to assume that such changes forced those hunter–gatherer groups that were heavily dependent on marine resources to reorganise their subsistence economy. In addition, the increases in the extent and duration of ice cover in the sea would have posed serious technological challenges to those hunters and fishers that were accustomed to open water.

4.6. Climate change and culture change–is there a connection?

The cold episodes and perturbations, especially in the marine ecosystem, that are likely to have followed from the changes detected in the environmental proxies provide a cogent reason for the reorganisation of land-use, technology, and mobility patterns indicated by the studied inland sites. Although the abrupt climatic cooling episodes most likely caused ecotone shifts and lower productivity and slowed the spread of pine forests in the variable forest/tundra environment of the inland region (Allen *et al.* 2007), the populations of reindeer and European elk, for example, can be expected to have recovered relatively quickly from the ecosystem changes, as they are cold-adapted species that respond negatively to increased ambient temperature (Chan *et al.* 2005; Tyler & Blix 1990; van Beest *et al.* 2012).

The reproductive success of these species seems to be more limited by the thickness of wintertime snow cover than by temperature because deep snow makes it more difficult for the animals to find food (Lee *et al.* 2000). Although the annual precipitation in the inland areas increased during the 8.2 ka event, according to the available proxy data, there are indications that in parts of the study area wintertime precipitation decreased (Allen *et al.* 2007). Hence, the physiological adaptations of northern ungulates to cold and the environmental variability within the study area together suggest that the reproductive success of these species would not necessarily have been seriously affected during periods of climatic cooling.

Although not discussed in detail in this dissertation, the importance of fish, birds, plants, and small mammals as food sources in addition to large mammals should not be underestimated. However, from the perspective of this study, the fact that the ecosystem changes were most likely more severe in the marine environment than in the terrestrial environment is more important than the actual composition of the food resource

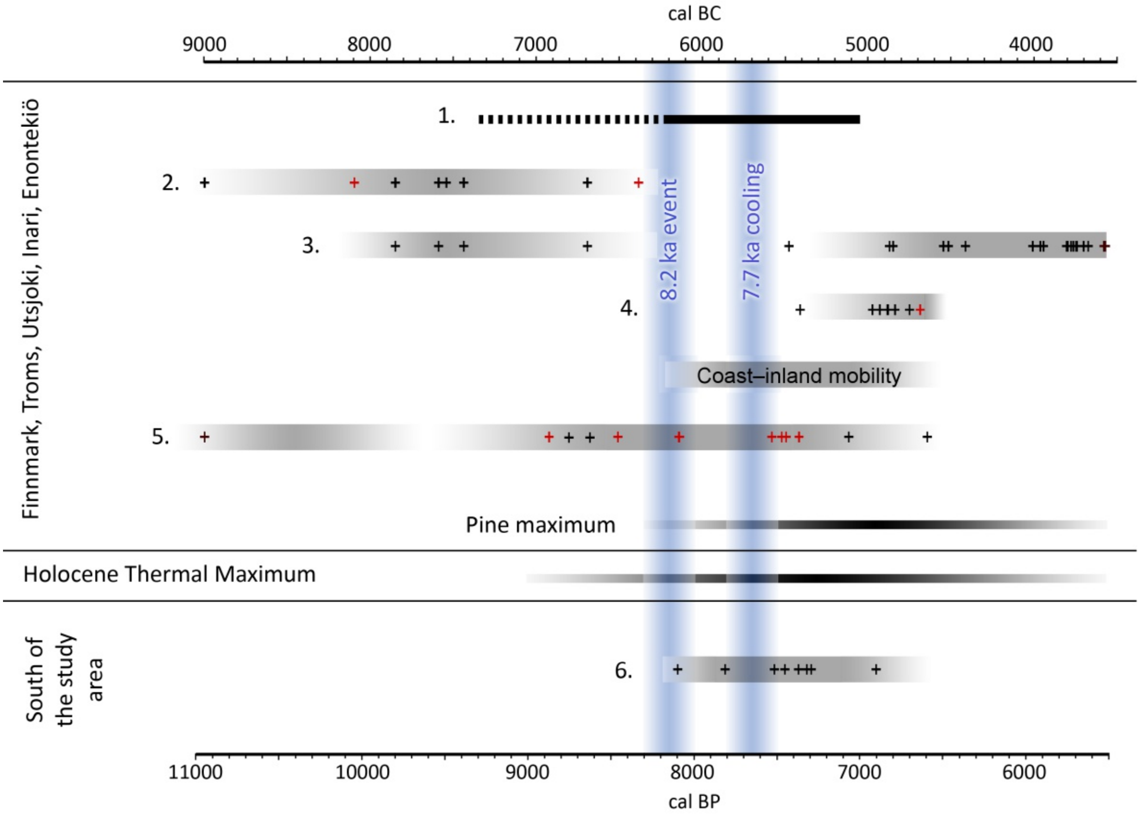


FIGURE 29. The suggested period of Late Mesolithic long-distance coast–inland residential mobility and a summary of the Holocene changes in material culture, settlement patterns, and natural environment discussed in the study, on the basis of shore displacement chronology and radiocarbon dates (14C median values marked with black (coast) and red (inland) crosses). 1. Quartz dominance on the Finnmark coast; 2. Use of formal blades in Finnmark and northernmost Finnish Lapland; 3. House-pits on the Finnmark coast; 4. Comb Ware pottery of the Säräisniemi 1 type in Finnmark and northernmost Finnish Lapland (the 14C dates are on food crust only); 5. Margin-retouched points in northernmost Finnish Lapland and Finnmark (four radiocarbon-dated contexts from Troms are included); 6. Margin-retouched points in the area south of 66°N. The use-period estimates (grey horizontal bars) are based on estimates by Grydeland (2000; 2005); Hesjedal *et al.* (1996; 2009); Olsen 1994; Schanche 1988; Woodman 1993; 1999; Paper V; see also chapter 4.6.2; and available radiocarbon dates (see Appendix II for dates and references). The durations of the HTM and the pine maximum are based on Kultti *et al.* (2006) and Figure 12). Note that the Storegga tsunami and the Tapes transgression most likely destroyed some coastal sites that predated the 8.2 ka event, and the latter phenomenon most likely also destroyed some of the then lowest-lying sites from the period between *ca*. 8500 and *ca*. 6500 cal BP (see Figure 21). However, the effects of these phenomena should have been least felt in eastern Finnmark (*cf*. Møller 1996; Romundset & Bondevik 2011) and it seems probable that pit-houses, for example, would not have been built close to the shoreline, and therefore, most would have been left unaffected by the tsunami and the rise in the sea level.

base, as it suggests that an increased importance of terrestrial resources can be expected at this point in time.

However, although the two successive marine cooling events that occurred *ca*. 8300–7500 cal BP offer a credible explanation for the organisational and technological changes observed in the archaeological material, i.e., the decrease in blade production and possibly pit-houses and the increase in quartz use on the Barents Sea coast, as well as the development of a coast–inland long-distance mobility pattern (**Fig. 29**), the temporal proximity of the changes does not provide direct evidence of causality (*cf.* Dincauze 2000; Eren 2012b; Robinson *et al.* 2013). In connection with the Younger Dryas climate change, Eren (2012b) suggests the examination of three key questions to make interpretations of climate-induced culture change more robust: whether there is good evidence of both environmental change and cultural change, whether there exists tight temporal co-variance between climate change and behavioural change, and whether there is evidence disproving other explanations for culture change. As the existence of both environmental and culture change during and after the 8.2 ka event has been demonstrated in the preceding chapters, it is appropriate to further scrutinise the data, especially in relation to the last two of these questions, to strengthen the case made in this study.

4.6.1. Temporal co-variance between climate change and behavioural change?

The time needed for the effects of an abrupt climatic change to become archaeologically observable is not easily determined and can be expected to be situational, as it is dependent on the time needed for demographic recuperation and economic reorganisation in any specific case. The time lag allowed when determining tight temporal co-variance is therefore a key question. As lowered carrying capacity due to abrupt climate change would be followed by an initially low population density and consequently reduced human activity (e.g., Riede 2009a), the odds of direct evidence of behavioural change being evident in the archaeological record without a time lag are small. This is especially true of areas with low archaeological research activity, such as northernmost Fennoscandia.

The analyses show changes in both material culture and larger-scale behavioural patterns, that is, technological organisation, settlement configuration, and land use. These changes, although related, are not necessarily synchronous. As mentioned earlier, the fact that some of the radiocarbon-dated margin-retouched point contexts predate the 8.2 ka event in the inland region suggests that such points were present there before the Barents Sea cooling and the changes that followed, according to the proxy records. This, however, is not surprising, as some use of the inland region by marine-adapted groups and interaction between inland and coastal groups during earlier phases of the Mesolithic seems unavoidable, despite the cultural border (Hood 1992b: 45, 85; Paper IV).

With respect to the effects of climatic cooling, however, more important than the earliest dates of points are the organisational changes indicated by the development of a new mobility pattern and the behavioural patterns indicated by the studied sites. The organisational and technological uniformity of these sites that postdate the successive cold episodes between *ca*. 8300 and *ca*. 7500 cal BP suggests that by *ca*. 7500 cal BP at the latest, a cultural and economic reorganisation had already taken place. At the same time, the dates of oblique point contexts in more southerly Finland suggest that the point-manufacturing concept started to spread south soon after the 8.2 ka event (Paper IV).

4.6.2. Other explanations for the changes in material culture?

It is well known that there is an endless supply of possible explanations for culture change, which in many cases are not independent of other variables and depend greatly on the theoretical orientation of the proponent. However, in the evolutionary and ecological framework adopted in this dissertation, the possibility that culture change was the result of gradual environmental and behavioural changes (*cf.* Eren 2012b; Jones 2009; Robinson *et al.* 2013) and the possibility of abrupt change caused by the Storegga tsunami stand out as obvious alternative explanations for the changes observed in material culture and subsistence strategy. In addition, as noted previously, a few explanations for the Late Mesolithic changes in the study area have been put forth in earlier research. I therefore concentrate on these explanations and alternatives and briefly address them in light of the results obtained in this study, as well as other, more recently published data.

Among the earlier explanations for changes in lithic technology and land use during the Late Mesolithic are the ideas that the margin-retouched point sites represent the first colonisation or at least the first permanent settling of inner Finnmark (Olsen 1994: 40, 45; Rankama 2003) and that the points appear in the area in tandem with the spread of pine forest (Olsen 1994: 39–41). However, recent archaeological and paleoecological studies have shown that the pioneer colonisation of the area took place prior to 9200 cal BP (*ca*. 7300 cal BC; Hood 2012), thus preceding the earliest known inland sites with margin-retouched points. In addition, the spread of pine forest began much earlier than was previously thought (Hood 2012; Jensen & Vorren 2008; Kultti *et al.* 2006; Paper I).

The idea that the decrease in blade production and the increased use of vein quartz at coastal sites was a consequence of quartz-adapted inland groups colonising the coastal sphere deserted by marine-adapted groups due to decreasing productivity (Rankama 2003; see also Hagen 2011) cannot be falsified with the present data. However, the increasing evidence of continuous margin-retouched point use in the coastal sphere makes it seem unlikely that the coastal groups would not have contributed to the development of the Phase III technology (Papers IV and V). Olsen's (1994:45) suggestion that the sites with margin-retouched points in the interior represent groups that left the coastal sphere due to social conflict is also difficult to falsify. However, no data supporting the suggestion of social conflict has so far been presented. Moreover, extensive social conflict, if it did indeed occur, was more probably a consequence of abrupt ecosystem turmoil and economic reorganisation than the actual reason for changes in land-use strategies (see chapter 1.5).

Grydeland (2005:71) also discusses scenarios of conflict and cooperation and suggests that the increase in quartz use in the Varangerfjord area towards the end of the Mesolithic was driven by a need for coastal hunter–gatherers to emphasise similarities and equivalence with the inlanders. Based on shore displacement chronology, Grydeland (2005) dates this change to the period after *ca*. 9350 cal BP (*ca*. 8300 BP or 7400 cal BC), and notes that at the same time, there also appears to have been a change towards a more sporadic use of coastal sites. Hagen (2011:74–77) links these changes to the 9300 cal BP cold event and suggests that quartz-adapted groups from the south settled in the area after the coastal population had weakened as a consequence of the cold event.

The possibility that the 9300 cal BP cold event, although not very marked in the marine proxies, had similar effects on the marine ecosystem in the easternmost part of the Finnmark coast, as I suggest the 8.2 ka event must have had on the whole of the Barents Sea coast, is intriguing. However, as is the case with the decrease in the number of house-pits (chapter 4.2), the shoreline dating of phenomena represented by sites at altitudes between approximately 37 and 25 metres above sea level at Varangerfjord is problematic, and the possibility that some of the changes observed by Grydeland in the Varanger area occurred considerably later cannot be ruled out. Nevertheless, regardless of whether the increase in quartz use and some other changes in the Varangerfjord area occurred after 9300 cal BP or during the transition from Phase II to Phase III, roughly coinciding with the 8.2 ka event, I suggest that the increase in quartz use is better explained by organisational changes and/or raw material availability than by cultural choices. The preference for chert and quartzite when available at the studied Late Mesolithic inland sites does not support the view that quartz was favoured for cultural reasons during the Late Mesolithic.

Although the possibility that the Late Mesolithic changes in the study area were driven by other and possibly gradual environmental or cultural changes cannot be totally excluded at the moment because of the inadequate temporal coverage and resolution of the existing data, there are no obvious aspects of the generally warming climate or the gradually expanding forest environment, for example, that would explain the shift away from marine resources. Although the succession of boreal forests in the inland region reached a climax at this point in time, alongside the pine maximum (Hood 2012; Kultti *et al.* 2006; Paper I), it does not seem likely that this development would have made the interior markedly more attractive for marine-adapted hunter–gatherers, unless there was a marked deterioration in marine productivity or an abrupt threshold-type change in the hunter–gatherer system, because stable old-growth boreal forests, although predictable in terms of patch composition, are relatively low in prey density (*cf.* Winterhalder 1981; 1983).

It is known that ecological systems are often nonlinear as well as dynamic and that even minor environmental change can cause an ecosystem to pass a threshold after which it may not be able to return to the preceding state (e.g., Burkett *et al.* 2005; Fagre *et al.* 2009). Treshold-type changes may result from climate change but also in response to other, even small, environmental changes that cause the exceeding of threshold values. Therefore, the possibility that a change other than the consequences of the climate event drove the system into an alternative stable state should also be kept in mind as a possible alternative when discussing the ecological and cultural changes in Late Mesolithic northern Fennoscandia. This type of alternative state could have been caused, for example, by the 8200 cal BP Storegga tsunami. As has been noted by Hagen (2011:67–70) in regard to coastal population size, the effects of the Storegga tsunami (Romundset & Bondevik 2011) would most likely have been similar in some ways to the expected effects of the 8.2 ka event. A population crash caused by the effects of the tsunami on the lowest-lying coastal sites can therefore explain some of the observed changes in the level of coastal activity. As noted before, a demographic collapse can also lead to a loss of technological knowledge, which could explain the major technological changes on the coast. However, the tsunami effects would not explain the development of a long-distance coast—inland residential mobility pattern combined with a low archaeological signal on the coast unless marine productivity also remained markedly low.

It therefore seems likely that the 8.2 ka event was the main driver of the sociocultural change since the current evidence suggests a gradual increase in coastal human activity after *ca*. 7800 cal BP or 5850 cal BC in the western part of the studied area and a few hundred years later in the eastern part (Hagen 2011:78), as well as a re-appearance of large coastal sites with pit-houses approximately 7000 cal BP, i.e., after the two successive marine cooling events but still during the Holocene Thermal and pine forest maxima. This suggests that the reason for the decrease in coastal activity during the Late Mesolithic was temporary and related to changes in the sea.

4.7. Technological traditions, cultural inertia, and environmental constraints

What, then, are the relationships between the Late Mesolithic change in technological and settlement organisation, the marine ecosystem changes most probably caused by the 8.2 ka event, and cultural evolution? When compared to what is known of the Mesolithic Phases I and II in the study area, in addition to a profound change in the way lithic technology was organised, the analysed Phase III sites and lithic artefacts seem to represent a change in the distribution of material culture traits, by which I mean the crossing of the cultural dividing border that may already have dveloped at the time of the pioneer colonisation of the area (chapter 5.1; Paper IV).

These types of long-standing borders between neighbouring groups or networks of groups, which are evident in the formation of differing material cultures and technologies, have been documented in many types of settings and by a variety of methods (e.g., Bergsvik 2011; Coia *et al.* 2012; Knutsson 2004; Knutsson & Knutsson 2012; Lemonnier 1986). The factors that slow down and guide the transmission of culture (and genes) between human populations include geomorphological barriers, linguistic differences, dominantly vertical modes of inheritance in small-scale traditional societies, and many types of social behaviour, such as rewarding of cooperation, punishing of defectors, territoriality, and suspicion towards outsiders, which cause and reinforce cultural diversity (Barbujani & Sokal 1990; Boyd & Richerson 2005: 133–251; Coia *et al.* 2012; Hewlett & Cavalli-Sforza 1986; Pagel & Mace 2004). Many of these factors are self-enforcing, a fact that can be considered a major reason for the cultural and linguistic diversity of our species.

However, human populations need to keep the size of the breeding population large enough to survive. This is achieved by maintaining a mating pool of adequate size that consistently provides suitable mates for group members that reach reproductive age (Wobst 1974). Because population density and mating distance are found to be inversely correlated (Hertell & Tallavaara 2011a:32; MacDonald & Hewlett 1999) a demographic collapse, especially when population size is initially small, can be easily envisioned as resulting in increased mobility, increased marriage across linguistic and geomorphological barriers, and increased horizontal transmission of cultural traits between neighbouring groups and ultimately to the merging of these groups (*cf.* Pagel & Mace 2004:276–277).

In addition to geomorphological boundaries, a factor that most likely reinforced the earlier cultural and possibly also linguistic divide by giving rise to territoriality (*cf.* Kelly 1995: 181–203) was the localised and most likely rich and mostly predictable aquatic resource base of the sea. If a reduction in productivity caused by the 8.2 ka event, especially in the marine environment, and a consequent decrease in population density is accepted as the most likely scenario, it is not farfetched to suggest that as a consequence of the long-distance coast–inland mobility pattern, or possibly even as a factor contributing to its development, there was increased interaction between the coastal and inland groups and more frequent acquisition of mates over the earlier cultural divide.

This scenario also explains why the point type was put into use not only in areas on both sides of the earlier coast–inland material culture divide but also in the rest of eastern Fennoscandia after the 8.2 ka event. The oblique point, which appears to continue the millennia-long coastal margin-retouched point tradition, was included in the technological repertoire of the emerging adaptation that utilised both the coastal and inland areas. The rapid spread of the concept over most of eastern Fennoscandia at this point in time, most likely in established hunter–gatherer networks, marks the disappearance or at least a weakening of the earlier material culture divide. Most probably the same networks had a major role in the introduction of Comb Ware pottery into northernmost Fennoscandia approximately 7000 cal BP (*ca*. 5000 cal BC) and slightly later in the distribution of amber, red slate, and copper in eastern and northern Fennoscandia (*cf.* Damm 2006).

A similar cultural divide also seems to have existed in northern Sweden, where the distribution of Late Mesolithic oblique points meets the distribution of contemporaneous handle cores (Paper I; chapter 4.1). Like the cultural border discussed above, this border coincides with a zone within which the Scandinavian Ice Sheet formed a barrier for post-glacial pioneer populations (*cf.* Knusson & Knutsson 2012) and thus seems to give archaeological support to the notion that history explains a significant fraction of material culture. Evolutionary forces, including selective behaviour, can only affect the frequencies of those variants that are present.

However, because it is clear that environmental constraints, marine cooling, and the properties of the available raw materials played major roles in the way the studied technology was organised, its development seems to be best explained by a combination of social, economic, and finally also technological reorganisation, that is, by history *and* environmental constraints.

5. CONCLUSIONS, LIMITATIONS, AND AVENUES FOR FUTURE RESEARCH

In this dissertation, I set out to study the relationship between the 8.2 ka climate event and the Late Mesolithic lithic technological changes technology in northernmost Fennoscandia. By presenting the first comprehensive survey of the date and extent of Late Mesolithic margin-retouched point use in Fennoscandia, by presenting new data from the inland areas of northernmost Fennoscandia, and by comparing the results of these segments of the study to archaeological and environmental data available from the Barents Sea coastal sphere, I have developed an internally coherent description of a scenario of environmental changes related to marine and climatic cooling as the drivers behind several organisational and cultural changes that took place in the northern and eastern Fennoscandian Late Mesolithic. In this final chapter, I summarise the main conclusions and briefly discuss the limitations of the results, as well as some topics for future research.

5.1. Conclusions

As Grydeland (2000; 2005) has noted, there are no reasons to suggest that the Mesolithic period on the Barents Sea coast was a time of constant population growth and environmental stability. On the contrary, the published proxies of climatic and marine conditions during the early Holocene show that there were severe fluctuations in the key variables that determine the productivity of the sea and thus directly affect the carrying capacity of the coastal environment. Between *ca*. 8300 and 7500 cal BP, there were two consecutive drops in salinity and temperature which most likely reflected a reduction in the influx of warm Atlantic waters into the Barents Sea. The first of these episodes was consistent with the widely felt 8.2 ka event, while the second cooling episode between *ca*. 7800 and 7500 cal BP was most likely more local but continued the period of low marine productivity.

In this dissertation, I show that these cooling episodes most likely caused major economic and technological reorganisation of human adaptations in the area. Although the changes in lithic technology known to have taken place during the Late Mesolithic in northernmost Fennoscandia were not necessarily synchronous and may therefore have resulted from differing processes, the new evidence presented in this study from Late Mesolithic inland sites and the large coast–inland-oriented foraging ranges suggested by this evidence are consistent with the expectation of a major reorganisation of land use and an increased utilisation of terrestrial resources as a consequence of decreased marine productivity.

The large coast–inland-oriented foraging ranges explain the way technology was organised at both the inland sites and coastal sites. The changes in settlement configuration brought about a clear change in the relationship between raw material availability and stone tool production, which explains why the importance of quartz as a raw material grew and why a variety of raw materials, including fine-grained chert and quartzite of the Barents Sea coast, as well as the low-workability quartzes of the interior, were used to produce margin-retouched points during the Late Mesolithic.

The new flake-based technology that developed was well adapted to high mobility within large territories that encompassed both the inland area, where only raw materials of low working quality were available, and the coast, with localised sources of more reliable and more workable raw materials, as it relaxed the need to restock with specific types of raw material.

At the same time, the margin-retouched points, now as a part of the mobile Late Mesolithic long-distance tool kit, seem to continue a technological tradition that can be traced back to the Upper Palaeolithic Ahrensburgian points of north central Europe. The technology thus shows that both cultural and environmental dimensions affected the design of tools and weapons. This means that other groups with different cultural backgrounds could very well have developed other technological solutions even in the same environmental circumstances. The Late Mesolithic handle-core-based technology that was used to produce bladelets from quartz but also from raw materials of better working quality in the area directly west of the region studied in this dissertation may therefore represent a different solution to the same set of problems.

The study also shows that the Late Mesolithic margin-retouched points in northern Fennoscandia are most likely related to their counterparts in more southerly parts of eastern Fennoscandia and that the transmission of the point concept to the south from the Barents Sea coastal sphere can also be linked to the changes caused by the 8.2 ka event, namely, increased mortality and demographic reorganisation in northernmost Fennoscandia. These changes led to the inclusion of the Finnmark coast in the hunter–gatherer network that covered most of eastern Fennoscandia and within which socially transmitted information, as well as exchanged goods, spread rapidly during subsequent periods.

5.2. Limitations

The primary limitation in the archaeological data used in the study is the still relatively low number of radiocarbon-dated contexts and studied sites in the area. This limitation raises the question of representativity and prevents a more secure chronological fixing of phenomena dated using shore displacement chronology or by a limited number of radiocarbon dates. Luckily, however, in regard to the dating of large-scale phenomena, in Fennoscandia, shore displacement chronology offers a complementary dating method that I have been able to use in this study alongside radiocarbon dates.

On the other hand, the representativeness of available data is a problem in all archaeological research, and this problem has to be accepted to be able to make inferences about cultural history and past human behaviour. Nevertheless, it should be kept in mind that the conclusions presented in the study are based on currently available evidence and that the way the study is constructed should make it possible to test the conclusions presented if and when new data become available.

The fact that the study was conducted from an "inland" perspective can also be taken as a limitation, although the results of the study offer new evidence that can be used to interpret coastal changes as well. The study approach also offers advantages in the form of unmixed sites with good preservation and a good perspective on the way raw material moved in the region. A more comprehensive survey of margin-retouched point sites and use on the Barents Sea coast and the inclusion of coastal sites in the analyses of raw material composition, site structure, and technology at Late Mesolithic sites, not to mention analyses of technological organisation at sites dating to the earlier Mesolithic phases, would obviously have made the study more robust. Such analyses, however, are not possible within the limits of a single dissertation. The available data from coastal sites seem nevertheless to be consistent with the data from the inland sites and will hopefully be supplemented in the future.

The study also leaves open the question of why the arrowhead concept was transmitted so quickly over such a wide geographical area. The small margin-retouched arrowheads of the Late Glacial Ahrensburgian reindeer hunters (Baales 1999; Riede 2009c), as well as studies on the penetrative and cutting qualities of oblique and transverse arrowheads (Brizzi *in press*; Friis-Hansen 1990; Seppä 1997), suggest that the Late Mesolithic points discussed in this dissertation were for the most part well fit for the hunting of relatively large game, including the northern ungulates that dominate the refuse fauna at the studied sites. The functional efficiency of the point concept can therefore be a major factor in the rapid adoption of the point type in the south. The fact that the assemblages include also points with a transverse edge and consequently considerably lower penetrative qualities, however, suggests that some of the variation in the Late Mesolithic points may relate to an increased importance of small game and possibly to changes in the productivity of the Baltic Sea (Brizzi *in press*; Paper IV).

Because there are no directly preceding projectile points in the archaeological record in the area of present-day Finland, the spread of the point concept could also reflect a re-introduction of bow-and-arrow technology (*cf.* Riede 2009c). However, this scenario would require first that bow-and-arrow technology was lost after the country was first colonised and second that it was not re-introduced during several millennia between the pioneer colonisation phase and the 8.2 ka event, even if it was known in nearby regions (see, e.g., Burov 1981; Gerasimov 2012; Tarasov *et al.* 2007 on the area to the east of Finland). It therefore seems more plausible that prior to the introduction of the margin-retouched point concept from the north, arrowheads were made from organic materials and/or unstandardised quartz fragments and that the new arrowhead concept had qualities (possibly the easy producibility, standardised form, and superior functional properties) that made its users more successful in some respect and therefore targets of imitation (*cf.* Boyd & Richerson 2005; Rogers & Shoemaker 1971).

5.3. Future research

Many of the limitations that prevent reaching an archaeologically more comprehensive picture of the phenomena studied in this dissertation can be reduced by conducting further studies and by increasing the available data. In addition, a fruitful avenue for future research would be to build and test more formal models of culture–environment dynamics in the study area. This type of research would contribute to a better understanding of the environmental constraints in the area, as well as their effects on the way humans adapted to changes in various environmental variables, as well as to demographic changes. Most importantly, this type of research would increase the understanding of culture-induced diversity in behavioural solutions.

Future research will hopefully also include more detailed study of prehistoric human behavioural adaptation to the 8.2 ka event and other periods of climatic turmoil in Fennoscandia. To gain a better understanding of the interrelated effects of changes in the North Atlantic oceanic patterns and the climate in northernmost Fennoscandia, it could be beneficial to further scrutinise potential changes in technology and behaviour in connection with other known abrupt climatic cold periods. These include, for example, the 9.3 ka event mentioned above that may have affected coastal groups on the Finnmark coast (Hagen 2011; Korhola *et al*. 2002) and the early Holocene 10.2 ka event (Seppä *et al*. 2002; see also Tallavaara *et al*. in press), which roughly coincides with the earliest radiocarbon-dated sites with post-Swiderian blade technology in eastern Finnmark.

REFERENCES

Aagaard-Sørensen, S., Husum, K., Hald, M., Marchitto, T. & Godtliebsen, F. 2011. *Atlantic Water influx in the Nordic Seas over the past 14.000 cal yr BP: Mg/Ca paleo temperature reconstructions*. http://munin.uit.no/handle/10037/3007

Acerbi, A. & Parisi, D. 2006. Cultural Transmission Between and Within Generations. *Journal of Artificial Societies and Social Simulation* 9(1).

Adger, N. W., Barnett, J., Brown, K., Marshall, N. & O'Brien, K. 2012. Cultural dimensions of climate change impacts and adaptation. *Nature Climate Change* 3, 112–117.

Åhman, E. 1967. Riksantikvarieämbetets norrlandsundersökningar IV. Petrografisk översikt av Umeälvsmaterialet. *Fornvännen* 62, 8–11.

Allen, J. R. M., Long, A. J., Ottley, C. J., Pearson, D. G. & Huntley, B. 2007. Holocene climate variability in northernmost Europe. *Quaternary Science Reviews* 26, 1432–1453.

Alley, R. B. & Ágústsdóttir, A. M. 2005. The 8k event: cause and consequences of a major Holocene abrupt climate change. *Quaternary Science Reviews* 24, 1123–1149.

Andersson, C., Pausata, F. S. R., Jansen, E., Risebrobakken, B. & Telford, R. J. 2010. Holocene trends in the foraminifer record from the Norwegian Sea and the North Atlantic Ocean. *Climate of the Past* 6, 179–193.

Andrefsky, W. Jr. 1994. Raw-Material Availability and the Organization of Technology. *American Antiquity* 59(1), 21–34.

— 1998. *Lithics. Macroscopic approaches to analysis.* Cambridge, Cambridge University Press.

— 2001. Emerging Directions in Debitage Analysis. In: W. Andrefsky Jr. (Ed.), *Lithic Debitage: Context, Form, Meaning.* Salt Lake City, The University of Utah Press, 2–14.

Arponen, A. & Hintikainen, E. 1995. Strandforskjutningen i Enare trask mot bakgrunden av de arkeologiska fynden. *Finskt Museum* 1993, 5–25.

Baales, M. 1999. Economy and seasonality in the Ahrensburgian. In: S. K. Kozlowski., J. Gurba & L. L. Zaliznyak (Eds.), *Tanged points cultures in Europe*. Read at the International Archaeological Symposium, Lublin, 13–16 September 1993 Lublin, Poland: Maria Curie-Sklodowska University Press, 64–75.

Balascio, N. L. & Bradley, R. S. 2012. Evaluating Holocene climate change in northern Norway using sediment records from two contrasting lake systems. *Journal of Paleolimnology* 48, 259–273.

Bamforth, D. B. 1991. Technological Organization and Hunter-Gatherer Land Use: A California Example. American Antiquity 56(2), 216–234.

Bamforth, D. B. 2009. Top-down or bottom-up?: Americanist approaches to the study of hunter-gatherer mobility. In: S. B. McCartan, R. Schulting, G. Warren & P. Woodman (Eds.), *Mesolithic Horizons*. Papers presented at the Seventh International Conference on the Mesolithic in Europe, Belfast 2005. Volume I. Oxbow books, Oxford, 81–88.

Bang-Andersen, S. 2012. Colonizing contrasting landscapes. The pioneer coast settlement and inland utilization in southern Norway 10,000–9500 years before present. *Oxford Journal Of Archaeology* 31(2), 103–120.

Barber, D. C., Dyke, A., Hillaire-Marce,C., Jennings, A. E., Andrews, J. T., Kerwin, M. W., Bilodeau, G., McNeely, R., Southon, J., Morehead, M. D. & Gagnon, J.-M. 1999. Forcing of the cold event of 8,200 years ago by catastrophic drainage of Laurentide lakes. *Nature* 400, 344–348.

Barbjuani, G. & Sokal, R. R. 1990. Zones of sharp genetic change in Europe are also linguistic boundaries. *Proceedings of the National Academy of Sciences USA* 87, 1816–1819.

Barton, C. M. & Clark, G. A. 1997. Evolutionary Theory and Archaeological Explanation. In: C. M. Barton & G. A. Clark (Eds.), *Rediscovering Darwin: Evolutionary Theory and Archaeological Explanation*. Arlington, American Anthropological Association, 3–15.

Begon, M., Harper, J. L. & Townsend, C. R. 1996. *Ecology. Individuals, Populations and Communities*. Third edition. Oxford, Blackwell Science.

Bettinger, R. L. & Eerkens, J. W. 1997. Evolutionary implications of metrical variation in Great Basin projectile points. In: C. M. Barton & G. A. Clark (Eds.), *Rediscovering Darwin: Evolutionary*

Theory and Archaeological Explanation, 177–191. Arlington, American Anthropological Association.

— & Eerkens, J. W. 1999. Point typologies, cultural transmission, and the spread of bow-and-arrow technology in the prehistoric Great Basin. *American Antiquity* 64, 231–242.

Bentley, R. A., Lipo, C., Maschner, H. D. G. & Marler, B. 2008. Darwinian Archaeologies. In: R. A. Bentley, H. D. G. Maschner & C. Chippendale (Eds.), *Handbook of Archaeological Theories*. Altamira Press, Lanham-New York-Toronto-Plymouth, UK, 109–132.

Berger, J.-F. & Guilaine, J. 2009. The 8200 cal BP abrupt environmental change and the Neolithic transition: A Mediterranean perspective. *Quaternary International* 200, 31–49.

Bergsvik, K. A. 2011. East is east and west is west: On regional differences in Neolithic Norway. In: A. Olofsson (Ed.), Archaeology of Indigenous Peoples in the North. Proceedings from a workshop held in Vuollerim 6000 år, 3-4 December 2005. *Archaeology and Environment* 27, 133–159.

Binford, L. R. 1973. Interassemblage variability - the Mousterian and the 'functional' argument. In: C. Renfrew (Ed.), *The explanation of culture change: Models in Prehistory,* London, Duckworth, 227–254.

— 1978. *Nunamiut Ethnoarchaeology*. Academic Press, New York.

— 1979. Organization and Formation Processes: Looking at Curated Technologies. *Journal of Anthropological Research* 35, 255–273.

— 1990. Mobility, housing, and environment: a comparative study. *Journal of Anthropological Research* 46, 119–152.

— 2001. *Constructing Frames of Reference. An Analytical Method for Archaeological Theory Building Using Ethnographic and Environmental Data Sets*. Berkeley, Los Angeles, London, University of California Press.

— 2002 [1983]. *In Pursuit of the Past. Decoding the Archaeological Record*. University of California Press, Berkeley – Los Angeles – London.

Bjerck, H. B. 2008. Norwegian Mesolithic Trends: A Review. In: G. Bailey & P. Spikins (Eds.), *Mesolithic Europe*. New York, Cambridge University Press, 60–106.

Björck, S., Muscheler, R., Kromer, B., Andresen, C. S., Heinemeier, J., Johnsen, S. J., Conley, D., Koç, N., Spurk, M. & Veski, S. 2001. High-resolution analyses of an early Holocene climate event may imply decreased solar forcing as an important climate trigger. *Geology* 29(12), 1107–1110.

Blades, B. S. 2001. *Aurignacian Lithic Economy: Ecological Perspectives from Southwestern France*. Kluwer Academic/Plenum Pub., New York.

Blankholm, H.-P. 2008. The Stone Age of the southern- and middle Troms region in Norway in its northern Fennoscandian context. In: A. Olofsson (Ed.), Archaeology of Settlements and Landscapes in the North. *Vuollerim Papers on Hunter-gatherer Archaeology* 2, 9–22.

Blockley, S. P. E, Lane, C. S., Hardiman, M., Rasmussen, S. O., Seierstrad, I. K., Steffensen, J. P., Svensson, A., Lotter, A. F., Turney, C. S. M., Bronk Ramsey, C., INTIMATE members 2012. Synchronisation of palaeoenvironmental records over the last 60,000 years, and an extended INTIMATE event stratigraphy to 48,000 b2k. *Quaternary Science Reviews* 36, 2–10.

Bond, G., Showers, W., Cheseby, M., Lotti, R., Almasi, P., de Menocal, P., Priore, P., Cullen, H., Hajdas, I. & Bonani, G. 1997. A Pervasive Millennial-Scale Cycle in North Atlantic Holocene and Glacial Climates. *Science* 278, 1257–1266.

Bonsall, C., Macklin, M. G., Anderson, D. E. & Payton, R. W. 2002. Climate change and the adoption *of* agriculture in north-west Europe. *European Journal of Archaeology* 5(1), 9–23.

Boone, J. L. 2002. Subsistence strategies and early human population history: An evolutionary ecological perspective. *World Archaeology* 34, 6–25.

Boyd, R. & Richerson, P. J. 1985. *Culture and the Evolutionary Process*. Chicago, University of Chicago Press.

— & Richerson, P. J. 2005. The Origin and Evolution of Cultures. Oxford, Oxford University Press.

Brizzi, V. *in press*. Tranciante Trasverso, Qui Prodest? In: F. Molina González & J. A. Cámara Serrano (Eds.) Violencia y guerra en la Prehistoria. *Cuadernos de Prehistoria y Arqueología de la Universidad de Granada* 23 (2014).

Bronk Ramsey, C. 2010. OxCal 4.1.7. http://c14.arch.ox.ac.uk/oxcal/OxCal.html

Broughton, J. M. & Cannon, M. D. (Eds.) 2010a. *Evolutionary Ecology and Archaeology. Applications to Problems in Human Evolution and Prehistory*. The University of Utah Press, Salt Lake City.

— & Cannon, M. D. 2010b. Evolutionary Ecology and Archaeology: An Introduction. In: J. M. Broughton & M. D. Cannon (Eds.), *Evolutionary Ecology and Archaeology. Applications to Problems in Human Evolution and Prehistory*. The University of Utah Press, Salt Lake City, 1–12.

— & O'Connell, J. F. 1999. On Evolutionary Ecology, Selectionist Archaeology, and Behavioral Archaeology. American Antiquity 64, 153–165.

Budja, M. 2007. The 8200 cal BP "climate event" and the process of neolithisation in south-eastern Europe. *Documenta Praehistorica* XXXIV, 191–201.

Burkett, V., Wilcox, D., Stottlemyer, R., Barrow, W., Fagre, D., Baron, J., Price, J., Nielsen, J. L., Allen, C. D., Peterson, D. L., Ruggerone, G. & Doyle, T. 2005. Nonlinear dynamics in ecosystem response to climatic change: Case studies and policy implications. *Ecological Complexity* 2(4), 357–394.

Burov, G. M. 1981. Der Bogen bei den mesolithischen Stämmen Nordosteuropas. In: B, Gramsch (Ed.), *Mesolithikum in Europa*. Potsdam, 373–388.

Bøe, J. & Nummedal, A. 1936. *Le Finnmarkien. Les origines de la civilisation dans l'extrême-nord de'l Europe*. Instututtet for sammenlignende kulturforskning, serie B: skrifter XXXII. Oslo, Instututtet for sammenlignende kulturforskning.

Callahan, E. 1979. *The basics of biface knapping in the eastern fluted point tradition: a manual for flintknappers and lithic analysts*. Archaeology of Eastern North America 7(1).

— 1987. An Evaluation of the Lithic Technology in Middle Sweden During the Mesolithic and Neolithic, *Aun* 8. Societas Archaeologica Uppsaliensis, Uppsala.

— , Forsberg, L., Knutsson, K. & Lindgren, C. 1992. Frakturbilder. Kulturhistoriska kommentarer till det säregna sönderfallet vid bearbetning av kvarts. *TOR* 24, 27–63.

Calvo, E., Grimalt, J. O., & Jansen, E. 2002. High resolution UK37 sea surface temperature reconstruction in the Norwegian Sea during the Holocene. *Quaternary Science Reviews* 21, 1385–1394.

Came, R. E., Oppo, D. W. & McManus, J. F. 2007. Amplitude and timing of temperature and salinity variability in the subpolar North Atlantic over the past 10 k.y. *Geology* 35(4), 315–318.

Carpelan, C. 2003. Inarilaisten arkeologiset vaiheet. In: V.-P. Lehtola (Ed.), *Inari – Aanaar. Inarin historia jääkaudesta nykypäivään*.Oulu, Inarin kunta, 29–95.

— 2004. Environment, Archaeology and Radiocarbon Dates. Notes from the Inari Region, Northern Finnish Lapland. *Iskos* 13, 17–45.

Carr, P.J. (Ed.) 1994. *The Organization of North American Prehistoric Chipped Stone Technologies*. International Monographs in Prehistory Archaeological Series 7.

Cavalli-Sforza, L. L. & Feldman, M. W. 1981. *Cultural Transmission and Evolution: A Quantitative Approach*. Princeton, Princeton University Press.

Chan, K.-S., Mysterud, A., Øritsland, N. A., Severinsen, T. & Stenseth, N. C. 2005. Continuous and discrete extreme climatic events affecting the dynamics of a high-arctic reindeer population. *Oecologia* 145, 556–563.

Chatters, J. C. 1987. Hunter-Gatherer Adaptations and Assemblage Structure. *Journal of Anthropological Archaeology* 6, 335–375.

Chistyakova, N. O., Ivanova, E. V., Risebrobakken, B., Ovsepyan, E. A. & Ovsepyan, Y. S. 2010. Reconstruction of the Postglacial Environments in the Southwestern Barents Sea Based on Foraminiferal Assemblages. *Oceanology* 50(4), 573–581.

Clark, P. U., Marshall, S. J., Clarke, G. K. C., Hostetler, S. W., Licciardi, J. M. & Teller, J. T. 2001. Freshwater Forcing of Abrupt Climate Change During the Last Glaciation. *Science* 293, 283–287.

Cochrane, S. K. J., Denisenko, S. G., Renaud, P. E., Emblow, C. S., Ambrose, W. G. Jr, Ellingsen, I. H. & Skarðhamar, J. 2009. Benthic macrofauna and productivity regimes in the Barents Sea – Ecological implications in a changing Arctic. *Journal of Sea Research* 61, 222–233.

Coia, V., Boschi, I., Trombetta, F., Cavulli, F., Montinaro, F., Destro-Bisol, G., Grimaldi, S. & Pedrotti, A. 2012. Evidence of high genetic variation among linguistically diverse populations on a micro-geographic scale: a case study of the Italian Alps. Journal of Human Genetics 57, 254–260.

Collard, M., Shennan, S., Buchanan, B. & Bentley, R. A. 2008. Evolutionary Biological Methods and Cultural Data. In: A. Bentley, H. D. G. Maschner & C. Chippindale (Eds.), *Handbook of Archaeological Theories*, 203–223. Plymouth, Altamira Press.

Cotterell, B. & Kamminga, J. 1990. Mechanics of Pre-industrial Technology. Cambridge University Press, Cambridge.

Cronk, L. 1991. Human Behavioral Ecology. *Annual Review of Anthropology* 20, 25–53.

Cziesla, E., 1990. On refitting of stone artifacts. In: E. Cziesla, S. Eickhoff, N. Arts & D. Winter (Eds.), *The Big Puzzle: International Symposium on Refitting Stone Artifacts*. Studies in Modern Archaeology 1. Holos Verlag, Bonn, 9–44.

Daley, T. J., Thomas, E. R., Holmes, J. A., Street-Perrott, F. A., Chapman, M. R., Tindall, J. C., Valdes, P. J., Loader, N. J., Marshall, J. D., Wolff, E. V., Hopley, P. J., Atkinson, T., Barber, K. E., Fisher, E. H., Robertson, I., Hughes, P. D. M. & Roberts, C. N. 2011. The 8200 yr BP cold event in stable isotope records from the North Atlantic region. *Global and Planetary Change* 79, 288–302.

Damm, C. 2006. Interregional Contacts across Northern Fennoscandia 6000-4000 BC. In: V.-P. Herva (Ed.), *People, Material Culture and Environment in the North*. Proceedings of the 22nd Nordic Archaeological Conference, University of Oulu, 18-23 August 2004. Studia humaniora ouluensia 1, 131–140. Oulu, University of Oulu.

Daniels, J. 2010. *Unpublished digital atlas*.

Darmark, K. & Sundström, L. 2005. *Postboda 3, en sen mesolitisk lägerplats i Uppland*. SAU Skrifter 9. Societas Archaeologica Uppsaliensis, Uppsala.

Delworth, T. L., Clarck, P. U., Holland, M., Johns,W. E., Kuhlbrodt, T., Lynch-Stieglitz, J., Morrill, C., Seager, R., Weaver, A. J. & Zhang, R. 2008. The Potential for Abrupt Change in the Atlantic Meridional Overturning Circulation. In: *Abrupt Climate Change*. A report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. U.S. Geological Survey, Reston, VA, U.S.A, 258–359.

Dincauze, D. F. 2000. *Environmental archaeology: principles and practice*. Cambridge, Cambridge University Press.

Edinborough, K. 2009. Population History and the Evolution of Mesolithic Arrowhead Technology in South Scandinavia. In: S. J. Shennan (Ed.), *Pattern and Process in Cultural Evolution*. Berkeley, University of California Press*,* 191−202.

Eerkens, J. W. & Lipo, C. P. 2007. Cultural Transmission Theory and the Archaeological Record: Providing Context to Understanding Variation and Temporal Changes in Material Culture. *Journal of Archaeological Research* 15, 239–274.

Engelstad, E. 1984. Diversity in arctic maritime adaptations. An example from the late Stone Age of arctic Norway. Acta Borealia: A Nordic Journal of Circumpolar Societies 1(2), 3–24.

— 1989. Mesolithic House Sites in Arctic Norway. In: C. Bonsall (Ed.), *The Mesolithic in Europe. Papers presented at the third international symposium. Edinburgh* 1985. Edinburgh, John Donald Publishers Limited, 331–337.

Eren, M. I. (Ed.) 2012a. *Hunter-Gatherer Behavior: Human Response During the Younger Dryas*. Left Coast Press, Walnut Creek.

— 2012b. On Younger Dryas Climate Change as a Causal Determinate of Prehistoric Hunter-Gatherer Culture Chnage. In: M. I. Eren (Ed.), *Hunter-Gatherer Behavior: Human Response During the Younger Dryas*. Left Coast Press, Walnut Creek, 11–23.

— , Greenspan, A. & Sampson, C. G. 2008. Are Upper Paleolithic blade cores more productive than Middle Paleolithic discoidal cores? A replication experiment. *Journal of Human Evolution* 55, 952–961.

Eronen, M., Hyvärinen, H. & Zetterberg, P. 1999. Holocene humidity changes in northern Finnish Lapland inferred from lake sediments and submerged Scots pines dated by tree-rings. *The Holocene* 9(5), 569–580.

Erästö, P., Holmström, L, Korhola, A. & Weckström, J. submitted. Finding a consensus on credible features among several paleoclimate reconstructions. Submitted to the *Annals of Applied Statistics*.

Fagre, D. B., Charles, C. W, Allen, C. D, Birkeland, C., Chapin, F. S. III, Groffman,

P. M., Guntenspergen, G. R., Knapp, A. K., McGuire, A. D., Mulholland, P. J., Peters, D. P. C., Roby, D. D. & Sugihara, G. 2009. *Thresholds of climate change in Ecosystems: Final Report, Synthesis and Assessment Product* 4.2. U.S. Geological Survey A report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research.

Fernández López de Pablo, J. & Jochim, M. A. 2010. The impact of the 8,200 cal BP climatic event on human mobility strategies during the Iberian Late Mesolithic. *Journal of Anthropological Research* 66, 39–68.

Fleitmann, D., Mudelsee, M., Burns, S. J., Bradley, R. S., Kramers, J. & Matter, A. 2008. Evidence for a widespread climatic anomaly at around 9.2 ka before present. *Paleoceanography* 23, PA1102.

Fletcher, C. H. III, Fairbridge, R. W., Møller, J. J. & Long, A. J. 1993. Emergence of the Varanger Peninsula, Arctic Norway, and climate changes since deglaciation. *The Holocene* 3, 116−127.

Forsberg, L. & Knutsson, K. 1999. Converging conclusions from different archaeological perspectives: The early settlement of northern Sweden. In: A. Thévenin (Ed.), *L'Europe des dernier chasseurs: Èpipaléolithique et Mesolithique*. Documents préhistoriques 12, 313–319.

Friis-Hansen, J. 1990. Mesolithic cutting arrows: functional analysis of arrows used in the hunting of large game. *Antiquity* 64, 494–504.

Fuglestvedt, I. 2007. The Ahrensburgian Galta 3 site in SW Norway. Dating, technology and cultural affinity. *Acta Archaeologica* 78(2), 87–110.

Førland, E. J. (Ed.), Benestad, R. E., Flatøy, F., Hanssen-Bauer, I., Haugen, J. E., Isaksen, K., Sorteberg, A. & Ådlandsvik, B. 2009. *Climate development in North Norway and the Svalbard region during 1900–2100*. The Norwegian Polar Institute, Report series no. 128.

Gamble, C. S. & Boismier, W. A. (Eds.) 1991. *Ethnoarchaeological Approaches to Mobile Campsites: Hunter-Gatherer and Pastoralist Case Studies*. International Monographs in Prehistory Ethnoarchaeological Series 1, Ann Arbor.

— , Davies, W. Pettitt, P. & Richards, M. 2004. Climate change and evolving human diversity in Europe during the last glacial. *Philosophical Transactions of the Royal Society B: Biological Sciences* 359, 243–254.

Gerasimov 2012 = Герасимов, Д. В. 2012. *Динамика каменных индустрий Мезолита - Неолита Карельского Перешейка*. Санкт-Петербург.

Gifford, D. P. 1980. Ethnoarchaeological contributions to the taphonomy of human sites. In: A. K. Behrensmeyer & A. P. Hill (Eds.), *Fossils in the making: Vertebrate taphonomy and paleoecology*. University of Chicago Press, Chicago, 93–106.

Gjøsæter, H., Dommasnes, A., Falkenhaug, T., Hauge, M., Johannesen, E., Olsen, E. & Skagseth, Ø. (Eds.) 2009. Havets ressurser og miljø 2009. *Fisken og havet, særnummer* 1. Havforskninsinstututtet. http://www.imr.no/publikasjoner/andre_publikasjoner/havets_ressurser_og_miljo/nb-no

González-Sampériz, P., Utrilla P., Mazo, C., Valero-Garcés, B., Sopena, M. C., Morellón, M., Sebastián, M., Moreno, A. & Martínez-Bea, M. 2009. Patterns of human occupation during the early Holocene in the central Ebro Basin (NE Spain) in response to the 8.2 ka climatic event. *Quaternary Research* 71, 121–132.

Gould, R. A. 1971. The archaeologist as ethnographer: a case from the Western Desert of Australia. *World Archaeology* 3(2), 43–177.

Gronenborn, D. 2009. Climate fluctuations and trajectories to complexity in the Neolithic: towards a theory. *Documenta Praehistorica* XXXVI, 97–110.

Grydeland, S.-E. 2000. Nye perspektiver på eldre steinalder i Finnmark - En studie fra indre Varanger. *Viking* LXIII, 10–50.

— 2005. The Pioneers of Finnmark – from the earliest coastal settlements to the encounter with the inland people of Northern Finland. In: H. Knutsson (Ed.), Pioneer settlements and colonization processes in the Barents region. Vuollerim Papers on Hunter-gatherer Archaeology 1, 43–77.

Grøn, O., 1989. General Spatial Behaviour in Small Dwellings: a Preliminary Study in Ethnoarchaeology and Social Psychology. In: C. Bonsall (Ed.), *The Mesolithic in Europe*. Papers presented at the third International Symposium, Edinburgh 1985. John Donald Publishers Ltd, Edinburgh, 99–105.

— 2003. Mesolithic dwelling places in south Scandinavia: their definition and social interpretation. *Antiquity* 77, 685–708.

Haapasaari, M., 1988. The oligotrophic heath vegetation in northern Fennoscandia and its zonation. *Acta Botanica Fennica* 135, 1–219.

Hafliðason, H., Lien, R., Sejrup, H. P., Forsberg, C. F. & Bryn, P. 2005. The dating and morphometry of the Storegga Slide. *Marine and Petroleum Geology* 22, 123–136.

Hagen, O. E. 2011. *Overgangen ESA II - ESA III på Nordkalotten – naturforutsetninger og kulturell endring*. MA thesis, University of Tromsø. http://hdl.handle.net/10037/3978

Hakala, A. V. K. 1997. Origin and prehistory of the Fennoscandian reindeer with reference to the taxonomy and background in glacial Europe. In: E.-L. Schulz. & C. Carpelan (Eds.), *Varhain Pohjoisessa. Maa. Varhain Pohjoisessa hankkeen artikkeleita*. Helsinki Papers in Archaeology 10. Helsinki, University of Helsinki, 59–80.

Hald, M. 2009. Past Climate Change and Perspectives for Archaeological Research: Examples from Norway, Svalbard, and Adjoining Seas. *Arctic Anthropology* 46(1–2), 8–16.

Halinen, P. 2005. Prehistoric Hunters of Northernmost Lapland. Settlement patterns and subsistence strategies. *Iskos* 14.

Havas, H. 1999. *Innland uten landgrenser. Bosetningsmodeller i det nordligeste Finland og Norge i perioden 9000-6000 BP.* MA thesis. Tromsø, University of Tromsø.

Helskog, K. 1980a. The Chronology of the Younger Stone Age in Varanger, North Norway. Revisited. *Norwegian Archaeological Review* 13(1), 47–60.

— 1980b. *Subsistence-Economic Adaptations to the Alpine Regions of Interior North Norway*. PhD Dissertation. University of Wisconsin-Madison. University Microfilms, Ann Arbor, Michigan.

Henrich, J. 2004. Demography and Cultural Evolution: How Adaptive Cultural Processes can Produce Maladaptive Losses: The Tasmanian Case. *American Antiquity* 69(2), 197–214.

Henriksen, S. 2010. ID 104342: En tuft fra Eldre Steinalder. In: M. Skandfer (Ed.), Tønsnes havn, Tromsø Kommune, Troms. Rapport fra arkeologiske utgravninger i 2008 og 2009. *Tromura,* kulturhistorie 40. Tromsø museum, Tromsø, 50–71.

Hertell, E. & Tallavaara, M. 2011a. High Mobility or Gift Exchange – Early Mesolithic Exotic Chipped Lithics in Southern Finland. In: T. Rankama (Ed.), *Mesolithic Interfaces. Variability in Lithic Technologies in Eastern Fennoscandia*. Monographs of the Archaeological Society of Finland 1, 11–41. http://www.sarks.fi/masf/masf_1/masf_1.html

— & Tallavaara, M. 2011b. Hunter-Gatherer Mobility and the Organization of Core Technology in Mesolithic North-Eastern Europe. In: T. Rankama (Ed.), *Mesolithic Interfaces. Variability in Lithic Technologies in Eastern Fennoscandia*. Monographs of the Archaeological Society of Finland 1, 95–110. http://www.sarks.fi/masf/masf_1/masf_1.html

Hesjedal, A., Damm, C., Olsen, B. and Storli I. 1996. Arkeologi på Slettnes. Dokumentasjon av 11.000 års bosetning. *Tromsø Museums Skrifter* XXVI.

— , Ramstadt, M. & Niemi, A. R. 2009. Undersøkelsene på Melkøya: Melkøyaprosjektet - kulturhistoriske registreringer og utgravninger 2001 og 2002. Tromura, Kulturvitenskap 36. http://munin.uit.no/handle/10037/2437

Hewlett, B. S. & Cavalli-Sforza L. L. 1986. Cultural Transmission Among Aka Pygmies. *American Anthropologist* 88(4), 923–934.

Hicks, S. & Hyvärinen, H. 1997. The vegetation history of northern Finland. In: E.-L. Schulz & C. Carpelan (Eds.), *Varhain pohjoisessa - Early in the north. Maa - The land. Varhain Pohjoisessa -hankkeen artikkeleita - Reports of the Early in the North Project*. Helsinki papers in archaeology 10. Helsinki, University of Helsinki, 25–33.

Hildén, M., Silfverberg, H. & Talman, R. 2010. Accessions to the Zoological Museum of the Finnish Museum of Natural History, University of Helsinki in 2009. *Memoranda Societatis pro Fauna et Flora Fennica* 86, 86–89.

Hjermann, D. Ø., Stenseth, N. C. & Ottersen, G. 2004. Indirect climatic forcing of the Barents Sea capelin: a cohort effect. *Marine Ecology Progress Series* 273, 229–238.

Hodgetts, L. M. 1999. *Animal bones and human society in the late younger stone age of arctic Norway.* Durham University. http://etheses.dur.ac.uk/4491/

Hoffman, J. S., Carlson, A. E., Winsor, K., Klinkhammer, G. P., LeGrande, A. N., Andrews, J. T. & Strasser, J. C. 2012. Linking the 8.2 ka event and its freshwater forcing in the Labrador Sea. *Geophysical Research Letters* 39, L18703.

Hood, B. C. n.d. *Steinalders steinråstoffbruk i Finnmark*. University of Tromsø, Dept. of Archaeology and Social Anthropology. http://m.en.uit.no/ansatte/organisasjon/artikkel?p_document_id=168384&p_dimension_id=88154&p_menu=28713

— 1988. Undersøkelse av en steinalderboplass ved Aksujavri, Kautokeino kommune, Finnmark. In: E. Engelstad & M. Holm–Olsen (Eds.), Arkeologisk feltarbeid i Nord-Norge og på Svalbard 1986. *Tromura kulturhistorie* 14, 23–31.

— 1992a. Chert sources and distribution patterns in the stone age of West Finnmark, North Norway: A preliminary view. *Acta Borealia: A Nordic Journal of Circumpolar Societies* 9(2), 69–84.

— 1992b. *Prehistoric Foragers of the North Atlantic: Perspectives on Lithic Procurement and Social Complexity in the North Norwegian Stone Age and the Labrador Maritime Archaic*. Electronic Doctoral Dissertations for UMass Amherst.

— 1994. Lithic Procurement and Technological Organization in the Stone Age of West Finnmark, North Norway. *Norwegian Archaeological Review* 27, pp. 65–85.

— 2012. The Empty Quarter? Identifying the Mesolithic of Interior Finnmark, North Norway. *Arctic Anthropology* 49(1), 105–135.

Huang, Y. & Knutsson, K. 1995. Functional analysis of Middle and Upper Palaeolithic quartz tools from China. *TOR* 27, 7–46.

Hyvärinen, H. 1975. Absolute and relative pollen diagrams from northernmost Fennoscandia. *Fennia* 142, 1–23.

Jennings, T. A., Pevny, C. D. & Dickens, W. A. 2010. A biface and blade core efficiency experiment: implications for Early Paleoindian technological organization. *Journal of Archaeological Science* 37, 2155–2164.

Jensen, C. & Vorren, K.-D. 2008. Holocene vegetation and climate dynamics of the boreal alpine ecotone of northwestern Fennoscandia. *Journal of Quarternary Science* 23(8), 719−743.

Jochim, M. A. 1989. Optimization and stone tool studies: problems and potential. In: R. Torrence (Ed.), *Time, Energy and* Stone *Tools*. Cambridge, Cambridge University Press, 106−111.

Johansson, P. & Kujansuu R. 2005. Deglasiaatio. In: P. Johansson & R. Kujansuu (Eds.), *Pohjois-Suomen maaperä*. Maaperakarttojen 1:400 000 selitys. Espoo, Geologian tutkimuskeskus, 149–157.

Johnson, J. & Morrow, C. (Eds.) 1987. *The Organization of Core Technology*. Westview Special Studies in Archaeological Research. Westview Press, Boulder.

Johnson, M. 2010. *Archaeological Theory: An Introduction*. Wiley-Blackwell, Singapore.

Jones, E. L. 2009. Climate change, patch choice, and intensification at Pont d'Ambon (Dordogne, France) during the Younger Dryas. *Quaternary Research* 72(3), 371–376.

Jones, K. T. 1993. The Archaeological Structure of a Short-Term Camp. In: J. Hudson (Ed.), *From Bones to Behavior. Ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains*. Center for Archaeological Investigations Southern Illinois University at Carbondale Occasional Paper 21, 101–114.

Jussila T., Kriiska A. & Rostedt T. 2012. Saarenoja 2 – An Early Mesolithic Site in South-Eastern Finland: Preliminary Results and Interpretations of studies Conducted in 2000 and 2008–10. *Fennoscandia Archaeologica* XXIX, 3–27.

Kankaanpää, J. & Rankama, T. 2005. Early Mesolithic pioneers in Northern Finnish Lapland. In: H. Knutsson (Ed.), Pioneer settlements and colonization processes in the Barents region. *Vuollerim Papers on Hunter-gatherer Archaeology* 1, 109–161.

Kelly, R. L. 1988. The three sides of a biface. *American Antiquity* 53, 717–734.

— 1995. *The Foraging Spectrum: Diversity in Hunter-Gatherer Lifeways*. Smithsonian Institution Press, Washington and London.

— 2001. *Prehistory of the Carson Desert and* Stillwater Mountains*: Environment, Mobility, and Subsistence in a Great Basin Wetland.* University of Utah Anthropological Papers Number 123. University of Utah Press, Salt Lake City.

— , Poyer, L. & Tucker, B. 2005. An Ethnoarchaeological Study of Mobility, Architectural Investment, and Food Sharing among Madagascar's Mikea. *American Anthropologist* 107(3), 403–416.

Kent, S. 1991. The Relationship between Mobility Strategies and Site Structure.

In: E. M. Kroll & T. D. Price (Eds.), *The Interpretation of Archaeological Spatial Patterning*. Plenum Press. New York and London, 33–59.

Kleppe, J. I. n. d. Nyheter. *Steinalderliv i Øst–Finnmark*. SciencePub WWW-Page. http://www.ngu.no/sciencepub/norsk/PAGES/nyheter_03.08.html

Knutsson, H. & Knutsson, K. 2012. The postglacial colonization of humans, fauna and plants in northern Sweden. *Arkeologi i Norr* 2013, 1–27.

Knutsson, K. 1998. Convention and lithic analysis. In: L. Holm. & K. Knutsson (Eds.), Proceedings from the Third Flint Alternatives Conference at Uppsala, Sweden, October 18-20, 1996. *Occasional Papers in Archaeology* 16, 71–93.

Knutsson, K. 2004. The Historical Construction of Norrland. In: H. Knutsson (Ed.), *Arrival*. Coast to Coast Books 12. Uppsala, Uppsala Universirty; Societas Archaeologica Upsaliensis, 45–71.

— 2005. Bridging the abyss of time. Material culture, cultural reproduction and the sacred time of origin. In: H. Knutsson (Ed.), *Pioneer settlements and colonization processes in the Barents region.* Vuollerim Papers on Hunter-gatherer Archaeology 1. Vuollerim, Vuollerim 6000 år, 117–141.

Kobashi, T., Severinghaus, J. P., Brook, E. J., Barnola, J.-M. & Grachev, A. M. 2007. Precise timing and characterization of abrupt climate change 8200 years ago from air trapped in polar ice. *Quaternary Science Reviews* 26, 1212–1222.

Koivisto, S. 2010. Luihin ja ytimiin. Pyyntia ja elamaa Itameren aarella noin 7500 vuotta sitten. *Helsingin pitäjä* 2011, 8–21.

Korhola, A., Vasko, K., Tolonen, H. T. T. & Olander, H. 2002. Holocene temperature changes in northern Fennoscandia reconstructed from chironomids using Bayesian modeling. *Quaternary Science Reviews* 21, 1841–1860.

Kosheleva, E. A. & Subetto, D. A. 2011. = Кошелева, Е. А., Субетто, Д. А., 2011. Раннеголоцен овые изменения прир одн ой среды и инициальн ое заселение Фенноскандии *. *общество. среда. развитие* (*Terra Humana*), 237–242.

Kuhn, S. L. 1994. A Formal Approach to the Design and Assembly of Mobile Toolkits. *American Antiquity* 59, 426–442.

Kultti, S., Mikkola, K. Virtanen, T. Timonen, M. & Eronen, M. 2006. Past changes in the Scots pine forest line and climate in Finnish Lapland – a study based on megafossils, lake sediments, and GIS-based vegetation and climate data. *The Holocene* 16, 381–391.

Larson, M. L. 1994. Toward a holistic analysis of chipped stone assemblages. In: P. J. Carr (Ed.), *The organization of North American Prehistoric chipped stone tool technologies*. International Monographs in Prehistory Archaeological Series 7, 57–69.

— & Kornfeld, M. 1997. Chipped Stone Nodules: Theory, Method, and Examples. *Lithic Technology* 22, 5–18.

Lauritzen, S.-E. & Lundberg, J. 1999. Calibration of the speleothem delta function: an absolute temperature record for the Holocene in northern Norway. *The Holocene* 9(6), 659–669.

Lee, S. E., Press, M. C., Lee, J. A., Ingold, T. & Kurttila, T. 2000. Regional effects of climate change on reindeer: a case study of the Muotkatunturit region in Finnish Lapland. *Polar Research* 19(1), 99–105.

Lehtinen, M., Nurmi, P. & Rämö, T. 1998. *Suomen Kallioperä 3000 vuosimiljoonaa*. Jyväskylä, Suomen Geologinen Seura.

Lemonnier, P. 1986. The study of material culture today: Toward an anthropology of technical systems. *Journal of Anthropological Archaeology* 5, 147–186.

Lilleøren, K. S., Etzelmüller, B., Schuler, T. V., Gisnås, K. & Humlum, O. 2012. The relative age of mountain permafrost – estimation of Holocene permafrost limits in Norway. *Global and Planetary Change*, 209–223.

Lindgren, C. 2004. *Människor och kvarts. Sociala och teknologiska strategier under mesolitikum i östra Mellansverige.* Stockholm Studies in Archaeology 29, Riksantikvarieämbetet Arkeologiska Undersökningar, Skrifter no. 54, Coast to Coast books No. 11. Stockholms Universitet, Stockholm.

Loeng, H. 1991. Features of the physical oceanographic conditions of the Barents Sea. In: E. Sakshaug, C. C. E. Hopkins & N. A. Britsland (Eds.), Proceedings of the Pro Mare Symposium on Polar Marine Ecology, Trondheim, 12-16 May 1990. *Polar Research* 10(1), 5–18.

— & Drinkwater, K. 2007. An overview of the ecosystems of the Barents and Norwegian Seas and their response to climate variability. *Deep Sea Research*

Part II: Topical Studies in Oceanography 54(23–26), 2478–2500.

Luho, V. 1957. Fruhe Kammkeramik. *Suomen Muinaismuistoyhdistyksen Aikakauskirja* 58, Studia Neolithica in Honorem Aarne Äyräpää, 141–159.

MacDonald D. H. & Hewlett, B. S. 1999. Reproductive interests and forager mobility. *Current Anthropology*, 40, 501–523.

Magny, M., Bégeot, C., Guiot, J. & Peyron, O. 2003. Contrasting patterns of hydrological changes in Europe in response to Holocene climate cooling phases, *Quaternary Science Reviews* 22, 1589–1596.

Manninen, M. A. 2003. Chaîne opératoire *-analyysi ja kvartsi: Esimerkkinä kvartsin-iskentäpaikka Utsjoki Leakšagoađejohka* 3, Master's thesis. E-thesis, University of Helsinki. http://urn.fi/URN:NBN:fi-fe20031946

— 2005. Problems in Dating Inland Sites — Lithics and the Mesolithic in Paistunturi, Northern Finnish Lapland. In: H. Knutsson (Ed.), Pioneer settlements and colonization processes in the Barents region. *Vuollerim Papers on Hunter-gatherer Archaeology* 1, 29–41.

— 2006. Mesoliittiset asumuksenpohjat Pohjois-Lapissa. Huomioita liikkumisesta ja asumuksista. *Arkeologipäivät* 2005, 106–117.

— & Hertell, E. 2011. Few and Far between – an Archive Survey of Finnish Blade Finds. In: T. Rankama (Ed.), *Mesolithic Interfaces. Variability in Lithic Technologies in Eastern Fennoscandia*. Monographs of the Archaeological Society of Finland 1, 112–141. http://www.sarks.fi/masf/masf_1/masf_1.html

Maschner, H. D. G. 1996. "Middle Range Theory". In: B. M. Fagan (Ed.) *The Oxford Companion to Archaeology*. Oxford University Press.

Matiskainen, H. 1982. *Suomen mesoliittisen kivikauden sisäinen kronologia 14C-ajoitukseen tukeutuvan Itämeren kehityshistorian perusteella*. Unpublished Licenciate thesis. University of Helsinki.

— 1986. Beitrage zur Kentnisse der mesolithischen Schragschneidepfeile und Microlithen aus Quarz. *Iskos* 6, 77–98.

— 1989. The Chronology of the Finnish Mesolithic. In: C. Bonsall (Ed.), *The Mesolithic in Europe.* III *Int. Mesol. Symp. Edinburgh* 1985, 379–390. Edinburgh, John Donald Publishers Limited.

— 2002. *Riihimäen esihistoria*. Hämeenlinna, Riihimäen kaupunginmuseo.

Mauss, M. 1905. Essai sur les variations saisonnières des sociétés eskimos. Étude de morphologie sociale (avec la collaboration de H. Beuchat). *L'Année Sociologique* IX.

Mayewski, P. A., Rohling, E. E., Stager, J. C., Karlén, W., Maasch, K. A., Meeker, L. D., Meyerson, E. A., Gasse, F., van Kreveld, S., Holmgren, K., Lee-Thorp, J., Rosqvist, G., Rack, F., Staubwasser, M., Schneider, R. R. & Steig, E. J. 2004. Holocene climate variability. *Quaternary Research* 62, 243–255.

McClure, S. B., Barton, C. M. & Jochim, M. A. 2009. Human behavioral ecology and climate change during the transition to agriculture in Valencia, Eastern Spain. J*ournal of Anthropological Research* 65, 253–269.

Mercuri A. M., Sadori L. & Uzquiano Ollero, P. 2011. Mediterranean and north-African cultural adaptations to mid-Holocene environmental and climatic changes. *The Holocene* 21, 186–206.

Mesoudi, A. & O'Brien, M. J. 2007. The learning and transmission of hierarchical cultural recipes. *Biological Theory* 3(1) (2008), 63–72.

MJrek 2013 = Register of archaeological sites in mainland Finland. National Board of Antiquities. Accessed in 2013.

Moore, M. W. & Newman, K. 2013. Ballistically anomalous stone projectile points in Australia. *Journal of Archaeological Science* 40(6), 2614–2620.

Morrill, C. & Jacobsen, R. M. 2005. How widespread were climate anomalies 8200 years ago? *Geophysical Research Letters* 32, L19701.

Munoz, S. E., Gajewski, K. & Peros, M. C. 2010. Synchronous environmental and cultural change in the prehistory of the northeastern United States. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)* 107(51), 22008–22013.

Mäkilä, M. & Muurinen, T. 2008. Kuinka vanhoja ovat Pohjois-Suomen suot? *Geologi* 60, 179–184.

Møller, J. J. 1987. Shoreline relation and prehistoric settlement in northern Norway. *Norsk Geografisk Tidsskrift* 41, 45−60.

— 1996. Issmelting og strandforskyving. Modell for utforsking av strandnær bosetning. *Ottar* 4/96, 4–13.

— & Holmeslet, B. 1998. *Program*

Sealevel Change, Ver. 3.51, 7. jan. 1998. http://www.imv.uit.no/annet/sealev/download/s.132.htm

Naustvoll, L.-J. & Kleiven, M. 2009. Primær- og sekundærproduksjon. In: H. Gjøsæter, A. Dommasnes, T. Falkenhaug, M. Hauge, E. Johannesen, E. Olsen & Ø. Skagseth (Eds.), Havets ressurser og miljø 2009. *Fisken og havet, særnummer* 1. Havforskninsinstututtet, 30–31. http://www.imr.no/publikasjoner/andre_publikasjoner/havets_ressurser_og_miljo/nb-no

Nelson, M. C. 1991. The Study of Technological Organization. In: M. B. Schiffer (Ed.), *Archaeological Method and Theory* 3. University of Arizona Press, Tuscon, 57–100.

Newson, L., Richerson, P. J. & Boyd, R. 2007. Cultural Evolution and the Shaping of Cultural Diversity. In: D. Cohen & S. Kitayama (Eds.), *The Handbook of Cultural Psychology*. New York, Guilford Press, 454–476.

NGRIP 2004 = North Greenland Ice Core Project members 2004. *North Greenland Ice Core Project Oxygen Isotope Data*. IGBP PAGES/World Data Center for Paleoclimatology, Data Contribution Series # 2004-059. NOAA/NGDC Paleoclimatology Program, Boulder CO, USA.

Niemi, A. R. 2010. Life by the Shore. Maritime Dimensions of the Late Stone Age, Arctic Norway. In: W. Østreng (Ed.), *Transference. Interdisciplinary Communications 2008/2009*. Centre for Advanced Study, Oslo. http://www.cas.uio.no/Publications/Seminar/0809Niemi.pdf

— 2012. *Undersøkelser av chertbrudd i Melsvik, Alta*. WWW-page. http://www.norark.no/category/geografi/finnmark/alta/melsvik/

Nilsen, R. A. & Skandfer, M. 2010. ID 104380: En boplass med nedgravde tufter fra Eldre Steinalder. In: M. Skandfer (Ed.), Tønsnes havn, Tromsø Kommune, Troms. Rapport fra arkeologiske utgravninger i 2008 og 2009. *Tromura,* kulturhistorie 40. Tromsø museum, Tromsø, 82–115.

Nordqvist, K. & Seitsonen, O. 2009. New Mesolithic sites in the Finnish Lapland Wilderness. Research of the Muotke-duoddara doložat project in 2005–2007. *Mesolithic Miscellany* 19(2), 3–11.

Nummedal, A. 1929. Stone Age finds in Finnmark. *Skrifter. Instituttet for Sammenlignende Kultforskning Serie B*, 13.

Nyman, M., Weckström, J. & Korhola, A. 2007. Chironomid response to environmental drivers during the Holocene in a shallow treeline lake in northwestern Fennoscandia. *The Holocene* 18(2), 215–227.

Odner, K. 1966. *Komsakulturen i Nesseby og Sør-Varanger*. Tromsø/Oslo/Bergen, Universitetsforlaget.

Olofsson, A. 1995. *Kölskrapor, mikrospånkärnor och mikrospån*. Arkeologiska studier vid Umea Universitet 3. Umeå, Umeå Universitet.

— 2003. Early Colonization of Northern Norrland: Technology, Chronology, and Culture. In: *Pioneer Settlement in the Mesolithic of Northern Sweden*. Archaeology and Environment 16. Umea, Umea University.

Olsen, B. 1994. *Bosetning og samfunn i Finnmarks forhistorie*. Oslo.

Olsson, I. U. 1980. Content of 14C in marine mammals from northern Europe. *Radiocarbon* 22, 662–675.

Pagel, M. & Mace, R. 2004. The cultural wealth of nations. Nature 428, 275–278.

Panja, S. 2003. Mobility strategies and site structure: a case study of Inamgaon. *Journal of Anthropological Archaeology* 22, 105–125.

Panter-Brick, C., Layton, R. H. & Rowley-Conwy, P. (Eds.) 2001. *Hunter-Gatherers. An Interdisciplinary Perspective*. Cambridge University Press, Cambridge.

Parry, W. & Kelly, R. 1987. Expedient Core Technology and Sedentism. In: J. Johnson & C. Morrow (Eds.), *The Organization of Core Technology*. Westview Special Studies in Archaeological Research. Westview Press, Boulder, 285–304.

Pesonen, P., Hertell, E., Manninen, M. A. & Tallavaara, M. n. d. *Radiocarbon Database of the Postglacial Human Dispersal in the North Project*.

— & Tallavaara, M. 2006. Esihistoriallinen leiripaikka Lohjan Hossanmaella – kvartseja ja yllättaviä ajoituksia. *Suomen Museo* 2005, 5–26.

Pfister, C. & Brázdil, R. 2006. Social vulnerability to climate in the “Little Ice Age”: an example from Central Europe in the early 1770s. *Climate of the Past* 2(2), 115–129.

Polyak, L., Alley, R. B., Andrews, J. T., Brigham-Grette, J., Cronin, T. M., Darby, D. A., Dyke, A. S., Fitzpatrick, J. J., Funder, S., Holland, M., Jennings,

A. E., Miller, G. H., O'Regan, M., Savelle, J., Serreze, M., St.John, K., White, J. W. C. & Wolff, E. 2010. History of sea ice in the Arctic. *Quaternary Science Reviews* 29, 1757–1778.

Prasciunas, M. M. 2007. Bifacial Cores and Flake Production Efficiency: An Experimental Test of Technological Assumptions. American Antiquity 72(2), 334–348.

Påsse, T., & Daniels, J. 2011. Comparison between a new and an old semi-empirical Fennoscandian shore-level model. In: A. Ikonen & T. Lipping (Eds.), *Proceedings of a Seminar on Sea Level Displacement and Bedrock Uplift*, 10-11 June 2010, Pori, Finland. Posiva Working Report 2011-07, 47–50.

Pälsi, S. 1916. *Kulttuurikuvia kivikaudelta*. Otava, Helsinki.

Rankama, T. 1995. Review of Bjørnar Olsen: Bosetning og samfunn i Finnmarks forhistorie. Universitetsforlaget, Oslo, 1994. 158 pp. Norwegian Archaeological Review 28(2), 138–142.

— 1996. *Prehistoric riverine adaptations in subarctic Finnish Lapland: The Teno river drainage.* Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in the Department of Anthropology at Brown University. UMI Dissertation Services.

— 1997. *Ala-Jalve: Spatial, technological, and behavioral analyses of the lithic assemblage from a Stone Age-Early Metal Age site in Utsjoki, Finnish Lapland*. British Archaeological Reports, International Series 681. Oxford.

— 2002. Analyses of the quartz assemblages of houses 34 and 35 at Kauvonkangas in Tervola. In: H. Ranta (Ed.), *Huts and Houses. Stone Age and Early Metal Age Buildings in Finland*. National Board of Antiquities, Helsinki, 79–108.

— 2003. The colonisation of northernmost Finnish Lapland and the inland areas of Finnmark. In: L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler & A. Åkerlund (Eds.), *Mesolithic on the Move*. Exeter, Oxbow Books, 684–687.

— & Kankaanpää, J. 2008. Eastern arrivals in post-glacial Lapland: the Sujala site 10,000 cal BP. *Antiquity* 82(318), 884–899.

— & Kankaanpää, J. 2011. First evidence of eastern Preboreal pioneers in arctic Finland and Norway. *Quartär* 58, 183–209.

— Manninen, M. A., Hertell, E. & Tallavaara, M. 2006. Simple production and social strategies: do they meet? Social dimensions in Eastern Fennoscandian quartz technologies. In: J. Apel & K. Knutsson (Eds.), *Skilled Production and Social Reproduction. Aspects of Traditional Stone Tool Technologies*. SAU Stone Studies 2. Uppsala, Societas Archaeologica Uppsaliensis., 245–261.

— & Ukkonen, P. 2001. On the early history of the wild reindeer (*Rangifer tarandus* L.) in Finland. *Boreas* 30, 131–147.

Rasic, J., Andrefsky, W. Jr., 2001. Alaskan blade cores as specialized components of mobile toolkits: assessing design parameters and toolkit organization. In: W. Andrefsky Jr. (Ed.), *Lithic Debitage: Context, Form, Meaning.* University of Utah Press, Salt Lake City, 61–79.

Rasmussen, S. O., Vinther, B. M., Clausen H. B. & Anderssen, K. K.. 2007. Early Holocene climate oscillations recorded in three Greenland ice cores. *Quaternary Science Reviews* 26, 1907–1914.

Reimer, P. J., Baillie, M. G. L., Bard, E., Bayliss, A., Beck, J. W., Blackwell, P. G., Bronk Ramsey, C., Buck, C. E., Burr, G. S., Edwards, R. L., Friedrich, M., Grootes, P. M., Guilderson, T. P., Hajdas, I., Heaton, T. J., Hogg, A. G., Hughen, K. A., Kaiser, K. F., Kromer, B., McCormac, F. G., Manning, S. W., Reimer, R. W., Richards, D. A., Southon, J. R., Talamo, S., Turney, C. S. M., van der Plicht, J., & Weyhenmeyer, C. E. 2009. IntCal09 and Marine09 radiocarbon age calibration curves, 0-50,000 years cal BP. *Radiocarbon,* 51(4), 1111–1150.

Renouf, P. 1989. Prehistoric Hunter-Fishers of Varangerfjord, Northeastern Norway. British Archaeological Reports, International Series 487. Oxford.

Renssen, H., Goosse, H. & Fichefet, T. 2002. Modeling the effect of freshwater pulses on the early Holocene climate: The influence of high-frequence climate variability. *Paleocenography* 17(2), 10-1–16.

— , Goosse, H., Fichefet, T. & Campin, J.-M. 2001. The 8.2 kyr BP event simulated by a global atmosphere–sea-ice–ocean model. *Geophysical*

Research Letters 28, 1567–1570.

— , Seppä, H., Heiri, O., Roche, D. M., Goosse, H. & Fichefet, T. 2009. The spatial and temporal complexity of the Holocene thermal maximum. Nature Geosci*ences* 2(6), 411–414.

Richerson, P. J. & Boyd, R. 1992 Cultural inheritance and evolutionary ecology. In: B. Winterhalder & E. A. Smith (Eds.), *Evolutionary Ecology and Human Behavior*, 61–92. Aldine de Gruyter, New York.

— & Boyd, R. 2005. *Not By Genes Alone. How Culture Transformed Human Evolution*. Chicago, University of Chicago Press.

Riede, F. 2006. The Scandinavian Connection. The Roots of Darwinian Thinking in 19th Century Scandinavian Archaeology. *Bulletin of the History of Archaeology* 16(1), 4–19.

— 2009a. Climate and Demography in Early Prehistory: Using Calibrated 14C Dates as Population Proxies. *Human Biology* 81(2), 309–337.

— 2009b. Climate change, demography and social relations: an alternative view of the Late Palaeolithic pioneer colonization of southern Scandinavia. In: S. B. McCartan, R. Schulting, G. Warren & P. Woodman (Eds.), *Mesolithic Horizons*, Vol. I. Oxbow books, Oxford, 3–10.

— 2009c. The loss and re-introduction of bow-and-arrow technology: a case study from the Southern Scandinavian Late Palaeolithic. *Lithic Technology* 34(1), 27–45.

— , Apel, J. & Darmark, K. 2012. Cultural evolution and archaeology. Historical and current trends. In: R. Berge., M. E. Jasinski & K. Sognnes (Eds.), *N-TAG TEN. Proceedings of the 10th Nordic TAG conferenceat Stiklestad, Norway* 2009. British Archaeological Reports International Series 2399, 99–107.

Risebrobakken, B., Moros, M., Ivanova, E. V., Chistyakova, N. & Rosenberg, R. 2010. Climate and oceanographic variability in the SW Barents Sea during the Holocene. *The Holocene* 20(4), 609–621.

Roberts, B. W. & Vander Linden, M, 2011. Investigating Archaeological Cultures: Material Culture, Variability, and Transmission. In: B. W. Roberts & M. Vander Linden (Eds.), *Investigating Archaeological Cultures: Material Culture, Variability, and Transmission*. New York, Springer.

Robinson, E., Van Strydonck, M., Gelorini, V. & Crombé, P. 2013. Radiocarbon chronology and the correlation of hunter-gatherer sociocultural change with abrupt palaeoclimate change: the Middle Mesolithic in the Rhine-Meuse-Scheldt area of northwest Europe. *Journal of Archaeological Science* 40(1), 755–763.

Rogers E. M. & Shoemaker, F. F. 1971. *Communication of innovations: a cross-cultural approach*. Free Press, New York.

Rohling, E. & Pälike H. 2005. Centennial-scale climate cooling with a sudden cold event around 8,200 years ago. *Nature* 434, 975–979.

Romundset, A. & Bondevik, S. 2011. Propagation of the Storegga tsunami into ice-free lakes along the southern shores of the Barents Sea. *Journal of Quaternary Science* 26(5), 457–462.

Rosén, P., Segerström, U., Eriksson, L. Renberg, I. & Birks, H. J. B. 2001. Holocene climatic change reconstructed from diatoms, chironomids, pollen and near-infrared spectrometry at an alpine lake (Sjuodjijaure) in northern Sweden. *The Holocene* 11(5), 551–562.

Rosendahl, H. 1936. Roches employees dans l'âge de la Pierre au Finnmark. In: J. Bøe & A. Nummedal 1936. *Le Finnmarkien. Les origines de la civilisation dans l'extrême-nord de'l Europe.* Instututtet for sammenlignende kulturforskning, serie B: skrifter XXXII. Oslo, Instututtet for sammenlignende kulturforskning, 133–137.

Sakshaug, E. 1997. Biomass and productivity distributions and their variability in the Barents Sea. *ICES Journal of Marine Science* 54, 341–350.

— & Slagstad, D. 1992. Sea Ice and Wind: Effects on Primary Productivity in the Barents Sea. *Atmosphere-Ocean* 30(4), 579–591.

Sarala, P. & Ojala, V. J. 2011. *Geochemical and indicator mineral exploration methods and ongoing projects in the glaciated terrains in northern Finland.* Excursion guide, 26–30 August 2011. 25th International Applied Geochemistry Symposium, 22–26 August 2011 Rovaniemi, Finland. Vuorimiesyhdistys - Finnish Association of Mining and Metallurgical Engineers, Serie B, Nro B92-11. http://www.iags2011.fi/25thIAGS2011_E5_net.pdf

Schanche, K. 1988. *Mortensnes - en boplass i Varanger. En studie av samfunn og materiell kultur gjennom*

10.000 år. MA thesis. Tromsø, University of Tromsø.
Schiffer, M. B. 1976. *Behavioral Archaeology*. Academic Press, New York.
Schmidt, I., Bradtmöller, M., Kehl, M., Pastoors, A., Tafelmaier, Y., Weninger, B. & Weniger, G.-C. 2012. Rapid climate change and variability of settlement patterns in Iberia during the Late Pleistocene. *Quaternary International* 274, 179–204.
Schmittner, A, Chiang, J. C. H. & Hemming, S. R. (Eds.) 2007. *Ocean Circulation: Mechanisms and Impacts —Past and Future Changes of Meridional Overturning*. AGU Geophysical Monographs Series 173.
Schwartz, P. & Randall, D. 2003. *An Abrupt Climate Change Scenario and Its Implications for United States National Security*. Global Business Network, Washington. http://www.edf.org/documents/3566_AbruptClimateChange.pdf
Seppä, H. 1996. Post-glacial dynamics of vegetation and tree-lines in the far north of Fennoscandia. *Fennia* 174, 1–96.
— , Alenius, T., Bradshaw, R. H. W., Giesecke, T., Heikkilä, M. & Muukkonen, P. 2009a. Invasion of Norway spruce (*Picea abies*) and the rise of the boreal ecosystem in Fennoscandia. *Journal of Ecology* 97, 629–640.
— & Birks, H. J. B. 2001. July mean temperature and annual precipitation trends during the Holocene in the Fennoscandian tree-line area: pollen-based climate reconstructions. *The Holocene* 11(5), 527–539.
— , Birks, H. H. & Birks, H. J. B. 2002. Rapid climatic changes during the Greenland stadial 1 (Younger Dryas) to early Holocene transition on the Norwegian Barents Sea coast. *Boreas* 31, 215–225.
— , Birks, H. J. B., Giesecke, T., Hammarlund, D., Alenius, T., Antonsson, K., Bjune, A. E., Heikkilä, M., MacDonald, G. M., Ojala, A. E. K., Telford, R. J. & Veski, S. 2007. Spatial structure of the 8200 cal yr BP event in northern Europe. *Climate of the Past* 3, 225–236.
— , Bjune, A. E., Telford, R. J., Birks, H. J. B., Veski, S. 2009b. Last nine-thousand years of temperature variability in Northern Europe. *Climate of the Past* 5, 523–535.
— , Hammarlund, D., 2000. Pollen-stratigraphical evidence of Holocene hydrological change in northern Fennoscandia supported by independent isotopic data. *Journal of Paleolimnology* 24, 69–79.
Seppä, J. 1997. Poikkiteräisten kvartsinuolenkärkien tehokkuus. Kokeellisia tutkimuksia. *Turun maakuntamuseon monisteita* 13.
Shennan, S. J. 2005. Darwinian archaeology. In: C. Renfrew. & P. Bahn (Eds.), *Archaeology. The Key Concepts*. Routledge, London and New York, 44–47.
— 2008. Evolution in Archaeology. *Annual Review of Anthropology* 37, 75–91
— 2009. Pattern and Process in Cultural Evolution. An Introduction. In: S. J. Shennan (Ed.), *Pattern and Process in Cultural Evolution,* 1−18. Berkeley, University of California Press.
Shott, M. 1986. Technological Organization and Settlement Mobility: An Ethnographic Examination. *Journal of Anthropological Research* 42(1), 15–51.
Siiriäinen, A. 1981a. On the Cultural Ecology of the Finnish Stone Age. *Suomen Museo* 1980, 5–40.
— 1981b. Problems of the East Fennoscandian Mesolithic. *Finskt Museum* 1977, 5–31.
Simonsen, P. 1961. *Varanger-funnene* II. *Fund og udgravninger på fjordens sydkust*. Tromsø museums skrifter vol. VII, hefte II. Tromsø, Tromsø museum.
— 2001. Alta-kraftverkene. Kulturhistoriske registreringer og utgravninger 1984–1987. Del A: Vir'dnejav'ri nord. *Tromura kulturhistorie* 34. Tromsø Museum, Universitetet i Tromsø.
Skandfer, M. 2003. *Tidlig, nordlig kamkeramikk. Typologi-kronologi-kultur*. PhD dissertation in archaeology. University of Tromsø. http://www.ub.uit.no/munin/handle/10037/284
— 2005. Early, Northern Comb Ware in Finnmark: the Concept of Säräisniemi 1 Reconsidered. *Fennoscandia archaeologica* XXII, 3–27.
— 2009. "All change"? Exploring the role of technological choice in the Early Northern Comb Ware of Finnmark, Arctic Norway. In: P. Jordan & M. Zvelebil (Eds.), *Ceramics before Farming: the Origins and Dispersal of Pottery among Hunter-Gatherers of Northern Eurasia from 16 000 BP.* London: University College London Institute of Archaeology Publications (Left Coast Press), 347–373.
Sorvari, S. 2001. Climate Impacts on Remote Subarctic Lakes in Finnish Lapland: Limnological and Palaeolimnological Assessment with a

Particular Focus on Diatoms and Lake Saanajärvi. PhD dissertation in Hydrobiology, University of Helsinki, Finland. https://www.doria.fi/bitstream/handle/10024/2466/climatei.pdf?sequence=1

St. Amour, N. A. 2009. *A Multi-Proxy Study of Holocene Atmospheric Circulation Dynamics Recorded in Lake Sediments in Fennoscandia*. PhD. dissertation in Earth Sciences, University of Waterloo, Canada.

Staubwasser, M. & Weiss, H. 2006. Holocene climate and cultural evolution in late prehistoric–early historic West Asia. *Quaternary Research* 66(3), 372–383.

Stensrud, G. 2007. *Steinråstoffet i eldre steinalder i Troms. Symbolsk kommunikasjon eller optimal funksjon?* Master´s thesis, University of Tromsø. http://hdl.handle.net/10037/1040

Steward, J. H. 1955. Theory of Culture Change: The Methodology of Multilinear Evolution. Urbana: University of Illinois Press.

Stuiver, M., Reimer, P. J. & Reimer, R. 1986–2010. *Marine Reservoir Correction Database*. http://calib.qub.ac.uk/calib/

Surovell, T. A. 2009. *Toward a Behavioral Ecology of Lithic Technology: Cases from Paleoindian Archaeology*. The University of Arizona Press, Tucson.

— , Byrd Finley, J., Smith, G. M., Brantingham, P. J. & Kelly, R. 2009. Correcting temporal frequency distributions for taphonomic bias. *Journal of Archaeological Science* 36, 1715–1724.

Sørensen, M., Rankama, T., Kankaanpää , J., Knutsson, K., Knutsson, H., Melvold, S., Valentin Eriksen, B & Glørstad, H. 2013. The First Eastern Migrations of People and Knowledge into Scandinavia: Evidence from Studies of Mesolithic Technology, 9th-8th Millennium BC. *Norwegian Archaeological Review* 2013.

Tallavaara, M. 2005. Arkeologisen kiviaineiston nodulianalyysi. Sovellus-esimerkki Rääkkylän Vihin kampa-keraamisen ajan asuinpaikan piikivi-materiaaliin. *Muinaistutkija* 2/2005, 14–23.

— , Manninen, M. A., Pesonen, P. & Hertell, E. *in press*. Radiocarbon dates and postglacial colonisation dynamics in eastern Fennoscandia. *British Archaeological Reports International Series*.

— , Pesonen, P. & Oinonen, M. 2010. Prehistoric population history in eastern Fennoscandia. *Journal of Archaeological Science* 37(2), 251–260.

— & Seppä, H. 2012. Did the mid-Holocene environmental changes cause the boom and bust of hunter-gatherer population size in eastern Fennoscandia? The Holocene 22(2), 215–225.

Tanner, V. 1935. Note sur la position chronologique des trouvailles préhistoriques par rapport aux étages géologiques dans la région côtière de la Fenno-Scandie aux confins de l'océan Arctique. *Suomen Muinaismuistoyhdistyksen aika-kauskirja* 39(1).

Tarasov *et al*. 2007 = Тарасов, А. Ю., Мурашкин, А. И., Герман, К. Э. 2007. Новые исследования на Южном Оленьем острове Онеж-ского озера. *Кольский Сборник. Российская Академия Наук Институт Истории Материальной Культуры Посвящается 60-летию Владимира Яковлевича Шумкина*. Санкт-Петербург.

Thomas, E. R., Wolff, E. W., Mulvaney, R., Steffensen, J. P., Johnsen, S. J., Arrowsmith, C., White J. C. W., Vaughn, B. & Popp, T. 2007. The 8.2 ka event from Greenland ice cores. *Quaternary Science Reviews* 26, 70–81.

Torrence, R. 1983: Time budgeting and hunter-gatherer technology. In: G. Bailey (Ed.), *Hunter-Gatherer Economy in Prehistory*. Cambridge University Press, Cambridge, 11–22.

— (Ed.) 1989. *Time, Energy and Stone Tools*. Cambridge University Press, Cambridge.

Tyler, N. J. C. & Blix, A. S. 1999. Survival strategies in arctic ungulates. *Rangifer*, special issue 3, 211–230.

Törnqvist, T. E. & Hijma, P. 2012. Links between early Holocene ice-sheet decay, sea-level rise and abrupt climate change. *Nature Geoscience* 5, 601–606.

Ukkonen, P. 1997. Pohjois-Suomen eläimistön historiaa. In: E. L. Schulz. & C. Carpelan (Eds.), Varhain Pohjoisessa. Maa. Varhain Pohjoisessa hankkeen artikkeleita. *Helsinki Papers in Archaeology* 10, 49–57.

van Andel, T. H., Davies, W., Weninger, B., Jöris, O. 2003. Archaeological dates as proxies for the spatial and temporal human presence in Europe: a discourse on the method. In: T. H. van Andel & W. Davies (Eds.), *Neanderthals and Modern Humans in the European Landscape during the Last Glaciation:*

Archaeological Results of the Stage 3 Project. McDonald Institute for Archaeological Research Monograph Series, 21–29. Cambridge.

van Beest, F. M., Van Moorter, B. & Milner, J. M. 2012. Temperature-mediated habitat use and selection by a heat-sensitive northern ungulate. *Animal Behaviour* 84(3), 723–735.

van der Plicht, J., Akkermans, P. M. M. G., Nieuwenhuyse, O., Kaneda, A. & Russell, A. 2011. Tell Sabi Abyad, Syria: Radiocarbon Chronology, Cultural Change, and the 8.2 ka Event. *Radiocarbon* 53(2), 229–243.

Velle, G., Brodersen, K. P., Birks, H. J. B. & Willassen, E. 2010. Midges as quantitative temperature indicator species: Lessons for palaeoecology. *The Holocene* 20(6), 989–1002.

Veski, S., Heinsalu, A., Klassen, V. Kriiska, A. Lougas, L. Poska, A. & Saluaar, U. 2005. Early Holocene coastal settlements and palaeoenvironment on the shore of the Baltic Sea at Parnu, southwestern Estonia. *Quaternary International* 130, 75–85.

Vieira, L. E. A., Solanki, S. K., Krivova, N. A. & Usoskin, I. 2011. Evolution of the solar irradiance during the Holocene. *Astronomy & Astrophysics* 531, A6.

Voronina, E., Polyak, L., De Vernal, A., & Peyron, O. 2001. Holocene variations of sea-surface conditions in the southeastern Barents Sea, reconstructed from dinoflagellate cyst assemblages. *Journal of Quaternary Science* 16(7), 717–726.

Walker, M. J. C., Berkelhammer, M., Björck, S., Cwynar, L. C., Fisher, D. A., Long, A. J., Lowe, J. J., Newnham, R. M., Rasmussen, S. O. & Weiss, H. 2012. Formal subdivision of the Holocene Series/Epoch: a Discussion Paper by a Working Group of INTIMATE (Integration of ice-core, marine and terrestrial records) and the Subcommission on Quaternary Stratigraphy (International Commission on Stratigraphy). *Journal of Quaternary Science* 27(7), 649–659.

Wanner, H., Solomina, O., Grosjean, M, Ritz, S. P. & Jetel, M. 2011. Structure and origin of Holocene cold events. *Quaternary Science Reviews* 30(21–22), 3109–3123.

Waraas, T. A. 2001. *Veslandet i tidleg Preboreal tid. Fosna, Ahrensburg eller vestnorsk tidlegmesolitikum*? Hovudfagoppgave i arkeologi. Universitetet i Bergen.

Weninger, B., Alram-Stern, E., Bauer, E., Clare, L., Danzeglocke, U., Jöris, O., Kubatzki, C., Rollefson, G., Todorova, H. & van Andel, T. 2006. Climate forcing due to the 8200 cal yr BP event observed at Early Neolithicsites in the eastern Mediterranean. *Quaternary Research* 66, 401–420.

— , Schulting, R., Bradtmöller, M., Clare, L., Collard, M., Edinborough, K., Hilpert, J., Jöris, O., Niekus, M., Rohling, E. J. & Wagner, B. 2008. The catastrophic final flooding of Doggerlandby the Storegga Slide tsunami. *Documenta Praehistorica* XXXV, 1–24.

Whallon, R. 2006. Social networks and information: Non-"utilitarian" mobility among hunter-gatherers. *Journal of Anthropological Archaeology* 25(2), 259–270.

Wiersma, A. P. & Jongma, J. I. 2010. A role for icebergs in the 8.2 ka climate event. *Climate Dynamics* 35(2–3), 535–549.

— & Renssen, H. 2006. Model–data comparison for the 8.2 ka BP event: confirmation of a forcing mechanism by catastrophic drainage of Laurentide Lakes. *Quaternary Science Reviews* 25, 63–88.

Williams, A. N., Ulm, S., Goodwin, I. D. & Smith, A. 2010. Hunter-gatherer response to late Holocene climatic variability in northern and central Australia. *Journal of Quaternary Science* 25(6), 831–838.

— 2012. The use of summed radiocarbon probability distributions in archaeology: a review of methods. *Journal of Archaeological Science* 39, 578–589.

Winterhalder, B. 1981. Foraging strategies in the boreal forest: An analysis of Cree hunting and gathering. In: B. Winterhalder & E. A. Smith (Eds.), Hunter-Gatherer Foraging Strategies: Ethnographic and Archaeological Analyses. Chicago: University of Chicago Press, 66–98.

— 1983. The boreal forest, Cree-Ojibwa foraging, and adaptive management. In: R. W. Wein, R. R. Riewe & I. R. Methven (Eds.), Resources and Dynamics of the Boreal Zone. Ottawa: Association of Canadian Universities for Northern Studies, 331–345.

— & Smith, E. A. 1992. Evolutionary Ecology and the Social Sciences. In: B. Winterhalder & E. A. Smith (Eds.), *Evolutionary Ecology and Human*

Behavior. Aldine de Gruyter, New York, 3–23.
— & Smith, E. A. 2000. Analyzing Adaptive Strategies: Human Behavioral Ecology at Twenty-Five. *Evolutionary Anthropology* 9(2), 51–72.
Wobst, H. M. 1974. Boundary Conditions for Paleolithic Social Systems: A Simulation Approach. American Antiquity 39(2), 147–178.
Woodman, P. C. 1993. The Komsa Culture. A Re-examination of its Position in the Stone Age of Finnmark. *Acta Archaeologica* 63/1992, 57–76.
— 1999. The Early Postglacial Settlement of Arctic Europe. In: E. Cziesla, T. Kersting & S. Pratsch (Eds.), Den Bogen spannen… Festschrift für Bernhard Gramsch zum 65. Geburstag, Teil 1. *Beitrage zur Ur- und Frugeschichte Mitteleuropas* 20, 292–312.
Yu, S.-Y., Colman, S. M., Lowell, T. W., Milne, G. A., Fisher, T. G., Breckenridge, A., Boyd, M. & Teller, J. T. 2010. Freshwater Outburst from Lake Superior as a Trigger for the Cold Event 9300 Years Ago. *Science* 328(5983),1262–1266.

APPENDIX I. RADIOCARBON DATED MESOLTHIC UNGULATE BONE CONTEXTS IN FINNMARKSVIDDA,UTSJOKI,INARI, AND ENONTEKIÖ

Site	Context/area	Species	D/I	Dated sample	Lab. nr.	BP	calBC, 2σ	M cal BC	M cal BP	Reference
Virdnejávri 113	Bone "midden"	*Alces alces*	Indirect	Burnt bone	TUa-7193	8295 ± 35	7481 – 7191	7368	9317	Hood 2012
Lahdenperä 1		*Alces alces*	Direct	Burnt bone	Ua-41080	8024 ± 55	7081 – 6699	6934	8883	Pesonen *et al* . n.d.; Talavaara *et al* . in press
Virdnejávri 101	N-most pit	*Alces alces*	Indirect	Burnt bone	TUa-7192	7880 ± 35	7021 – 6638	6727	8676	Hood 2012
Saamen museo	A4A*	*Alces alces*	Indirect	Charcoal	Hel-3568	7330 ± 120	6430 – 6003	6200	8149	Rankama & Ukkonen 2001; Halinen 2005
Suonttajoki W1	A2, refuse pit	*Alces alces*	Indirect	Charcoal	Hel-3589	6940 ± 120	6029 – 5630	5832	7781	Rankama & Ukkonen 2001
Vuopaja N	A1, Pit*	*Alces alces*	Indirect	Charcoal	Hel-3569	6850 ± 110	5983 – 5564	5754	7703	Rankama & Ukkonen 2001; Halinen 2005
Virdnejávri 24	Burnt bone deposit	*Alces alces*	Indirect	Burnt bone	Beta-58655	5260 ± 250	4682 – 3535	4090	6039	Hood 2012; Simonsen 2001
Sujala	Area 2	*Rangifer tarandus*	Indirect	Burnt bone	Hela-1102	9265 ± 65	8695 – 8302	8492	10441	Rankama & Kankaanpää 2008
Sujala	Area 2	*Rangifer tarandus*	Indirect	Burnt bone	Hela-1442	9240 ± 60	8612 – 8305	8460	10409	Rankama & Kankaanpää 2008
Sujala	Area 2	*Rangifer tarandus*	Indirect	Burnt bone	Hela-1441	9140 ± 60	8541 – 8256	8367	10316	Rankama & Kankaanpää 2008
Sujala	Area 2	*Rangifer tarandus*	Indirect	Burnt bone	Hela-1103	8940 ± 80	8288 – 7826	8091	10040	Rankama & Kankaanpää 2008
Sujala	Area 2	*Rangifer tarandus*	Indirect	Burnt bone	Hela-1104	8930 ± 85	8287 – 7794	8079	10028	Rankama & Kankaanpää 2008
Virdnejávri 113	Bone "midden"	*Rangifer tarandus*	Indirect	Burnt bone	TUa-7193	8295 ± 35	7481 – 7191	7368	9317	Hood 2012
Kaunisniemi 3	Hearth	*Rangifer tarandus*	Direct	Burnt bone	Ua-40896	8004 ± 46	7063 – 6710	6924	8873	Paper IV
Virdnejávri 101	N-most pit	*Rangifer tarandus*	Indirect	Burnt bone	TUa-7192	7880 ± 35	7021 – 6638	6727	8676	Hood 2012
Museotontti	A11A, refuse pit	*Rangifer tarandus*	Indirect	Charcoal	Hel-2564	7750 ± 120	7029 – 6414	6610	8559	Halinen 2005
Museotontti	A11A, refuse pit*	*Rangifer tarandus*	Direct	Burnt bone	Ua-40895	7668 ± 40	6594 – 6449	6508	8457	Paper IV
Museotontti	A15, hearth*	*Rangifer tarandus*	Indirect	Charcoal	Hel-2728	7640 ± 120	6770 – 6232	6501	8450	Halinen 2005
Museotontti	A12, refuse pit*	*Rangifer tarandus*	Indirect	Charcoal	Hel-2565	7640 ± 110	6697 – 6238	6500	8449	Halinen 2005
Saamen museo	A31*	*Rangifer tarandus*	Indirect	Charcoal	Hel-3580	7600 ± 90	6634 – 6254	6458	8407	Halinen 2005
Vuopaja N	A2*	*Rangifer tarandus*	Indirect	Charcoal	Hel-3570	7530 ± 150	6677 – 6064	6385	8334	Halinen 2005
Suonttajoki W2	A1, refuse pit*	*Rangifer tarandus*	Indirect	Charcoal	Hel-3209	7300 ± 110	6401 – 5990	6172	8121	Halinen 2005
Museotontti	A3, Hearth*	*Rangifer tarandus*	Indirect	Charcoal	Hel-2559	7210 ± 120	6368 – 5847	6092	8041	Halinen 2005
Buolžajávri Nord-3	Hearth	*Rangifer tarandus*	Direct	Burnt bone	TRa-3322	7180 ± 55	6212 – 5927	6048	7997	Hood 2012
Aittalahti	A5A, refuse pit*	*Rangifer tarandus*	Indirect	Charcoal	Hel-3212	7060 ± 130	6215 – 5716	5933	7882	Halinen 2005
Suonttajoki W1	A2, refuse pit*	*Rangifer tarandus*	Indirect	Charcoal	Hel-3589	6940 ± 120	6029 – 5630	5832	7781	Rankama & Ukkonen 2001
Saamen museo	A10, pit 1*	*Rangifer tarandus*	Indirect	Charcoal	Hel-3123	6920 ± 130	6051 – 5617	5817	7766	Halinen 2005
Saamen museo	A10, pit 3*	*Rangifer tarandus*	Indirect	Charcoal	Hel-3124	6870 ± 150	6030 – 5518	5778	7727	Halinen 2005
Vuopaja N	A1, Pit*	*Rangifer tarandus*	Indirect	Charcoal	Hel-3569	6850 ± 110	5983 – 5564	5754	7703	Rankama & Ukkonen 2001; Halinen 2005
Saamen museo	A4B*	*Rangifer tarandus*	Indirect	Charcoal	Hel-3315	6760 ± 150	5987 – 5469	5680	7629	Halinen 2005
Aksujavri	L4, Bone concentr.	*Rangifer tarandus*	Indirect	Burnt bone	Tua-7194	6650 ± 30	5631 – 5526	5582	7531	Hood 2012
Majava	Hearth	*Rangifer tarandus*	Indirect	Charcoal	Hel-3593	6570 ± 120	5712 – 5318	5521	7470	Halinen 2005
Mávdnaávži 2	Hearth/pit	*Rangifer tarandus*	Indirect	Charcoal	Ua-40900	6580 ± 38	5553 – 5486	5519	7468	Paper IV
Vuopaja	A1, bone pit*	*Rangifer tarandus*	Direct	Burnt bone	Ua-40897	6526 ± 39	5607 – 5380	5495	7444	Paper IV
Mávdnaávži 2	Hearth/pit	*Rangifer tarandus*	Indirect	Burnt bone	Hela-963	6455 ± 45	5484 – 5327	5418	7367	Paper IV
Myllyjärämä	Hearth	*Rangifer tarandus*	Indirect	Charcoal	Hel-2711	6380 ± 110	5554 – 5064	5355	7304	Rankama & Ukkonen 2001
Jeagelnjarga	Probable hearth	*Rangifer tarandus*	Indirect	Burnt bone	TRa-423	6345 ± 35	5465 – 5222	5329	7278	Hood 2012
Sahaniemi	Hearth	*Rangifer tarandus*	Indirect	Charcoal	Hel-3211	6200 ± 110	5462 – 4848	5144	7093	Halinen 2005
Saamen museo	A16*	*Rangifer tarandus*	Indirect	Charcoal	Hel-3318	6080 ± 110	5297 – 4729	5006	6955	Halinen 2005

D/I = direct date on bone/indirect date from the same context as the bone; M = radiocarbon date median value. In the case of contexts with several radiocarbon dates, the encircled date has been used in Figure 13. Contexts marked with * after Halinen (2005).

APPENDIX II. LIST OF RADIOCARBON DATES USED IN THE STUDY

	C/I	Lab. Nr.	BP	cal BP, 2σ	M cal BP	M cal BC	Reference
Sites with formal blades							
Slettnes VII (B)	C	CAMS-6752	9610 ± 80	11193 – 10724	10949	9000	Hesjedal *et al*. 1996
Sujala (bone)	I	Hela-1103	8940 ± 80	10237 – 9775	10040	8091	Rankama & Kankaanpä
Slettnes IVA F45	C	Beta-49008	8880 ± 100	10229 – 9635	9970	8021	Hesjedal *et al*. 1996
Starehnjunni	C	unpub.	*ca*. 8700 ± ?	9700 – 9550	*ca*. 9650	*ca*. 7680	Niemi in Hood 2012
Slettnes IVA F45	C	Beta-49007	8550 ± 100	9886 – 9304	9539	7590	Hesjedal *et al*. 1996
Mortensnes F2R10	C	T-6415	8500 ± 120	9883 – 9135	9492	7543	Schanche 1988
Stuorrasiida	C	Tua-3467	8365 ± 50	9490 – 9260	9388	7439	Grydeland 2005
Karlebotn	C	T-5428	7710 ± 480	9742 – 7612	8642	6693	Engelstad 1989
Vuopaja N	I	Hel-3570	7530 ± 150	8626 – 8013	8334	6385	Arponen & Hintikainen
House-pits							
Slettnes F45	C	Beta-49008	8880 ± 100	10229 – 9635	9970	8021	Hesjedal *et al*. 1996
Starehnjunni	C	unpub.	*ca*. 8700 ± ?	9700 – 9550	*ca*. 9650	*ca*. 7680	Niemi in Hood 2012
Slettnes F45	C	Beta-49007	8550 ± 100	9886 – 9304	9539	7590	Hesjedal *et al*. 1996
Stuorrasiida	C	Tua-3467	8365 ± 50	9490 – 9260	9388	7439	Grydeland 2005
Karlebotn	C	T-5428	7710 ± 480	9742 – 7612	8642	6693	Engelstad 1989
Sundfjæra Midtre, tuft 6	C	Combined[A]		7465 – 7333	7427	5478	
Sundfjæra Midtre, tuft 6	C	Wk-12029	6635 ± 57	7591 – 7430	7519	5570	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 6	C	Wk-12034	6591 ± 38	7565 – 7430	7487	5538	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 6	C	Wk-12031	6539 ± 40	7562 – 7334	7454	5505	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 6	C	Wk-12030	6523 ± 49	7559 – 7322	7441	5492	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 6	C	Wk-12035	6445 ± 45	7430 – 7275	7363	5414	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 6	C	Wk-12033	6355 ± 37	7417 – 7175	7290	5341	Hesjedal *et al*. 2009
Slettnes VA, Hus A	C	Combined		6943 – 6695	6882	4873	
Slettnes VA, Hus A	C	Beta-52373	6000 ± 70	6990 – 6677	6842	4893	Hesjedal *et al*. 2009
Slettnes VA, Hus A	C	Beta-52374	6000 ± 60	7144 – 6667	6844	4895	Hesjedal *et al*. 2009
Slettnes VA, Hus A	C	Beta-49059	5730 ± 170	6956 – 6190	6547	4598	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 6	C	Wk-12027	6016 ± 56	7005 – 6695	6859	4910	Hesjedal *et al*. 2009
Slettnes VB, F54	C	Beta-58664	6130 ± 120	7291 – 6726	7016	5067	Hesjedal *et al*. 2009
Slettnes VB, F54	C	Beta-58662	5810 ± 110	6893 – 6351	6616	4667	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 6	C	Wk-12026	5800 ± 74	6779 – 6414	6600	4651	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 6	C	Wk-12025	5628 ± 43	6491 – 6311	6406	4457	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 5	C	Combined[A]		6628 – 6411	6497	3798	
Sundfjæra Midtre, tuft 5	C	Wk-12037	5187 ± 69	6180 – 5750	5953	4004	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 5	C	Wk-12028	4998 ± 49	5893 – 5613	5733	3784	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 5	C	Wk-12044	4905 ± 58	5855 – 5484	5642	3693	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 10	C	Combined[A]		6628 – 6411	6497	4548	
Sundfjæra Midtre, tuft 10	C	Wk-12004	5896 ± 40	6831 – 6637	6716	4767	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 10	C	Wk-12003	5509 ± 41	6401 – 6215	6307	4358	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 8	C	Wk-12018	5684 ± 40	6629 – 6352	6466	4517	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 3	C	Combined		6440 – 6305	6364	4415	
Sundfjæra Midtre, tuft 3	C	Wk-12014	5646 ± 48	6535 – 6309	6427	4478	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 3	C	Wk-12011	5551 ± 45	6436 – 6281	6347	4398	Hesjedal *et al*. 2009
Slettnes IVB, F36	C	Combined[A]		5749 – 5332	5912	3963	
Slettnes IVB, F36	C	Beta-49013	5330 ± 130	6399 – 5762	6109	4160	Hesjedal *et al*. 2009
Slettnes IVB, F36	C	Beta-49014	5210 ± 60	6182 – 5769	5977	4028	Hesjedal *et al*. 2009
Slettnes IVB, F36	C	Beta-49009	4870 ± 100	5891 – 5326	5613	3664	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 2	C	Combined		6000 – 5910	5958	4009	
Sundfjæra Midtre, tuft 2	C	Wk-12001	5273 ± 67	6262 – 5915	6064	4115	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 2	C	Wk-11997	5279 ± 66	6263 – 5919	6069	4120	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 2	C	Wk-12000	5184 ± 83	6183 – 5745	5951	4002	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 2	C	Wk-11999	5168 ± 37	5996 – 5762	5928	3979	Hesjedal *et al*. 2009
Slettnes IVB,F41	C	Beta-49028	5140 ± 50	5991 – 5749	5893	3944	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 8	C	Wk-12016	5080 ± 50	5925 – 5665	5817	3868	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 6	C	Wk-12032	5064 ± 45	5915 – 5664	5815	3866	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 3	C	Wk-12008	5047 ± 43	5907 – 5663	5811	3862	Hesjedal *et al*. 2009
Slettnes VB, F67	C	Beta-49042	5000 ± 140	6175 – 5333	5754	3805	Hesjedal *et al*. 2009
Sundfjæra NV, tuft 13	C	Combined[A]		5892 – 5656	5747	3778	
Sundfjæra NV, tuft 13	C	Wk-11969	5207 ± 94	6261 – 5745	5983	4034	Hesjedal *et al*. 2009
Sundfjæra NV, tuft 13	C	Wk-11967	5012 ± 65	5905 – 5612	5757	3808	Hesjedal *et al*. 2009
Sundfjæra NV, tuft 13	C	Wk-11968	4759 ± 88	5650 – 5312	5488	3539	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 3	C	Wk-12009	5000 ± 64	5897 – 5610	5741	3792	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 4	C	Wk-12020	4964 ± 88	5911 – 5492	5713	3764	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 1	C	Wk-10738	4947 ± 86	5908 – 5485	5696	3747	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 9	C	Wk-11995	4919 ± 54	5858 – 5491	5692	3703	Hesjedal *et al*. 2009
Slettnes IVB,F39	C	Beta-49024	4940 ± 90	5906 – 5482	5691	3742	Hesjedal *et al*. 2009
Sundfjæra Midtre, tuft 8	C	Wk-12017	4910 ± 58	5861 – 5485	5646	3697	Hesjedal *et al*. 2009
Slettnes IVB,F37	C	Combined		5655 – 5332	5529	3580	
Slettnes IVB,F37	C	Beta-49017	4970 ± 110	5938 – 5473	5722	3773	Hesjedal *et al*. 2009
Slettnes IVB,F37	C	ETH-8897	4770 ± 60	5602 – 5325	5505	3556	Hesjedal *et al*. 2009
Advik, house f	C	T-197	4800 ± 150	5907 – 5062	5521	3572	Helskog 1980a
Slettnes IVB,F40	C	ETH-8898	4730 ± 60	5588 – 5321	5469	3520	Hesjedal *et al*. 2009
Slettnes IVB,F38	C	Beta-49021	4680 ± 90	5600 – 5062	5412	3463	Hesjedal *et al*. 2009

Säräisniemi 1 pottery							
Inganeset (Kjerringneset IV)	I	Tua-3025	5990 ± 55	6955 – 6676	6830	4881	Skandfer 2003
Lossoas hus	C	Tua-3024	6065 ± 55	7156 – 6757	6924	4975	Skandfer 2003
Mennikka (Skogfoss)	I	Tua-3022	5795 ± 55	6734 – 6469	6594	4645	Skandfer 2003
Mennikka (Skogfoss)	I	Tua-3027	5975 ± 60	6952 – 6669	6815	4866	Skandfer 2003
Noatun Innmarken	I	Tua-3023	6185 ± 65	7256 – 6932	7083	5134	Skandfer 2003
Noatun Innmarken	I	Tua-3029	5850 ± 55	6786 – 6503	6665	4716	Skandfer 2003
Noatun Neset	I	Beta-131296	5950 ± 90	7145 – 6547	6788	4839	Skandfer 2003
Noatun Neset Vest	I	Tua-3026	6030 ± 70	7156 – 6678	6880	4931	Skandfer 2003
Nordli	C	Tua-3028	6570 ± 60	7578 – 7333	7477	5528	Skandfer 2003
Nordli	C	Tua-3021	6330 ± 50	7415 – 7164	7262	5313	Skandfer 2003
Rönkönraivio	I	Hela-38	5830 ± 85	6854 – 6437	6637	4752	Carpelan 2004
MRP, north of 68°N							
Slettnes VII, Sjakt B		CAMS 6752	9610 ± 80	11193 – 10724	10949	9000	Hesjedal *et al* . 1996
Kaunisniemi 3		Ua-40896	8004 ± 46	9012 – 8659	8873	6924	Paper IV
Tönsnes 104380, Tuft 1		Combined		8973 – 8646	8756	6807	
Tönsnes 104380, Tuft 1		Wk-24651	7896 ± 30	8970 – 8596	8692	6743	Nilsen & Skandfer 2010
Tönsnes 104380, Tuft 1		Wk-24650	7913 ± 30	8975 – 8604	8721	6772	Nilsen & Skandfer 2010
Tönsnes 104380, Tuft 1		Wk-24636	7933 ± 30	8978 – 8637	8766	6817	Nilsen & Skandfer 2010
Tönsnes 104380, Tuft 1		Wk-24638	7898 ± 30	8971 – 8596	8695	6746	Nilsen & Skandfer 2010
Tönsnes 104380, Tuft 1		Wk-24637	7929 ± 30	8978 – 8635	8756	6807	Nilsen & Skandfer 2010
Tönsnes 104380, Tuft 1		Wk-24641	7962 ± 30	8990 – 8655	8849	6900	Nilsen & Skandfer 2010
Tönsnes 104380, Tuft 1		Wk-24642	7963 ± 30	8991 – 8656	8850	6901	Nilsen & Skandfer 2010
Tönsnes 104380, Tuft 1		Wk-24639	8001 ± 30	9006 – 8765	8880	6931	Nilsen & Skandfer 2010
Museotontti		Hel-2564	7750 ± 120	8587 – 8476	8559	6610	Halinen 2005
Tönsnes 104342		Combined[A]		8696 – 8593	8623	6674	Henriksen 2010
Tönsnes 104342		wk-24630	7928 ± 30	8978 – 8633	8754	6805	Henriksen 2010
Tönsnes 104342		wk-24631	7801 ± 30	8639 – 8483	8577	6628	Henriksen 2010
Tönsnes 104342		wk-24582	7796 ± 30	8637 – 8480	8573	6624	Henriksen 2010
Tönsnes 104342		wk-24583	7915 ± 30	8975 – 8605	8725	6776	Henriksen 2010
Tönsnes 104342		wk-24586	7868 ± 30	8772 – 8587	8643	6694	Henriksen 2010
Museotontti		Ua-40895	7668 ± 40	8475 – 8412	8458	6508	Paper IV
Jomppalanjärvi W		Ua-40899	7265 ± 40	8173 – 8003	8091	6142	Paper IV
Almenningen 1		Tua-3538	7260 ± 95	8316 – 7933	8087	6138	Blankholm 2008
Tönsnes 104380, Tuft 1		Wk-24635	7017 ± 30	7935 – 7790	7863	5914	Nilsen & Skandfer 2010
Aksujavri		Tua-7194	6650 ± 30	7571 – 7507	7531	5582	Hood 2012
Devdis I		T-1343	6575 ± 150	7708 – 7170	7471	5552	Helskog 1980b
Mavdnaavzi 2		Ua-40900	6580 ± 38	7502 – 7435	7478	5528	Paper IV
Vuopaja		Ua-40897	6526 ± 39	7556 – 7329	7444	5495	Paper IV
Mavdnaavzi 2		Hela-963	6455 ± 45	7425 – 7327	7367	5418	Paper IV
Slettnes VA:1		Combined[A]		7313 – 7018	7205	5068	
Slettnes VA:1		Beta-49052	6390 ± 80	7458 – 7163	7321	5372	Hesjedal *et al* . 1996
Slettnes VA:1		Beta-49057	6390 ± 100	7500 – 7027	7316	5367	Hesjedal *et al* . 1996
Slettnes VA:1		Beta-49056	6170 ± 170	7422 – 6676	7054	5105	Hesjedal *et al* . 1996
Slettnes VA:1		Beta-49053	5930 ± 110	7154 – 6480	6766	4817	Hesjedal *et al* . 1996
Mortensnes F8R12		T-6416	5770 ± 190	7156 – 6202	6594	4645	Schanche 1988
Slettnes VA:1		Beta-49054	5470 ± 120	6496 – 5945	6255	4306	Hesjedal *et al* . 1996
Tönsnes 104380, Tuft 1		Combined		6181 – 5995	6082	4133	
Tönsnes 104380, Tuft 1		Wk-24634	5306 ± 30	6185 – 5993	6084	4135	Nilsen & Skandfer 2010
Tönsnes 104380, Tuft 1		Wk-24643	5295 ± 30	6184 – 5954	6081	4132	Nilsen & Skandfer 2010
MRP, south of 66°N							
Lahdenkangas 1		Ua-40898	7284 ± 42	8177 – 8013	8098	6149	Paper IV
Rasi		Ua-40894	6981 ± 92	7976 – 7628	7813	5864	Paper IV
Kapatuosia		unpublished	6975 ± 75	7946 – 7675	7808	5859	MJRek
Arolammi 7D		GIN-11042	6630 ± 70	7617 – 7423	7516	5567	Matiskainen 2002
Muurahaisniemi		Hela-1947	6460 ± 45	7435 – 7275	7370	5421	Pers. comm. P. Pesonen
Rastklippan		Combined[B]		7427 – 7278	7361	5412	
Rastklippan		Ua-3656	6540 ± 75	7575 – 7312	7453	5504	Paper I
Rastklippan		Ua-3654	6410 ± 75	7432 – 7030	7339	5390	Paper I
Rastklippan		Ua-3655	6355 ± 75	7432 – 7030	7290	5341	Paper I
Hommas		Combined		7235 – 7020	7132	5268	
Hommas**		Hela-2054	6359 ± 39	7245 – 6990	7110	5161	Koivisto 2010
Hommas**		Hela-2051	6382 ± 41	7255 – 7005	7149	5200	Koivisto 2010
Hommas		Combined		7329 – 7102	7217	5183	
Hommas*		Hela-2052	6647 ± 41	7413 – 7109	7258	5309	Koivisto 2010
Hommas*		Hela-2053	6563 ± 41	7322 – 6975	7170	5221	Koivisto 2010
Arolammi 7D		GIN-11037	6050 ± 40	7137 6786	6902	4780	Matiskainen 2002

C/I = coast/inland, MRP = margin-retouched points, dates combined using the OxCal R_Combine function, A = X-Test fails at 5%. *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). The circled dates are used in Figure 29.

APPENDIX III. SUMMARY OF PAPERS I–V

I Manninen, M. A. & Knutsson, K. 2011. Northern Inland Oblique Point Sites—a New Look into the Late Mesolithic Oblique Point Tradition in Eastern Fennoscandia. In: T. Rankama (Ed.), *Mesolithic Interfaces—Variability in Lithic Technologies in Eastern Fennoscandia*. Monographs of the Archaeological Society of Finland 1, 143–175.

The paper presents the first comprehensive survey of inland sites with margin-retouched points in northern Fennoscandia and their geographical and chronological distributions. A total of 31 sites from the counties of Norrbotten and Vasterbotten in Sweden, the counties of Finnmark and Troms in Norway, and the county of Lapland in Finland are described, and their relation to sites with margin-retouched points on the Barents Sea coast and more southerly Finland are discussed.

After a presentation and analysis of the available data, it is concluded that most reliable contexts with margin-retouched points at the northern inland sites are all dated to a short period *ca*. 7750–7050 cal BP (*ca*. 5800–5100 cal BC), while a clear majority of points appears to date to *ca*. 8450–6650 cal BP (*ca*. 6500−4700 cal BC), thus confirming the notion that margin-retouched points in the inland areas of northern Fennoscandia are a predominantly Late Mesolithic phenomenon.

Analyses of the arrowheads from the studied sites suggest that flake blanks from platform cores were used in point manufacture. This makes the mode of blank production a common denominator between these points, Phase III points in Barents Sea coastal sites (Hesjedal *et al.* 1996:186; Olsen 1994:34), and oblique points in more southerly Finland (Matiskainen 1986; Pesonen & Tallavaara 2006; Paper IV), while it differentiates these points from the Phase I margin-retouched points of northernmost Norway which were usually produced from blades (Hesjedal *et al.* 1996:166; Woodman 1999:301–302). The shapes of both the early and late margin-retouched points were also found to vary considerably. The results nevertheless indicate that oblique and transverse-edged points are more common than single-edged or double-edged tanged points among the Late Mesolithic coastal and inland points, while the contrary is true for the coastal Phase I points.

We also conclude that the flake blanks used in the production of Late Mesolithic margin-retouched points were not of a standardised shape and that the manufacture of points was not dependent on specific raw materials, although chert and fine-grained quartzite were preferred when available. The studied assemblages include points made of quartz, quartz crystal, slate, rhyolite and different types of chert and quartzite. It is also noted that this type of technology enables organisational strategies not tied to specific lithic raw material sources and facilitates movement in regions where access to raw materials differs from area to area.

The dating of the inland sites with margin-retouched points is also compared with the results of recent paleoecological studies conducted in the area. The comparison indicates that the sites were located in a boreal climax forest environment. This knowledge, together with an evaluation of available radiocarbon dates from surrounding areas, contradicts the earlier explanation (Olsen 1994:39–41) that the spread of oblique point technology in the inland areas of northern Norway was linked to a colonisation of previously inhabited areas and related to the spread of the boreal forest.

It is also suggested in the paper that the discussed arrowheads belong to a technological tradition that expanded rapidly over the whole of eastern and northern Fennoscandia during the Late Mesolithic through an interconnected network of hunter–gatherer groups. In addition to similar points and technology being used at the sites, the radiocarbon date spans for Late Mesolithic margin-retouched points at the northern inland sites (*ca*. 8450–6650 cal BP or 6500–4700 cal BC), on the Finnmark coast (*ca*. 7450–6250 cal BP or 5500–4300 cal BC) and in southern Finland (*ca*. 7450–6850 cal BP or 5500–4900 cal BC) are roughly the same.

A comparison between the distribution of Late Mesolithic margin-retouched points and the contemporaneous but more westerly distribution of handle cores (Olofsson 1995; 2003) is also made in the paper. The distributions of these two artefact types were found to be spatially exclusive. Based on this result, it is suggested that handle cores and the Late Mesolithic margin-retouched points are artefact types that represent contemporaneous but spatially exclusive social networks. It is further suggested that because the contact zone between these networks is in the area where the last remnants of the Scandinavian ice sheet melted at the end of the last glacial cycle, the border could reflect a historical border derived from the time when the first colonisers arriving from the south and those arriving from the east met in northern Sweden in the early Holocene.

The paper also provides a graph showing the shore displacement dates of margin-retouched point sites in relation to all sites on the southern shore of Varangerfjord (eastern Finnmark). Based on the graph, it is suggested that erosion and a packing of sites to certain altitudes caused by the mid-Holocene Tapes transgression were most likely the major factors contributing to what appears to be an absence of margin-retouched points in the archaeological record during Phase II and the beginning of Phase III, because during the Mesolithic as a whole, the number of coastal sites with margin-retouched points seems to correlate with the overall number of sites in the studied part of the coast and because there is a relatively high number of sites above the altitude corresponding to the transgressive phase.

II Manninen, M. A. 2009. Evidence of mobility between the coast and the inland region in the Mesolithic of Northern Fennoscandia. In: S. B. McCartan, R. Schulting, G. Warren & P. Woodman (Eds.), *Mesolithic Horizons*, Vol. I. Oxbow books, Oxford, 102–108.

In this paper, I present a mobility model based on evidence from the Mávdnaávži 2 site in northernmost Finnish Lapland and a group of oblique points made of coastal cherts from the Lake Inari region, some 150 km from the Barents Sea coast. I use Minimum Analytical Nodule analysis to study future activity planning and the relative length of occupation at Mávdnaávži 2. Raw material composition and use indicate that the site was a single-occupation hunting camp used by a group that had utilised the Barents Sea coastal area at some point in their seasonal round. Using these results and an interpretation of earlier finds from the Lake Inari area, I propose a model of coast–inland mobility and that the coastal raw materials in the Lake Inari region were brought to the area as parts of mobile tool kits.

The mobility model predicts what types of Late Mesolithic assemblages should be found in and between the Barents Sea coast and the Lake Inari area, that is, a decreasing proportion of coastal raw materials and an increasing use of quartz with increasing distance from the coastal sources of raw materials and an almost exclusive use of quartz while moving gradually back towards the coastal area.

The paper includes a comparison between the size distribution of quartz artefacts at the Mávdnaávži 2 site and a nearby quartz knapping floor (Leakšagoađejohka 3, Manninen 2003). The result of the comparison suggests that flakes were brought to the Mávdnaávži 2 site for use as scraper blanks.

III Tallavaara, M., Manninen, M. A., Hertell, E. & Rankama, T. 2010. How flakes shatter: a critical evaluation of quartz fracture analysis. *Journal of Archaeological Science* 37, 2442–2448.

The paper presents an experimental study of quartz flake fragmentation in which the inherent tendency of quartz flakes to shatter during detachment is scrutinised by studying statistically the effects of individual knapping style, indenter hardness, and relative thickness of flakes (thickness/length) as possible sources of variation in quartz flake fragmentation patterns. The study builds on and evaluates earlier results by Callahan *et al.* (1992), who found that quartz flake fragmentation is not random but rather clearly patterned and follows the rules of material science. In addition, the paper discusses the possible effects of flake fragmentation on the technological organisation of prehistoric quartz users.

The study demonstrates that quartz reduction does not always produce similar fragment distributions, even if the flaking method is controlled, and shows that differing fragment and fracture types are typical for detachments produced with hard and soft indenters. The results also suggest that the relative thickness of a flake has an effect on fragmentation. Increasing relative thickness increases the probability of a flake staying intact and decreases the probability of radial and particularly bending fractures.

Together with the results obtained by Callahan *et al.* (1992), our results suggest that quartz users most likely reduced fragmentation by producing thicker flakes or by using bipolar flaking. This conclusion is supported by studies in which artefacts made of quartz have been compared with artefacts made of more resilient raw materials. We further suggest that the production of thicker flakes has enhanced the durability of tools made of the fragile raw material because thicker tools are more resistant to breakage.

We conclude that if predictability in the technological process were desired, quartz must have been a problematic raw material for prehistoric knappers in many respects. For example, a quartz core contains more waste than, e.g., a chert core of equal size, due to its fragmentation tendency, the probable attempts to reduce it by producing thicker flakes, and the poor durability of quartz tools. A quartz core thus contains less usable tool edge than a comparable amount of a better raw material. This means that quartz would not be a desirable raw material especially when transportation costs are of importance.

IV

Manninen, M. A. & Tallavaara, M. 2011. Descent History of Mesolithic Oblique Points in Eastern Fennoscandia – a Technological Comparison Between Two Artefact Populations. In: T. Rankama (Ed.), *Mesolithic Interfaces – Variability in Lithic Technologies in Eastern Fennoscandia*. Monographs of the Archaeological Society of Finland 1, 177–211.

This paper discusses scenarios explaining how the margin-retouched point concept spread in Fennoscandia during the Late Mesolithic and the descent history of the arrowhead concept in Finland. We analyse a sample of 158 points from two geographically separate areas to determine whether they represent the same technological tradition with a common descent history or separate developments with a possible common distant ancestry.

The paper draws on radiocarbon dates and on a technological analysis designed to gather information on point shape and the manufacturing process. Measurable characteristics of point shape and the manufacturing process are compared statistically by geographic source area (i.e., northern Finnish Lapland or more southerly Finland) and by raw material.

The starting point in the paper is the conception, derived from cultural transmission theory, that because in Finland the margin-retouched point concept spread to areas in which directly preceding lithic arrowhead types were 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. However, because we presume that human behaviour is always a result of both cultural and environmental factors, we also study how much of the observed variation can be explained by environmental constraints, namely differing degrees of raw material availability and differing raw material properties.

The results of the technological analysis indicate that all of the points in both groups were made using flake blanks produced with platform reduction. Quartz was found to have been used to produce the majority of the points in the southern group, whereas chert was the most common raw material in the north. The variables initially considered as possibly reflecting differences in overall arrow technology (point weight, basal thickness, and basal width) exhibited only small differences between the point populations. 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.

The effect of raw material is studied in the paper 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. The results show that the thickness of quartz points increases with their length, which makes the quartz points thicker as a group, and that quartz points are oriented perpendicularly in relation to the blank regardless of the area of origin, whereas chert points are oriented parallel to the longitudinal axis of the flake as often as they are oriented perpendicularly to the axis.

The possible effects of different transmission mechanisms *versus* the effects of raw materials on the within-group variation are evaluated by studying correlation amongst variables in the different groups. The results of this analysis show that more significant correlation exists amongst the variables in the quartz points than amongst those in the southern group of points. It is therefore concluded that differences in raw material composition and properties explain most of the intergroup differences observed in the point data. The properties of quartz (fragility and proneness to fragmentation) reduced the degree of variation in the southern group and forced a more standardised and robust point shape in comparison with chert. Therefore, the differences in the degree of variation between points from the two geographical areas cannot be attributed directly to differing transmission mechanisms. The results suggest that the same technology was used to produce points in southern and northern Finland.

Based on the conclusion that all the studied points represent the same technological tradition, we study the spread of the margin-retouched point concept using radiocarbon dates. The results show that radiocarbon dates from oblique point contexts are consistent with the shore displacement dates of the point type in Finland and indicate that the point concept was present in northern Finland possibly as early as *ca*. 8850 cal BP (*ca*. 6900 cal BC), while the earliest contexts in southern Finland, according to shore displacement chronology and radiocarbon dating, are not earlier than *ca*. 8050 cal BP (*ca*. 6100 cal BC). We therefore suggest that in Finland, the concept spread from the north towards the south and that it most likely originated in a millennia-long tradition of producing margin-retouched points known from the Mesolithic of the Norwegian Barents Sea coast.

Lastly, we discuss the possibility that the spread of the point concept in Finland during the Late Mesolithic was related to climatic changes, that is, to the 8.2 ka event and the Holocene Thermal Maximum. We suggest that the environmental crisis caused by the 8.2 ka event in northernmost Fennoscandia led to social and economic reorganisation and to increased inter-group contact and cultural transmission between historically distinct populations descending from colonisation waves that originally spread to the area from west and southeast of the Scandinavian Ice Sheet. After the point concept was adopted by the "southern" population, the gradually warming climate after the event and the associated population growth, especially in the more southern parts of Finland, could then have caused the technology to be rapidly transmitted southwards.

V Manninen, M. A. & Knutsson, K. 2014. Lithic raw material diversification as an adaptive strategy—Technology, mobility, and site structure in Late Mesolithic northernmost Europe. *Journal of Anthropological Archaeology* 33, 84–98.

In this paper, we study the relationship between the organisation of stone tool production technology and settlement configuration, using assemblages from five practically contemporaneous (*ca*. 7650–7050 cal BP or 5700–5100 cal BC) inland sites with margin-retouched points. In addition to studying the site structure and technological organisation at these sites, we test the premise that high residential mobility and a low availability of tool stone with good working qualities leads to economising, especially intensification and formalisation. We first examine the degree of residential mobility from site structure, using behavioural inferences drawn from ethnographic and ethnoarchaeological research, and we then employ Minimum Analytical Nodule analysis to gain an understanding of raw material composition, use, and movement and their relation to raw material abundance and properties.

The results indicate that the sites represent short occupation spans and groups with high residential mobility. We find evidence for this from site structure as well as from the organisation of lithic technology. The results also show that the proportion of quartz in the site assemblages increases linearly with increasing distance to the closest known source of fine-grained raw material. In addition, there is an inverse correlation between arrowhead length and the distance to the closest known raw material source, suggesting intensification of raw material use with increasing distance to the source. The technology used to produce the lithic assemblages is nevertheless informal in most aspects, which means that in this case, there is no clear correlation between a low availability of raw material of good workability and a primarily formal lithic inventory. We also lack evidence of intensified use of tools and bipolar-on-anvil exhaustion of cores made of low-abundance raw materials, i.e., patterns that could indicate a maximisation of non-local raw material.

However, we find evidence that even if the localised raw materials of better workability were preferred when available, at sites located far from sources of such raw materials, the undesired properties of quartz were compensated for by favourable technological choices (producing relatively thicker platform flakes from quartz, using bipolar reduction on quartz, and using flake blanks in a way that reduced the risk of failure).

We conclude that restricted availability of high-quality raw material, due for instance to increased mobility or changes in the size or location of the foraging range, does not necessarily lead to formalisation and intensification but can in certain situations, as in the studied case, lead to the application of an adaptive strategy that can be called raw material diversification. This strategy can be regarded as a type of asset allocation in which investments are distributed to reduce risk in the event of a decline in a particular part of the investment portfolio. We suggest that the strategy entails a widening of the actively used raw material repertoire to include raw materials of relatively lower workability and a consequent alteration, often in the form of simplification and informalisation, of existing technological concepts. Consequently, we suggest that the flake-based technology used at the studied sites is a solution that continues to culturally reproduce the millennia-long margin-retouched point tradition while balancing organisational dimensions that increase the utility of quartz and those that maximise the utility of the intermittently available raw materials of better flakeability and controllability.

PAPERS I-V

Manninen, M. A. & Knutsson, K. 2011. Northern Inland Oblique Point Sites – a New Look into the Late Mesolithic Oblique Point Tradition in Eastern Fennoscandia. In: T. Rankama (Ed.), *Mesolithic Interfaces – Variability in Lithic Technologies in Eastern Fennoscandia*. Monographs of the Archaeological Society of Finland 1, 143–175.

PAPER I

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

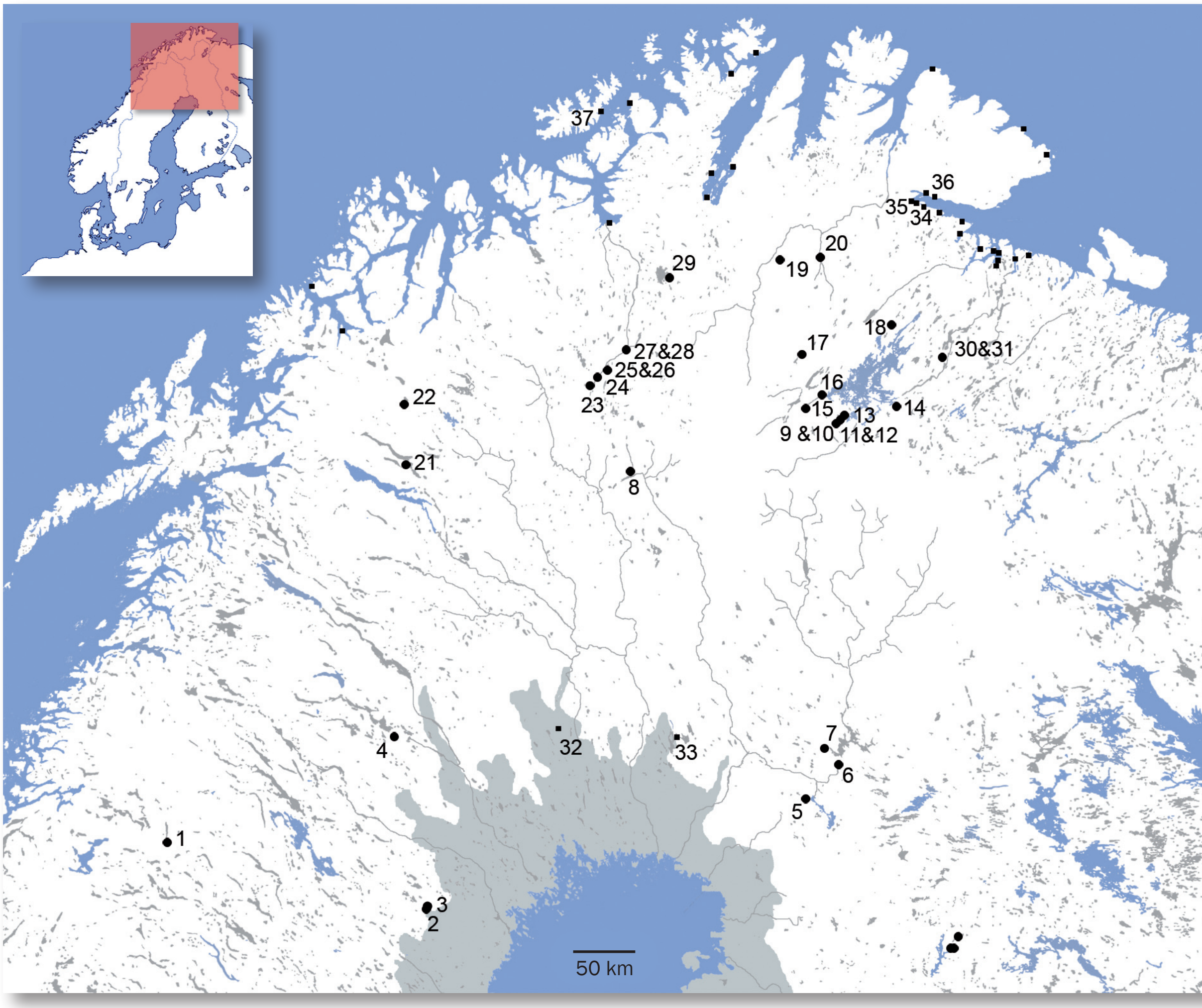


Figure 1. The study area and the oblique point sites in northern Fennoscandia. The extent of the Baltic Sea at *c.* 6400 calBC is marked with light grey (following Andersson 2000). Larger dots: inland oblique point sites. Smaller dots: coastal oblique point sites. Sites discussed in the paper: 1. Rastklippan; 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.

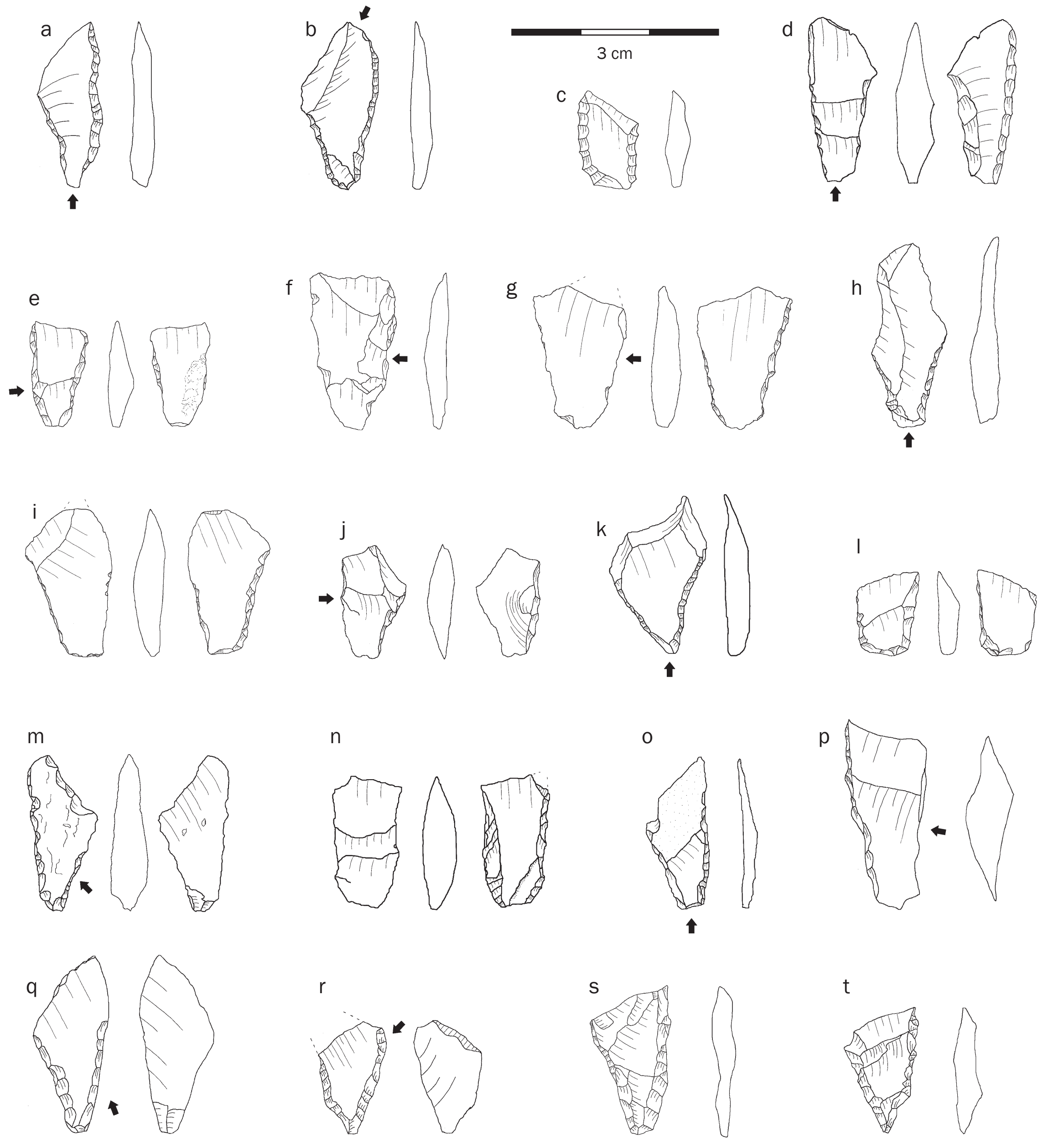


Figure 2. Examples of oblique points from the inland sites. When discernible the orientation of the original blank is marked with an arrow. a) Rastklippan 1969, quartzite; b) Rastklippan 1969, chert; c) Lappviken, porphyry; d) Tallholmen, quartzite; e) Lautasalmi (KM 15846:78), chert; f) Museotontti (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.

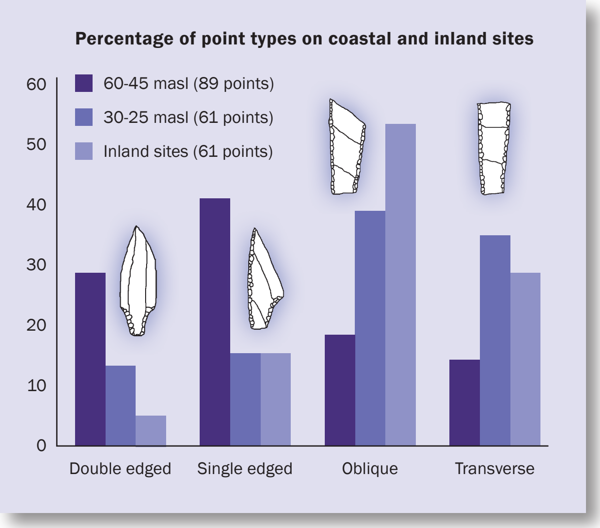


Figure 3. Edge types of points from sites at Varangerfjord divided in two temporal groups (roughly Early and Late Mesolithic) on the basis of altitude above sea level (data from Odner 1966 and Simonsen 1963) and from the inland sites Mávdnaávži 2, Devdis I, Rastklippan and Aksujavri. Point type drawings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

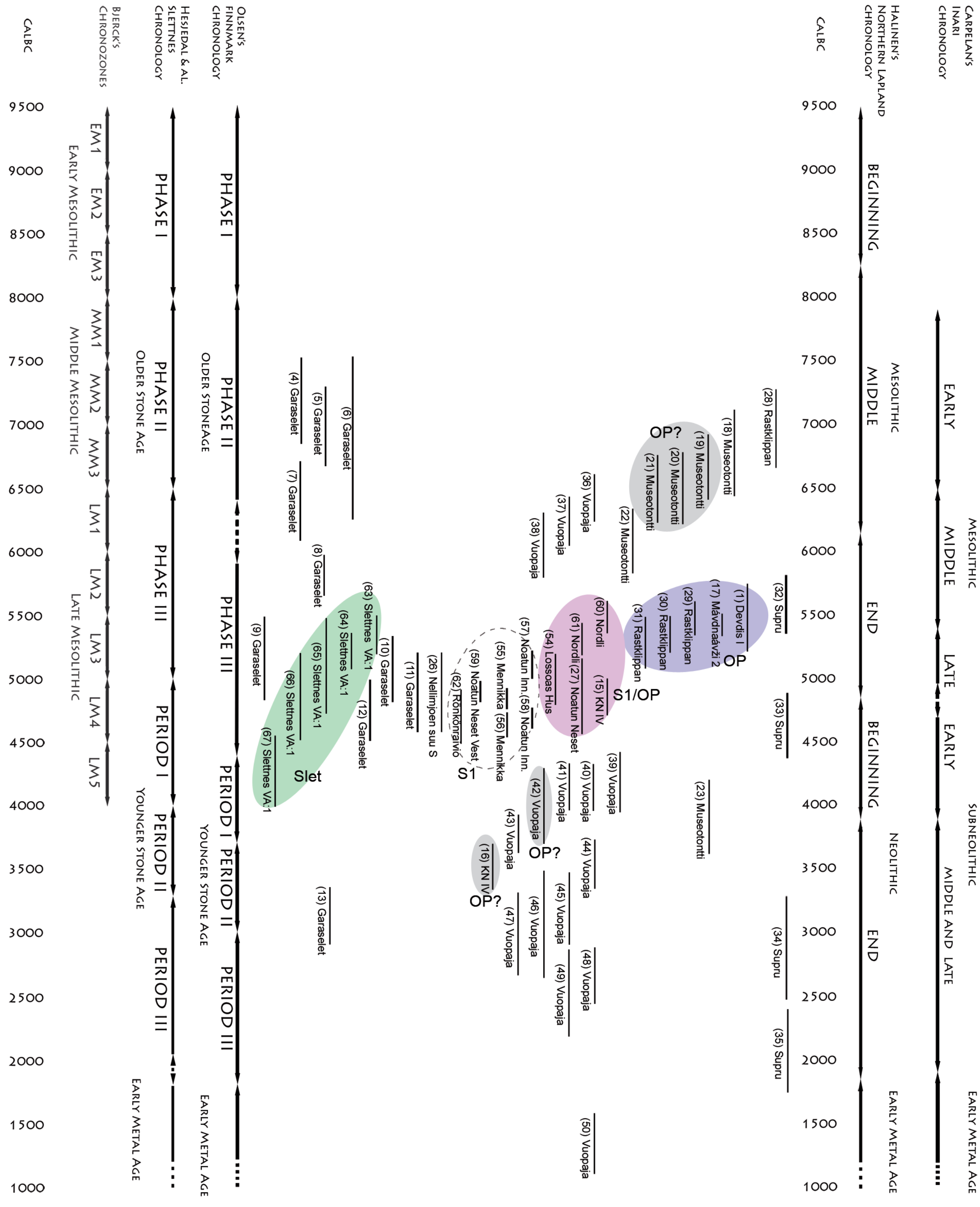


Figure 5. Calibrated radiocarbon dates from inland oblique point sites, Säräisniemi 1 food crust and the coastal site of Slettnes VA:1. Dates from secure inland contexts are marked with purple (OP), dates from Säräisniemi 1 food crust are marked with light red (S1/OP, sites with oblique points) and a 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

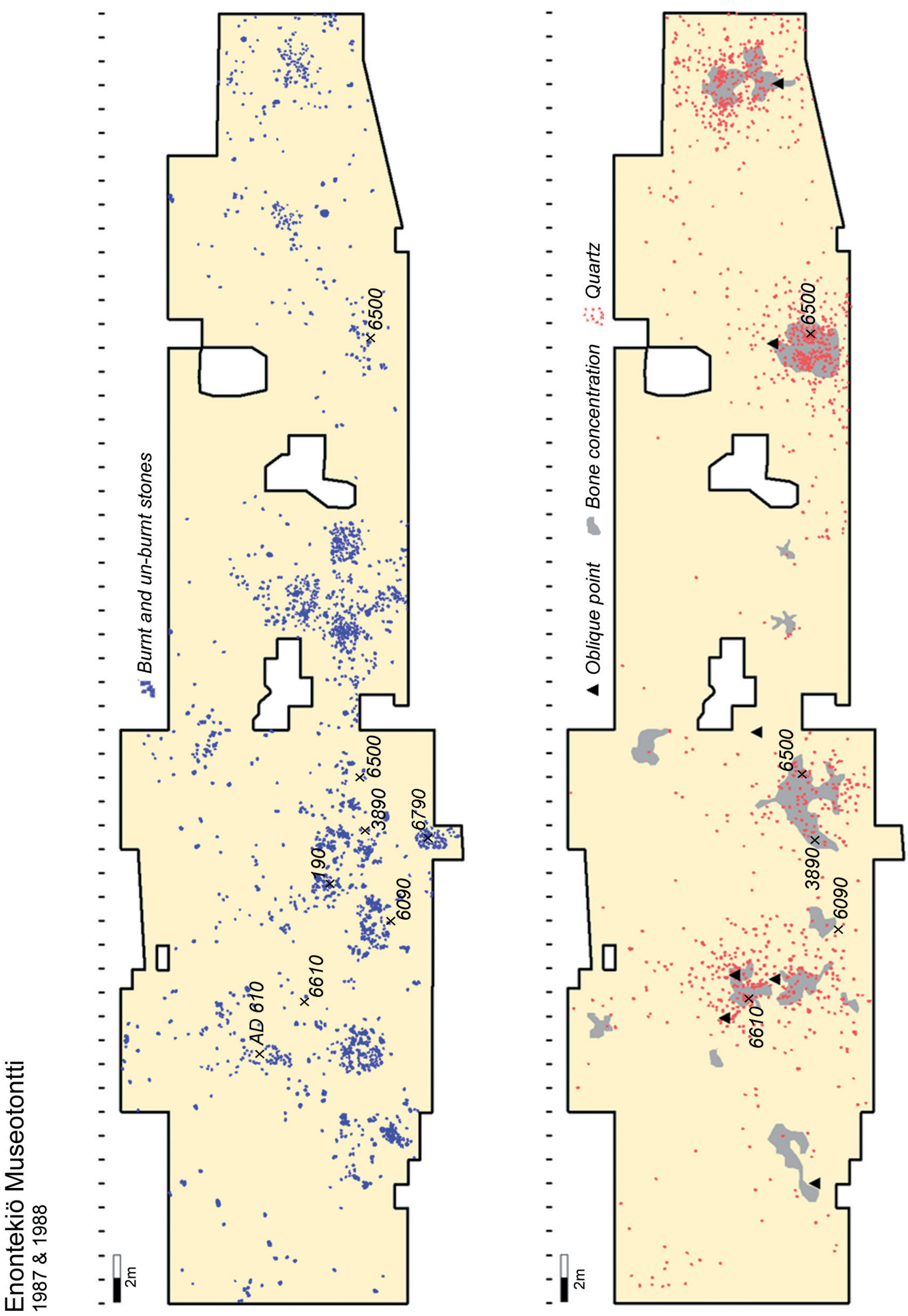


Figure 6. Oblique points, radiocarbon dates and concentrations of stones and finds at the Museotontti site. Dates are marked as calibrated median ages BC. Maps drawn by M. A. Manninen after maps by P. Halinen and M. Koponen in Kankaanpää (1988) and Halinen (1988; 2005).

	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 typo-chronologies, 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

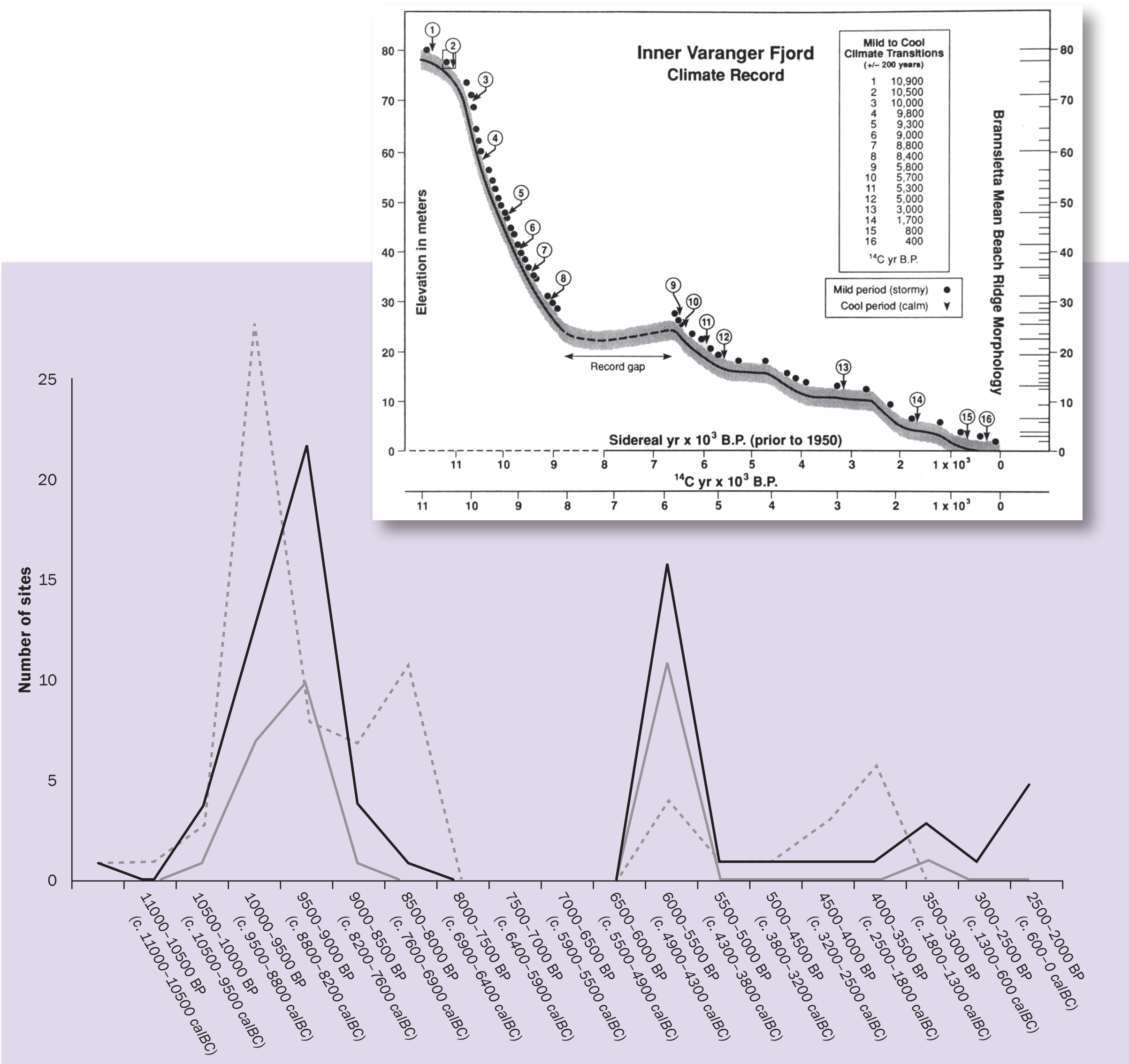


Figure 8. The number of sites in 500 year blocks according to altitude above the sea level on the southern shore of the Varangerfjord. The graphs indicate the total number of sites (solid black line, n=74) and sites with oblique points (solid grey line, n=30) according to the corrected altitude (reduced 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.

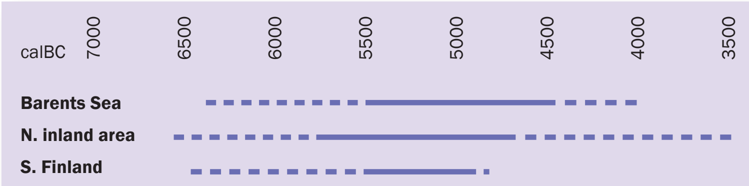


Figure 10. Roughly defined use-periods of late oblique points in Eastern Fennoscandia according to data from radiocarbon dates and shore displacement chronologies with the best evidence marked with a solid line.

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 km² 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).

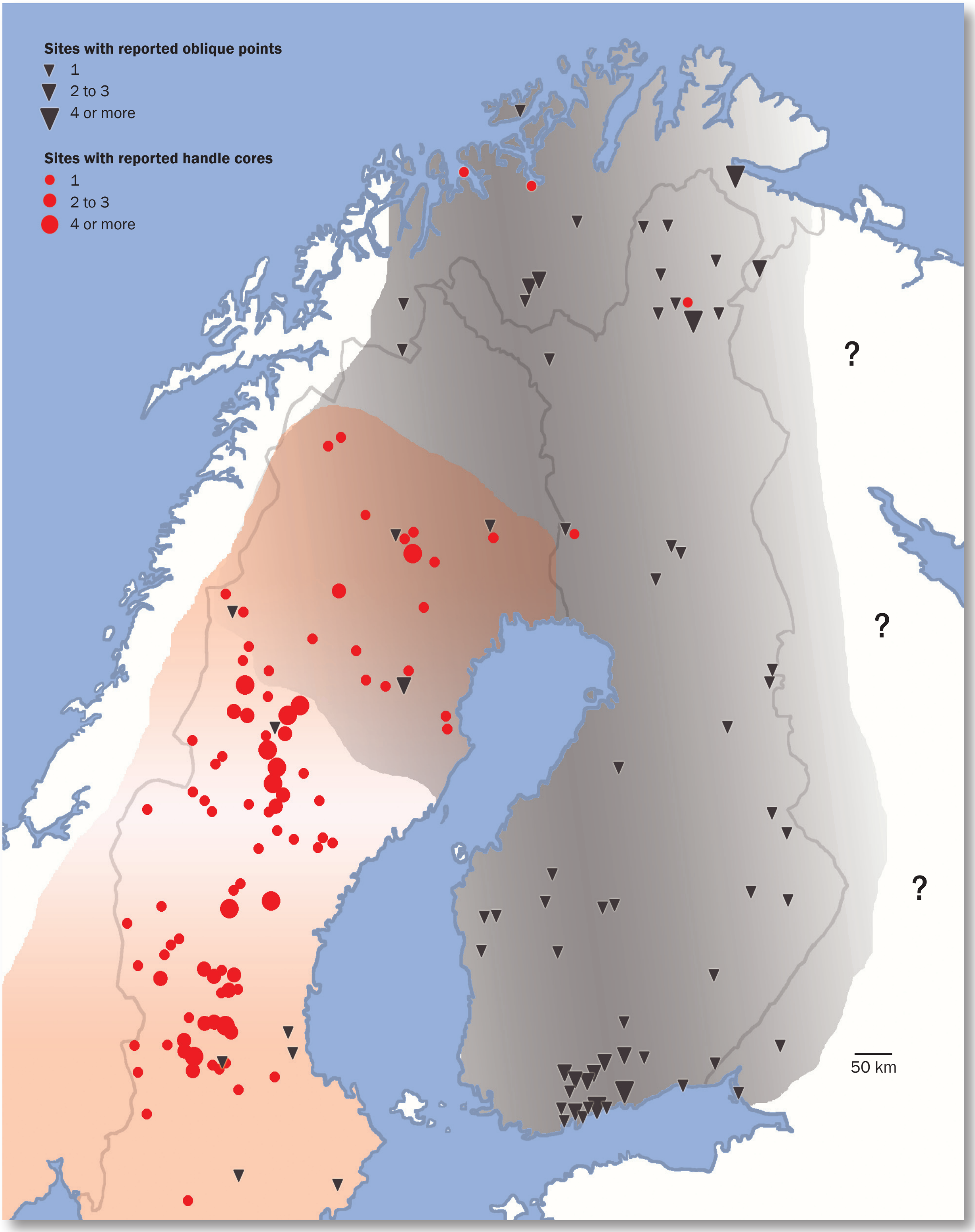


Figure 11. Rough areas of distribution of sites with oblique points (triangles) and handle cores (dots) in Finland, Sweden and northern Norway. In Norway only the two known handle cores from northern Norway, the northern inland oblique point sites, and the unequivocally late oblique point sites on the 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

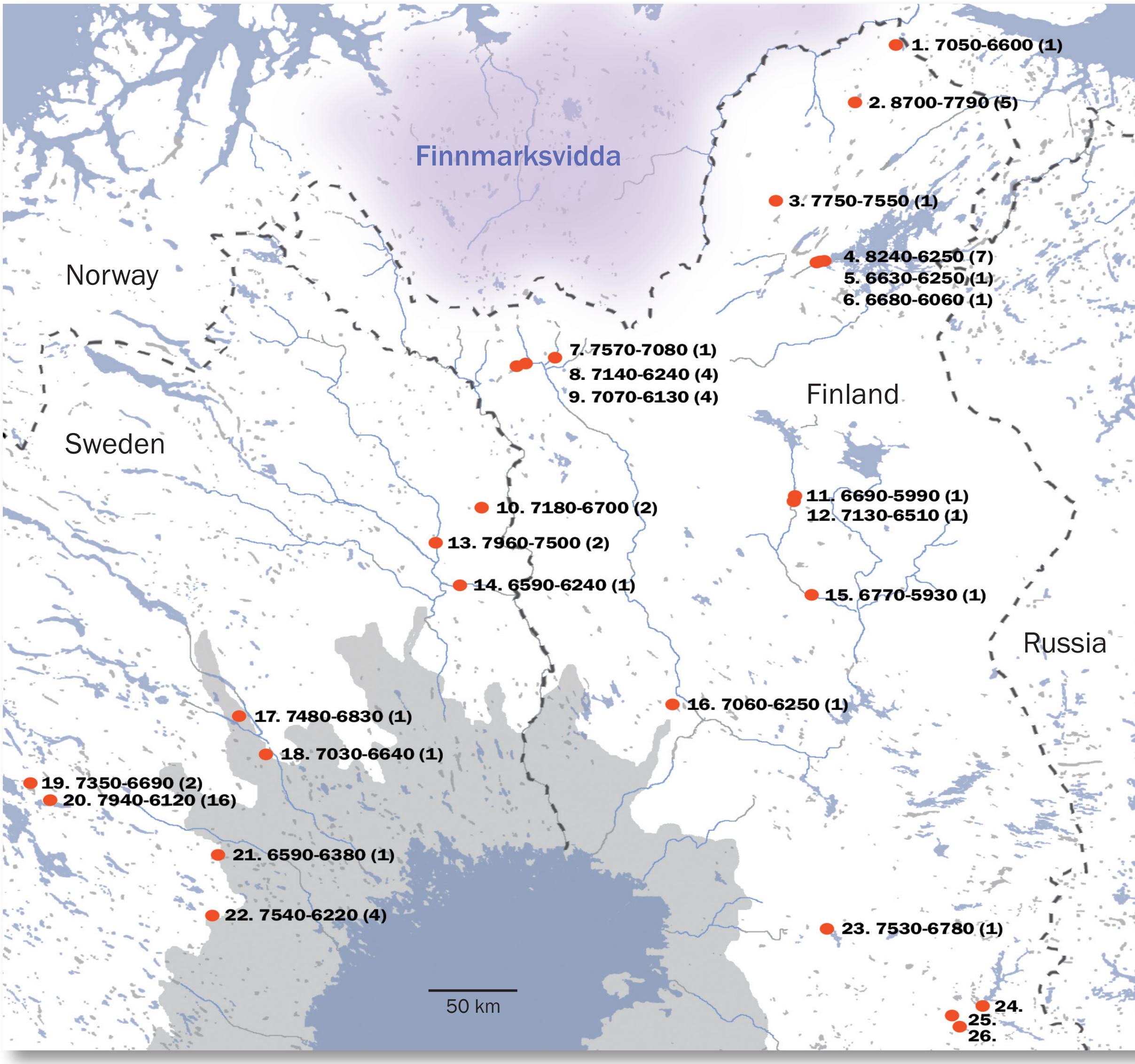


Figure 13. Sites with radiocarbon dates of *c.* 6400 calBC or older from areas around Finnmarksvidda. The extent of the Baltic Sea at approximately 6400 calBC is marked with light grey (following Andersson 2000). The number of dates falling within the given calBC interval is marked in brackets. The sites: 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 post-glacial 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.

Acknowledgements

The writing of this paper has been financed by the Finnish Cultural Foundation, the Finnish Graduate School in Archaeology (MM) and the Swedish-Finnish Cultural Foundation (KK). This research has benefited from the criticism by reviewers of the Interfaces in the Mesolithic Stone Age of Eastern Fennoscandia project. We also thank Charlotte Damm, Knut Helskog and Bryan Hood for their willingness to share information about new data from northern Norway. Any errors or omissions, however, are our own.

References

Andersson, L. 2000. *Norden*3 simulation. Producerad av Leif Andersson SGU efter matematisk modell av Tore Påsse SGU.

Andersson, S. & Wigforss, J. 2004. *Senmesolitikum i Göteborgs- och Alingsåsområdena*. Coast to coast-books no 12. GOTARC Serie C, Arkeologiska skrifter, no 58. Göteborgs universitet, Göteborg.

Arponen, A. 1987. *Inari* 13 *Kk Vuopaja. Kivi-varhaismetallikautisen asuinpaikan kaivaus*. Excavation report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Arponen, A. 1988. *Inari* 13 *Kk Vuopaja. Kivi-varhaismetallikautisen asuinpaikan kaivaus*. Excavation report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Arponen, A. 1989. *Inari* 417 *Rahajärvi Satamasaari*. Inspection report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Arponen, A. 1990. *Inari* 727 *Ukonjärvi Kirakkajoen voimala*. Inspection report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Arponen, A. 1991. *Inari. Rahajärven arkeologinen inventointi* 1990. Survey report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Arponen, A. & Hintikainen, E. 1995. Strandförskjutningen i Enare träsk mot bakgrunden av de arkeologiska fynden. *Finskt Museum* 1993, 5–25.

Banfield, A. W. F. 1961. Revision of the Reindeer and Caribou, genus *Rangifer*. *National Museum of Canada Bulletin* 177, Biological Series 66. Ottawa, National Museum of Canada.

Barnekow, L. 2000. Holocene regional and local vegetation history and lake-level changes in the Torneträsk area, northern Sweden. *Journal of Paleolimnology* 23, 399–420.

Bergman, I. 1995. *Från Döudden till Varghalsen*. Studia Archaeologica Universitatis Umensis 7. Umeå, Umeå Universitet.

Bergman, I., Olofsson, A., Hörnberg, G., Zackrisson, O. & Hellberg, E. 2004. Deglaciation and colonization: Pioneer settlements in Northern Fennoscandia. *Journal of World Prehistory* 18(2), 155–177.

Bjerck, H. B. 2008. Norwegian Mesolithic Trends: A Review. In G. Bailey & P. Spikins (eds.), *Mesolithic Europe,* 60–106. New York, Cambridge University Press.

Bøe, J. & Nummedal, A. 1936. *Le Finnmarkien. Les origines de la civilisation dans l'extrême-nord de'l Europe*. Instututtet for sammenlignende kulturforskning, serie B: skrifter XXXII. Oslo, Instututtet for sammenlignende kulturforskning.

Carpelan, C. 1962. *Lautasalmi* 1, 1962. *Kaivauskertomus.* Excavation report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Carpelan, C. 2003. Inarilaisten arkeologiset vaiheet. In V.-P. Lehtola (ed.), *Inari – Aanaar. Inarin historia jääkaudesta nykypäivään,* 29–95. Oulu, Inarin kunta.

Carpelan, C. 2004. Environment, Archaeology and Radiocarbon Dates. Notes from the Inari Region, Northern Finnish Lapland. *Iskos* 13, 17–45.

Christiansson, H. & Wigenstam, H. 1980. Nordarkeologipojektets Arvidsjaursinventering. *Fornvännen* 75, 163–169.

Damm, C. 2006. Interregional Contacts across Northern Fennoscandia 6000-4000 BC. In V.-P. Herva (ed.), *People, Material Culture And Environment In The North. Proceedings of the 22nd Nordic Archaeological Conference, University of Oulu, 18-23 August 2004.* Studia humaniora ouluensia 1, 131–140. Oulu, University of Oulu.

Engelstad, E. 1989. Mesolithic House Sites in Arctic Norway. In C. Bonsall (ed.), *The Mesolithic in Europe. Papers presented at the third international symposium. Edinburgh* 1985, 331–337. Edinburgh, John Donald Publishers Limited.

Eronen, M., Hyvärinen, H. & Zetterberg, P. 1999. Holocene humidity changes in northern Finnish Lapland inferred from lake sediments and submerged Scots pines dated by tree-rings. *The Holocene* 9(5), 569–580.

Flagstad, Ø. & Røed, K. H. 2003. Refugial Origins of Reindeer (Rangifer tarandus L.) Inferred from Mitochondrial DNA Sequences. *Evolution* 57(3), 658–670.

Fletcher, C. H. III, Fairbridge, R. W., Møller, J. J. & Long, A. J. 1993. Emergence of the Varanger Peninsula, Arctic Norway, and climate changes since deglaciation. *The Holocene* 3, 116–127.

Forsberg, L. 1996. The Earliest Settlement of Northern Sweden – Problems and Perspectives. In L. Larsson (ed.), The Earliest Settlement of Scandinavia and its relationship with neighbouring areas. *Acta Archaeologica Lundensia*, Series in 8, No. 24, 241–250. Stockholm, Almquist & Wiksell International.

Gjessing, G. 1942. *Yngre steinalder i Nord-Norge*. Instituttet for sammenlignende kulturforskning, serie B: skrifter XXXIX. Oslo, Instituttet for sammenlignende kulturforskning.

Grydeland, S.-E. 2000. Nye perspektiver på eldre steinalder i Finnmark - En studie fra indre Varanger. *Viking* LXIII, 10–50.

Grydeland, S.-E. 2005. The Pioneers of Finnmark – from the earliest coastal settlements to the encounter with the inland people of Northern Finland. In H. Knutsson (ed.), Pioneer settlements and colonization processes in the Barents region. *Vuollerim Papers on Hunter-gatherer Archaeology* 1, 43–77. Vuollerim, Vuollerim 6000 år.

Guinard, M. & Groop, N. 2007. Handtagskärnor och tvärpilar. In N. Stenbäck (ed.), *Stenålder i Uppland. Uppdragsarkeologi och eftertanke*. Arkeologi W4 Uppland Studier. Uppsala, Riksantikvarieämbetet, UV GAL; Societas archaeologica Upsaliensis; Upplandsmuseet.

Gustafsson, P. 1970. Styrelseberättelse för år 1969, fältarbeten och undersökningar. *Västerbottens Norra Fornminnesförening, meddelanden* XXXI, 5–7. Skellefteå, Västerbottens Norra Fornminnesförening.

Halinen, P. 1986. *Enontekiö* 89 *Hetta Museotontti. Kivikautisen asuinpaikan koekaivaus*. Excavation report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Halinen, P. 1988. *Enontekiö* 89 *Museotontti. Kivikautisen asuinpaikan kaivaus* 30.5.-30.6.1988. Excavation report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Halinen, P. 1995. *Ounasjärven alueen esihistoriallisten peuranpyytäjäyhteisöjen asutusmallit*. Unpublished Licenciate thesis. University of Helsinki.

Halinen, P. 2005. Prehistoric hunters of northernmost Lapland. Settlement patterns and subsistence strategies. *Iskos* 14. Helsinki, The Finnish Antiquarian Society.

Halinen, P., Seitsonen, O., Seitsonen, S. & Nordqvist, K. 2008. Excavations at the Juoksemajärvi Westend Stone Age dwelling site in 2002. In M. Lavento (ed.), *Karelian Isthmus – Stone Age Studies in* 1998–2003. Iskos 16, 235–265. Helsinki, The Finnish Antiquarian Society.

Hallgren, F. 2008. *Identitet i praktik. Lokala, regionala och överregionala sociala sammanhang inom nordlig trattbägarkultur*. Coast to coast-book 17. Stockholm, Uppsala University.

Havas, H. 1999. *Innland uten landgrenser. Bosetningsmodeller i det nordligeste Finland og Norge i perioden 9000-6000 BP*. MA thesis. Tromsø, University of Tromsø.

Hedman, S. D. 2009. Gammal-äldre-äldst. Något om Norrbottens mesolitikum. *Arkeologi i Norr* 11, 1–22.

Helskog, E. 1978. Finnmarksviddas forhistorie. In *Finnmarksvidda: natur-kultur*. NOU 1978: 18A, 135–144. Oslo-Bergen-Tromsø, Universitetsforlaget.

Helskog, E 1981. *Inberetning om utgravninger, Kautokeino kommune* 1981. Excavation report on archive. Tromsø museum, Tromsø.

Helskog, K. 1974. Stone Age settlement patterns in interior North Norway. *Arctic Anthropology* XI, 1974, Supplement, 266–271.

Helskog, K. 1976. *Inberetning om arkeologisk registrering på Finnmarksvidda* 1976. Survey report on archive, Tromsø museum, Tromsø.

Helskog, K. 1980a. The Chronology of the Younger Stone Age in Varanger, North Norway. Revisited. *Norwegian Archaeological Review* 13(1), 47–60.

Helskog, K. 1980b. *Subsistence-Economic Adaptations to the Alpine Regions of Interior North Norway*. PhD thesis. University of Wisconsin-Madison. Ann Arbor, University Microfilms.

Helskog K., Indrelid, S. & Mikkelsen, E. 1976. Morfologisk klassifiering av slåtte steinartefakter. *Universitetets Oldsaksamling Årbok* 1972–1974, 9–40.

Hesjedal, A., Damm, C., Olsen, B. & Storli I. 1996. Arkeologi på Slettnes. Dokumentasjon av 11.000 års bosetning. *Tromsø Museums Skrifter* XXVI. Tromsø, Tromsø museum.

Hicks, S. & Hyvärinen, H. 1997. The vegetation history of northern Finland. In E.-L. Schulz & C. Carpelan (eds.), *Varhain pohjoisessa - Early in the north. Maa - The land. Varhain Pohjoisessa -hankkeen artikkeleita - Reports of the Early in the North Project*. Helsinki papers in archaeology 10, 25–33. Helsinki, University of Helsinki.

Holm, L. 1991. *The use of stone and hunting of reindeer*. Archaeology and Environment 12. Umeå, Umeå Universitet.

Hood, B. C. 1986. *Report on a Stone Age Excavation at Aksujavri, Kautokeino K., Finnmark, June* 1986. Excavation report on archive, Tromsø Museum.

Hood, B. C. 1988. Undersøkelse av en steinalderboplass ved Aksujavri, Kautokeino kommune, Finnmark. In E. Engelstad & M. Holm–Olsen (eds.), Arkeologisk feltarbeid i Nord-Norge og på Svalbard 1986. *Tromura*, Kulturhistorie 14, 23–31. Tromsø museum, Tromsø.

Hood, B. C. 1992. *Prehistoric Foragers of the North Atlantic: Perspectives on Lithic Procurement and Social Complexity in the North Norwegian Stone Age and the Labrador Maritime Archaic*. *Electronic Doctoral Dissertations for UMass Amherst.* Paper AAI9219445. http://scholarworks.umass.edu/dissertations/AAI9219445

Itkonen, I. 1913. Tietoja Inarin kirkonkylän seudun muinaisuudesta. *Suomen Museo* XX, 1913, 3–9.

Jensen, C. & Vorren, K.-D. 2008. Holocene vegetation and climate dynamics of the boreal alpine ecotone of northwestern Fennoscandia. *Journal of Quarternary Science* 23(8), 719–743.

Johansson, P. & Kujansuu R. 2005. Deglasiaatio. In P. Johansson & R. Kujansuu (eds.), *Pohjois-Suomen maaperä*. Maaperäkarttojen 1:400 000 selitys, 149–157. Espoo, Geologian tutkimuskeskus.

Jordan, P. & Shennan, S. 2009. Diversity in hunter–gatherer technological traditions: Mapping trajectories of cultural 'descent with modification' in northeast California. *Journal of Anthropological Archaeology* 28, 342–365.

Jungner, H. 1979. Radiocarbon Dates I. Helsinki, University of Helsinki Dating laboratory.

Jungner, H. & Sonninen, E. 1989. *Radiocarbon Dates* III. Helsinki, University of Helsinki Dating laboratory.

Jungner, H. & Sonninen, E. 1996. *Radiocarbon Dates* IV. Helsinki, University of Helsinki Dating laboratory.

Jungner, H. & Sonninen, E. 1998. *Radiocarbon Dates* V. Helsinki, University of Helsinki Dating laboratory.

Kankaanpää, J. 1988. *Enontekiö 89 Museotontti. Kivikautisen asuinpaikan kaivaus* 1.–31.7.1987. Excavation report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Kankaanpää, J. 1990. *Enontekiö 89 Museotontti. Kivikautisen asuinpaikan kaivaus 1989.* Excavation report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Kankaanpää, J. 1998. *Pello 24 Kaaraneskoski 1. Kivikautisen asuinpaikan kaivaus* 1.-30.6.1998. Excavation report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Kankaanpää, J. & Rankama, T. 2005. Early Mesolithic pioneers in Nortern Finnish Lapland. In H. Knutsson (ed.), Pioneer settlements and colonization processes in the Barents region. *Vuollerim Papers on Hunter-gatherer Archaeology* 1, 109–161. Vuollerim, Vuollerim 6000 år.

Kehusmaa, A. 1972. *Kemijärven Neitilä* 4. Helsingin yliopiston arkeologian laitos, moniste 3. Helsinki. Helsingin yliopisto.

Knutsson, K. 1993. Garaselet-Lappviken-Rastklippan. Introduktion till en diskussion om Norrlands Äldsta Bebyggelse. *Tor,* vol. 25, 5–51.

Knutsson, K. 1998. Convention and lithic analysis. In L. Holm & K. Knutsson (eds.), *Proceedings from the Third Flint Alternatives Conference at Uppsala, Sweden, October* 18-20, 1996. OPIA 16, 71–93. Uppsala, Uppsala University.

Knutsson, K. 2004. The Historical Construction of Norrland. In H. Knutsson (ed.), *Arrival*. Coast to Coast Books 12, 45–71. Uppsala, Uppsala Universirty; Societas archaeologica Upsaliensis.

Knutsson, K. 2005a. Bridging the abyss of time. Material culture, cultural reproduction and the sacred time of origin. In H. Knutsson (ed.), *Pioneer settlements and colonization processes in the Barents region.* Vuollerim Papers on Hunter-gatherer Archaeology 1, 117–141. Vuollerim, Vuollerim 6000 år.

Knutsson, K. 2005b. Rastklippan och historiens mening. Ekologi, socialt minne och materiella diskurser. In R. Engelmark, T. B. Larsson & L. Rathje (eds.), *En lång historia: Festskrift till Evert Baudou på* 80-*års dagen*. Archaeology and Environment 20 - *Kungl. Skytteanska samfundets handlingar 57,* 235–259. Umeå. Institutionen för arkeologi och samiska studier.

Knutsson, K. *manuscript. Rastklippan. En jaktstation från senatlantisk tid i Tärnafjällen.* Raä 1000, Tärnasjön, Sorsele sn, Lappland.

Korteniemi, M. & Suominen, E. 1998. Nuoliharju W – Suomen vanhin pyyntikuoppa? *Rajamailla* IV/1997, 51–67.

Kotivuori, H. 1987a. *Inari* 81, 355, 357 ja 374-391 - *Imatran Voima Oy:n voimalinjan inventointi välillä Vajukoski-Pulmanki* 1986. *Osa* 1/3. (*linjan väöittömässä tuntumassa olevat kohteet*). Survey report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Kotivuori, H. 1987b. *Inari* 25, 61, 127, 194, 351, 353 ja 394-402 - *Imatran Voima Oy:n voimalinjan inventointi välillä Vajukoski-Pulmanki* 1986. *Osa* 2/3. (*linjan sivuilta tarkastetut kohteet*). Survey report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Kotivuori, H. 1996. Pyytäjistä kaskenraivaajiksi. Rovaniemen asutus noin 6000 eKr.–1300 jKr. In V. Kallio (ed.), *Rovaniemen historia vuoteen* 1721. *Kotatulilta savupirtin suojaan*. Jyväskylä, Rovaniemen kaupunki, Rovaniemen maalaiskunta & Rovaniemen seurakunta.

Kotivuori, H. 2007. Rivitalot Jäämeren rannalla. In E.-K. Harlin & V.-P. Lehtola (eds.), *Peurakuopista kirkkokenttiin - Saamelaisalueen 10 000 vuotta arkeologin näkökulmasta*. Publications of the Giellagas Institute 9, 56–63. Saarijärvi, University of Oulu.

Kullman, L. 1999. Early Holocene Tree Growth at a High Elevation Site in the Northernmost Scandes of Sweden (Lapland): A Palaeobiogeographical Case Study Based on Megafossil Evidence. *Geografiska Annaler. Series A, Physical Geography*, Vol. 81, No. 1, 63–74.

Kultti, S., Mikkola, K. Virtanen, T. Timonen, M. & Eronen, M. 2006. Past changes in the Scots pine forest line and climate in Finnish Lapland – a study based on megafossils, lake sediments, and GIS-based vegetation and climate data. *The Holocene, vol. 16, 381–391.*

Lahti, E.-K. 2004. *Utsjoki Màvdnaàvži 2 Mikael Manninen 2004 Luuanalyysi.* Manuscript.

Larsson, L. 2003. The Mesolithic of Sweden in retrospective and progressive perspectives. In L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler & A. Åkerlund (eds.), *Mesolithic on the Move,* xxii–xxxii. Exeter, Oxbow Books

Leskinen, S. 2002. The Late Neolithic House at Rusavierto. In H. Ranta (ed.), Huts *and Houses. Stone Age and Early Metal Age Buildings in Finland,* 147–169. Helsinki, National Board of Antiquities.

Liden, O. 1942. *De flinteggade benspetsarnas nordiska kulturfas. Studier i anslutning till nya sydsvenska fynd*. Skrifter utgivna av Kung. Humanistiska Vetenskapssamfundet i Lund, XXXIII. Lund, Kung. Humanistiska Vetenskapssamfundet.

Luho, V. 1948. Alajärven Rasin poikkiteräiset nuolenkärjet. *Suomen museo* 1947–1948, 5–21.

Luho, V. 1957. Frühe Kammkeramik. *Suomen Muinaismuistoyhdistyksen Aikakauskirja* 58, Studia Neolithica in Honorem Aarne Äyräpää, 141–159.

Luho, V. 1967. *Die Suomusjärvi-Kultur. Die mittel- und spätmesolitische zeit in Finnland.* Suomen muinaismuistoyhdistyksen aikakauskirja 66. Helsinki, Suomen muinaismuistoyhdistys.

Manninen, M. A. 2005. Problems in Dating Inland Sites — Lithics and the Mesolithic in Paistunturi, Northern Finnish Lapland. In H. Knutsson (ed.), *Pioneer settlements and colonization processes in the Barents region.* Vuollerim Papers on Hunter-gatherer Archaeology 1, 29–41. Vuollerim, Vuollerim 6000 år.

Manninen, M. A. 2006. Mesoliittiset asumuksenpohjat Pohjois-Lapissa. Huomioita liikkumisesta ja asumuksista. *Arkeologipäivät* 2005, 106–117. Hamina, Suomen arkeologinen seura.

Manninen, M. A. 2009. Evidence of mobility between the coast and the inland region in the Mesolithic of Northern Fennoscandia. In S. B. McCartan, R. Schulting, G. Warren and P. Woodman (eds.), *Mesolithic Horizons. Papers presented at the Seventh International Conference on the Mesolithic in Europe, Belfast 2005. Volume* I, 102–108. Oxford, Oxbow books.

Manninen M. A. & Knutsson, K. *in preparation*. Technology, Mobility and Site Structure – Five Late Mesolithic Short-term Camps in Northern Fennoscandia.

Manninen, M. A., Tallavaara, M. & Hertell, E. 2003. Subneolithic Bifaces and Flint Assemblages in Finland. Outlining the History of Research and Future Questions. In C. Samuelsson & N. Ytterberg (eds.), *Uniting Sea, Stone Age Societies in the Baltic Sea Region*. OPIA 33, 161–179. Uppsala, Uppsala University.

Manninen, M. A. & Valtonen, T. 2002. Havaintoja esihistoriallisesta kvartsin käytöstä Utsjoen Paistunturissa. *Muinaistutkija* 1/2002, 35–44.

Manninen, M. A. & Valtonen, T. 2006. Research of the Báišduottar – Paistunturi project in Northern Finnish Lapland 1997–2004. In V.-P. Herva, (ed.), *People, Material Culture and Environment in the North. Proceedings from the Nordic Archaeology Conference* 2004*, Oulu, Finland*. Studia humaniora ouluensia 1, 52–63. Oulu, University of Oulu.

Matiskainen, H. 1982. *Suomen mesoliittisen kivikauden sisäinen kronologia* 14C-*ajoitukseen tukeutuvan Itämeren kehityshistorian perusteella*. Unpublished Licenciate thesis. University of Helsinki.

Matiskainen, H. 1986. Beiträge zur Kentnisse der mesolithischen Schrägschneidepfeile und Microlithen aus Quarz. *Iskos* 6, 77–98.

Matiskainen, H. 1989. The Chronology of the Finnish Mesolithic. In C. Bonsall (ed.) *The Mesolithic in Europe.* III *Int. Mesol. Symp. Edinburgh* 1985, 379–390. Edinburgh, John Donald Publishers Limited.

Matiskainen, H. 2002. *Riihimäen esihistoria*. Hämeenlinna, Riihimäen kaupunginmuseo.

Moberg, C.-A. 1955. *Studier i Bottnisk stenålder* I–V. Kungl. Vitterhets Historie och Antikvitets Akademiens Handlingar, Antikvariska serien 3. Lund, Almqvist & Wiksell.

Møller, J. J. 1987. Shoreline relation and prehistoric settlement in northern Norway. *Norsk georafisk Tidsskrift,* Vol. 41, 45–60.

Møller, J. J. & Holmeslet, B. 1998. *Program Sealevel Change, Ver.* 3.51, 7. jan. 1998. http://www.imv.uit.no/annet/sealev/download/s.132.htm

Nieminen, E.-L. 1985. *Inari* 331 *Supru, Suprunoja. Kertomus kivikautisen asuinpaikan kaivauksesta* 1984. Excavation report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Nordqvist, K. & Seitsonen, O. 2008. Archaeological research in the former municipalities of Koivisto and Kuolemajärvi, Karelian Isthmus in 2003: results and observations. In Lavento, M. (ed.), *Karelian Isthmus – Stone Age Studies in* 1998–2003. Iskos 16, 215–234. Helsinki, The Finnish Antiquarian Society.

Nordqvist, K. & Seitsonen, O. 2009. New Mesolithic sites in the Finnish Lapland Wilderness. Research of the Muotkeduoddara doložat project in 2005–2007. *Mesolithic Miscellany* 19:2, 3–11.

Odner, K. 1966. *Komsakulturen i Nesseby og Sør-Varanger*. Tromsø/Oslo/Bergen, Universitetsforlaget.

Olsen, B. 1994. *Bosetning og samfunn i Finnmarks forhistorie*. Oslo, Universitetsforlaget.

Olofsson, A. 1995. *Kölskrapor, mikrospånkärnor och mikrospån*. Arkeologiska studier vid Umeå Universitet 3. Umeå, Umeå Universitet.

Olofsson, A. 2003. Early Colonization of Northern Norrland: Technology, Chronology, and Culture. In *Pioneer Settlement in the Mesolithic of Northern Sweden*. Archaeology and Environment 16. Umeå, Umeå University.

Pesonen, P. 2005. Sarvingin salaisuus – Enon Rahakankaan varhaismesoliittinen ajoitus. *Muinaistutkija* 2/2005, 2–13.

Pälsi, S. 1929. *Inari Vuopaja*. Excavation report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Rankama, T. 1996. *Prehistoric riverine adaptations in subarctic Finnish Lapland: The Teno river drainage.* Dissertation Submitted in Partial Fulfilment of the Requirements for the Degree of Doctor of Philosophy in the Department of Anthropology at Brown University. UMI Dissertation Services.

Rankama, T. 2003. The colonisation of northernmost Finnish Lapland and the inland areas of Finnmark. In L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler & A. Åkerlund (eds.), *Mesolithic on the Move,* 684–687. Exeter, Oxbow Books.

Rankama, T. 2009. Quartz analysyes of the Kaaraneskoski site, Finland. In S. B. McCartan, R. Schulting, G. Warren & P. Woodman (eds.), *Mesolithic Horizons*. *Papers presented at the Seventh International Conference on the Mesolithic in Europe, Belfast 2005. Volume* II, 813–819. Oxford, Oxbow books.

Rankama, T. & Kankaanpää, J. 1997. *Utsjoki* 209 *Jomppalanjärvi W. Arkeologisen kohteen tarkastus*. Inspection report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Rankama, T. & Kankaanpää, J. 2008. Eastern arrivals in post-glacial Lapland: the Sujala site 10,000 cal BP. *Antiquity* 82(318), 884–899.

Rankama, T. & Kankaanpää, J. *this volume.* The Kaaraneskoski Site in Pello, South-Western Lapland – at the Interface between the "East" and the "West".

Rankama, T. & Ukkonen, P. 2001. On the early history of the wild reindeer (*Rangifer tarandus* L.) in Finland. *Boreas* 30, 131–147.

Robertsson, A.-M. & Hätterstrand, L. *manuscript*. *Rapport över pollenanalys av jordprov från Rastklippan, Sorsele ns, Norrbotten*. SGU Uppsala.

Schanche, K. 1988. *Mortensnes - en boplass i Varanger. En studie av samfunn og materiell kultur gjennom 10.000 år*. MA thesis. Tromsø, University of Tromsø.

Schulz, E.-L. 2004. Ankkapurhan arkeologisen aineiston radiohiiliajoitukset. In Uino, P. (ed.), *Ammoin Ankkapurhassa. Kymenlaaksossa kivikaudella*. Museovirasto, Helsinki.

Schulz, H.-P. 1990. On the Mesolithic Quartz Industry in Finland. *Iskos* 9, 7–23.

Seppälä, S.-L. 1993. *Inari 13 Vuopaja. Kivi- ja varhaismetallikautisen asuinpaikan kaivaus* 13.-27.7.1993. Excavation report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Seppälä, S.-L. 1994. *Inari 13 Vuopaja. Kivi- ja varhaismetallikautisen asuinpaikan kaivaus* 13.6.-18.7.1994. Excavation report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Seppälä, S.-L. 2007. Inarin Saamen museon ja Vuopajan arkeologiset tutkimukset 1909–1994. In Harlin, E.-K. & Lehtola, V.-P. (eds.), *Peurakuopista kirkkokenttiin - Saamelaisalueen 10 000 vuotta arkeologin näkökulmasta*. Publications of the Giellagas Institute 9, 76–91. Saarijärvi, University of Oulu.

Siiriäinen, A. 1982. A communication relating to a Stone Age find from the village of Inari (Lapland). *Fennoscandia antiqua* I, 5–12.

Simonsen, P. 1961. *Varanger-funnene* II. *Fund og udgravninger på fjordens sydkust*. Tromsø museums skrifter vol. VII, hefte II. Tromsø, Tromsø museum.

Simonsen, P. 1963. *Varanger-funnene* III. *Fund og udgravninger i Pasvikdalen og ved den østlige fjordstrand.* Tromsø museums skrifter vol. VII, hefte III. Tromsø, Tromsø museum.

Simonsen, P. 1986. Fortsatte undersøkelser ved Virdnejavri, Kautokeino K., Finnmark. *Tromura, Kulturhistorie* 6. Arkeologisk feltarbeid i Nord-Norge 1985, 1–11. Tromsø, Universitetet i Tromsø.

Simonsen, P. 1987. Virdnejavri lokaliteter 24, 113 og 127, Kautokeino kommune. *Tromura, Kulturhistorie* 17. Arkeologisk feltarbeid i Nord-Norge og på Svalbard 1987, 27–41. Tromsø, Universitetet i Tromsø.

Sjögren, K.-G. 1991. Om västsvensk mesolitisk kronologi. In H. Browall, P. Persson & K.-G. Sjögren (eds.), *Västsvenska stenåldersstudier,* 11–32. Göteborg, Göteborgs universitet.

Skandfer, M. 2003. *Tidlig, nordlig kamkeramikk. Typologi-kronologi-kultur*. http://www.ub.uit.no/munin/handle/10037/284. University of Tromsø.

Skandfer, M. 2005. Early, Northern Comb Ware in Finnmark: the Concept of Säräisniemi 1 Reconsidered. *Fennoscandia archaeologica* XXII, 3–27.

Sohlström. B. 1989. *Inari* 406, *Nellimjoen suu S. Prov- och utgrävning av en stenåldersboplats* 1988. Excavation report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Sohlström. B. 1992. En stenåldershydda, en bosättningsanalys. *Kentältä poimittua*. Museovirasto, esihistorian toimisto, julkaisu N:o 2, 27–37.

Šumkin,V. Ja. n.d.. *The Stone Age of Eastern Lappland*. Unpublished Doctoral Dissertation, Institute for the History of Material Culture, St. Petersburg. English Translation on File, Department of Archaeology, Tromsø Museum.

Šumkin, V. Ja. 1986. Mezolit Kol'skogo poluostrova. *Sovetskaja Arkheologija* 2, 15–33.

Sundqvist, L. 1978. Boplatsen Garaselet i norra Västerbotten. In Till Ernst Westerlund 9 november 1975. Studier i Norrländsk forntid. *Acta Bothniensia Occidentalis. Skrifter i västerbottnisk kulturhistoria*, 130–137. Umeå, Västerbottens museum.

Sundqvist, L. 1983. *Rapport över undersökningar av områden kring boplatserna* Raä 79 *Garaseletviken, Jörn sn och* Raä 67 *Lappviken, Jörn sn, Västerbotten*. Rapport Skellefteå Museum. Skellefteå.

Tansem, K. 1999. *Fra Komsakultur til eldre steinalder i Finnmark*. Stensilserie B NR 54. Tromsø, Universitetet i Tromsø.

Thuestadt, A. E. 2005. *En romlig analyse av tidlig eldre steinalderlokaliteter i Vest-Finnmark og Troms*. Hovedfagsoppgave i arkeologi, Universitetet i Tromsø.

Torvinen, M. 1978. *Ranua, Kujala, Uutelanniemi. Kivikautisen asuinpaikan tarkastus* 3.10.1978. Inspection report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Ukkonen, P. 1994. Inari 13 Vuopaja (KM 27809) / S.-L. Seppälä 1993. In Seppälä, S.-L. 1993. *Inari 13 Vuopaja. Kivi- ja varhaismetallikautisen asuinpaikan kaivaus* 13.-27.7.1993. Excavation report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Ukkonen, P. 1995. Inari 13 Vuopaja (KM 28365) / S.-L. Seppälä 1994. In Seppälä, S.-L. 1994. *Inari 13 Vuopaja. Kivi- ja varhaismetallikautisen asuinpaikan kaivaus* 13.6.–18.7.1994. Excavation report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Valtonen, T. 1999. *Utsjoen Paistunturien inventointi* 6.6–28.6. *ja* 9.8.–26.8.1999. Survey report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Whallon, R. 2006. Social networks and information: Non-"utilitarian" mobility among hunter-gatherers. *Journal of Anthropological Archaeology*, Vol. 25:2, 259–270.

Woodman, P. C. 1993. The Komsa Culture. A Re-examination of its Position in the Stone Age of Finnmark. *Acta Archaeologica* 63/1992, 57–76.

Woodman, P. C. 1999. The Early Postglacial Settlement of Arctic Europe. In E. Cziesla, T. Kersting & S. Pratsch (eds.), *Den Bogen spannen… Festschrift für Bernhard Gramsch zum 65. Geburstag,* Teil 1. Beiträge zur Ur- und Frügeschichte Mitteleuropas 20, 292–312. Weissbach, Beier & Beran.

Åkerlund, A. 1996. *Human Responces to Shore Displacement. Living by the Sea in Eastern Middle Sweden during the Stone Age.* Riksantikvarieämbetet Arkeologiska undersökningar Skrifter 16. Stockholm, Riksantikvarieämbetet.

Åkerlund, A., Gustafson, P., Hammar, D., Lindgren, C., Olsson, E. & Wikell, R. 2003. Peopling a Forgotten Landscape. In L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler & A. Åkerlund (eds.), *Mesolithic on the Move,* xxxiii–xliv. Exeter, Oxbow Books.

Åkvist-Nordlund, H. 1992. *Garaselet. En stratigrafisk studie genom sammanfogning av stenartefakter.* C-uppsats. Institutionen för arkeologi vid Uppsala universitet. Uppsala.

Östlund, O. 2004. Kangos - Rapport arkeologisk förundersökning. *Stenåldersboplats samt skärvstensförekomst Raä 22 samt Raä 98 Junosuando socken, Norrbottens län, Västerbotten.* Norrbottens läns museum 2004. Unpublished manuscript.

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 Kuošnâjávri 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

PAPER II

Manninen, M. A. 2009. Evidence of mobility between the coast and the inland region in the Mesolithic of Northern Fennoscandia. In: S. B. McCartan, R. Schulting, G. Warren & P. Woodman (Eds.), *Mesolithic Horizons*, Vol. I. Oxbow books, Oxford, 102–108. Reprinted with permission from Oxbow books.

16. Evidence of mobility between the coast and the inland region in the Mesolithic of northern Fennoscandia

Mikael A. Manninen

Excavations conducted in 2004 at the Mesolithic Mávdnaávži 2 site in northern Finnish Lapland revealed an assemblage consisting mainly of chert deriving from the Barents Sea coast, although artefacts of local raw material were also found. Several details in the technological organization suggest that the site represents a location where a small number of foragers coming from the coast camped before moving on. The finds also provoke a new interpretation of a small number of finds of coastal raw materials found in assemblages dominated by local quartz further in the inland area. In the paper this data is used to devise a model of Late Mesolithic coast-inland mobility in northern Fennoscandia.

Keywords: technological organization, mobility, Finnmark, Lapland, Finland, lithic technology, oblique point, Late Mesolithic, chert.

Introduction

According to current knowledge, the pioneer habitation of the coast of Finnmark dates to *c.* 10,000–9500 BP (*c.* 9500–8800 cal BC; Thommessen 1996). Views on the pioneer settlement of the inland area of Finnmark and northern Finnish Lapland (earliest date *c.* 7830 cal BC, e.g. Carpelan 2004, 21–6) differ among researchers with the discussion centring on the question of whether the first settlers in the inland area arrived from the south (more southerly Finland), the north (Barents Sea coast), or possibly the east (Russia).

Without going any deeper into the discussion on pioneer settlement, it is important to note that there are clear typological and technological differences in many of the assemblages dated to the second phase (roughly 8000–6000 cal BC) of the Mesolithic in the area (*c.* 9000–7500/7000 BP, according to Olsen's (1994) chronology). This suggests that more or less separate populations used the inland area and the coastal area at the end of this phase (e.g. Kankaanpää and Rankama 2005, 101) and possibly also later, during the third Mesolithic phase (*c.* 6000–4400 cal BC or 7500/7000–5600 BP) (e.g. Olsen 1994, 36–42; but see Rankama 2003). However, the amount of interaction between the two populations and the possible use of both the coast and the inland by a single population, have not been sufficiently studied and the questions remain open.

Mesolithic mobility in the study area has mainly been touched upon in studies about the direction of inland settlement on the basis of raw material selection and environmental history, and the amount of sedentism vs. mobility indicated by investment in house constructions, raw material use, or artefact diversity (e.g. Bølviken *et al.* 1982, 48–51; Engelstad 1989, 335–36; Grydeland 2000; 2005; Halinen 2005, 89–90, 102, 108–9; Havas 1999; K. Helskog 1974; Odner 1964; Olsen 1994, 40–4; Rankama, 2003; Schanche 1988, 148–9). Hood (1992, 171–220) has conducted the most comprehensive research on Mesolithic mobility in the area, but in his study, as well as in other studies completed before the three-phase division of the Mesolithic in the area was developed, the Mesolithic material has been studied as a more or less monolithic entity.

In this paper I discuss the Late Mesolithic, i.e. the third Mesolithic phase of Finnmark, northern Finnish Lapland, and adjacent areas, with a special emphasis on sites around and north of Lake Inari (Figure 16.1). I then use this new evidence to devise a model of Late Mesolithic mobility between the Barents Sea coast and the inland region using the concept of technological organization (Nelson 1991; Tallavaara 2005). This framework is defined by Nelson (1991, 57) as: 'the study of the selection and integration of strategies for making, using, transporting, and discarding tools and the materials needed for their manufacture and maintenance. Studies of the organization of technology consider economic and social variables that influence those strategies.'

The geological basis for the model

The area under discussion is divided by a geological boundary. The dividing line between the Fennoscandian shield and younger sedimentary rocks of the Caledonian mountains runs roughly along the border between Finland and Norway (Lehtinen *et al.* 1998, 95). This border affects the division of lithic raw material sources: known sources of different kinds of light and dark grey fine-grained cherts are present only in the area north of the borderline between the Fennoscandian shield and the Caledonian mountains.

Hood (1992) has studied the distribution of lithic raw materials in north Norway and, according to him, sources of two types of grey chert are known from the Barents Sea coast, namely Kvenvik chert and Porsanger chert. Besides these sources, a previously unknown quarry of grey chert has been located by Halinen (2005, 27–8; 2006) in Guonjarvárri, in the northernmost part of the borough of Enontekiö, Finland (Figure 16.1). In addition, secondary rolled pebbles of several kinds of cherts can be found in the Precambrian tillites of Varangerfjord (Hood, pers. comm.). There are also sources of oolithic chert and probable, but thus far unknown, sources of tuffaceous chert in the area (Hood 1992), but these raw materials cannot be mistaken for the grey cherts.

In the area of present-day Finland the sole locally available lithic raw materials are macrocrystalline quartz and, to some degree, also different kinds of quartzites. Quartzites and macrocrystalline quartz are also available at the coast. The one-sidedness of the location of chert raw material sources opens concrete possibilities to study the flow of coastal raw materials into the inland area and to make inferences about mobility patterns, especially when combined with analyses of technological organization.

Types and dates of the Late Mesolithic

The typo-chronological definition for Late Mesolithic (*c*. 6000–4400 cal BC) in Finnmark presented by Olsen (1994, 33–5) is used in this paper for the whole study area, including northern Finnish Lapland and the county of Tromsø east of Malangenfjord. Halinen, however, has suggested a slightly different date (*c*. 6150–4850 cal BC) for the end of the third phase of the Mesolithic, since the oldest sites with Säräisniemi 1 pottery have been dated to

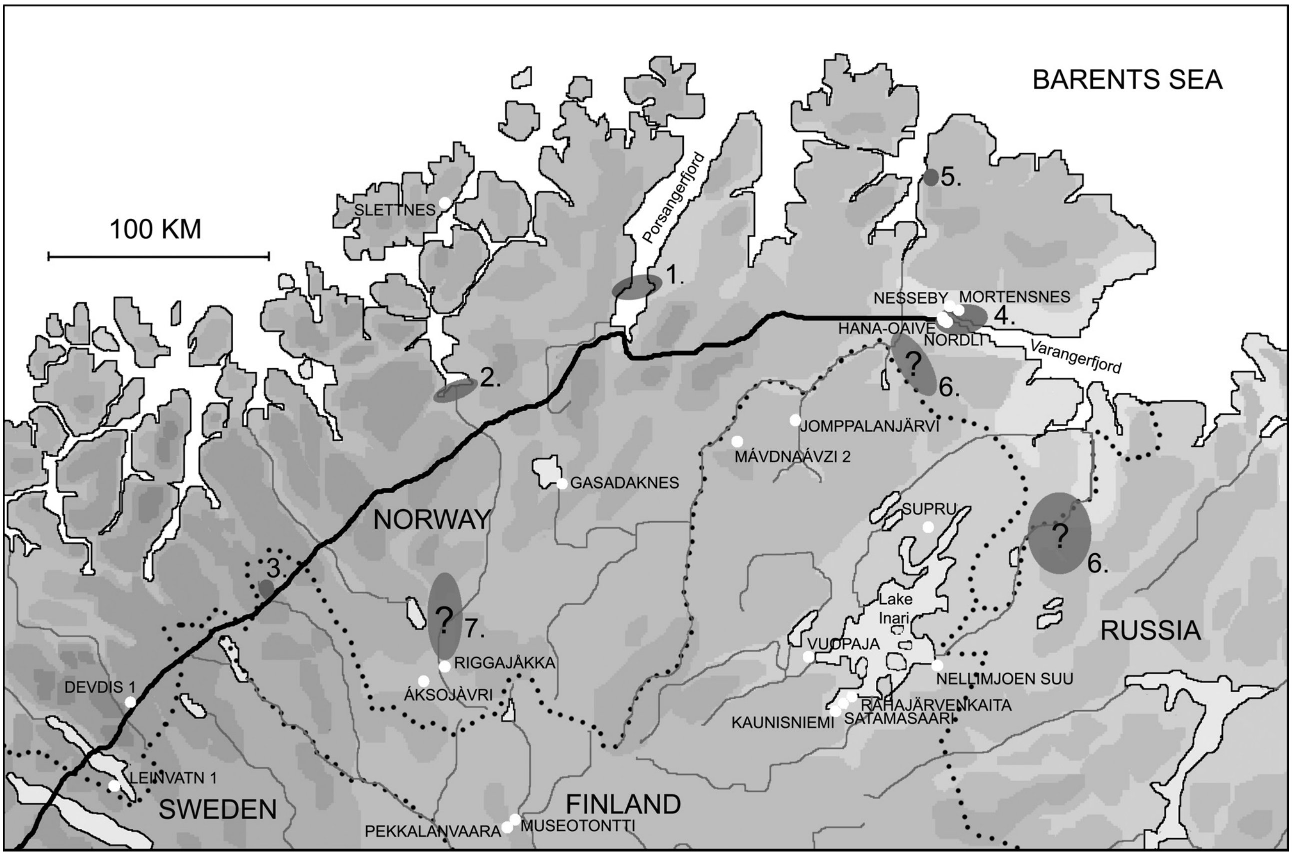


Figure 16.1. Map showing the study area and adjacent areas in Finland, Norway, Russia and Sweden. The black line indicates the border between the Fennoscandian shield and the Caledonian mountains. Known chert sources in the area are marked with numbers from 1 to 5: Porsanger chert (1); Kvenvik chert (2); Guonjarvárri quarries (3); Varanger tillites (4); Oolithic chert (5). Numbers 6 and 7 indicate possible source areas for tuffaceous chert (6) and metachert/quartzite (7) (data from Hood 1992; Halinen, pers. comm.). Sites that have yielded oblique points in excavations and surveys are marked with white dots. Data from Arponen 1990; Gjessing 1942; Halinen 2005; E. Helskog 1978; K. Helskog 1980; Hesjedal et al. 1996; Hood 1988; Manninen 2005; Nummedal 1938; Odner 1966; Kankaanpää and Rankama 2005; Schanche 1988; Simonsen 1961.

Site	Lab. No.	Date BP	cal BC 2σ	Type
Supru, Suprunoja	**Hel-2117**	6650±120	**5780-5360**	OP (a)
Devdis 1	**T-1343**	6575±150	**5800-5200**	OP (a)
Nordli	**TUa-3028**	6570±60	**5630-5460**	OP, Sär1(c)
	TUa-3021	6330±50	**5390-5210**	
Mávdnaávži 2	**Hela-963**	6455±45	**5490-5320**	OP (b)
Slettnes VA	**Beta-49052**	6390±80	**5510-5210**	OP (a)
	Beta-49056	6170±170	**5500-4700**	
	Beta-49053	5930±110	**5100-4500**	
	Beta-49054	5470±120	**4550-3950**	
Nellimjoen suu S	**Hel-2678**	6000±120	**5250-4600**	OP, Sär1 (a)
Rönkönraivio	**Hela-38**	5830±85	**4900-4660**	Sär 1 (c)
Mortensnes 8R12	**T-6416**	5770±190	**5250-4200**	OP (a)

Figure 16.2. Dates from charcoal (a), burnt bone (b), and food crust on pottery (c) associated with oblique points (OP) and Säräisniemi 1 Ware (Sär1) in the study area. Data from Carpelan 2004; Helskog 1980; Hesjedal et al .1996; Kankaanpää and Rankama 2005; Schanche 1988; Sohlström 1992; Skandfer 2003. (Atmospheric data from Reimer et al. 2004; Bronk Ramsey 2005).

circa 4900 cal BC in northern Finnish Lapland (Carpelan 2004, 26–9; Halinen 2005, 32, 34; Torvinen 2000).

According to the typo-chronology (based on Woodman 1993), the characteristic type of lithic artefact used during the third phase of the Mesolithic, is the oblique arrowhead (e.g. K. Helskog 1980, figures 16–18; Manninen 2005, figure 7; Olsen 1994, figure 16; Schanche 1988, figure 28). I will henceforth call it the oblique point, although the edge angle varies and some points could be called single edged or even transverse (Helskog 1980, 73; Manninen 2005, 37). Points of this type have been found also on some sites that are usually considered Early Neolithic on account of a presence of Säräisniemi 1 sherds (Engelstad 1989, 336; Gjessing 1942, 174–7; Nummedal 1938, 2–7; Simonsen 1961, 104–5; Sohlström 1992).

Whether the occurrence, typologically, of both Late Mesolithic and Early Neolithic artefacts at the same sites is a consequence of pottery being adopted by the Late Mesolithic population in the area, or the spread of a new pottery-making population re-occupying old sites, is a question outside the scope of this paper. However, it is interesting to note that the earliest dates of Säräisniemi 1 pottery and the latest dates of contexts with oblique points clearly overlap in the study area (Figure 16.2). In this paper I have therefore chosen to group together all sites with oblique points and to ignore the traditional idea that sites should be divided into Late Mesolithic vs. Early Neolithic, according to the presence or non-presence of Säräisniemi 1 pottery.

In the map (Figure 16.1) the sites that have yielded oblique points in northern Finnish Lapland (Arponen 1990; Halinen 2005; Kankaanpää and Rankama 2005; Manninen 2005) are presented alongside the published sites from north Norway (E. Helskog 1978; K. Helskog 1980; Hood 1988; Nummedal 1938; Simonsen 1961; Odner 1966; Schanche 1988). Most of the sites are concentrated around the biggest lake in the area, Lake Inari, and on the shores of Varangerfjord, but the picture is probably biased since most of the archaeological research in Finnmark and northern Finnish Lapland has been conducted in these areas.

Many of the sites around, and north of Lake Inari have yielded oblique points of grey chert as well as points of tuffaceous chert, black chert, quartz and quartzite. It is once more worth emphasizing that no chert sources are known from this area and consequently, especially the fine-grained grey cherts found on some of the sites, must have been imported from the coast. Raw materials, as well as ready-made tools, could obviously have been transported to the inland area through many different mechanisms. A key site in this sense is the Mávdnaávži 2 site, situated around 50km as the crow flies from the nearest point of the Barents Sea coast. The assemblage from the site strongly suggests direct movement of people between the coast and the inland region.

The Mávdnaávži 2 site

The Mávdnaávži 2 site is situated on a small moraine ridge on the bank of a small stream in the Báišduottar – Paistunturi wilderness area. The site was found in a survey conducted in 1999 (Valtonen 1999). An excavation led by the author was conducted at the site in June 2004. Scarce vegetation and wind erosion enabled reliable surface observations of find distribution, making it possible to place the excavation accordingly. The limits of an area covering 52 square meters were marked and excavated. The area was kept as small as possible to avoid further erosion of the riverbank.

The structure of the site is clear. Activity at the site was situated parallel to the riverbank. The floor of a dwelling with, roughly, a three-metre diameter had been cleared out of stones at the north-east end of the otherwise stony camp area. Approximately 6m south-west of the hut there was an outdoor activity area. Both inside the hut and in the centre of the outdoor activity area there were traces of a fireplace. Stones had not been used in constructing the hearths, but burnt sand, and in the fireplace inside the dwelling burnt bone, small fire-cracked stones and charcoal indicated the place where the hearth had once been. Both hearths were surrounded by clearly defined lithic scatters. The only clear post-depositional disturbance in the horizontal stratigraphy was the movement of some artefacts on the surface along reindeer tracks. Vertically, all artefacts were situated in a tight, mostly four- to five-centimetre-thick layer right below the surface.

The scatter in the outdoor activity area consisted of retouch flakes, flake blanks and scrapers of quartz and quartzite, and a flake of black chert. The activity area inside the hut consisted of debitage, retouched flakes, backed pieces, and intact and broken oblique points of grey chert. An accelerator mass spectrometry (AMS) dating obtained from burnt bone (from a small pit associated with the hearth inside the hut) gives the site a Late Mesolithic date (Figure 16.2). Although a single date, the result is in accordance with the typologically Late Mesolithic find material and is therefore considered reliable.

Nodule	No of art.	Weight g	Tools	Tool types
GyC	726	**137.1**	47	Points, retouched pieces
BC	1	**0.9**	0	
GQz	8	**29.5**	4	Scrapers
LGyQz	6	**12.1**	1	Scraper
BQz	7	**9**	1	Scraper
GyQz	4	**10.1**	1	Scraper
WQz	4	**6.6**	0	
P	1	**4.9**	1	Abrader
Q	187	**277.2**	13	Scrapers

Figure 16.3. Analytical nodules in the Mávdnaávži 2 assemblage. Tool-counts include all tool fragments. GyC = grey chert, BC = black chert, GQz = green quartzite, LGyQz = Light-grey fine-grained quartzite, BQz = Greyish-brown banded quartzite, GyQz = Grey fine-grained quartzite, WQz = coarse-grained white quartzite, P = pumice, Q = quartz.

Duration of the site's use – analyses and considerations

Although the Mávdnaávži 2 site is quite obviously a campsite with a short life span, it is impossible to infer solely by reconstructing the general site structure and by classifying the finds, what kind of mobility strategy the site was a part of. With this is mind, analyses suitable for the study of future activity planning (Larson 1994) and the relative length of occupation were conducted.

The survey finds collected when the site was found in 1999 include eight artefacts of grey chert, three of quartz, and one of quartzite. The excavation yielded altogether 932 lithic artefacts. Of these 718 are of grey chert, 184 of quartz, and 28 of different kinds of quartzite. In addition, one flake of black chert and a piece of pumice were found. All the lithic artefacts were divided into analytical nodules (*sensu* e.g. Larson 1994). According to this division the assemblage consists of nine analytical nodules, i.e. the piece of pumice, five kinds of quartzite, two kinds of chert and the artefacts of white quartz (Figure 16.3). Although the raw material of the quartz artefacts varies from white to transparent, they were all classified as one analytical nodule. The reason for this is the fact that in the local quartz both transparent and milky quartz are often encountered in the same piece.

The only raw materials available locally are quartz and coarse-grained white quartzite. Of these, quartz has been frequently encountered in surveys but the coarse-grained quartzite only occasionally (Manninen 2005, 32–3). All the other raw materials used at the Mávdnaávži 2 site are exotic to the area. The nearest known sources for grey chert are located on the shores of Porsangerfjord and Varangerfjord (Figure 16.1) and it is quite safe to say that the grey chert at the site has a coastal origin. The same applies to the piece of pumice and probably also for the black chert. The fine-grained quartzites are not local, but with current knowledge it is not possible to define a source area for them.

At the site grey chert was used for oblique points and other kinds of backed pieces and retouched flakes (Figure 16.3). All the points and point fragments found in the excavation were located within the hut area, mostly in and around the hearth. It is probable that some of the point fragments have been left at the spot as a consequence of repairing broken arrows. The relatively large amount of point fragments that do not refit with other fragments supports this view. There are, however, three base fragments and three distal parts of points that do refit. At least two of these have broken during manufacture by fractures initiating from retouch scars. An interesting detail is that two of the six fragments are burnt and were obviously dropped into the fire. This has resulted in refits between burnt basal parts of points and un-burnt tips.

The overall picture of the chert material suggests that points at the site were manufactured mainly from irregular flakes/blade-flakes, but it is unclear whether the flakes were brought to the site as ready-made blanks or as a core that was not left there. It seems also likely that at least part of the retouched chert flakes are actually rejected point preforms.

Quartz and quartzite were used for scrapers. The quartz and quartzite flakes, as well as the sixteen scrapers of these raw materials found in the excavation, were located next to the presumed hearth in the middle of the outside activity area. Five of the six quartzite scrapers found at the site are made of different kinds of fine-grained quartzite. Besides these, the quartzite assemblage consists of retouch flakes of the same raw materials and three larger pieces of quartzite, of which two fit together and form a complete flake.

The quartz assemblage is more difficult to tackle because of the homogeneity of the material and difficulties related

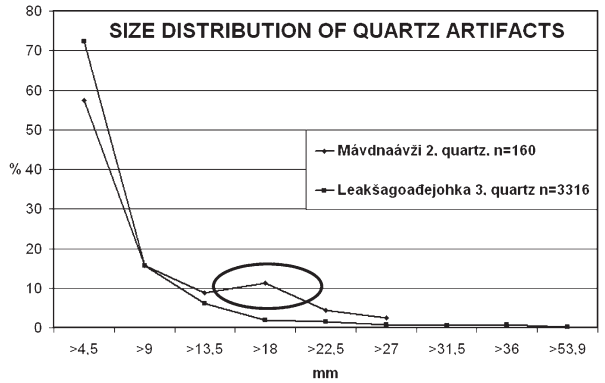


Figure 16.4. Size distribution of quartz artefacts. Leakšagoađejohka 3 (see Manninen 2002).

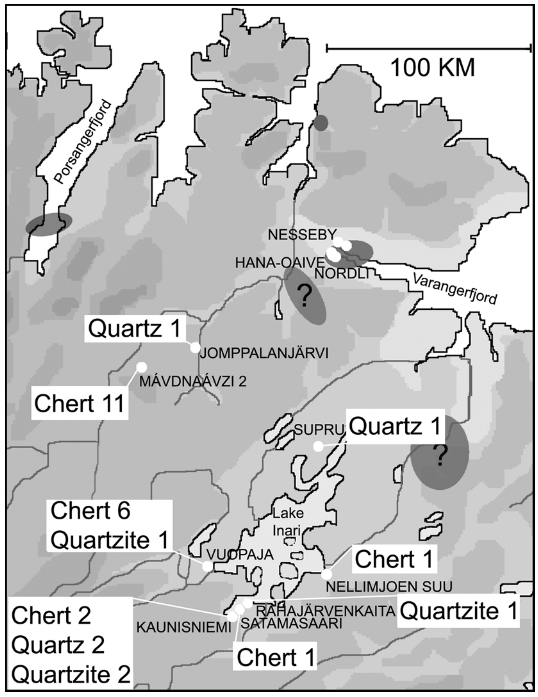


Figure 16.5. The amount of oblique points of different raw materials at sites around and north of Lake Inari. Grey chert: Utsjoki Mávdnaávži 2, 11 points; Inari Vuopaja, 4 points; Inari Kaunisniemi 3, 1 point. The other chert points are of tuffaceous chert and black chert.

to the study of quartz (Rankama *et al.*, in press). In addition to the twelve scrapers in the quartz assemblage there are several clear retouch flakes, one bipolar core, and a fair amount of flakes and fragments of different sizes. The size distribution of the quartz assemblage, however, did not seem to be a result of a complete reduction sequence. To find out if this is true, the size distribution of the assemblage was compared to the size distribution of a quartz-knapping floor situated circa 15km south-east of the Mávdnaávži 2 site (Manninen 2002) (Figure 16.4).

The comparisons revealed that there is an over-representation of quartz artefacts with a minimum dimension of *c.* 20mm in the assemblage and a relatively small amount of small flake fragments and chips. This corresponds with the picture given by the quartzite artefacts of a situation where ready-made scrapers and scraper blanks were brought along to the site and retouched to make new scrapers and to rejuvenate used edges.

In summary, the results of the analyses suggest that the site was a single-occupation hunting camp used by a group of foragers coming from the coast. All the lithic material was brought to the site as ready-made tools, flake blanks, and possibly also as a core of grey chert. Although tools of coastal raw material were carried along to the site, local quartz was used for re-tooling. The technology was not specialized in a way that moving away from the sources of coastal fine-grained raw materials would have affected it. In fact, the manufacturing of scrapers from blanks of local quartz indicates that quartz blanks were also collected for further use; and the discarding of blanks of fine-grained quartzite and chert reveal that these raw materials were not overly valued. This, combined with the fact that several different kinds of exotic raw materials were used at the site, is clear evidence of a highly mobile group, who had a technology suitable for all the raw materials encountered while changing places both in the coastal area and in the inland region.

The Model based on the Lake Inari region

The traces of a mobile group at Mávdnaávži 2 unrestricted by the locations of sources for fine-grained lithic raw-materials, encourages one to evaluate whether some of the other known Late Mesolithic assemblages indicate a similar pattern. The data presented here covers only the sites with reported oblique points or points that I have observed while analysing 'older' assemblages. It is probable that the amount of sites with oblique points will increase with further analysis, and it should be noted that there are more sites with Late Mesolithic dates in the area than the ones discussed here (see Kankaanpää and Rankama 2005). Therefore the model presented in this paper should be considered provisional until further analysis has been conducted.

In the area around and north of Lake Inari, excavations have been conducted at, at least, three other sites with oblique points: Inari Supru Suprunoja (Nieminen 1984), Inari Vuopaja (Seppälä 1993; 1994), and Inari Nellimjoen suu S (Sohlström 1992). The Mávdnaávži 2 site, however, is the only clear single-occupation site. Besides the excavated sites, there are at least five sites that have yielded oblique points in surveys: Inari Satamasaari, Inari Rahajärvenkaita, Inari Kaunisniemi 2, Inari Kaunisniemi 3 (Arponen 1990), and Utsjoki Jomppalanjärvi W (Rankama and Kankaanpää 1997).

Oblique points of grey chert (five points), black chert (two points), tuffaceous chert (three points), quartz (four points) and different kinds of quartzite (three points) have been found at these sites (Figure 16.5). At the Utsjoki Jomppalanjärvi W site, an implement of grey chert has also been found alongside an oblique point of quartz (Rankama and Kankaanpää 1997). The material from

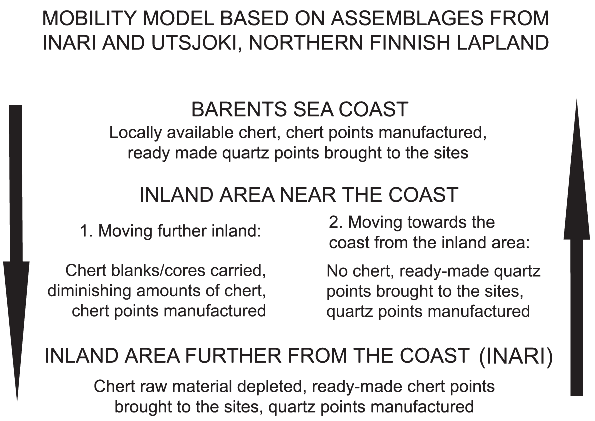


Figure 16.6. Schematic mobility model based on the assemblages discussed in the text. The model predicts what kind of Late Mesolithic assemblages should be found in and between the Barents Sea coast and the inland region.

these sites is too limited to make any definite conclusions, but it should be noted that the Mávdnaávži 2 site is the only site with evidence of chert point manufacture. For instance, the extensively excavated multi-period Inari Vuopaja-Saamenmuseo site complex on the western shore of Lake Inari has yielded two points of black chert, and four points and three flakes/bladeflakes of grey chert in two separate concentrations, but no debitage from chert point manufacture.

Although restricted, the available material allows the making of a schematic mobility model for the area (Figure 16.6). The starting point in the model is the area with the chert sources, i.e. the Barents Sea coast. The amount of grey chert, as well as other coastal raw materials, decreases towards the Lake Inari region. This should be seen in the archaeological material as a succession from sites with chert point manufacturing debitage and chert points, to sites where only quartz points and debitage is found. This would also result in sites with only quartz points and debitage and sites with only chert points and chert point manufacturing debitage in the same area, i.e. in the 'transitional zone' between the coast and the Lake Inari region. The model also predicts that oblique quartz points should be found at Late Mesolithic coastal sites, an artefact category thus far not reported in the literature concerning the coastal sites. In support of the model, however, Grydeland (2000, 44–5) has noted that quartz artefacts are very common at many Late Mesolithic sites, for instance on the shores of Varangerfjord.

To conclude, the fact that the same forager groups used both the coastal region and the inland region in the Late Mesolithic of northern Fennoscandia, as has been suggested in some of the earlier research, seems to be, if not verified, at least highly probable in light of the new data. The model presented in this paper, derived from a combination of previous research and the new data, still needs further developing and testing. It is clear, however, that long distance mobility existed in the area during the Late Mesolithic, at least to some degree. The nature of, and the reasons for this mobility, however, still need further research.

Acknowledgements

The excavations at the Mávdnaávži 2 site and the lithic analyses were financed by the Finnish Cultural Foundation, and the writing of this paper by the Emil Aaltonen foundation. I thank Petri Halinen, Esa Hertell, Bryan Hood, Eeva-Kristiina Lahti, Tuija Rankama, Hanna Suisto, Miikka Tallavaara, Riikka Tevali, Taarna Valtonen and Meri Varonen for their aid and comments, and the organizers of MESO 2005 for the opportunity to present this paper.

References

Arponen, A. 1990. *Inari. Rahajärven arkeologinen inventointi 1990*. Archived survey report. Helsinki, National Board of Antiquities, Department of Archaeology.

Bronk Ramsey, C. 2005. OxCal 3.10. WWW program and documentation available at http://www.rlaha.ox.ac.uk/oxcal/oxcal.htm (accessed 10/2007).

Bølviken, E., Helskog, E., Helskog, K., Holm-Olsen, I. M., Solheim, L. and Bertelsen, R. 1982. Correspondence analysis: an alternative to principal components. *World Archaeology* 14 (1), 41–60.

Carpelan, C. 2004. Environment, Archaeology and Radiocarbon Dates. Notes from the Inari Region, Northern Finnish Lapland, in M. Lavento (ed.), *Early in the North, 5*, 17–45. Iskos 13. Helsinki, The Finnish Antiquarian Society.

Engelstad, E. 1989. Mesolithic House Sites in Arctic Norway, in Bonsall, C. (ed.) *The Mesolithic in Europe. Papers presented at the Third International Symposium, Edinburgh 1985*, 331–7. Edinburgh, John Donald Publishers.

Gjessing, G. 1942. *Yngre steinalder i Nord-Norge*. Serie B, Skrifter 39. Oslo, Instututtet for sammenlignende kulturforskning.

Grydeland, S.-E. 2000. Nye perspektiver på eldre steinalder i Finnmark – En studie fra indre Varanger. *Viking* LXIII, 10–50.

Grydeland, S.-E. 2005. The Pioneers of Finnmark – from the earliest coastal settlements to the encounter with the inland people of Northern Finland, in H. Knutsson (ed.), *Pioneer settlements and colonization processes in the Barents region*, 43–77. Vuollerim Papers on Hunter-Gatherer Archaeology 1. Vuollerim, Vuollerim Museum Press.

Halinen, P. 2005. *Prehistoric Hunters of Northernmost Lapland. Settlement patterns and subsistence strategies*. Iskos 14. Helsinki, The Finnish Antiquarian Society.

Havas, H. 1999. *Innland uten landgrenser. Bosetningsmodeller I det nordligeste Finland og Norge I perioden 9000-6000 BP*. MA thesis, University of Tromsø.

Helskog, E. 1978. Finnmarksviddas kulturhistorie, in *Finnmarksvidda – nature – kultur*, 135–44. Norges offentlige utredninger (NOU) 1978, 18A. Oslo, Universitets-forlaget.

Helskog, K. 1974. Stone Age Settlement Patterns in Interior North Norway. *Arctic Anthropology* XI (Supplement), 266–71.

Helskog, K. 1980. *Subsistence-Economic Adaptations to the Alpine Regions of Interior North Norway*. PhD thesis. University of Wisconsin-Madison. Ann Arbor, University Microfilms.

Hesjedal, A., Damm, C., Olsen, B. and Storli, I., 1996. *Arkeologi på Slettnes. Dokumentasjon av 11. 000 års bosetning*. Tromsø Museums Skrifter 26, Tromsø, University of Tromsø.

Hood, B. C. 1988. Undersøkelse av en steinalderboplass ved Aksujavri, Kautokeino kommune, Finnmark, in E. Engelstad and M. Holm-Olsen (eds.), *Arkeologisk feltarbeid i Nord-Norge og på Svalbard 1986*, 23–31. Tromura, Kulturhistorie 14. Tromsø, Universitetet i Tromsø.

Hood, B. C. 1992. *Prehistoric Foragers of the North Atlantic: Perspectives on Lithic Procurement and Social Complexity in the North Norwegian Stone Age and the Labrador Maritime Archaic*. Unpublished PhD thesis, University of Massachusetts.

Kankaanpää, J. and Rankama, T. 2005. Early Mesolithic pioneers in Northern Finnish Lapland, in H. Knutsson (ed.), *Pioneer settlements and colonization processes in the Barents region*, 109–61. Vuollerim Papers on Hunter-Gatherer Archaeology 1. Vuollerim, Vuollerim Museum Press.

Larson, M. L. 1994. Toward a Holistic Analysis of Chipped Stone Assemblages, in P. J. Carr (ed.), *The Organization of North American Prehistoric Chipped Stone Tool Technologies*, 57–69. International Monographs in Prehistory, Archaeological Series 7. Ann Arbor, Department of Anthropology, University of Michigan.

Lehtinen, M., Nurmi, P. and Rämö, T. 1998. *Suomen Kallioperä 3000 vuosimiljoonaa*. Jyväskylä, Suomen Geologinen Seura.

Manninen, M. A. 2002. *Utsjoki Leakšagoađejohka 3. Esihistoriallisen kvartsikeskittymän kaivaus*. Archived excavation report. Helsinki, National Board of Antiquities, Department of Archaeology.

Manninen, M. A. 2005. Problems in Dating Inland Sites – Lithics and the Mesolithic in Paistunturi, Northern Finnish Lapland, in H. Knutsson (ed.), *Pioneer settlements and colonization processes in the Barents region*, 29–41. Vuollerim Papers on Hunter-Gatherer Archaeology 1. Vuollerim, Vuollerim Museum Press.

Nelson, M. C. 1991. The Study of Technological Organization, in M. B. Schiffer (ed.), *Archaeological Method and Theory* 3, 57–100. Tuscon, University of Arizona Press.

Nieminen, E.-L. 1984. *Inari 331 Supru, Suprunoja. Kertomus kivikautisen asuinpaikan kaivauksesta 1984*. Archived excavation report. Helsinki, National Board of Antiquities, Department of Archaeology.

Nummedal, A. 1938. Yngre stenaldersfunn fra Nyelven og Karlebotn I Østfinnmark II. *Universitetets oldsaksamling årbok* 1937, 1–26.

Odner, K. 1964. Erharv og bosetning i Komsakulturen. *Viking* XXVIII, 117–28.

Odner, K. 1966. *Komsakulturen i Nesseby og Sør-Varanger*. Skrifter XII. Tromsø, Tromsø Museums.

Olsen, B. 1994. *Bosetning og samfunn i Finnmarks forhistorie*. Oslo, Universitetsforlaget.

Rankama, T. and Kankaanpää, J. 1997. *Utsjoki 209 Jomppalanjärvi W. Arkeologisen kohteen tarkistus*. Archived inspection report. Helsinki, National Board of Antiquities, Department of Archaeology.

Rankama, T. 2003. The colonisation of northernmost Finnish Lapland and the inland areas of Finnmark, in L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler and A. Åkerlund (eds.), *Mesolithic on the Move: Papers presented at the Sixth International Conference on the Mesolithic in Europe, Stockholm 2000*, 684–7. Oxford, Oxbow Books.

Rankama, T., Manninen, M. A., Hertell, E. and Tallavaara, M. (in press). Simple Production And Social Strategies - Do They Meet? Social Dimensions in Eastern Fennoscandian Quartz Technologies, in *Skilled production and Social reproduction: Aspects of Traditional Stone-Tool Technologies*. Societas Archaeologica Upsaliensis (SAU) Report Series. Uppsala, Societas Archaeologica Upsaliensis.

Reimer P. J., Baillie, M. G. L., Bard, E., Bayliss, A., Beck, J. W., Bertrand, C., Blackwell, P. G., Buck, C. E., Burr, G., Cutler, K. B., Damon, P. E., Edwards, R. L., Fairbanks, R. G., Friedrich, M., Guilderson, T. P., Hughen, K. A., Kromer, B., McCormac, F. G., Manning, S., Bronk Ramsey, C., Reimer, R. C., Remmele, S., Southon, J. R., Stuiver, M., Talamo, S., Taylor, F. W., van der Plicht, J., and Weyhenmeyer, C. E. 2004. IntCal04 terrestrial radiocarbon age calibration, 0-26 cal kyr BP. *Radiocarbon* 46 (3), 1029–58.

Schanche, K. 1988. *Mortensnes - en boplass i Varanger. En studie av samfunn og materiell kultur gjennom 10.000 år*. MA thesis, University of Tromsø.

Seppälä, S.-L. 1993. *Inari 13 Vuopaja. Kivi- ja varhaismetallikautisen asuinpaikan kaivaus* (13–27 July 1993). Archived excavation report. Helsinki, National Board of Antiquities, Department of Archaeology.

Seppälä, S.-L. 1994. *Inari 13 Vuopaja. Kivi- ja varhaismetallikautisen asuinpaikan kaivaus* (13 June–18 July 1994). Archived excavation report. Helsinki, National Board of Antiquities, Department of Archaeology.

Simonsen, P. 1961. *Varanger-Funnene II. Fund og udgravninger på fjordens sydkyst*. Tromsø Museums Skrifter VII (2). Tromsø, Tromsø Museum.

Skandfer, M. 2003. *Tidlig, nordlig kamkeramikk. Typologi-kronologi-kultur*. Unpublished PhD thesis. University of Tromsø.

Sohlström, B. 1992. En stenåldershydda – en bosättningsanalys. *Kentältä poimittua. Museovirasto, esihistorian toimisto, julkaisu* 2, 27–38.

Tallavaara, M. 2005. Arkeologisen kiviaineiston nodulianalyysi. Sovellusesimerkki Rääkkylän Vihin kampakeraamisen ajan asuinpaikan piikivimateriaaliin. *Muinaistutkija* 2/2005, 14–23.

Thommessen, T. 1996. The Early Settlement of Northern Norway, in L. Larsson, L. (ed.), *The Earliest Settlement of Scandinavia and its relationship with neighbouring areas*, 235–40. Acta Archaeologica Lundensia, Series in 8°, 24. Stockholm, Almquist & Wiksell International.

Torvinen, M. 2000. Säräisniemi 1 ware. *Fennoscandia Archaeologica* XVI, 3–35.

Valtonen, T. 1999. *Utsjoen Paistunturien inventointi* (6–28 June and 9–26 August 1999). Archived survey report. Helsinki, National Board of Antiquities, Department of Archaeology.

Woodman, P. C. 1993. The Komsa Culture: a re-examination of its position in the Stone Age of Finnmark. *Acta Archaeologica* 63/1992, 57–76.

PAPER III

Tallavaara, M., Manninen, M. A., Hertell, E. & Rankama, T. 2010. How flakes shatter: a critical evaluation of quartz fracture analysis. *Journal of Archaeological Science* 37, 2442–2448. Reprinted with permission from Elsevier.

Journal of Archaeological Science 37 (2010) 2442–2448

Contents lists available at ScienceDirect

Journal of Archaeological Science

journal homepage: http://www.elsevier.com/locate/jas

How flakes shatter: a critical evaluation of quartz fracture analysis

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ARTICLE INFO

Article history:
Received 11 March 2010
Received in revised form
5 May 2010
Accepted 6 May 2010

Keywords:
Experimental archaeology
Quartz
Flake fragmentation
Fracture analysis
Lithic technology
Technological organisation
Statistical analyses

ABSTRACT

Despite its worldwide use as a stone tool raw material, quartz is known to be a difficult material for archaeologists. The main reason for this is the tendency of quartz flakes to fragment during detachment, which complicates the use of traditional lithic analyses. In this article we present an experimental study of quartz flake fragmentation. We evaluate the method called *fracture analysis* that has been developed and used explicitly for the study of quartz assemblages. The method assumes high predictability of quartz flake fragmentation, but our experiments show that there is significant variation in fragmentation that fracture analysis does not take into account. Our results indicate that this variation is partly explained by indenter hardness, the relative thickness of the detached flake, as well as individual knapper-related factors. These results undermine the applicability of quartz fracture analysis in its current form. In addition, we discuss the effects of flake fragmentation on the technological organisation of prehistoric quartz users and suggest that it has affected reduction strategies as well as blank and tool dimensions. We also suggest that there should be mobility-related differences in archaeological assemblages in terms of the quality of the quartz raw material and that the curation of quartz should be low in relation to better quality raw materials used parallel with it.

1. Introduction

Different varieties of macrocrystalline quartz have been widely used as raw material for small stone tools in different parts of the world (e.g. Ballin, 2008; Bisson, 1990; Callahan, 1987; de la Torre, 2004; Flenniken, 1980; Holdaway and Stern, 2004; Leng, 1998; Pearson, 2003; Rankama et al., 2006; Seong, 2004). However, quartz assemblages pose a problem for archaeologists since they do not lend themselves easily to traditional lithic analyses. One of the main reasons for this is the inherent tendency of quartz flakes to shatter during detachment. The fragmentation of flakes clearly complicates techno-typological and aggregate analyses of debitage and can also lead astray those working with stone tool typologies.

In the late 1980s and early 1990s, a group of archaeologists from Sweden and the United States developed a method that explicitly takes advantage of this troublesome characteristic of quartz (Callahan et al., 1992; see also Knutsson, 1988, 1998; Knutsson and Lindgren, 2004). They called the method *fracture analysis*. The essential assumption behind fracture analysis is that the proportions of different fragment types (including intact flakes) produced during core reduction are fixed.

Even though Callahan et al. (1992) considered their results preliminary, fracture analysis has subsequently been employed without further scrutiny of the original arguments (Darmark and Sundström, 2005; Falkenström and Lindberg, 2007; Huang and Knutsson, 1995; Lindberg, 2009; Lindgren, 2004; Rankama, 2002, 2003, 2009; Räihälä, 1998, 1998; Sandén, 1998). In this article, we present the first independent test of the premises of fracture analysis. Our experimental data and statistical analyses show that the essential assumption about the predictability of quartz flake fragmentation is problematic, thus undermining the applicability of the method in its present form. Hoping that our work will contribute to future refinements of quartz analysis, we also explore the factors that cause this unexpected variation in fragmentation by considering the effects of indenter hardness, flake dimensions and differences relating to individual knapping styles. In addition, we discuss the possible effects of flake fragmentation on the technological organisation of prehistoric quartz users.

2. Principles of quartz fracture analysis

In theory, quartz behaves in essentially the same way as any brittle material, such as flint. The basic flake initiation and termination types can be observed in quartz flakes although the fracture surfaces are often noticeably more rugged in quartz than in flint. The biggest difference from a lithic technological perspective derives from flake fragmentation. Although flint flakes also often

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0305-4403/$ – see front matter
doi:10.1016/j.jas.2010.05.005

fragment during detachment (Amick and Mauldin, 1997; Hiscock, 2002), fragmentation is much more common in quartz. The reasons behind the higher fragmentation tendency of quartz flakes can probably be found in such properties as the raw material's relatively low tensile and compressive strength and its fairly high amount of internal flaws (Cotterell and Kamminga, 1990:129; Domanski et al., 1994).

Through analyses of experimental and archaeological materials in Sweden, Callahan et al. (1992) showed that the fragmentation of quartz flakes is not random but follows the laws of material science. They argued that fragmentation is caused by different variants and combinations of radial and bending fractures (Figs. 1 and 2). Radial fracturing causes flakes to split radially from the point of percussion, whereas flakes snapped crosswise develop through bending fractures. Unlike radial fractures, the latter are not associated with the applied force at the point of percussion but are most likely formed through vibrations developing in the flake during detachment. Callahan et al. also argued that the proportions of different fragment types produced during core reduction are predictable when the reduction method employed (bipolar or platform) is known.

All this should make it possible for analysts first to classify excavated quartz material into different fragment types and then to compare these archaeological fracture profiles (distributions of fragment types) to experimental ones in order to determine how they differ, i.e. whether some fragment types are over or underrepresented in the archaeological assemblage. These differences have been used to infer the kinds of cultural formation processes that have formed the studied archaeological quartz assemblages (e.g. Huang and Knutsson, 1995; Lindberg, 2009; Lindgren, 2004; Rankama, 2003, 2009; Räihälä, 1998, 1999). Drawing reliable conclusions about the differences presupposes that the experimental fragment distributions used as comparisons do not differ from each other in any significant manner. So far, this has been assumed rather than tested statistically.

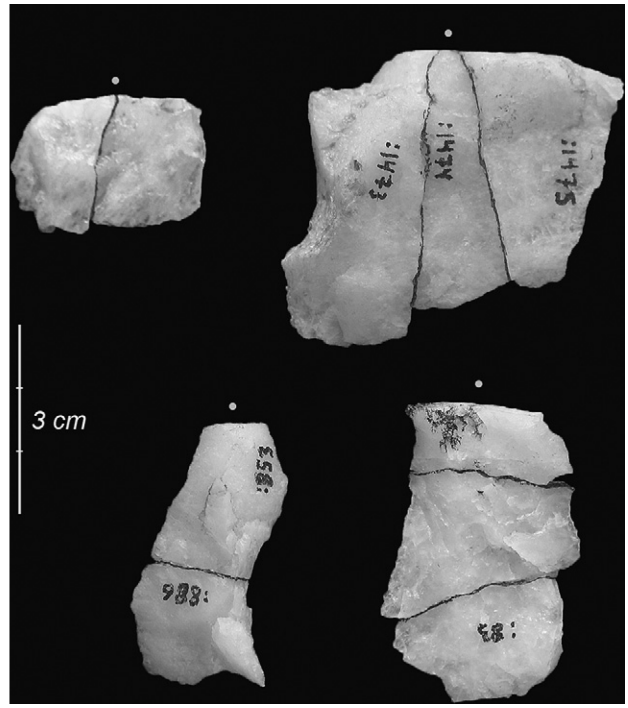

Fig. 2. Prehistoric examples of radial (top) and bending fractures in conjoined quartz flakes from the Leakšagoađejohka 3 knapping floor in Finland (Manninen, 2003).

Another problem relates to the detection of differences between archaeological and experimental fracture profiles. Ever since the publication of the original article, comparisons of profiles have been done by eye, which, in our view, is a major problem, as eyeballing can be very subjective. Since the analysis is basically all about comparing fragment distributions, in other words counts of different fragment types, χ^2-statistics offers an evident and more objective way to determine whether the observed archaeological fragment distribution differs from the expected fragment distribution based on the experimental data.

However, the construction of a reasonable baseline distribution that is based on experimental data demands again that the distributions produced in different experiments do not differ statistically from each other. This requirement is, in many ways, essential to the applicability of fracture analysis. Therefore, we wanted to study whether or not the requirement is fulfilled, and if not, what might cause variation in the fragmentation.

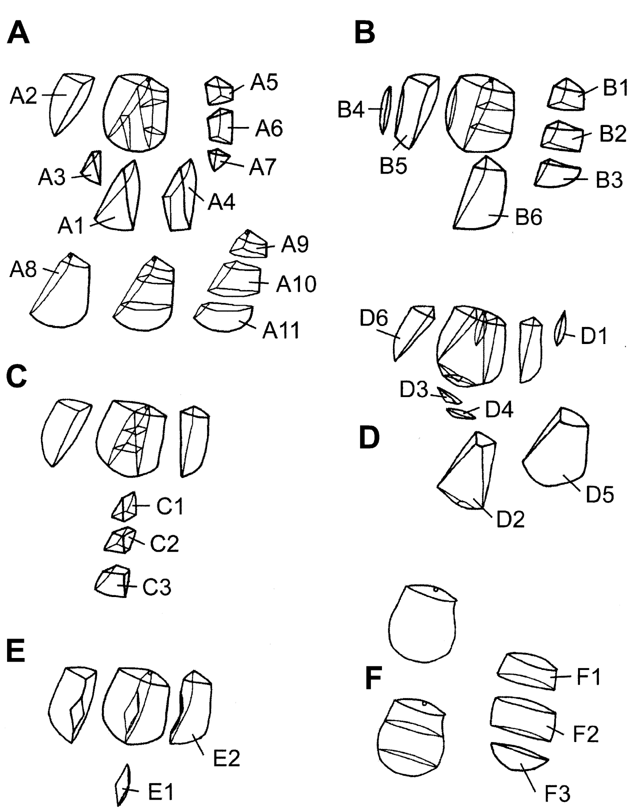

Fig. 1. Exploded views of quartz fragment types (modified from Callahan et al., 1992: Fig. 3; Rankama, 2002: Fig. 2).

Table 1
Categorisation of observed fragment types (see Fig. 1 for reference). These fragment categories are used in the graphs and in the statistical analyses.

Fragment category (abbreviation)	Fragment types included
Side fragment (sidefr)	A2, A8, B5, B6, D5, D6
Distal fragment (distfr)	A3, A7, A11, B3, C3, F3
Intact flake (intact)	F
Proximal end of side fragment (peosfr)	A5, A9, B1
Proximal fragment (proxfr)	F1
Medial fragment (medialfr)	A6, A10, B2, C2, F2
Proximal end of middle fragment (peomfr)	C1
Chip (chip)	
Middle fragment (middlefr)	A1, A4, D2

Table 2
Frequencies of different fragment types in the experimental knapping series. The series are labelled using the initials of the knapper's first and last names and the indenter type (H = hard hammer, S = soft hammer). For the χ^2-test[a] the last three fragment categories were excluded.

Series	Fragment category								
	sidefr	distfr	intact	peosfr	proxfr	medialfr	peomfr	chip	middlefr
EHH	29	24	15	11	14	9	3	6	4
MTH	26	35	8	16	14	7	2	6	5
TRH	17	17	20	15	8	5	1	0	0
MMH	23	32	15	22	11	13	4	7	0
EHS	13	22	15	15	17	11	0	2	1
MTS	8	37	13	16	17	17	1	5	0
TRS	16	24	15	21	11	18	0	6	1
MMS	17	28	14	28	13	28	0	14	2

[a] $\chi^2 = 67.18$, d$f = 35$, $P < 0.001$.

3. Experimental design and treatment of the data

In order to test whether quartz core reduction always produces similar fragment distributions, we designed a simple experiment where four knappers (the authors of the present article) each reduced two quartz cores, one with hard hammer (sandstone pebble, 206 g) and the other with soft hammer (reindeer antler, 325 g). All the cores derived from the same large chunk of quarried

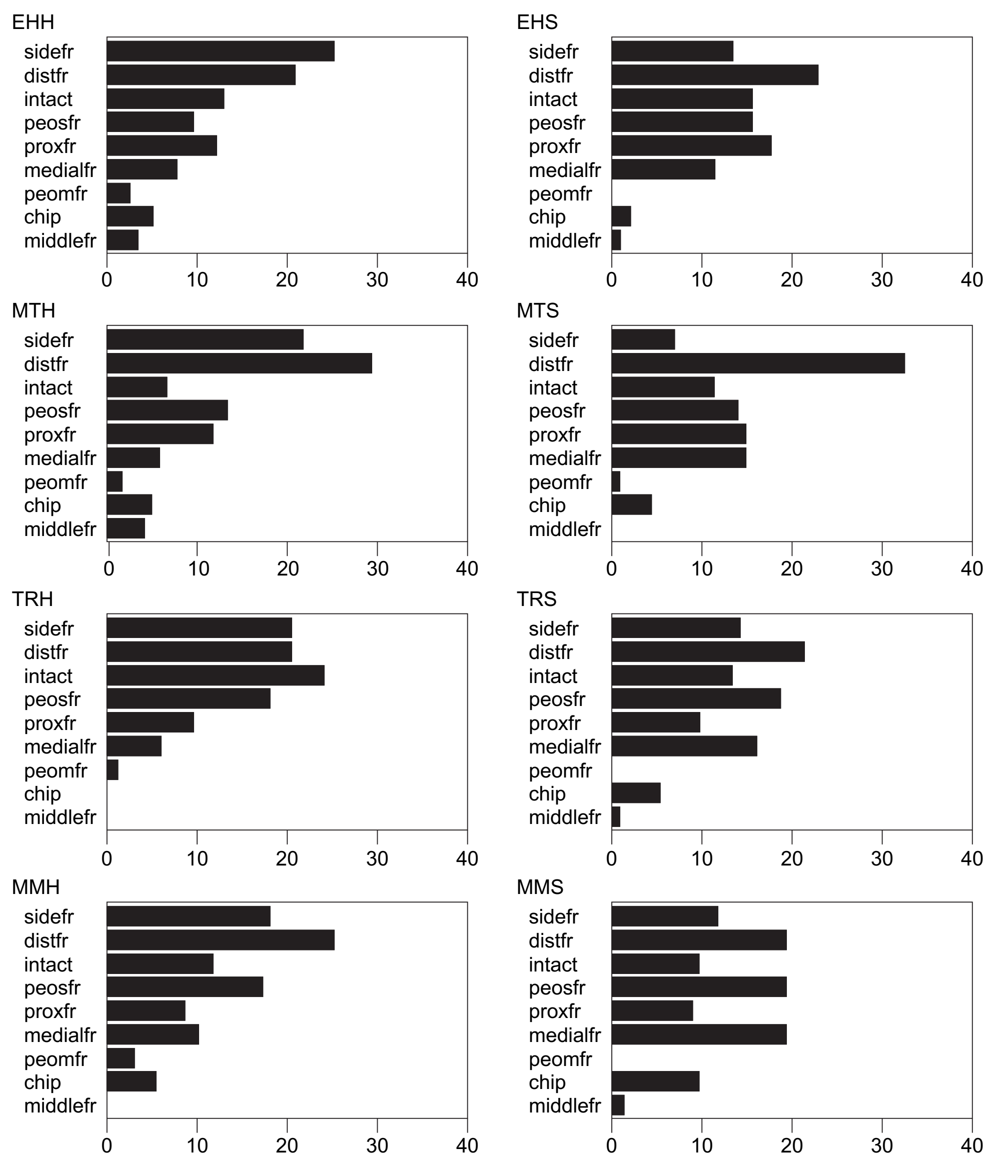

Fig. 3. Fracture profiles of the experimental series. The *X*-axis gives the proportion (%) of each fragment category. The series are labelled using the initials of the knapper's first and last name and the indenter type (H = hard hammer, S = soft hammer).

vein quartz to ensure that the raw material remained constant throughout the experiment.

We considered individual knapping style and indenter hardness as possible sources of variation and therefore as independent variables. Indenter characteristics have proven to have an effect on flake formation and probably on fragmentation as well (Dibble and Pelcin, 1995; Mourre, 1996; Pelcin, 1997). It also seems reasonable that individual differences between knappers, such as applied hammer velocity, flaking angles and modes of core support, affect fragmentation. As we were not able to control all these individual-related factors separately, we focused only on the general differences in the knapping series produced by different knappers. In addition to knapping style and intender hardness, we explored the effects of flake dimensions on fragmentation. Since Callahan et al. (1992) were able to show satisfactorily that bipolar and platform reduction methods produce fragment distributions that look different, we did not vary the flaking method in our experiment. Instead, all the cores were reduced using free-hand platform flaking.

The aim of each knapper was to produce 50 detachments from the core. In reality, the number varied between 47 and 57, the total number being 413. After each successful blow, all detached pieces — the intact flake or a group of fragments — were bagged and tagged. During the first round of analysis, the pieces of fragmented flakes were conjoined and glued together and the initial determination of fragment types was made by all the participants. Before gluing, the fracture planes were coloured to ease fragment type identification. During the second round, MM and MT measured the length, width, thickness and weight of each intact and conjoined flake. They also re-analysed the fragment types and made some changes to the earlier determinations (see Supplementary data). Despite all efforts, part of the fragments cannot be classified according to the classification scheme. There are altogether 91 unidentified pieces in the data that are mainly small unconjoinable fragments and secondary detachments. It is worth noting that the scale-like fragment types reported by Mourre (1996) are not included in this scheme and therefore, if present, are included in the group of unidentified fragments.

Finally, the data were analysed by MT to determine, first, whether individual fragment distributions differed from each other in a statistically significant way, and second, whether individual knapping style and indenter hardness had an effect on flake fragmentation. The analysis was carried out using methods suitable for categorical data: correspondence analysis, loglinear modelling and logistic regression (e.g. Agresti, 2002; Greenacre, 2007). For the analysis, the different fragment types were grouped according to the categorisation used in previous studies (Table 1).

4. Results

Table 2 and Fig. 3 show the fragment distributions of the eight experimental series. Visual inspection alone suggests that the distributions differ from each other, and this observation is strongly supported by χ^2-test statistics. For the statistical test, we excluded middle fragments and proximal ends of middle fragments since their frequencies are very low. In addition, chips were excluded from the statistical analyses since they are not very informative regarding actual flake fragmentation.

As our experiment demonstrated that quartz core reduction does not always produce similar fragment distributions even if the flaking method is controlled, the next question naturally became, whether indenter hardness and/or individual knapping style might explain the variation in the fragment distributions. Fig. 4 shows the first two dimensions of a correspondence analysis where the three fragment categories mentioned above have been excluded. It

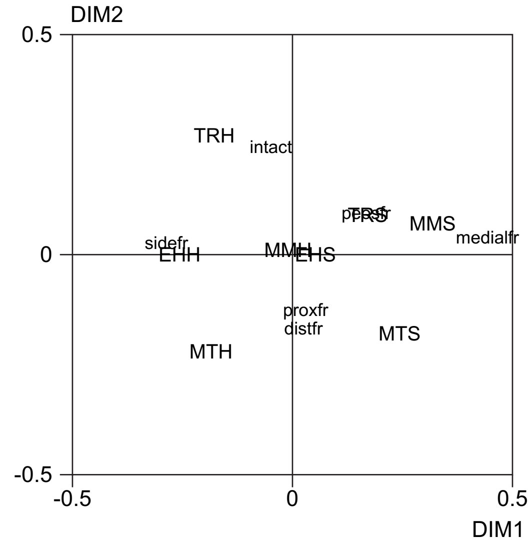

Fig. 4. The first two dimensions of the correspondence analysis of the fragment data. The series are labelled using the initials of the knapper's first and last name and the indenter type (H = hard hammer, S = soft hammer). For this analysis, chips, middle fragments, and their proximal ends were excluded.

suggests that at least indenter hardness does have an effect on flake fragmentation, since the series produced with different indenters appear to place themselves at the opposite ends of the first dimension. The correspondence analysis also shows that side fragments, i.e. radial fractures, are typical of detachments produced with hard indenters, whereas medial fragments, probably formed through bending, are more typical of soft indenters.

The two-dimensional solution further suggests that individual knapping style might have an effect on fragmentation, since different knappers are placed on different levels of the second dimension although EH and MM are very close to each other. These differences may also be associated with skill: EH and MM are more experienced knappers than TR and MT. This may indicate that increasing skill will decrease variation between individual knappers. Therefore, the individual-related variation in fragmentation may have been less severe in the prehistoric context than in modern experiments. However, further experiments are needed to confirm the possible effects of skill on the fragmentation.

The idea that both indenter hardness and individual knapping style and/or skill have an effect on flake fragmentation is supported by the results of loglinear modelling (Table 3). The model that takes into account the association between indenter hardness and fragment distribution already fits the data, but the fit is significantly enhanced when the interaction between the individual knapper and fragment distribution is included. It is noteworthy that Model 3 is almost as good as a saturated model ($D^* = 0.9$).

Table 3
Goodness-of-fit tests and model comparisons for loglinear models of the experimental data (see Table 2). For this analysis, chips, middle fragments, and their proximal ends were excluded. I = indenter hardness, K = knapper, F = fragment category.

Model	Deviance G^2	*df*	*P*-value[a]	Models compared	Deviance difference	*P*-value[b]
M_0 intercept	140.76	47	<0.0001			
M_1 I, K, F	69.86	38	0.0012	M_0–M_1	70.90 ($df = 9$)	<0.0001
M_2 K, I*F	41.21	33	0.15	M_1–M_2	28.65 ($df = 5$)	<0.0001
M_3 I*F, K*F	12.68	18	0.81	M_2–M_3	28.53 ($df = 15$)	0.02

[a] *P*-value for G^2.
[b] *P*-value for deviance difference.

Since it seems intuitively reasonable that flake dimensions may have something to do with flake fragmentation, we modelled the effects of flake dimensions using logistic regression analysis. The response categories chosen for the analyses were the occurrence of intact flakes, the occurrence of bending fractures and the occurrence of radial fractures. As occurrences of bending and radial fractures are not mutually exclusive, we built separate models for each response category instead of using multinomial logistic regression. To avoid multicollinearity we did not use all the dimension measures as independent variables but instead created a new variable, *relative thickness* (thickness (mm)/length (mm)), and used it as an explanatory variable in the models. We used only flakes whose dimensions could be measured reliably. The effect of indenter hardness was also studied with these models.

The results in Table 4 suggest that the relative thickness of the flake has an effect on fragmentation. Increasing relative thickness increases the odds of flake staying intact and evidently decreases the odds of radial and, especially, bending fractures. Indenter hardness seems to have a statistically significant effect only on the occurrences of radial fractures, which supports the earlier observations by Mourre (1996). However, despite the statistically significant effects of the relative thickness of flake and indenter hardness, the predictive power of all the models is weak. This indicates that there are still many unmeasured factors affecting flake fragmentation. These factors probably relate to differences in knapping styles and/or skill that we were not able to measure here. It is also likely that factors dependent on the variety of quartz, such as the amount of internal flaws, cause variation in fragmentation that is random and not dependent on basic fracture mechanics.

5. Discussion

5.1. Problems of fracture analysis

In Section 2, we argued that for fracture analysis to work, experimentally produced fragment distributions should not differ from each other in a statistically significant way. It now appears that this premise is not valid, as there are clear differences between our experimental series. Differences are evident also in the experimental data produced by Callahan et al.: for the four experimental series produced by platform flaking, $\chi^2 = 36.28$, d$f = 15$ and $P = 0.002$ (Callahan et al., 1992: 44, fragment categories 5, 6 and 9 excluded).

It is also clear that there are several factors causing variation in the fragmentation of quartz flakes. Previously, it has been shown that flaking method is such a factor (Callahan et al., 1992) and our results add indenter hardness, flake dimensions, and factors relating to individual knapping style and/or skill to the list. Our results also suggest that there are still other factors that have not yet been studied. Similarly, experiments by Amick and Mauldin (1997) on different raw materials show that several factors, including raw material properties, reduction type, and strategy of reduction, affect breakage patterns.

All this means that it is not reasonable to simply construct a general baseline fragment distribution from the experimental data against which archaeological fragment distributions are compared. The problems of such a procedure are evident in Fig. 5 that shows the means and ranges of proportions of each fragment category in the published experimental data and gives a rough idea of the variation observed so far. When interpreting this figure one should, however, keep in mind that the proportions are dependent on each other so that not all kinds of unaltered fragment distributions that the figure might indicate are possible.

Our results also indicate that the analyst should have a great deal of prior information about the factors that have affected the fragmentation of particular archaeological quartz assemblages before choosing an appropriately produced baseline distribution for the comparisons. Without that information, it would be impossible to determine if and in what way the archaeological fragment distribution differs from the original, non-altered fragment distribution (see also Darmark and Sundström, 2005). In practice, part of this information, especially that relating to differences between individual knappers, is impossible to acquire. The information concerning flaking methods and, especially, indenter hardness, is also difficult to extract from fragmented quartz assemblages. Cases where a mixture of different flaking methods and indenter types has been used are especially difficult. The analysis is further complicated by post-depositional breakage of flakes caused by e.g. trampling (Prentiss and Romanski, 1989; Rankama and Kankaanpää, 1999).

5.2. The technological organisation of quartz users

Assuming that predictability in the technological process has been desirable, quartz has, most likely, been a problematic raw material for prehistoric people. Although quartz users had out of

Table 4
The results of the logistic regression analyses. Occurrences of intact flakes, bending fractures and radial fractures were modelled using indenter hardness and the relative thickness of the flake as explanatory variables. For the indenter hardness soft hammer is the reference category. $N = 316$.

Parameter	Estimate	Std error	Wald χ^2	P-value	Odds ratio	Odds ratio 95% conf. limits	
						Lower	Upper
Response variable = intact flake, N (yes) = 115, N (no) = 201							
Null-deviance = 414.4, df = 315; Deviance = 387.4, df = 313; Log-likelihood = −193.7							
Intercept	−1.89	0.34	31.09	<0.0001	0.15	0.08	0.293
Indenter	−0.26	0.25	1.12	0.29	0.77	0.47	1.25
Relative thickness	5.76	1.22	22.15	<0.0001	318.25	28.88	3507.32
Response variable = bending fractures, N (yes) = 152, N (no) = 164							
Null-deviance = 437.6, df = 315; Deviance = 376.2, df = 313; Log-likelihood = −188.1							
Intercept	2.40	0.39	37.38	<0.0001	10.99	5.10	23.70
Indenter	0.04	0.25	0.02	0.88	1.04	0.63	1.70
Relative thickness	−10.32	1.60	41.33	<0.0001	0.00003	0.00000	0.00076
Response variable = radial fractures, N (yes) = 125, N (no) = 191							
Null-deviance = 424.2, df = 315; Deviance = 416.1, df = 313; Log-likelihood = −208.1							
Intercept	−0.11	0.31	0.14	0.71	0.89	0.49	1.63
Indenter	0.51	0.24	4.53	0.03	1.66	1.04	2.64
Relative thickness	−2.33	1.14	4.20	0.04	0.10	0.01	0.90

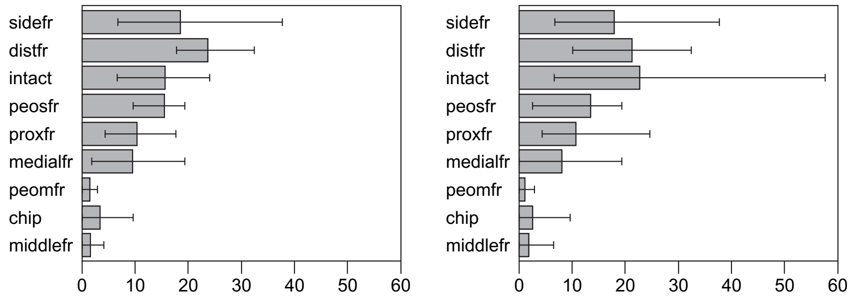

Fig. 5. The means and ranges of proportions (%) of fragment categories in the experimental data (this article; Callahan et al., 1992). The left side gives the values for the platform core reduction ($N = 12$) and the right side for the combined platform and bipolar core reduction ($N = 16$).

necessity adapted to using flake fragments as tool blanks, the fragmentation of the flakes still made the material quite difficult to cope with. At least some archaeological assemblages where comparisons between quartz and other raw materials have been possible show that quartz artefacts are relatively thicker than artefacts made from other raw materials (e.g. Manninen and Tallavaara, in preparation; Siiriäinen, 1977; Tallavaara, 2007; Wadley and Mohapi, 2008; see also Fig. 6). In the light of our experimental results, this could indicate that quartz users intentionally tried to reduce fragmentation by producing thicker flakes. Another way to reduce fragmentation could have been the use of bipolar flaking: Callahan et al. (1992) report that in their experiments the amount of intact flakes was higher in bipolar than in platform core reduction. Therefore, it is reasonable to expect relatively higher ratios of bipolar flaking with quartz than with e.g. chert. The fact that bipolar reduction seems to have been used particularly on quartz in many parts of the world lends support to this notion (e.g. Broadbent, 1979; Flenniken, 1980; Hiscock, 1996; Leng, 1998).

Despite efforts to reduce it, some flake fragmentation is inevitable during quartz reduction, and even if some of the fragments are usable, it is still likely that some, if not most, of the fragments are either too small or otherwise unsuitable for use as tool blanks. Thus, a quartz core contains more waste than e.g. a chert core of equal size. The relative fragility of quartz means also that quartz tools are more prone to breakage than tools made of many other raw materials. In addition to enhanced predictability in flaking, the production of thicker flakes has therefore enhanced also the durability of the tools since thicker tools are more resistant to breakage (Fig. 6). The fragility of quartz should also be seen at the micro level, i.e. in relation to the durability of tool edges. This idea is supported by an experimental study where the efficiency of quartz

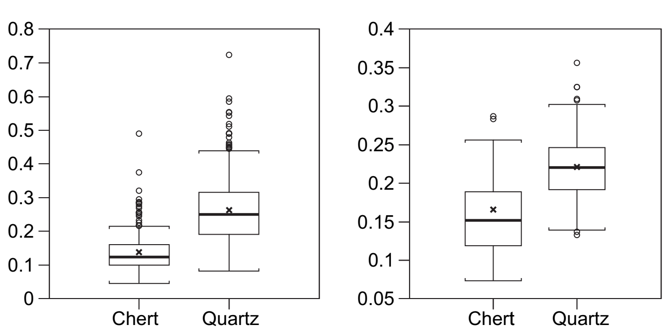

Fig. 6. The relative thicknesses (thickness/length) of quartz and chert artefacts in two archaeological assemblages from Eastern Fennoscandia. The left side is based on the debitage from the Vihi site, eastern Finland ($N = 593$, Tallavaara, 2007). Only flakes, whose length could be measured reliably, are included. The right side is based on the transverse and oblique arrowhead data from Finland ($N = 158$, Manninen and Tallavaara, in preparation).

and flint tools was evaluated (Knutsson, 1992: 16–17). At the beginning of the experiment, both materials were equally efficient, but during the subsequent rounds quartz tools lost their efficiency much faster than flint tools due to the rapid dulling of the working edges.

Due to the fragmentation tendency, the attempts to reduce it by producing thicker flakes, and the poor durability of quartz tools, a quartz core contains less usable tool edge than a comparable amount of a better raw material. This means that quartz is a problematic material especially when raw material transportation costs are of importance, e.g. during residential and logistic moves. However, as there is notable variation in the amount of fragmentation between different quartz varieties, it is likely that there are situational differences in their use. Therefore, we suggest that the proportion of better quality, i.e. less fragmentation prone, quartz should be higher in the archaeological assemblages of more mobile groups as compared with the assemblages of less mobile people. We suggest further that due to high transportation costs, quartz should be curated to a lesser degree when used alongside better raw materials. This should manifest itself for example in a lower reduction intensity of tools (Orton, 2008). Relatively expedient use of quartz should be enhanced also by its generally good availability.

6. Conclusion

Above, we have shown that there is more variation in the fragmentation of quartz flakes than has been previously assumed, since indenter hardness, flake dimensions and other factors relating to individual differences in knapping style and/or skill have a significant effect on fragmentation. This observation undermines the applicability of fracture analysis in its present form but does not necessarily render the whole method useless. In the future, it might be possible to construct confidence intervals for the fragment proportions in the baseline fragment distribution so that large enough differences between archaeological and baseline distributions could be detected reliably. However, more experimental research on the variability in fragmentation is necessary.

The problems of fracture analysis definitely do not undermine the general value of the research done on the fragmentation of quartz flakes (see also Knutsson, 1988, 1990, 1998; Lindgren, 1998). The results of these studies are valuable to everyone studying quartz assemblages and provide a cure for the so-called flint syndrome (Knutsson, 1998), where quartz and flint assemblages are approached in essentially the same way without acknowledging the differences between these raw materials. These differences do not mean that the same methods, such as techno-typological and aggregate analyses of debitage or use wear and reduction analyses of tools, cannot be applied to both raw materials, only that fragmentation has to be taken into account when a quartz assemblage is under study.

Knowledge of the factors affecting fragmentation and of its effects is important also in terms of the technological organisation of prehistoric quartz users. Based on the information gained here and in previous studies, we have argued that fragmentation should have affected reduction strategies as well as blank and tool dimensions. Due to its relatively high transportation costs, quartz should be a problematic raw material especially to mobile quartz users who should therefore use better quality quartz more than less mobile people. Partly for the same reason, it is expectable that the curation of quartz should be lower than that of raw materials with more predictable fracture properties used in parallel with quartz. These hypotheses can be tested in subsequent studies.

Acknowledgements

We wish to thank statistician Henni Pulkkinen and one anonymous reviewer for their valuable comments on the manuscript. This research was made possible by grants from the Finnish Cultural Foundation (MT, MM, EH, TR), the Finnish Academy of Science and Letters (MT), the Niilo Helander Foundation (MM, EH) and the Academy of Finland (TR).

Appendix. Supplementary data

Supplementary data associated with this article can be found in the online version, at doi:10.1016/j.jas.2010.05.005.

References

Agresti, A., 2002. Categorical Data Analysis. Wiley-Interscience, New Jersey.
Amick, D.S., Mauldin, R.P., 1997. Effects of raw material on flake breakage patterns. Lithic Technology 22, 18–32.
Ballin, T.B., 2008. Quartz technology in Scottish prehistory. Scottish Archaeological Internet Report 26. Available from: http://www.sair.org.uk.
Bisson, M.S., 1990. Lithic reduction sequences as an aid to the analysis of Late Stone Age quartz assemblages from the Luano Spring, Chingola, Zambia. The African Archaeological Review 8, 103–138.
Broadbent, N., 1979. Coastal Resources and Settlement Stability. A Critical Study of a Mesolithic Site Complex in Northern Sweden, Aun 3. Societas Archaeologica Uppsaliensis, Uppsala.
Callahan, E., 1987. An Evaluation of the Lithic Technology in Middle Sweden During the Mesolithic and Neolithic, Aun 8. Societas Archaeologica Uppsaliensis, Uppsala.
Callahan, E., Forsberg, L., Knutsson, K., Lindgren, C., 1992. Frakturbilder. Kulturhistoriska kommentarer till det säregna sönderfallet vid bearbetning av kvarts. TOR 24, 27–63.
Cotterell, B., Kamminga, J., 1990. Mechanics of Pre-industrial Technology. Cambridge University Press, Cambridge.
Darmark, K., Sundström, L., 2005. Postboda 3, en sen mesolitisk lägerplats I Uppland. SAU Skrifter 9. Societas Archaeologica Uppsaliensis, Uppsala.
Dibble, H., Pelcin, A., 1995. The Effect of hammer mass and velocity on flake mass. Journal of Archaeological Science 22, 429–439.
Domanski, M., Webb, J.A., Boland, J., 1994. Mechanical properties of stone artefact materials and effect of heat treatment. Archaeometry 36, 177–208.
Falkenström, P., Lindberg, K., 2007. Brott i kvarts (with English summary). In: Stenbäck, N. (Ed.), Stenåldern i Uppland: uppdragsarkeologi och eftertanke. Arkeologi E4 Uppland – studier, vol. 1. Riksantikvarieämbetet, Societas Archeologica Uppsaliensis, Upplandmuseet, Uppsala, pp. 227–266.
Flenniken, J.J., 1980. Replicative systems analysis: a model applied to the vein quartz artifacts from the Hoko River site. A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy. Washington State University. Department of Anthropology, UMI Dissertation Services.
Greenacre, M., 2007. Correspondence Analysis in Practice. Chapman & Hall/CRC, Boca Raton.
Hiscock, P., 1996. Mobility and technology in the Kakadu coastal wetlands. Bulletin of the Indo-Pacific Prehistory Association 15, 151–157.
Hiscock, P., 2002. Quantifying the size of artefact assemblages. Journal of Archaeological Science 29, 251–258.
Holdaway, S., Stern, N., 2004. A Record in Stone: The Study of Australia's Flaked Stone Artefacts. Aboriginal Studies Press, Canberra.
Huang, Y., Knutsson, K., 1995. Functional analysis of middle and upper Palaeolithic quartz tools from China. TOR 27, 7–46.
Knutsson, K., 1988. Making and using stone tools. In: The Analysis of the Lithic Assemblages from Middle Neolithic Sites with flint in Västerbotten, Northern Sweden, Aun 11. Societas Archaeologica Uppsaliensis, Uppsala.
Knutsson, K., 1990. A new lithic scene. the archaeological context of used tools. In: Gräslund, B., Knutsson, H., Knutsson, K., Taffinder, J. (Eds.), The Interpretative Possibilities of Microwear Studies, Aun 14. Societas Archaeologica Uppsaliensis, Uppsala, pp. 15–30.
Knutsson, K., 1992. Forskning-Inlärning-Förmedling. Årsbok 1990–1991, Flatenprojektet. Riksantikvarieämbetet och Statens historiska museer, Stockholm.
Knutsson, K., 1998. Convention and lithic analysis. In: Holm, L., Knutsson, K. (Eds.), Proceedings of the Third Flint Alternatives Conference at Uppsala, Sweden, October 18–20, 1996. Occasional Papers in Archaeology 16. Department of Archaeology and Ancient History, Uppsala University, Uppsala, pp. 71–93.
Knutsson, K., Lindgren, C., 2004. Making sense of quartz. In: Lindgren, C., Appendix 1.
Leng, J., 1998. Early Palaeolithic quartz industries in China. In: Petraglia, M.D., Korisetter, R. (Eds.), Early Human Behaviour in Global Context. The Rise and Diversity of the Lower Palaeolithic Record. Routledge, London, pp. 418–436.
Lindberg, K., 2009. Ways to interpret quartz. In: McCartan, S., Schulting, R., Warren, G., Woodman, P. (Eds.), Mesolithic Horizons. Oxbow Books, Oxford, pp. 820–826.
Lindgren, C., 1998. Shapes of Quartz and shapes of minds. In: Holm, L., Knutsson, K. (Eds.), Proceedings of the Third Flint Alternatives Conference at Uppsala, Sweden, October 18–20, 1996. Occasional Papers in Archaeology 16. Department of Archaeology and Ancient History, Uppsala University, Uppsala, pp. 95–103.
Lindgren, C., 2004. Människor och kvarts. Sociala och teknologiska strategier under mesolitikum i östra Mellansverige (with English summary). Stockholm Studies in Archaeology 29, Riksantikvarieämbetet Arkeologiska Undersökningar, Skrifter no. 54, Coast to Coast books No. 11. Stockholms Universitet, Stockholm.
Manninen, M.A., 2003. Chaîne opératoire -analyysi ja kvartsi: Esimerkkinä kvartsiniskentäpaikka Utsjoki Leakšagoađejohka 3, Master's thesis. E-thesis, University of Helsinki. Available from: http://urn.fi/URN:NBN:fi-fe20031946.
Manninen, M.A. and Tallavaara, M., in preparation. Descent history of Mesolithic oblique points in eastern Fennoscandia – a technological comparison between two artefact populations. In Rankama, T. (Ed.), Mesolithic Interfaces - Variability in Lithic Technologies in Eastern Fennoscandia. Helsinki.
Mourre, V., 1996. Les industries en quartz au paleolithique. Terminologie, méthodologie et technologie. Paléo 8, 205–223.
Orton, J., 2008. A useful measure of the desirability of different raw materials for retouch within and between assemblages: the raw material retouch index (RMRI). Journal of Archaeological Science 35, 1090–1094.
Pearson, G.A., 2003. First report of a newly discovered Paleoindian quarry site on the Isthmus of Panama. Latin American Antiquity 14, 311–322.
Pelcin, A., 1997. The effect of indentor type on flake attributes: evidence from a controlled experiment. Journal of Archaeological Science 24, 613–621.
Prentiss, W.C., Romanski, E.J., 1989. Experimental evaluation of Sullivan and Rozen's debitage typology. In: Amick, D.S., Mauldin, R.P. (Eds.), Experiments in Lithic Technology. BAR International Series, vol. 528, pp. 89–99.
Rankama, T., 2002. Analyses of the quartz assemblages of houses 34 and 35 at Kauvonkangas in Tervola. In: Ranta, H. (Ed.), Huts and Houses. Stone Age and Early Metal Age Buildings in Finland. National Board of Antiquities, Helsinki, pp. 79–108.
Rankama, T., 2003. Quartz analyses of Stone Age house sites in Tervola, southern Finnish Lapland. In: Samuelsson, C., Ytterberg, N. (Eds.), Uniting Sea. Stone Age Societies in the Baltic Sea Region. Occasional Papers in Archaeology, vol. 33. Department of Archaeology and Ancient History, Uppsala University, Uppsala, pp. 204–224.
Rankama, T., 2009. Quartz analyses of the Kaaraneskoski Site, Lapland. In: McCartan, S., Schulting, R., Warren, G., Woodman, P. (Eds.), Mesolithic Horizons. Oxbow Books, Oxford, pp. 813–819.
Rankama, T., Kankaanpää, J., 1999. More pieces in vertical movement. Papers dedicated to Ari Siiriäinen. In: Huurre, M. (Ed.), Dig It All. Finnish Antiquarian Society, Archaeological Society of Finland, Helsinki, pp. 45–63.
Rankama, T., Manninen, M.A., Hertell, E., Tallavaara, M., 2006. Simple production and social strategies: do they meet? Social dimensions in Eastern Fennoscandian quartz. In: Apel, J., Knutsson, K. (Eds.), Skilled Production and Social Reproduction. Aspects of Traditional Stone Tool Technologies. SAU Stone Studies, vol. 2. Societas Archaeologica Uppsaliensis, Uppsala, pp. 245–261.
Räihälä, O., 1998. Suomussalmen Salonsaari – kivikautinen leiripaikka Kiantajärven rannalla. Kentältä poimittua 4. Kirjoitelmia arkeologian alalta. Museoviraston julkaisuja No. 7. Museovirasto, Helsinki, pp. 5–23.
Räihälä, O., 1999. Tutkimuksia Suomussalmen kivikautisesta asutuksesta kvartsien fraktuurianalyysin avulla. Studia Historica Septentrionalia 35. Rajamailla V, pp. 117–136.
Sandén, E., 1998. Using Quartz Fracture in Interpreting a Stone Age Site. In: Holm, L., Knutsson, K. (Eds.), Proceedings of the Third Flint Alternatives Conference at Uppsala, Sweden, October 18–20, 1996. Occasional Papers in Archaeology 16. Department of Archaeology and Ancient History, Uppsala University, Uppsala, pp. 141–153.
Seong, C., 2004. Quartzite and vein quartz as lithic raw materials reconsidered: a view from the Korean Paleolithic. Asian Perspectives 43, 73–91.
Siiriäinen, A., 1977. Quartz, chert and obsidian, a comparison of raw materials in a Late Stone Age aggregate in Kenya. Finskt Museum 1974, 15–29.
Tallavaara, M., 2007. Vihiä teknologisista strategioista: Tutkimus Rääkkylän Vihin kampakeraamisen ajan asuinpaikan piikivi- ja kvartsiaineistoista, Master's thesis. E-thesis, University of Helsinki, http://urn.fi/URN:NBN:fi-fe20072153.
de la Torre, I., 2004. Omo revisited. evaluating the technological skills of Pliocene Hominids. Current Anthropology 45, 439–465.
Wadley, L., Mohapi, M., 2008. A segment is not a monolith: evidence from the Howiesons Poort of Sibudu, South Africa. Journal of Archaeological Science 35, 2594–2605.

PAPER IV

Manninen, M. A. & Tallavaara, M. 2011. Descent History of Mesolithic Oblique Points in Eastern Fennoscandia – a Technological Comparison Between Two Artefact Populations. In: T. Rankama (Ed.), *Mesolithic Interfaces – Variability in Lithic Technologies in Eastern Fennoscandia*. Monographs of the Archaeological Society of Finland 1, 177–211.

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).

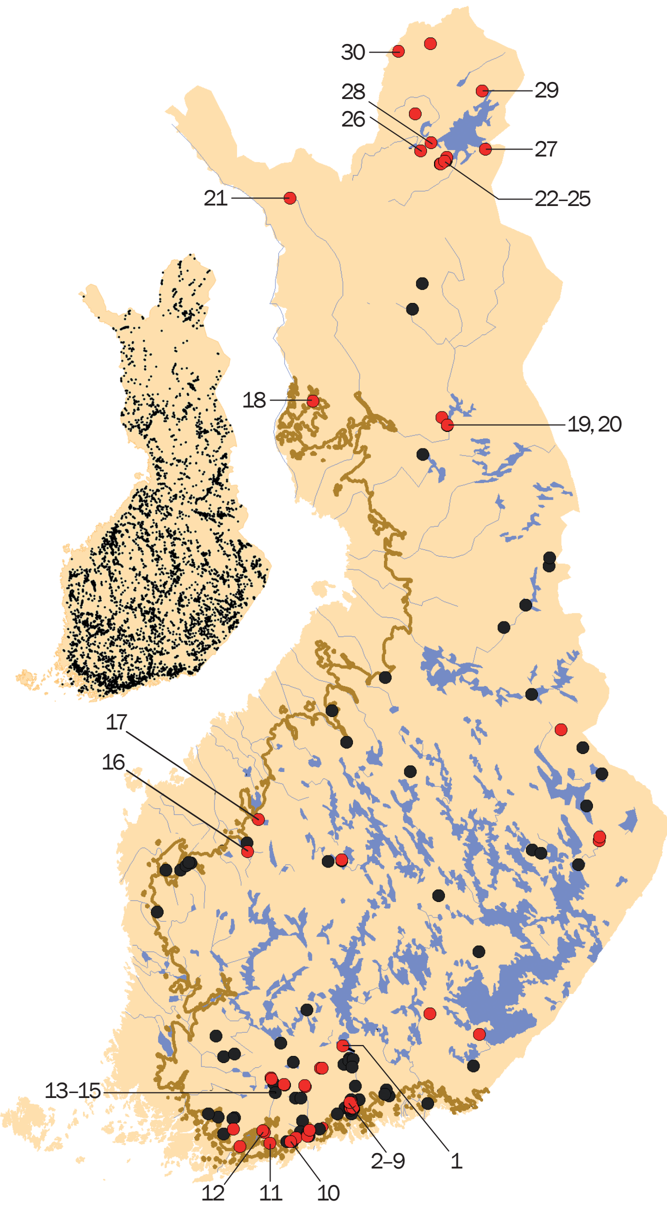

Figure 2. Small map: The distribution of known Stone Age and Early Metal Age dwelling sites in Finland (n= 9188) (MJREK 2008). Large map: The sites with reported oblique points in Finland (see Appendix II). The Litorina Sea shoreline at *c.* 6400 calBC is marked with a brown line. The sites with points 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.

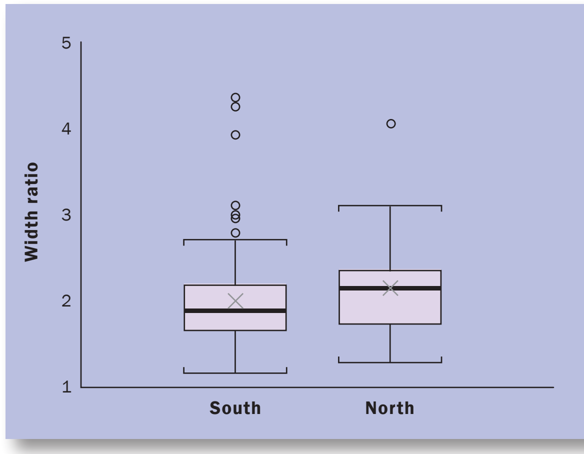


Figure 3. The width ratio (maximum width/basal width) in the studied point groups. South n=103, north n=31. The top and bottom of the box indicate the 25th and 75th percentiles, the black band indicates the data median, and the grey cross indicates the data mean. The ends of the vertical lines indicate 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.

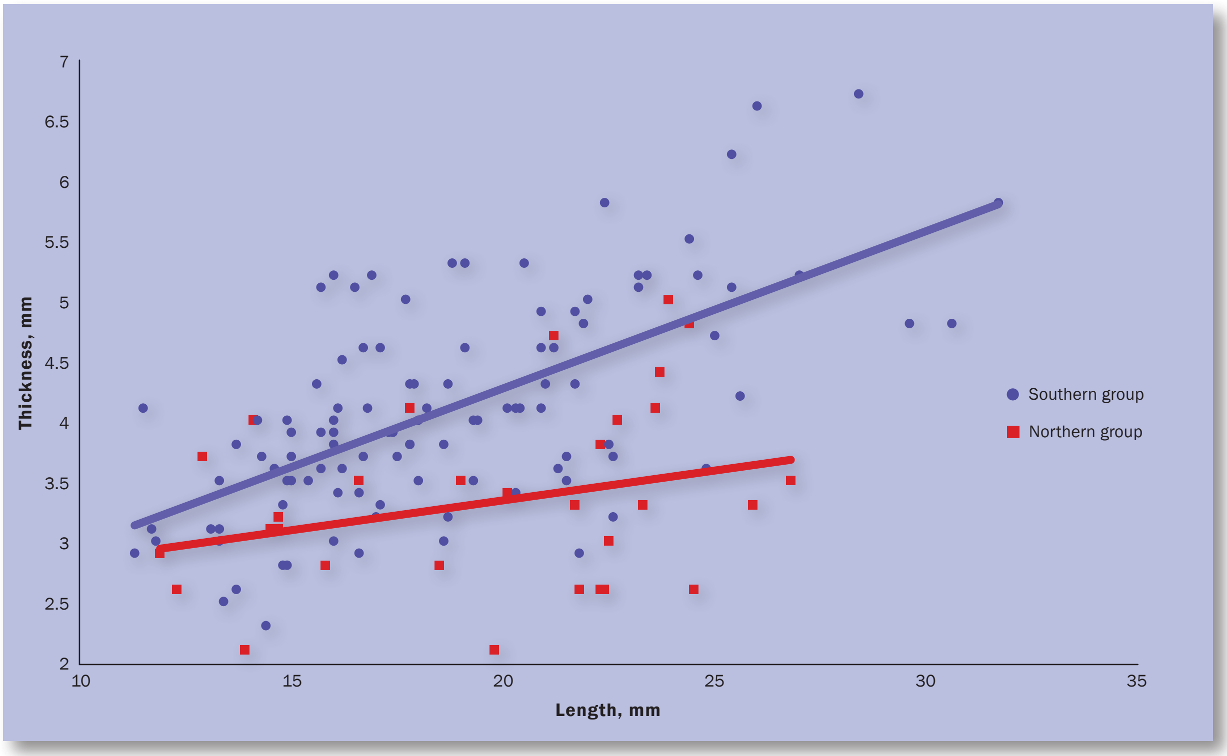


Figure 4. Maximum thickness and length of points in the southern (n=106) and northern (n=32) oblique point populations with linear trendlines of the measured intact points and the points with broken tips (1.5 mm added to length).

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**).

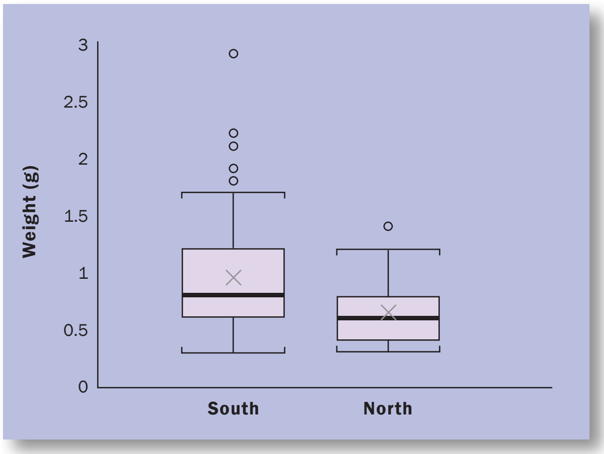


Figure 5. Point weight in the oblique point populations. South n=100, north n=34.

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**).

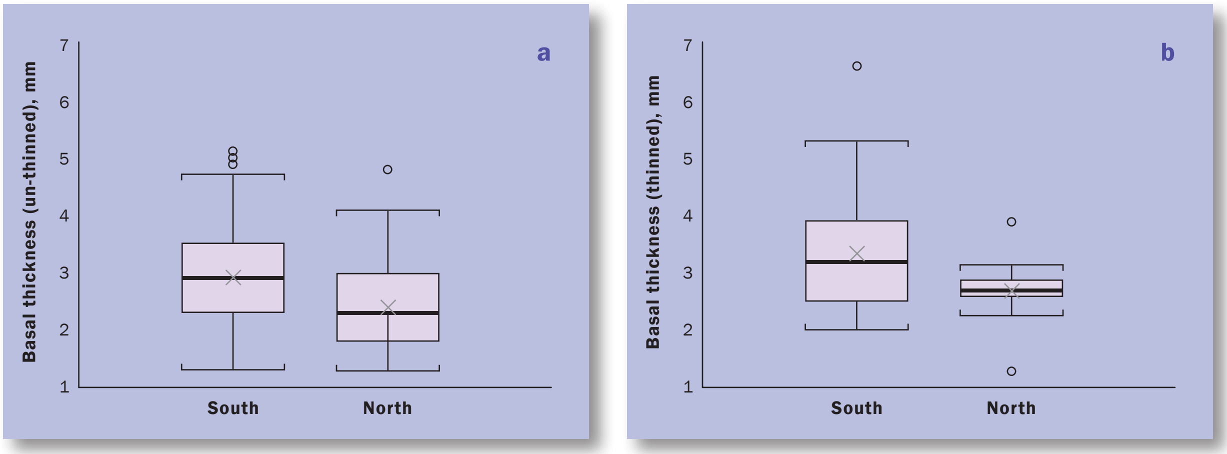


Figure 6. The basal thickness of the un-thinned (a) and thinned (b) points. South, a) n=81, b) n=27. North, a) n=27; b) n=7.

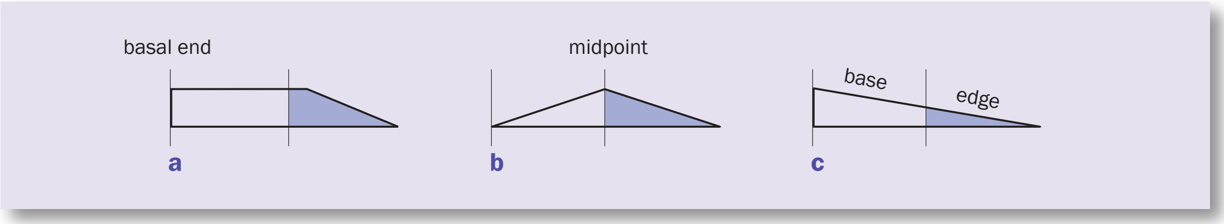


Figure 7. Side view profiles of oblique points: a) point with a base of even thickness , b) point with a tapering base, and c) point with a relatively thick basal end. In addition, the figure shows the variables used to define the midpoint/basal thickness ratio.

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

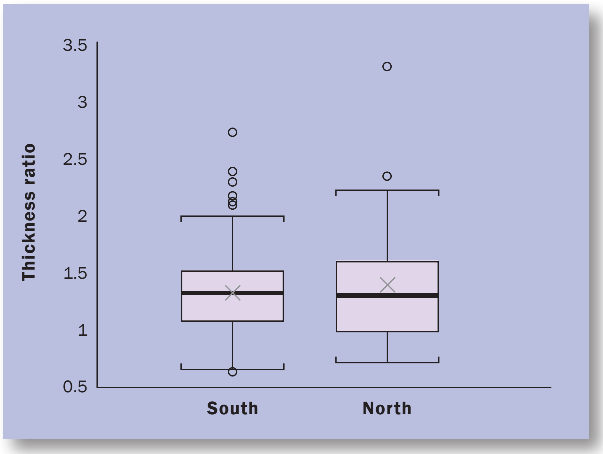


Figure 8. Point midpoint thickness to base thickness ratio. South n=121, north n=37.

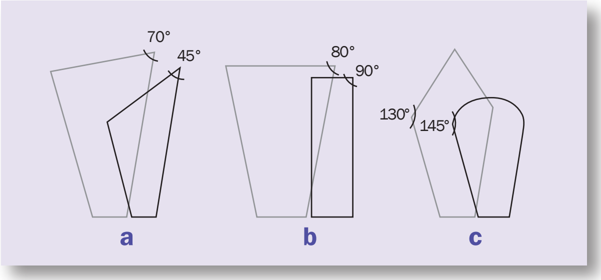


Figure 9. A schematic representation of the smaller edge angles taken from the various point outline shapes. Drawing by M. A. Manninen.

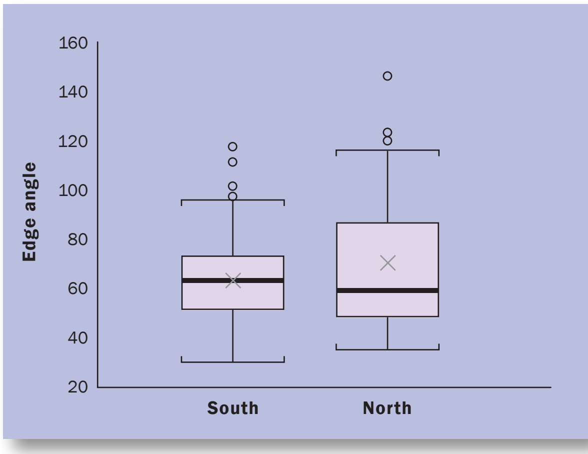


Figure 10. Edge angle variation (smaller edge angle) in the studied point populations. South n=110, north n=31.

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

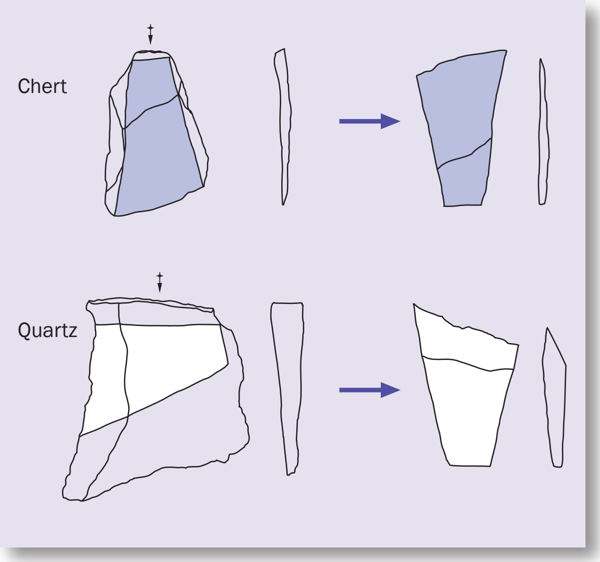


Figure 14. Typical features that distinguish the points in the northern (top) and southern (bottom) group of oblique points. (Note that despite the large number of points oriented parallel to the longitudinal axis of the flake, over half of the northern points were still oriented perpendicularly in relation 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.

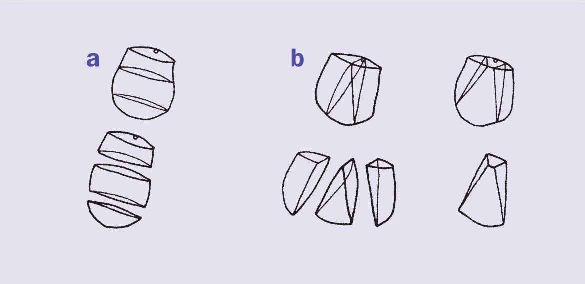


Figure 16. The fragment types most likely to resemble oblique points, from crosswise split flakes (a) and flakes split by radial fractures (b). Based on Knutsson (1998) and Rankama (2002).

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

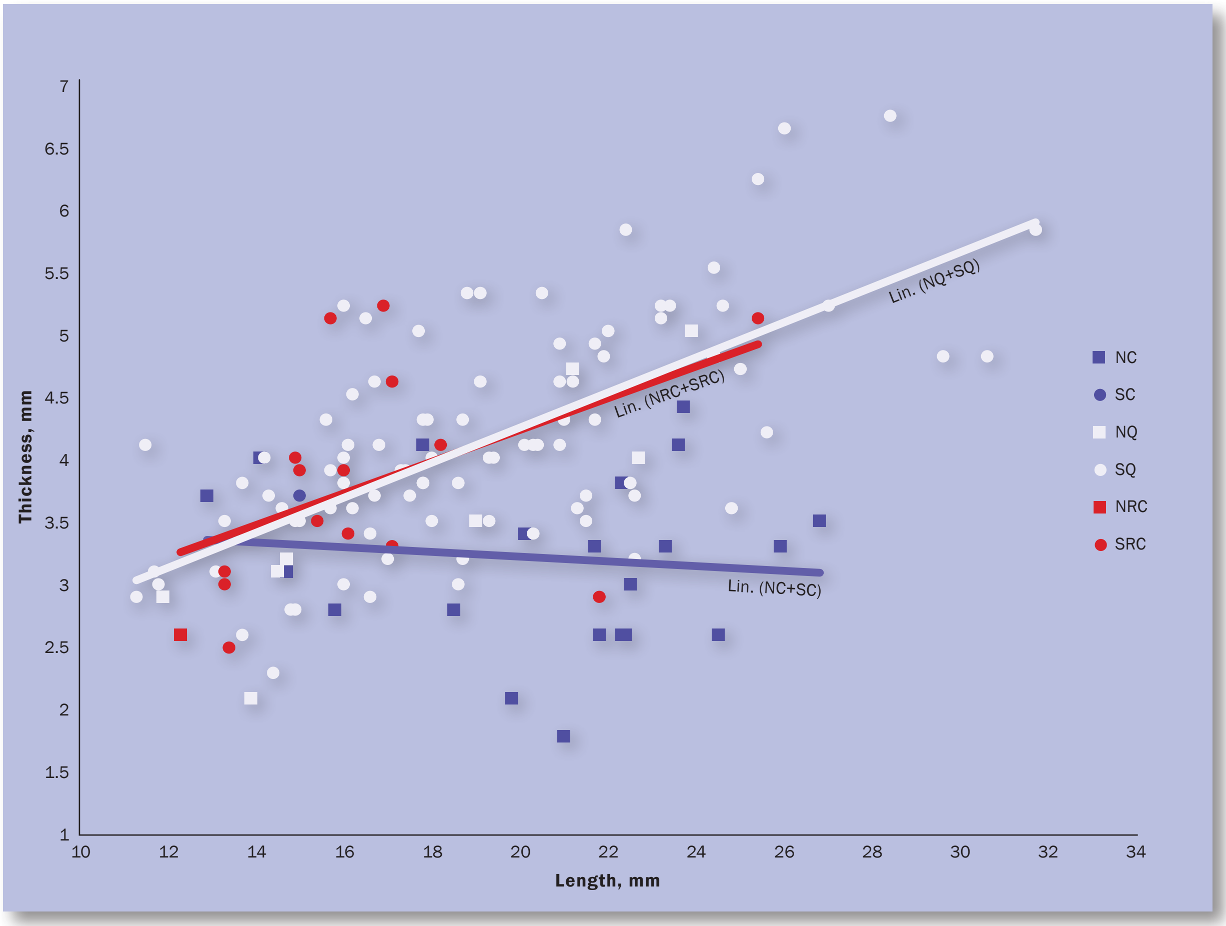


Figure 17. Thickness/length ratios of intact points and points with broken tips (1.5 mm added to length) made of different raw materials in the northern (N) and southern (S) groups of points. Chert (C) n=22, quartz (Q) n=98, rock crystal (RC) n=16.

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**).

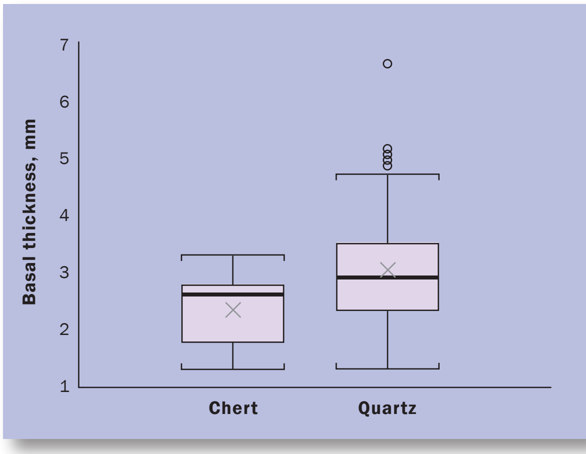


Figure 18. Basal thickness in points from different raw materials. Chert n=25; quartz n=129.

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.

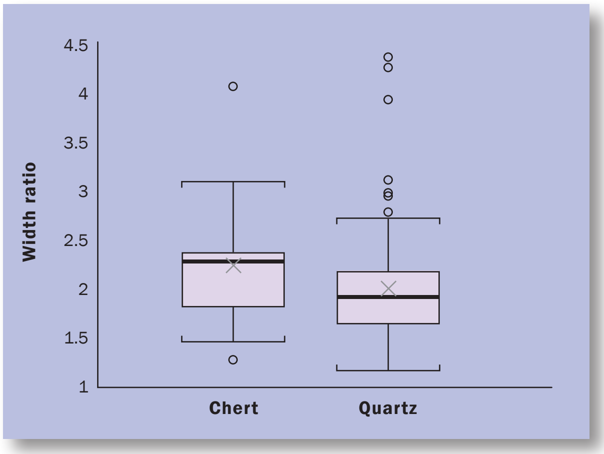


Figure 21. Width ratio (Maximum/basal width). The greater the value, the more triangular or tanged/trumpet-like the point is. A value close to 1 indicates a point with straight edges. Chert n=21, quartz n=111.

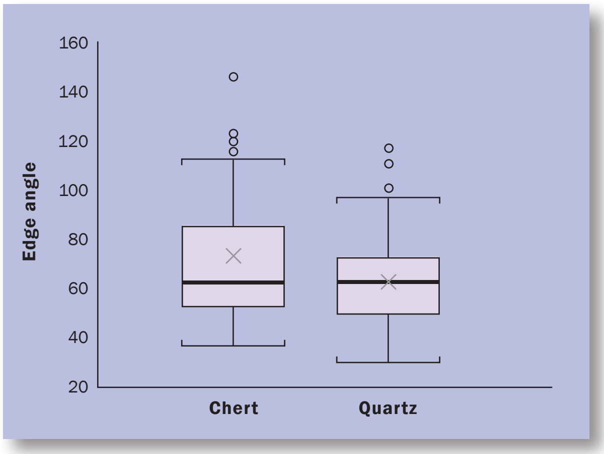


Figure 22. Edge angle variation according to raw material. Chert n=21, quartz n=118.

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-

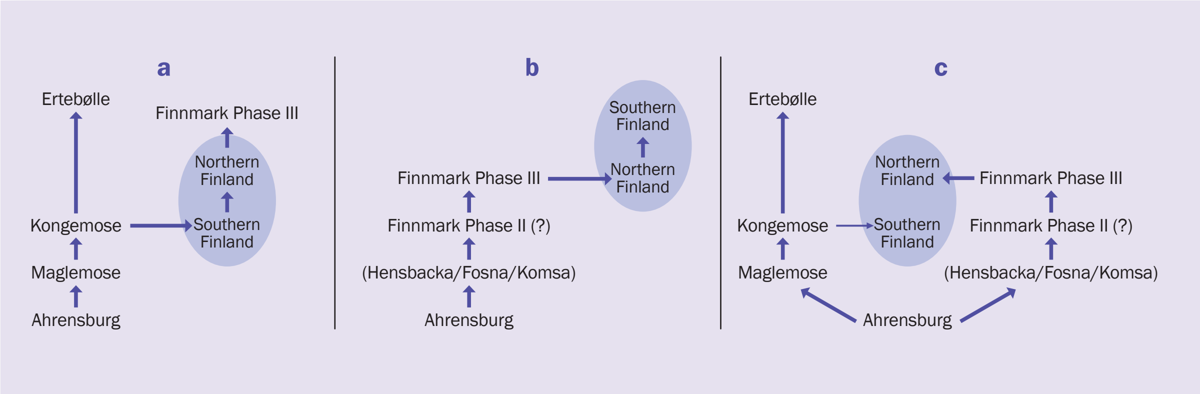


Figure 23. Alternative descent scenarios for the arrival of the margin-retouched point concept in Finland: A) the south-to-north scenario, B) the north-to-south scenario, and C) the south-and-north scenario.

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]

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

[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.

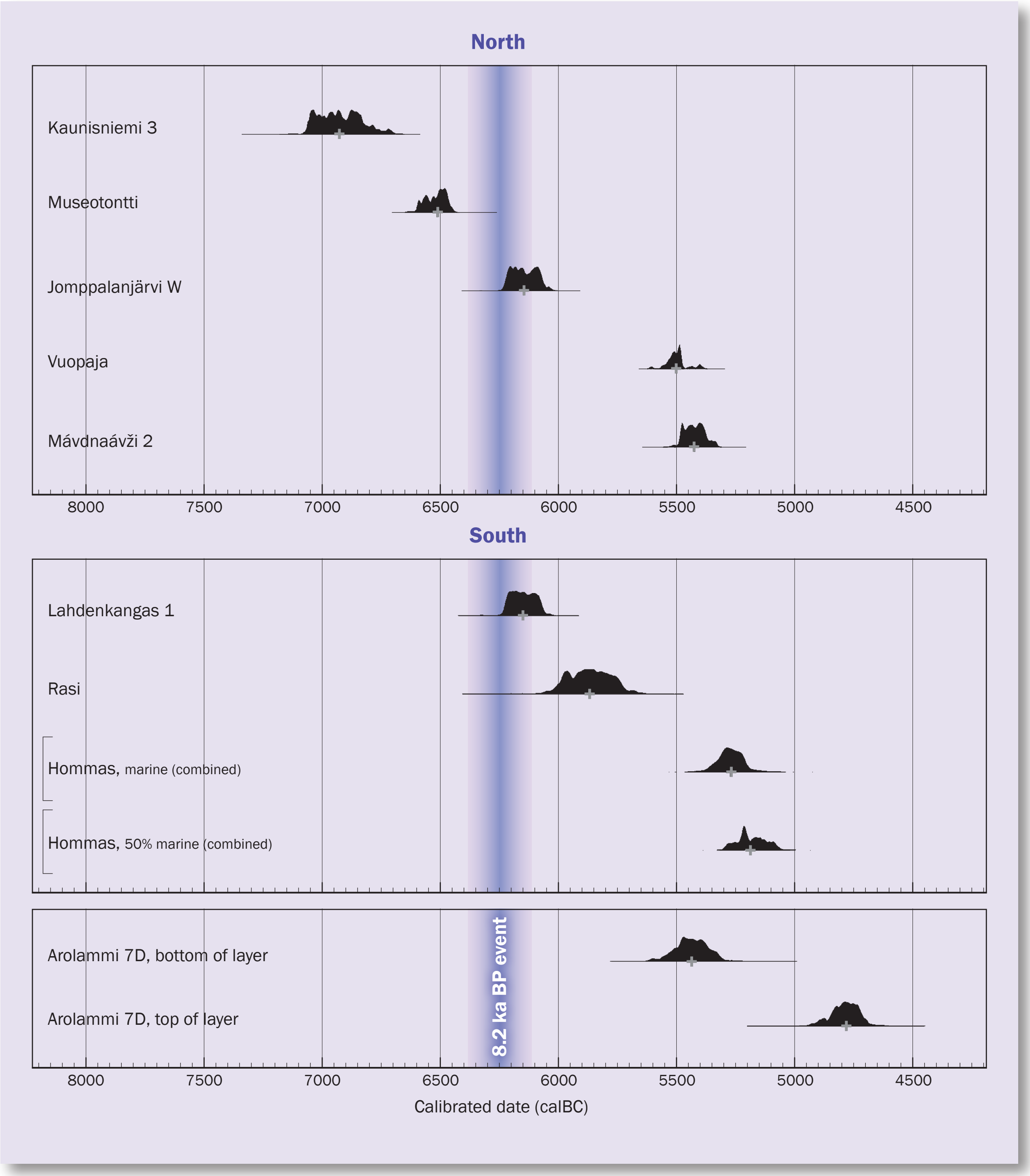


Figure 24. Calibrated dates from oblique point contexts in Finland. Dates on burnt bone are preferred when available. The dates from Arolammi 7D are on charcoal from the find layer with oblique points. See Appendix IV for details and specific dates. Calibrated with OxCal v4.1.7. Atmospheric and marine 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.

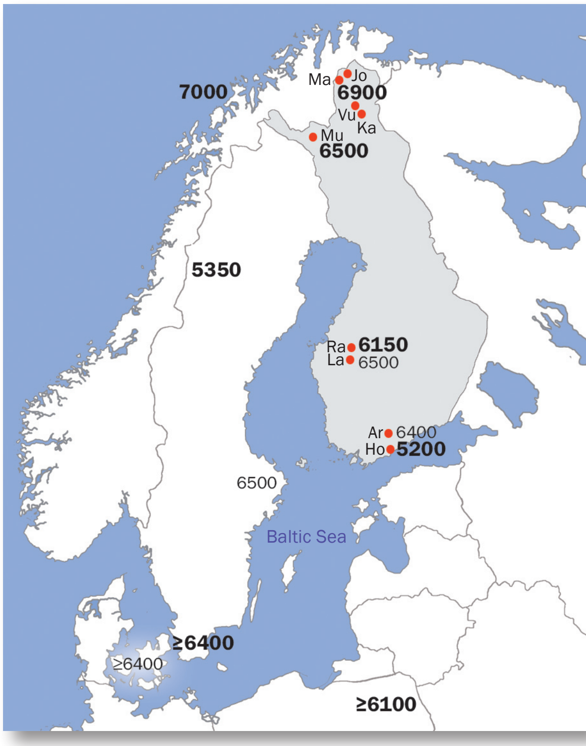


Figure 25. Margin-retouched points around the Baltic Sea, *c.* 7000–5000 calBC. The map shows the earliest shore displacement dates (in italics) and the median values of the earliest radiocarbon dates in the relevant parts of Finland, Sweden, and Norway. The locations of the radiocarbon-dated oblique 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 south-east 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 south-eastern 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.

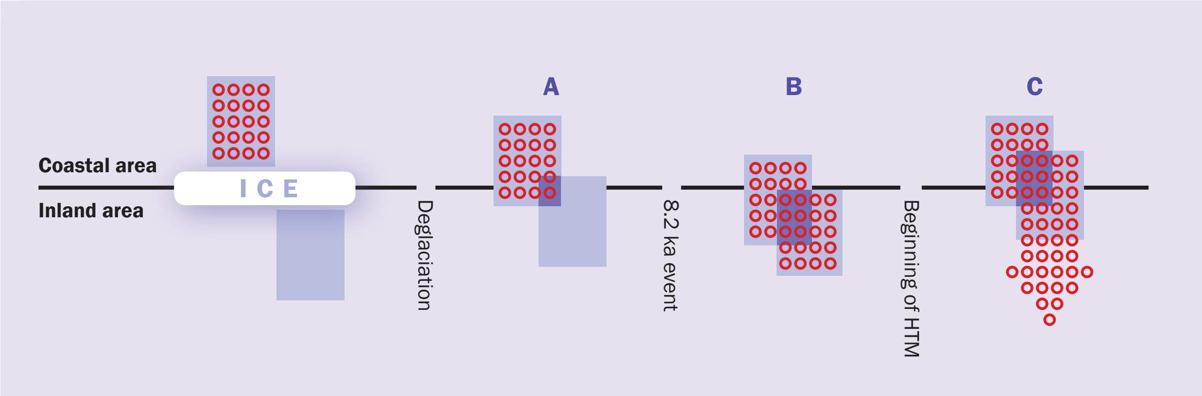


Figure 26. Schematic representation of changes that would have facilitated the transmission of the oblique point technology from the Barents Sea coast to southern Finland across the coast/inland interface between the two historically distinct populations (blue squares). The size of the dark blue areas 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.

Acknowledgements

The work presented in this paper has been supported by the Finnish Cultural Foundation and the Finnish Graduate School in Archaeology. We wish to thank our two reviewers and the members of the Interfaces in the Mesolithic Stone Age of Eastern Fennoscandia project for reading, commenting on, and improving the paper. We would also like to thank the personnel of the National Board of Antiquities' archives and the Riihimäki City Museum for their help.

References

Alley, R. B. & Ágústsdóttir, A. M. 2005. The 8k event: cause and consequences of a major Holocene abrupt climate change. *Quaternary Science Reviews* 24, 1123–1149.

Amick, D. S. & Mauldin, R. P. 1997. Effects of raw material on flake breakage patterns. *Lithic Technology* 22, 18–32.

Arponen, A. 1991. *Inari. Rahajärven arkeologinen inventointi* 1990. Survey report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Bang-Andersen, S. 1996. Coast/inland relations in the Mesolithic of southern Norway. *World Archaeology* 27(3), 427–443.

Barber, D. C., Dyke, A., Hillaire-Marce,C., Jennings, A. E., Andrews,J. T., Kerwin, M. W., Bilodeau, G., McNeely, R., Southon, J., Morehead, M. D. & Gagnon, J.-M. 1999. Forcing of the cold event of 8,200 years ago by catastrophic drainage of Laurentide lakes. *Nature* 400, 344–348.

Bettinger, R. L. & Eerkens, J. W. 1997. Evolutionary implications of metrical variation in Great Basin projectile points. In C. M Barton & G. A. Clark (eds.), *Rediscovering Darwin: Evolutionary Theory and Archaeological Explanation*, 177–191. Arlington, American Anthropological Association.

Bettinger, R. L. & Eerkens, J. W. 1999. Point typologies, cultural transmission, and the spread of bow-and-arrow technology in the prehistoric Great Basin. *American Antiquity* 64, 231–242.

Binford, L. 1973. Interassemblage variability - the Mousterian and the 'functional' argument. In C. Renfrew (ed.), *The explanation of culture change: Models in Prehistory,* 227–254. London, Duckworth.

Bjerck, H. B. 2008. Norwegian Mesolithic Trends: A Review. In G. Bailey & P. Spikins (eds.), *Mesolithic Europe,* 60–106. New York, Cambridge University Press.

Boyd, R. & Richerson, P. J. 1985. *Culture and the Evolutionary Process*. Chicago, University of Chicago Press.

Callahan, E., Forsberg, L., Knutsson, K. & Lindgren, C. 1992. Frakturbilder. Kulturhistoriska kommentarer till det säregna sönderfallet vid bearbetning av kvarts. *Tor* 24, 27–63.

Cavalli-Sforza, L. L. & Feldman, M. W. 1981. *Cultural Transmission and Evolution: A Quantitative Approach*. Princeton, Princeton University Press.

Cheshier, J. & Kelly, R. L. 2006. Projectile Point Shape and Durability: The Effect of Thickness: Length. *American Antiquity* 71(2), 353–363.

Cochrane, S. K. J., Denisenko, S. G., Renaud, P. E., Emblow, C. S., Ambrose, W. G. Jr, Ellingsen, I. H. & Skarðhamar, J. 2009. Benthic macrofauna and productivity regimes in the Barents Sea – Ecological implications in a changing Arctic. *Journal of Sea Research* 61, 222–233.

Crabtree, D. E. 1967. Notes on Experiments in Flintknapping: 3. The Flintknapper's Raw Materials. *Tebiwa*, Vol. 10(1), 8–24.

Darmark, K. 2007. Den flathugna pilspetsens fylogeni. In N. Stenbäck (ed.), *Stenålder i Uppland. Uppdragsarkeologi och eftertanke*. Arkeologi W4 Uppland Studier, 31–65. Uppsala, Riksantikvarieämbetet, UV GAL; Societas archaeologica Upsaliensis; Upplandsmuseet.

Domanski, M., Webb, J. A. & Boland, J. 1994. Mechanical properties of stone artefact materials and effect of heat treatment. *Archaeometry* 36, 177–208.

Duplessy, J.-C., Ivanova, E., Murdmaa, I., Paterne, M. & Labeyrie, L. 2001. Holocene Paleoceanography of the northern Barents Sea and variations of the northward heat transport by the Atlantic Ocean. *Boreas* 30, 2–16.

Edinborough, K. 2009. Population History and the Evolution of Mesolithic Arrowhead Technology in South Scandinavia. In S. J. Shennan (ed.), *Pattern and Process in Cultural Evolution,* 191–202. Berkeley, University of California Press.

Eerkens, J. W. & Lipo, C. P. 2007. Cultural Transmission Theory and the Archaeological Record: Providing Context to Understanding Variation and Temporal Changes in Material Culture. *Journal of Archaeological Research* 15, 239–274.

Erä-Esko, A. 1957. Die steinzeitlichen Forschungen der letzen Jahre in Nord-Finnland. *Suomen Muinaismuistoyhdistyksen Aikakauskirja* 58, 28–40.

Europaeus, A. 1927. Stenålderskeramik från kustboplatser I Finland. *Suomen muinaismuistoyhdistyksen aikakauskirja* XXXVI, 45–77

Fast, J. 1995. *Esbo Oitans Kakola. Boplats från sten- och tidig metallålder*. Excavation report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Fast, J. 1996. *Espoo Sperrings Hiekkakuoppa NE. Kivikautisen asuinpaikan kaivaus*. Excavation report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Fischer, A. 1990. Hunting with Flint-Tipped Arrows: Results and Experiences from Practical Experiments. In C. Bonsall (ed.), *The Mesolithic in Europe. III Int. Mesol. Symp. Edinburgh 1985*, 29–39. Edinburgh, John Donald Publishers Limited.

Fischer, A., Hansen, P. V. & Rasmussen, P. 1984. Macro and micro wear traces on lithic projectile points. *Journal of Danish Archaeology* 3, 19–46.

Fletcher, C. H. III, Fairbridge, R. W., Møller, J. J. & Long, A. J. 1993. Emergence of the Varanger Peninsula, Arctic Norway, and climate changes since deglaciation. *The Holocene* 3, 116–127.

Freundt, E. A. 1948. Komsa – Fosna – Sandarna. Problems of the Scandinavian Mesolithicum. *Acta Archaeologica* XIX, 1–68.

Fuglestvedt, I. 2007. The Ahrensburgian Galta 3 site in SW Norway. Dating, technology and cultural affinity. *Acta Archaeologica* 78:2, 87–110.

Galimova, M. 2006. Final Palaeolithic-Early Mesolithic Cultures with Trapezia in the Volga and Dnieper Basins: The Question of Origin. *Archaeologia Baltica* 7, 136–148.

Glørstad, H. 2004. Svinesundmaterialet i lys av annen forskning i Oslofjordsdistriktet og i Vest-Sverige. In H. Glørstad (ed.), Bind 4. Oppsummering av Svinesundprosjektet. *Varia* 57, 47–58. Oslo, Universitetets kulturhistoriske museer, Fornminneseksjonen.

Granö, J. G. 1918. Meri. In T. Homén (ed.), *Itä-Karjala ja Kuollan Lappi*. Osa I, Kuollan Lappi, 16–19. Helsinki, Otava.

Grydeland, S.-E. 2005. The Pioneers of Finnmark – from the earliest coastal settlements to the encounter with the inland people of Northern Finland. In H. Knutsson (ed.), Pioneer settlements and colonization processes in the Barents region. *Vuollerim Papers on Hunter-gatherer Archaeology* 1, 43–77. Vuollerim, Vuollerim 6000 år.

Guinard, M. & Groop, N. 2007: Handtagskärnor och tvärpilar. In N. Stenbäck (ed.), *Stenålder i Uppland. Uppdragsarkeologi och eftertanke*. Arkeologi W4 Uppland Studier. Uppsala, Riksantikvarieämbetet, UV GAL; Societas archaeologica Upsaliensis; Upplandsmuseet.

Halinen, P. 1995. *Ounasjärven alueen esihistoriallisten peuranpyytäjäyhteisöjen asutusmallit*. Unpublished Licenciate thesis. University of Helsinki, Institute of Cultural Research, Archaeology.

Halinen, P. 2005. *Prehistoric Hunters of Northernmost Lapland. Settlement patterns and subsistence strategies*. Iskos 14. Helsinki, The Finnish Antiquarian Society.

Hartz, S., Lübke, H. & Terberger, T. 2007. From fish and seal to sheep and cattle: new research into the process of neolithisation in northern Germany. *Proceedings of the British Academy* 144, 567–594.

Heikkilä, M. & Seppä, H. 2003. A 11,000 yr palaeotemperature reconstruction from the southern boreal zone in Finland. *Quaternary Science Reviews* 22, 541–554.

Helskog, E. 1974. The Komsa Culture: Past and Present. *Arctic Anthropology* XI, 1974, Supplement, 261–265.

Henriksen, S. 2010. ID 104342: En tuft fra Eldre Steinalder. In M. Skandfer (ed.), Tønsnes havn, Tromsø Kommune, Troms. Rapport fra arkeologiske utgravninger i 2008 og 2009. *Tromura,* kulturhistorie 40, 50–71. Tromsø museum, Tromsø.

Hesjedal, A., Damm, C., Olsen, B. & Storli, I. 1996. Arkeologi på Slettnes. Dokumentasjon av 11.000 års bosetning. *Tromsø Museums Skrifter* XXVI.

Hood, B. C. 1988. Undersøkelse av en steinalderboplass ved Aksujavri, Kautokeino kommune, Finnmark. In E. Engelstad & M. Holm–Olsen (eds.), Arkeologisk feltarbeid i Nord-Norge og på Svalbard 1986. *Tromura*, kulturhistorie 14, 23–31. Tromsø museum, Tromsø.

Hood, B. C. 1992. *Prehistoric Foragers of the North Atlantic: Perspectives on Lithic Procurement and Social Complexity in the North Norwegian Stone Age and the Labrador Maritime Archaic*. Electronic *Doctoral Dissertations for UMass Amherst.* Paper AAI9219445. http://scholarworks.umass.edu/dissertations/AAI9219445

Hughes, S. S. 1998. Getting to the Point: Evolutionary Change in Prehistoric Weaponry. *Journal of Archaeological Method and Theory* 5(4), 345–408.

Huurre, M. 1983. Pohjois-Pohjanmaan ja Lapin historia I. Pohjois-Pohjanmaan ja Lapin esihistoria. Kuusamo, Pohjois-Pohjanmaan, Kainuun ja Lapin maakuntaliittojen yhteinen historiatoimikunta.

Huurre, M., Keränen, J. & Turpeinen, O. 1988. *Hyrynsalmen historia*. Jyväskylä, Hyrynsalmen kunta ja seurakunta.

Hyvärinen, H. 1975. Absolute and relative pollen diagrams from northernmost Fennoscandia. *Fennia* 142, 1–23.

Jankowska, D. 1998. Environmental Conditions during the Neolithization of Pomerania. In M. Zvelebil, R. Dennell & L. Domanska (eds.), *Harvesting the Sea, Farming the Forest: The Emergence of Neolithic Societies in the Baltic Region*. Sheffield Archaeological Monographs 10, 121–128. Sheffield, Sheffield Academic Press Ltd.

Jordan, P. & Shennan, S. 2009. Diversity in hunter–gatherer technological traditions: Mapping trajectories of cultural 'descent with modification' in northeast California. *Journal of Anthropological Archaeology* 28, 342–365.

Jussila, T. 2005. *Luumäki Suo-Anttila Reijonkangas. Kivikautisen asuinpaikan kaivaus 2005*. Excavation report. http://www.dlc.fi/~microlit/tyot2005/LUUMAKI05.htm

Kankaanpää, J. & Rankama, T. 2005. Early Mesolithic pioneers in Nortern Finnish Lapland. In H. Knutsson (ed.), Pioneer settlements and colonization processes in the Barents region. *Vuollerim Papers on Hunter-gatherer Archaeology* 1, 109–161. Vuollerim, Vuollerim 6000 år.

Katiskoski, K. 1994. Kauhajoen ja Isojoen mesoliittisista asuinpaikoista. Iventointihavaintoja 1990-91. *Kentältä pomittua* 2, 30–39.

Kehusmaa, A. 1972. *Kemijärven Neitilä* 4. Helsingin yliopiston arkeologian laitos, moniste 3. Helsinki, Helsingin yliopisto.

Knutsson, K. 1993. Garaselet-Lappviken-Rastklippan. Introduktion till en diskussion om Norrlands Äldsta Bebyggelse. *Tor* 25, 5–51.

Knutsson, K. 1998. Convention and lithic analysis. In L. Holm & K. Knutsson (eds.), *Proceedings of the Third Flint Alternatives Conference at Uppsala, Sweden, October 18-20, 1996,* 71–93. Occasional Papers in Archaeology 16. Department of Archaeology and Ancient History, Uppsala University, Uppsala.

Kobashi, T., Severinghaus, J. P., Brook, E. J., Barnola, J.-M. & Grachev, A. M. 2007. Precise timing and characterization of abrupt climate change 8200 years ago from air trapped in polar ice. *Quaternary Science Reviews* 26, 1212–1222.

Kobusiewicz, M. 2009. The Lyngby point as a cultural marker. In M. Street, N. Barton & T. Terberger (eds.), *Humans, environment and chronology of the late glacial of the North European Plain*, 169–178. Mainz, Verlag des Römisch-Germanischen Zentralmuseums.

Koivikko, M. 1999. *Etelä-Saimaan vedenalaiset asuinpaikat - kivikautisten kohteiden inventointi ja topografisen mallin rakennus.* Unpublished MA-thesis. Univesity of Helsinki.

Koivisto, S. 2010a. Luihin ja ytimiin. Pyyntiä ja elämää Itämeren äärellä noin 7500 vuotta sitten. *Helsingin pitäjä* 2011, 8–21.

Koivisto, S. 2010b. Vantaa Hommas – myöhäismesoliittinen asuinpaikka kehäratalinjalla. *Kentältä poimittua* 7, 5–18. Helsinki, Museovirasto.

Korhola, A., Vasko, K., Toivonen, H. T. T. & Olander, H. 2002. Holocene temperature changes in northern Fennoscandia reconstructed from chironomids using Bayesian modelling. *Quaternary Science Reviews* 21, 1841–1860.

Kotivuori, H. 1996. Pyytäjistä kaskenraivaajiksi. Rovaniemen asutus noin 6000 eKr.–1300 jKr. In V. Kallio (ed.), *Rovaniemen historia vuoteen* 1721. *Kotatulilta savupirtin suojaan*. Jyväskylä, Rovaniemen kaupunki, Rovaniemen maalaiskunta & Rovaniemen seurakunta.

Kozłovski, S. K. 2002. Les premiers hommes modernes et les premiers agriculteurs en europe: Voies de diffusion et interactions entre populations. In M. Otte & J. K. Kozlowski (eds.), *Préhistoire de la Grande Plaine du Nord de l'Europe.* Actes du Colloque Chaire Francqui interuniversitaire au titre étranger, Université de Liège, 26 juin 2001, 9–34. Liège, Université de Liège.

Kozłovski, S. K. 2006. Mapping the Central/East European Terminal Palaeolithic/Earliest Mesolithic. *Archaeologia Baltica* 7, 29–35.

Kriiska, A. & Tvauri, A. 2002. *Eesti muinasaeg*. Tallinn, Avita.

Kultti, S., Mikkola, K., Virtanen, T., Timonen, M. & Eronen, M. 2006. Past changes in the Scots pine forest line and climate in Finnish Lapland – a study based on megafossils, lake sediments, and GIS-based vegetation and climate data. *The Holocene,* vol. 16, 381–391.

Lahelma, A. (ed.) 2002. *Porvoonjoen yläjuoksun esihistoriallisia ja kulttuurihistoriallisia kohteita Lahden, Hollolan ja Orimattilan alueella*. Jyväskylä, Lahden kaupunginmuseo.

Lahti, E.-K. 2004. *Utsjoki Màvdnaàvži 2 Mikael Manninen 2004 Luuanalyysi*. Osteological analysis on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Larsson, L. 1993. The Mesolithic of Southern Scandinavia. *Journal of World Prehistory*, vol. 4(3), 257–309.

Leskinen, S. 2003. *Lohja Harvakkalanlahti. Kivikautisen asuinpaikan kaivaus*. Excavation report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Leskinen, S. & Pesonen, P. 2008. *Vantaan esihistoria*. Keuruu, Vantaan kaupunki.

Luho, V. 1948. Alajärven Rasin poikkiteräiset nuolenkärjet. *Suomen Museo* 1947–1948, 5–21.

Luho, V. 1957. Frühe Kammkeramik. *Studia Neolithica in Honorem Aarne Äyräpää.* Suomen Muinaismuistoyhdistyksen Aikakauskirja 58, 141–159. Helsinki, Suomen muinaismuistoyhdistys.

Luho, V. 1967. *Die Suomusjärvi-Kultur. Die mittel- und spätmesolitische zeit in Finnland*. Suomen Muinaismuistoyhdistyksen Aikakauskirja 66. Helsinki, Suomen muinaismuistoyhdistys.

Luoto, T. P., Kultti, S., Nevalainen, L. & Sarmaja-Korjonen, K. 2010. Temperature and effective moisture variability in southern Finland during the Holocene quantified with midge-based calibration models. *Journal of Quaternary Science* 25, 1317–1326.

Mannermaa, K. 2010. *Radiohiiliajoitukseen menevän arkeologisen luunäytteen analyysi. Alajärvi Rasi, Inari Vuopaja, Inari Kaunisniemi 3, Enontekiö Museotontti, Kuortane Lahdenkangas, Utsjoki Jomppalanjärvi W*. Helsingissä 19.10. 2010. Unpublished osteological analysis.

Manninen, M. A. 2005. Problems in Dating Inland Sites — Lithics and the Mesolithic in Paistunturi, Northern Finnish Lapland. In H. Knutsson (ed.), *Pioneer settlements and colonization processes in the Barents region.* Vuollerim Papers on Hunter-gatherer Archaeology 1, 29–41. Vuollerim, Vuollerim 6000 år.

Manninen, M. A. 2009. Evidence of mobility between the coast and the inland region in the Mesolithic of Northern Fennoscandia. In S. B. McCartan, R. Schulting, G. Warren and P. Woodman (eds.), *Mesolithic Horizons. Papers presented at the Seventh International Conference on the Mesolithic in Europe, Belfast 2005. Volume* I, 102–108. Oxford, Oxbow books.

Manninen, M. A. & Hertell, E. *this volume*. Few and far between - an archive survey of Finnish blade finds.

Manninen, M. A. & Knutsson, K. *this volume*. Northern Inland Oblique Point Sites – a New Look into the Late Mesolithic Oblique Point Tradition in Eastern Fennoscandia

Manninen, M. A. & Knutsson, K. *in preparation*. Technology, Mobility, and Site Structure – Five Late Mesolithic Short-term Camps in Northern Fennoscandia.

Matiskainen, H. 1982. *Suomen mesoliittisen kivikauden sisäinen kronologia* 14C-*ajoitukseen tukeutuvan Itämeren kehityshistorian perusteella*. Unpublished Licenciate thesis. University of Helsinki.

Matiskainen, H. 1986. Beiträge zur Kentnisse der mesolithischen Schrägschneidepfeile und Microlithen aus Quarz. *Iskos* 6, 77–98.

Matiskainen, H. 1989a. *Studies on the chronology, material culture and subsistence economy of the Finnish Mesolithic*, 10 000–6000 *b.p*. Iskos 8. Helsinki, Suomen Muinaismuistoyhdistys.

Matiskainen, H. 1989b. The Chronology of the Finnish Mesolithic. In C. Bonsall (ed.), *The Mesolithic in Europe.* III *Int. Mesol. Symp. Edinburgh* 1985, 379–390. Edinburgh, John Donald Publishers Limited.

Matiskainen, H. 2002. *Riihimäen esihistoria*. Hämeenlinna, Riihimäen kaupunginmuseo.

Matiskainen, H. & Ruohonen, J. 2004. *Esihistorian pauloissa*. Hämeenlinna, Riihimäen kaupunginmuseo.

Miller, P. A., Giesecke, T., Hickler, T., Bradshaw, R. H. W., Smith, B., Seppä, H., Valdes, P. J. & Sykes, M. T. 2008. Exploring climatic and biotic controls on Holocene vegetation change in Fennoscandia. *Journal of Ecology* 96, 247–259.

MJREK 2008 = Register of archaeological sites in mainland Finland. National Board of Antiquities. http://kulttuuriymparisto.nba.fi/netsovellus/rekisteriportaali/portti/default.aspx. Accessed in 2008.

Munoz, S. E., Gajewski, K. & Peros, M. C. 2010. Synchronous environmental and cultural change in the prehistory of the northeastern United States. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)* 107(51), 22008–22013.

Møller, J. J., Yevzerov, V. Y., Kolka, V. V. & Corner, G. D. 2002. Holocene raised-beach ridges and sea-ice-pushed boulders on the Kola Peninsula, northwest Russia: indicators of climatic change. *The Holocene* 12(2), 169–176

Naustvoll, L.-J. & Kleiven, M. 2009. Primær- og sekundærproduksjon. In H. Gjøsæter, A. Dommasnes, T. Falkenhaug, M. Hauge, E. Johannesen, E. Olsen & Ø. Skagseth (eds.), Havets ressurser og miljø 2009. *Fisken og havet, særnummer* 1–2009,30–31. Havforskninsinstututtet. http://www.imr.no/publikasjoner/andre_publikasjoner/havets_ressurser_og_miljo/nb-no

Nielsen, R. A. & Skandfer, M. 2010. ID 104380: En boplass med nedgravde tufter fra Eldre Steinalder. In M. Skandfer (ed.), Tønsnes havn, Tromsø Kommune, Troms. Rapport fra arkeologiske utgravninger i 2008 og 2009. *Tromura,* kulturhistorie 40, 82–115. Tromsø museum, Tromsø.

Nordqvist, K. & Seitsonen, O. 2008. Archaeological research in the former municipalities of Koivisto and Kuolemajärvi, Karelian Isthmus in 2003: results and observations. In M. Lavento (ed.), *Karelian Isthmus – Stone Age Studies in* 1998–2003. Iskos 16, 215–234.

Odell, G. H. & Cowan, F. 1986. Experiments with Spears and Arrows on Animal Targets. *Journal of Field Archaeology* 13, 195–211.

Odner, K. 1966. *Komsakulturen i Nesseby og Sør-Varanger*. Tromsø/Oslo/Bergen, Universitetsforlaget.

Olsen, B. 1994. *Bosetning og samfunn i Finnmarks forhistorie*. Oslo, Universitetsforlaget.

Olsson, I. U. 1980. Content of ^{14}C in marine mammals from northern Europe. *Radiocarbon* 22, 662–675.

Oshibkina 2006 = Ошибкина, С. В. 2006. *Мезолит Восточного Прионежья. Культура Веретье*. Москва.

Perrin, T., Marchand, G., Allard, P. & Binder, D. 2009. Le second Mésolithique d'Europe occidentale: origines et gradient chronologique. *Fondation Fyssen – Annales* 24, 161–170.

Pesonen, P. & Tallavaara, M. 2006. Esihistoriallinen leiripaikka Lohjan Hossanmäellä – kvartseja ja yllättäviä ajoituksia. *Suomen Museo* 2005, 5–26.

Poutiainen, H. (ed.) 2002. *Sukupolvien maisema. Porvoonjokilaakson kansallismaiseman syntyvaiheita*. Jyväskylä, Lahden Kaupunginmuseo.

Prøsch-Danielsen, L. & Høgestøl, M. 1995. A coastal Ahrensburgian site found at Galta, Rennesøy, Southwest Norway. In A. Fischer (ed.), *Man and Sea in the Mesolithic. Coastal settlement above and below present sea level*. Oxbow Monograph 53, 123–130. Oxford.

Purhonen, P. & Ruonavaara, L. 1994. On Subsistence economy at the prehistoric dwelling-site area of Jönsas in Vantaa, Southern Finland. *Fenno-Ugri et Slavi 1992. Prehistoric economy and means of livelihood*, 88–97. Helsinki, National Board of Antiquities.

Pälsi, S. 1937. Pielisensuun Mutalan kivikautinen liesi. Kaivausselostus. *Suomen Museo* 1937, 1–13.

Rankama, T. 2002. Analyses of the Quartz Assemblages of Houses 34 and 35 at Kauvonkangas in Tervola. In H. Ranta (ed.), *Huts and Houses. Stone Age and Early Metal Age Buildings in Finland*, 79–108. Helsinki, National Board of Antiquities.

Rankama, T. 2003. The colonisation of northernmost Finnish Lapland and the inland areas of Finnmark. In L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler & A. Åkerlund (eds.), *Mesolithic on the Move,* 684–687. Exeter, Oxbow Books.

Rankama, T. 2009. Quartz analysyes of the Kaaraneskoski site, Finland. In S. B. McCartan, R. Schulting, G. Warren & P. Woodman (eds.), *Mesolithic Horizons. Papers presented at the Seventh International Conference on the Mesolithic in Europe, Belfast 2005. Volume* II, 813–819. Oxford, Oxbow books.

Rankama, T. & Kankaanpää, J. 1997. *Utsjoki* 209 *Jomppalanjärvi W. Arkeologisen kohteen tarkastus*. Inspection report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Rankama, T. & Kankaanpää, J. 2008. Eastern arrivals in post-glacial Lapland: the Sujala site 10 000 cal BP. *Antiquity* 82, 884-899.

Rankama, T. & Kankaanpää, J. *this volume*. The Kaaraneskoski Site in Pello, Southwestern Lapland – at the Interface between the "East" and the "West".

Rankama, T., Manninen, M. A., Hertell, E. & Tallavaara, M. 2006. Simple production and social strategies: do they meet? Social dimensions in Eastern Fennoscandian quartz technologies. In J. Apel & K. Knutsson (eds.), *Skilled Production and Social Reproduction. Aspects of Traditional Stone Tool Technologies*. SAU Stone Studies 2, 245–261. Uppsala, Societas Archaeologica Uppsaliensis.

Reimer, P. J., Baillie, M. G. L., Bard, E., Bayliss, A., Beck, J. W., Blackwell, P. G., Bronk Ramsey, C., Buck, C. E., Burr, G. S., Edwards, R. L., Friedrich, M., Grootes, P. M., Guilderson, T. P., Hajdas, I., Heaton, T. J., Hogg, A. G., Hughen, K. A., Kaiser, K. F., Kromer, B., McCormac, F. G., Manning, S. W., Reimer, R. W., Richards, D. A., Southon, J. R., Talamo, S., Turney, C. S. M., van der Plicht, J., & Weyhenmeyer, C. E. 2009. IntCal09 and Marine09 radiocarbon age calibration curves, 0-50,000 years cal BP. *Radiocarbon,* 51(4), 1111–1150.

Renssen, H., Goosse, H. & Fichefet, T. 2002. Modeling the effect of freshwater pulses on the early Holocene climate: The influence of high-frequence climate variability. *Paleocenography* 17(2), 10-1–16.

Richerson, P. J. & Boyd, R. 2005. *Not By Genes Alone. How Culture Transformed Human Evolution*. Chicago, University of Chicago Press.

Räihälä, O. 1999 Mesolithic Settlement on the River Emäjoki, North-East Finland. In M. Huurre (ed.), *Dig it all. Papers dedicated to Ari Siiriäinen*, 201–217. Helsinki, The Finnish Antiquarian Society & The Archaeological Society of Finland.

Sakshaug, E. 1997. Biomass and productivity distributions and their variability in the Barents Sea. *ICES Journal of Marine Science* 54, 341–350.

Sakshaug, E. & Slagstad, D. 1992. Sea Ice and Wind: Effects on Primary Productivity in the Barents Sea. *Atmosphere-Ocean* 30(4), 579–591.

Salomaa, R. & Matiskainen, H. 1983. Rannan siirtyminen ja arkeologinen kronologia Etelä-Pohjanmaalla. *Karhunhammas* 7, 21–36.

Schmitt, L., Larsson, S., Schrum, C., Alekseeva, I., Tomczak, M. & Svedhage, K. 2006. 'Why they came'; The *colonization of the* coast of western Sweden and its environmental context at the end of the last glaciation. *Oxford Journal of Archaeology* 25(1), 1–28.

Schmölcke, U., Endtmann, E., Klooss, S., Meyer, M., Michaelis, D., Rickert, B.-H. & Rößler, D. 2006. Changes of sea level, landscape and culture: A review of the south-western Baltic area between 8800 and 4000BC. *Palaeogeography, Palaeoclimatology, Palaeoecology* 240, 423–438.

Schuh, D. R. 1987. *Bowhunter's Encyclopedia*. Mechanicsburg, Stackpole Books.

Schulz, H.-P. 2002. *Juva Päiväranta 1 ja 2. Kivikautisen ja rautakautisen/historiallisen ajan asuinpaikkaryhmän koekaivaus 2002.* Excavation report. http://www.mikroliitti.fi/tyot2002/JUVA02.htm

Seppä, H., Birks, H. J. B., Giesecke, T., Hammarlund, D., Alenius, T., Antonsson, K., Bjune, A. E., Heikkilä, M., MacDonald, G. M., Ojala, A. E. K., Telford, R. J. & Veski, S. 2007. Spatial structure of the 8200 cal yr BP event in northern Europe. *Climate of the Past* 3, 225–236.

Seppä, H. & Hicks, S. 2006. Integration of modern and past pollen accumulation rate (PAR) records across the arctic tree-line: a method for more precise vegetation reconstructions. *Quaternary Science Reviews* 25, 1501–1516.

Seppälä, S.-L. 1993. *Inari 13 Vuopaja. Kivi- ja varhaismetallikautisen asuinpaikan kaivaus* 13.-27.7.1993. Excavation report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Seppälä, S.-L. 1994. *Inari 13 Vuopaja. Kivi- ja varhaismetallikautisen asuinpaikan kaivaus* 13.6.-18.7.1994. Excavation report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Shackley, M. S. 2000. The Stone Tool Technology of Ishi and the Yana of North Central California: Inferences for Hunter-Gatherer Cultural Identity in Historic California. *American Anthropologist* 102(4), 693–712.

Siiriäinen, A. 1977. Quartz, Chert and Obsidian, A comparison of Raw Materials in a Late Stone Age Aggregate in Kenya. *Finskt Museum* 1974, 15–29.

Siiriäinen, A. 1984. The Mesolithic of Finland. A Survey of Recent Investigations. In J. K. Kozlowski & S. K. Kozlowski (eds.), *Advances in Palaeolithic and Mesolithic Archaeology*. Archaeologia Interregionalis vol. 5 (1984), 173–191.

Sinisalo, H. 2004. *Kun keramiikkaa ei ole. Kivikautisten asuinpaikkojen ajoittaminen rannansiirtymisen ja esinetyyppien avulla*. Unpublished MA-thesis. University of Helsinki.

Sjöström, A. 1997. Ringsjöholm. A Boreal–Early Atlantic Settlement in Central Scania, Sweden. *Lund Archaeological Review* 3, 5–20.

Skandfer, M. 2003. *Tidlig, nordlig kamkeramikk. Typologi-kronologi-kultur*. PhD thesis. University of Tromsø. http://www.ub.uit.no/munin/handle/10037/284

Sorokin, A. M. 2006. The Final Palaeolithic in Central Russia. *Archaeologia Baltica* 7, 120–135.

Stuiver, M., Reimer, P. J. & Reimer, R. 1986–2010. *Marine Reservoir Correction Database*. http://calib.qub.ac.uk/calib/

Tallavaara, M. 2007. *Vihiä teknologisista strategioista: Tutkimus Rääkkylän Vihin kampakeraamisen ajan asuinpaikan piikivi- ja kvartsiaineistoista*, Master's thesis. E-thesis, University of Helsinki, http://urn.fi/URN:NBN:fi-fe20072153

Tallavaara, M., Manninen, M. A., Hertell, E. & Rankama, T. 2010a. How flakes shatter: a critical evaluation of quartz fracture analysis. *Journal of Archaeological Science* 37, 2442–2448.

Tallavaara, M., Pesonen, P. & Oinonen, M. 2010b. Prehistoric population history in eastern Fennoscandia. *Journal of Archaeological Science* 37, 251–260.

Ukkonen, P. 1994. Inari 13 Vuopaja (KM 27809) / S.-L. Seppälä 1993. In Seppälä, S.-L. 1993. *Inari 13 Vuopaja. Kivi- ja varhaismetallikautisen asuinpaikan kaivaus* 13.-27.7.1993. Excavation report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Ukkonen, P. 1995. Inari 13 Vuopaja (KM 28365) / S.-L. Seppälä 1994. In Seppälä, S.-L. 1994. *Inari 13 Vuopaja. Kivi- ja varhaismetallikautisen asuinpaikan kaivaus* 13.6.–18.7.1994. Excavation report on archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Vang Petersen, P. 1984. Chronological and Regional Variation in the Late Mesolithic of Eastern Denmark. *Journal of Danish Archaeology* 3, 7–18.

Vang Petersen, P. 1999. *Flint fra Danmarks oldtid*. København, Høst & Son.

Vinje, T. 2009. Sea-ice. In E. Sakshaug, G. Johnsen & K. Kovacs (eds.), *Ecosystem Barents Sea*, 65–82. Trondheim, Tapir Academic Press.

Voronina, E., Polyak, L., De Vernal, A., & Peyron, O. 2001. Holocene variations of sea-surface conditions in the southeastern Barents Sea, reconstructed from dinoflagellate cyst assemblages. *Journal of Quaternary Science* 16(7), 717–726.

Wadley, L. & Mohapi, M. 2008. A Segment is not a Monolith: evidence from the Howiesons Poort of Sibudu, South Africa. *Journal of Archaeological Science* 35, 2594–2605.

Waraas, T. A. 2001. *Veslandet i tidleg Preboreal tid. Fosna, Ahrensburg eller vestnorsk tidlegmesolitikum*? Hovudfagoppgåve i arkeologi. Universitetet i Bergen.

Wiessner, P. 1983. Style and social information in Kalahari San projectile points. *American Antiquity* 48, 253–276.

Woodman, P. C. 1993. The Komsa Culture. A Re-examination of its Position in the Stone Age of Finnmark. *Acta Archaeologica* 63/1992, 57–76.

Woodman, P. C. 1999. The Early Postglacial Settlement of Arctic Europe. In E. Cziesla, T. Kersting & S. Pratsch (eds.), *Den Bogen spannen… Festschrift für Bernhard Gramsch zum 65. Geburstag,* Teil 1. Beiträge zur Ur- und Frügeschichte Mitteleuropas 20, 292–312. Weissbach, Beier & Beran.

Wookey, P. A. 2007. Climate change and biodiversity in the Arctic–Nordic perspectives. *Polar Research* 26, 96–103.

Äyräpää, A. 1950. Die ältesten steinzeitlichen Funde aus Finnland. *Acta Archaeologica* XXI, 1–43.

Åkerlund, A. 1996. *Human Responses to Shore Displacement. Living by the Sea in Eastern Middle Sweden during the Stone Age*. Arkeologiska undersökningar Skrifter 16. Stockholm, Riksantikvarieämbetet.

Zagorska, I. 1993. The Mesolithic in Latvia, *Acta Archaeologica* 63, 97–117.

Zaliznyak, L. 1997. Mesolithic Forest Hunters in Ukrainian Polessye. *British Archaeological Reports International Series* 659.

Zhilin, M. G. 2005. The terminal Paleolithic – early Mesolithic. In H. Knutsson (ed.), *Pioneer settlements and colonization processes in the Barents region.* Vuollerim Papers on Hunter-gatherer Archaeology 1, 163–179. Vuollerim, Vuollerim 6000 år.

Zvelebil, M. 2006. Mobility, contact, and exchange in the Baltic Sea basin 6000–2000 BC. *Journal of Anthropological Archaeology* 25, 178–192.

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	Päivärinta 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	
KEMI-JÄRVI	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	
KUOR-TANE	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

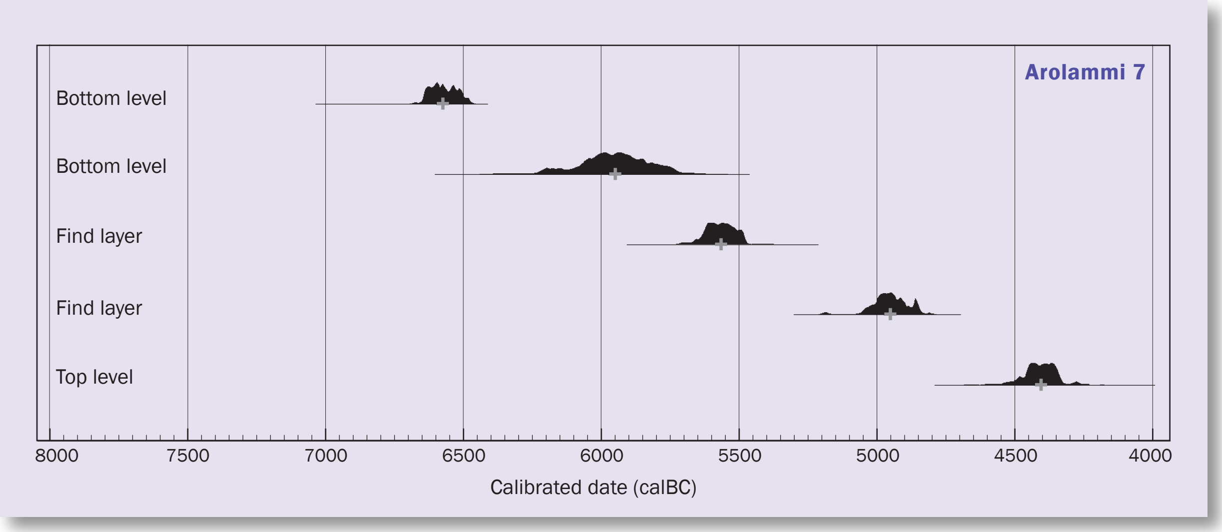
Location (ETRS89): 60° 41' 22.103" N, 24° 46' 53.906" E

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

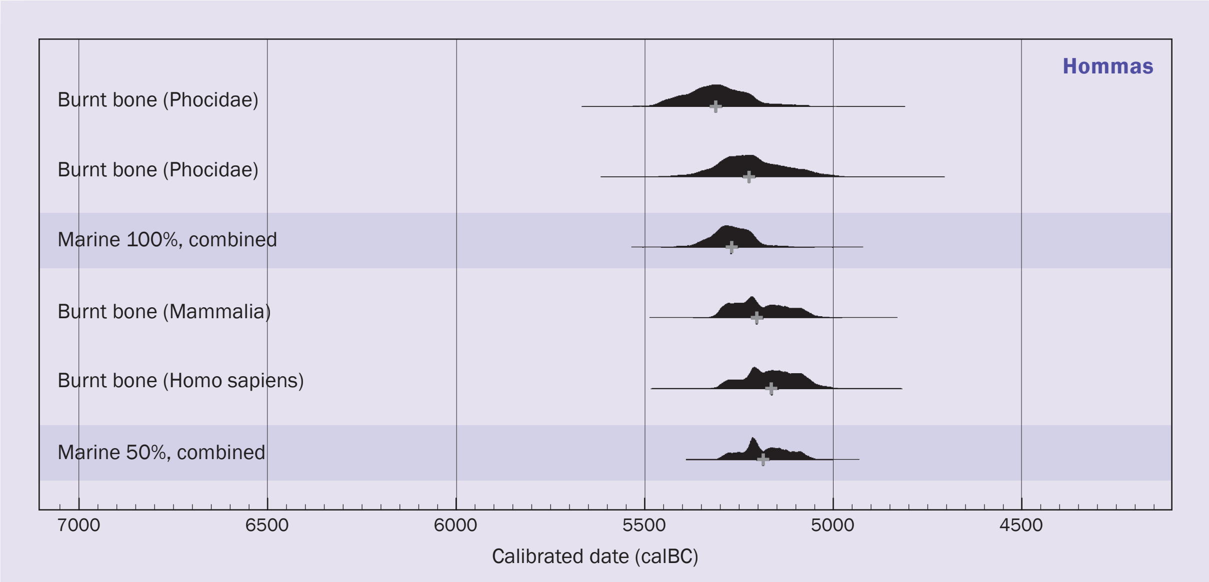
Location (ETRS89): 60° 18' 48.074" N, 24° 53' 21.629" E

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

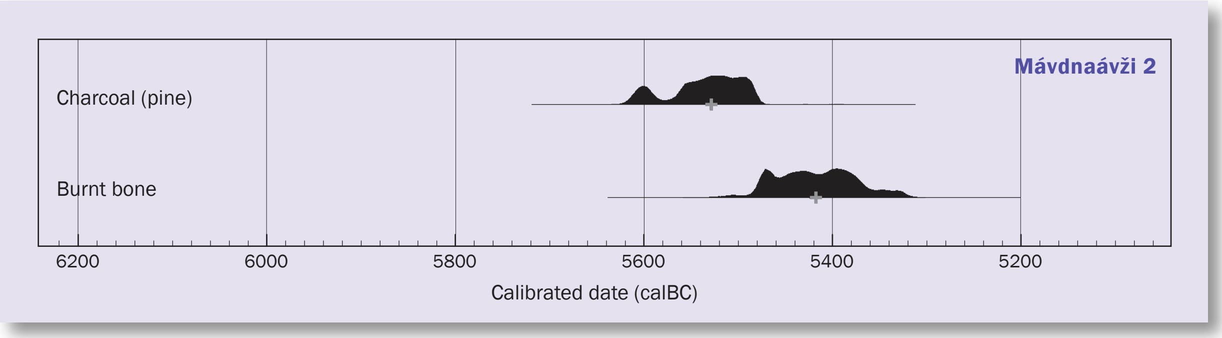
General: The site consists of a small round hut foundation with a *c.* 3 metres diameter and an outside activity area. In total, 52 square metres have been excavated to date. Within the area of the hut foundation, a central hearth surrounded by well-defined lithic concentrations was found. In the hearth 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

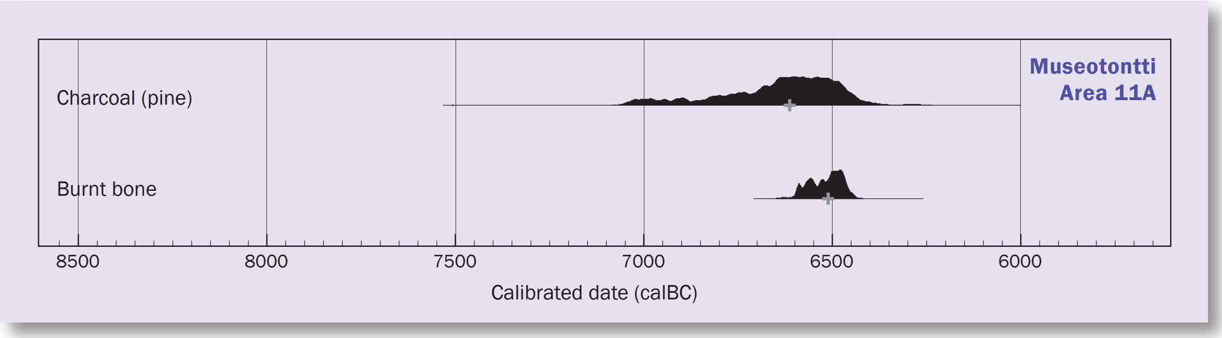
Location (ETRS89): 68° 23' 44.104" N, 23° 41' 53.234" E

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)).

PAPER V

Manninen, M. A., Knutsson, K. 2013. Lithic raw material diversification as an adaptive strategy—Technology, mobility, and site structure in Late Mesolithic northernmost Europe. *Journal of Anthropological Archaeology* 33, 84–98. Reprinted with permission from Elsevier.

Journal of Anthropological Archaeology 33 (2014) 84–98

Contents lists available at ScienceDirect

Journal of Anthropological Archaeology

journal homepage: www.elsevier.com/locate/jaa

Lithic raw material diversification as an adaptive strategy—Technology, mobility, and site structure in Late Mesolithic northernmost Europe

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ARTICLE INFO

Article history:
Received 8 October 2012
Revision received 3 December 2013

Keywords:
Lithic technology
Mobility
Site structure
Diversification
Intensification
Adaptation
Technological organization
Lithic raw material properties
Fennoscandia
Quartz

ABSTRACT

Formal technologies and intensified reduction are often seen as responses to increased mobility and low abundance of lithic raw material of good flakeability and controllability. Although patterns of lithic raw material availability and occurrence are in many ways analogous to those of subsistence resources, resource diversification, an adaptive strategy commonly discussed in relation to food procurement, is rarely discussed in connection to changes in lithic resource availability and technology. We present a case from northernmost Europe in which pronounced differences in raw material availability caused by a distinct geological setting existed within a relatively small area. We conclude that restricted availability of high-quality raw material due, for instance, to increased mobility or changes in the size or location of the foraging range does not necessarily lead to formalization and intensification and can, in certain situations, as in the studied case, lead to the application of an adaptive strategy that can be called raw material diversification. This strategy entails a widening of the raw material base to include raw materials of lower workability and a consequent alteration of existing technological concepts, often in the form of simplification and informalization.

Introduction

The relationship between the organization of hunter–gatherer stone tool production technology and settlement configuration has been explored from a variety of perspectives over the past few decades. Many interconnected topics, such as risk management, the scheduling of resource availability, production efficiency, and transport cost, have been and continue to be discussed in the organizational framework informed by optimization theory and behavioral ecology (e.g., Andrefsky, 1994a, 2009; Binford, 1979, 1980; Bleed, 1986; Bousman, 1993; Elston and Kuhn, 2002; Kelly, 1995; Kuhn, 1994; Nelson, 1991; Parry and Kelly, 1987; Surovell, 2009; Torrence, 1989).

It is widely accepted that links exist between lithic technological organization and the degree of residential mobility (e.g., Odell, 2003, pp. 190–201; Surovell, 2009). However, while inferences about the degree of hunter–gatherer residential mobility are well grounded in ethnoarchaeological and ethnographic data (e.g., Chatters, 1987; Gamble and Boismier, 1991; Gould, 1971; Kelly et al., 2005; Kent, 1991; Panja, 2003), many inferences about the organization of lithic technology in relation to other dimensions of hunter–gatherer adaptations are hampered by the fact that stone tools are not used to any significant degree by contemporary hunter–gatherers and therefore are in many cases only testable using archaeological data. This is also true of any correlations between lithic technology and the degree of mobility.

In a survey exploring the relationship between lithic raw material availability and the organization of lithic technology, Andrefsky (1994a) found that when there is an abundance of lithic raw material of good workability, both formal and informal tools tend to be produced, whereas a low abundance of such raw material tends to lead to the production of formal tools, such as prepared cores, i.e., tools and cores that have undergone additional effort in production and make efficient use of raw material. On the other hand, in situations in which only raw material of low workability is available, tools and cores are mostly informal. In line with these results, a decrease in the availability of high-workability raw materials is often found to lead to intensification of core reduction and a subsequent increase in the core-to-blank ratio (e.g., Blades, 2001, p. 97; Dibble et al., 1995, p. 267).

The increased reduction efficiency and core use life achieved by the use of formal technologies are often seen as advantageous for groups with high residential mobility because of such benefits as low carrying cost, raw material conservation and the decreased need for resupplying during long-distance journeys (e.g., Hertell and Tallavaara, 2011b; Kelly, 1988; Parry and Kelly, 1987; Rasic and Andrefsky, 2001). Consequently, formal lithic

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http://dx.doi.org/10.1016/j.jaa.2013.12.001

production, together with other forms of economizing behavior and intensification, is often assumed to eventuate from high residential mobility, especially when there is low and localized availability of good-workability raw materials within the foraging range.

However, also the use and transportation of flake blanks can have advantages for mobile groups in terms of low carrying costs (Kuhn, 1994; see also Surovell, 2009, pp. 142–150), and lately, the view that formal cores are more weight-efficient than informal flake cores has been challenged. It has been suggested that if the reduction of transport costs is the primary goal, then formal cores should be abandoned with increasing mobility, especially when the raw material package size is small (Eren et al., 2008; Jennings et al., 2010; Prasciunas, 2007).

In this paper, we present a case in which high residential mobility and low availability of high-workability tool stone did not lead to intensification and formalization but rather to an informalization of technology. We discuss possible reasons for this development by comparing the benefits of intensification *versus* diversification in situations in which the accessibility of high-workability raw material sources decreases due to increased long-distance residential mobility or other changes in the size and location of the foraging range.

To avoid circular reasoning and assumptions of static relations between lithic technological organization and settlement configuration, we use site structure in this paper as a proxy for the degree of residential mobility. Ethnoarchaeological research indicates that anticipated mobility, i.e., the length of time people expect to stay at a site, is a stronger determinant of site structure and maintenance than the actual length of occupation (Kent, 1991). This result implies that the site structure of highly mobile groups, regardless of the actual time spent at a site, can be expected to reflect anticipated mobility and recurrently show typical features of mobile camps, such as small dwelling and site sizes (e.g., Kent, 1991), low investment in housing (Binford, 1990), high feature discreteness (Chatters, 1987, p. 346; Gifford, 1980), and a low degree of debris accumulation and preventive site maintenance (Binford, 2002, p. 189; Jones, 1993). As these patterns can be expected to be identifiable also at prehistoric mobile hunter–gatherer sites, we evaluate the degree of residential mobility in the studied case using these indicators.

We then concentrate on the organization of lithic technology and study the relationships between raw material use, properties, and availability at the studied sites. However, we emphasize that if it is accepted that human adaptation is a "multidimensional phenomenon varying along potentially independent axes ... with individual cases identifiable as intersections of the many dimensions" (Chatters, 1987, p. 338; see also Bamforth, 2009), we should not expect strict covariation between any two organizational dimensions. Rather, the reasons behind any specific solution are likely to be multiple and situational and involve variables that are purely economic or determined by the physical environment, such as raw material availability and properties (e.g., Andrefsky, 1994a,b; Domanski et al., 1994), as well as variables that can be considered cultural or determined by the social environment, such as technological traditions and transmission mechanisms (e.g., Bettinger and Eerkens, 1999; Newman and Moore, 2013; Riede, 2006).

We suggest that in the studied case, a relatively informal lithic technology connected to long-distance residential mobility was mainly determined by the properties of a widely available but relatively poor-workability raw material, namely vein quartz, in addition to localized availability of high-workability raw materials. However, the results imply that the resulting technological solution was also affected by other organizational dimensions, most notably tradition and most likely also transport cost.

The setting

In the study area, located in northernmost Europe or more specifically in the northern parts of Finland, Sweden, and Norway, Stone Age hunter–gatherers faced a situation in which sources of fine-grained homogenous lithic raw materials were unevenly distributed and restricted in size, while raw materials of lower workability were widely available. Furthermore, from the early post-glacial pioneer phase onward, the area saw colonization and influences from many directions that resulted in several coexisting archaeological cultures with distinct technological traditions (e.g., Bjerck, 2008; Grydeland, 2005; Kankaanpää and Rankama, 2005; Manninen and Knutsson, 2011; Rankama and Kankaanpää, 2011; Woodman, 1999). This setting enables additional inferences about the dynamic relationship between adaptation and tradition and provides good opportunities to study the importance of raw material availability and properties to the organization of lithic technology.

The study area is divided by major geological boundaries (Fig. 1). Macrocrystalline vein quartz is commonly found in virtually all of the area, both as cobbles and boulders in glacial moraines and as veins in the bedrock, but because of its fragility and the usually high incidence of internal flaws, it is a raw material that can be considered less than favorable for the execution of elaborate technological concepts. At the same time, chert and other fine-grained lithic raw materials of considerably better flakeability and controllability are found only in beach and moraine deposits at the Atlantic coast and as localized sources associated predominantly with the Scandinavian Caledonides in northern Norway and the border zone between Sweden and Norway (e.g., Åhman, 1967; Bøe, 1999; Hood, 1992).

Lithic technology in the area largely followed the bedrock division. For instance, chipped lithics in the Mesolithic assemblages dating to ca. 8000–6500 cal BC in the region of Palaeoproterozoic

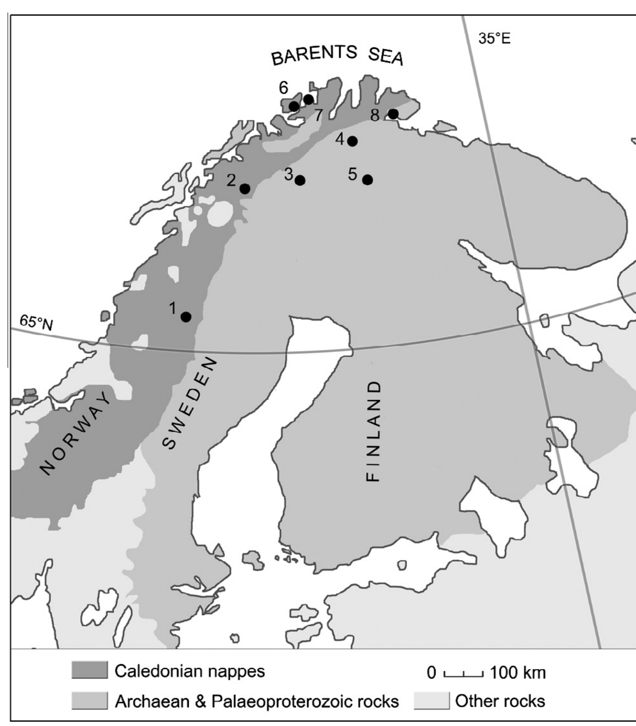

Fig. 1. Map showing bedrock division in northernmost Europe and the sites mentioned in the paper: (1) Rastklippan, (2) Devdis I, (3) Aksujavri, (4) Mávdnaávži 2, (5) Vuopaja, (6) Slettnes, (7) Melkøya, and (8) Mortensnes. Bedrock division based on Nordgulen and Andresen (2008).

and Archaean bedrock are dominated by quartz and simple flaking techniques (e.g., Hood, 2012; Kankaanpää and Rankama, 2005; Olofsson, 2003) while production of formal core blades from local raw materials is known from many sites along and near the Scandinavian Caledonides, such as the North Norwegian Barents Sea coastal area (e.g., Bjerck, 2008; Knutsson and Knutsson, 2014; Rankama and Kankaanpää, 2011; Woodman, 1993). Needless to say, due to the geologic setting, extending their foraging range far into the area of Palaeoproterozoic and Archaean bedrock necessitated the employment of strategies that secured adequate and suitable tool stone for forager groups that based their technology on fine-grained raw materials.

The correlations between raw material availability and lithic technology in the part of northern Europe discussed are therefore in most cases consistent with the results of Andrefsky's (1994a) aforementioned survey: in areas where quartz dominates the raw material base, technology tends to be simple and informal, whereas in areas close to the sources of fine-grained raw materials formal core blade production is also present.

However, roughly from the beginning of Phase III (ca. 6400 cal BC) of the North Norwegian Mesolithic chronology, fine-grained raw materials deriving from the Barents Sea coastal area are recurrently found at inland sites up to 150 km from the coast, in areas where these types of raw materials do not occur naturally (Hood, 2012; Manninen, 2009; Manninen and Knutsson, 2011). In tandem with the flow of coastal raw materials into the interior, sites in the coastal area show a sharp decrease in formal blade production, as well as an increase in the use of quartz and other raw materials of comparatively inferior workability (Fig. 2) (Grydeland, 2000, 2005; Hesjedal et al., 1996, 2009; Woodman, 1999).

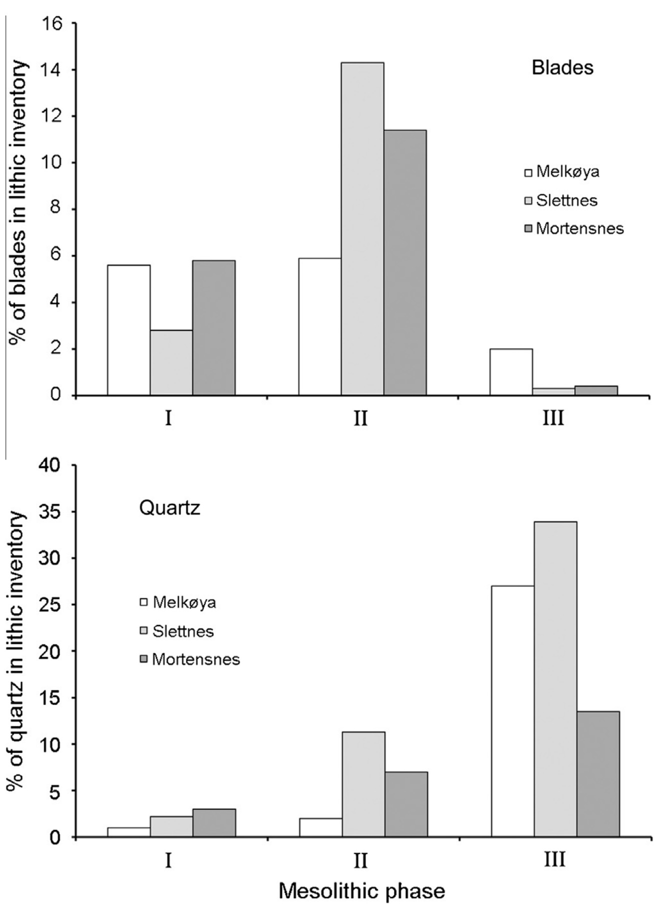

Fig. 2. The relative amounts of (core) blades and quartz at three multiperiod sites located on the Norwegian Barents Sea coast. Phases I (ca. 9500–8000 cal BC), II (ca. 8000–6400 cal BC), and III (ca. 6400–4400 cal BC), according to the local tripartite Mesolithic chronology: Melkøya (Hesjedal et al., 2009), Slettnes (Hesjedal et al., 1996), and Mortensnes (Schanche, 1988).

Instead of the earlier division into two technologies, i.e., a relatively formal and largely blade-based technology in the Barents Sea coastal area and an informal and almost exclusively quartz based technology in the inland area (Kankaanpää and Rankama, 2005; Manninen and Knutsson, 2011), these changes result in a more or less uniform lithic technology throughout the entire region. The increase in quartz use and the simplification of technology in the coastal area have been suggested to indicate a population crash, followed by colonization of the unoccupied areas by "inlanders" (Rankama, 2003; Hagen, 2011). However, the homogenization of lithic technology was accompanied by the spread of a new lithic arrowhead type first into the interior of northernmost Norway and Finland and then further south in Finland and Sweden (Manninen and Tallavaara, 2011), a fact that suggests that formal templates of the earlier "coastal" technological tradition strongly influenced the new technology.

This so-called oblique point is a microlithic arrowhead that is in many ways analogous to the classic Late Mesolithic transverse arrowheads of Western Europe. The point is made by reducing a flake blank into a roughly triangular shape by abrupt margin retouch while preserving a part of the blank edge as the cutting edge of the point. This type of arrowhead belongs to the post-glacial millennia-long tradition of production of margin-retouched points, initially from standardized blades, known from the North Norwegian Barents Sea coastal area (Hesjedal et al., 1996; Hood, 2012; Manninen and Knutsson, 2011; Manninen and Tallavaara, 2011; Odner, 1966; Woodman, 1999).

We thus have a situation in which, in areas close to comparatively high-quality lithic sources, the use of raw materials of poorer working quality peaks concurrently with an informalization of blank production, while in the areas of Archaean and Palaeoproterozoic bedrock and up to 150 km from the sources of high-quality raw material, the use of raw materials of good flakeability and controllability is recurrently observed in connection with margin-retouched points, i.e., with a arrowhead manufacturing concept that was previously confined primarily to the Barents Sea coast.

Manninen and Tallavaara (2011; see also Grydeland, 2005) argue that these changes were the result of a re-organization of hunter–gatherer subsistence economy and settlement configuration that was boosted by the 8.2 ka climate event. A drop in productivity and carrying capacity can be expected to be followed by a population decline and an increase in residential mobility (Binford, 2001, pp. 209–242; Kelly, 1995, pp. 221–232). In the area under discussion, the early mid-Holocene cold events are likely to have caused major drops in productivity, especially in the Barents Sea and would consequently have increased the importance of inland resources and related residential mobility for local hunter–gatherer groups (Manninen and Tallavaara, 2011; see also Hagen, 2011).

This type of development can be assumed to have increased the amount of inter-group marriage between coastal and inland groups and enhanced the probability of a shift to a wide-ranging coast–inland adaptation and merging of socially transmitted traditions. Such a mobility pattern would explain the carrying of coastal raw material into the interior as a part of the mobile toolkit (Manninen, 2009). This scenario, however, does not conform well to the expectation of a correlation between low availability of raw material of good workability and a primarily formal lithic inventory, as the new technology, while in some respects more formal than the technology previously used in the interior, is considerably less formal than the earlier blade-based technology used at the coast.

Two widely used explanations are usually put forth to account for the occurrence of non-local raw materials at hunter–gatherer sites, namely, extra-regional exchange and procurement associated with long-distance mobility. The latter of these two is usually seen as procurement embedded in long-distance residential mobility or logistic raw material procurement (Baugh and Ericson, 1994; Binford, 1979; Gould and Saggers, 1985; Hertell and Tallavaara, 2011a). However, long-distance mobility and exchange may also be directly related to marriage networks and other long-term social networks through which exotic goods also move (e.g., Hertell and Tallavaara, 2011a; Whallon, 2006). A reason other than increased residential mobility could therefore be suggested for the flow of fine-grained raw materials into the interior of northernmost Norway and Finland.

While maintaining emphasis on raw material availability and properties, the setting described, with its indications of increased mobility, thus leaves three specific questions that we need to address. (1) Why is stone tool production technology related to the late phase of the margin-retouched point tradition so informal, despite the low availability of raw materials of good flakeability and controllability? To be able to address this general question, which implies a deviation from Andrefsky's finding of a correlation between low abundance of good-workability raw material and production of formal tools, we have to study the behavioral contexts related to this production technology in some detail. (2) What types of patterns of raw material procurement and use can we detect? (3) What type of settlement configuration do the oblique-point sites represent?

The analyses

Currently there are some 50 sites in the northern parts of Norway, Sweden and Finland that have yielded oblique points (Hood, 2012; Manninen and Knutsson, 2011; Skandfer, 2003). We selected five sites, Devdis I (Helskog, 1980), Aksujavri (Hood, 1988), Rastkippan (Knutsson, 2005), Vuopaja (upper terrace, Seppälä, 1994), and Mávdnaávži 2 (Manninen, 2006, 2009), for further study. The selection is based on the presence of an excavated occupation phase with associated arrowheads and reliable radiocarbon dates (cf. Manninen and Knutsson, 2011; Manninen and Tallavaara, 2011). Although the sites are dispersed over a large area, they are practically contemporaneous (Table 1), and it is safe to say that the biotic environment and climate have been similar at all site locations. The studied sites are all located inland, some 50–150 km from the contemporary seashore, four in the northernmost parts of Finland and Norway and one in Sweden, further south along the Scandinavian Caledonides.

To clarify the nature of the site assemblages in relation to settlement configuration while avoiding expectations of static relations and covariation between hunter–gatherer settlement configuration and stone tool production intensity, we first evaluated the degree of residential mobility from site structure, using the behavioral patterns inferred from ethnographic and ethnoarchaeological research that suggest several common denominators in the spatial organization of mobile campsites. Many of these patterns are also detectable in prehistoric settings because they are a direct result of anticipated mobility, small group size, and short periods of occupation. To confirm our hypothesis of high residential mobility, we therefore expect to find evidence of small dwelling and site sizes, low investment in housing, high feature discreteness, low degrees of debris accumulation and site maintenance and the presence of family groups rather than single-sex task groups.

We then studied raw material composition by dividing by raw material and, when possible, by sourcing the lithic artifacts from each site. Finally, we studied the use of the different raw materials in stone tool production to gain an understanding of raw material use and movement and their relation to raw material abundance and properties.

In the analyses, we put special emphasis on economizing behavior because of its strong link to the studied variables. Patterns of economizing observed in earlier research suggest that as the distance to sources of raw materials of good workability increases, the use of strategies aimed at raw material and tool conservation can be expected to increase. Such strategies include increased formalization of tools made of scarce raw materials, small artifact size, exhaustion of cores by bipolar-on-anvil reduction, and increased utilization and rejuvenation of tool edges (Andrefsky, 1994b; Odell, 2003, p. 199; Ricklis and Cox, 1993).

Results

Site structure

Of the five sites, Mávdnaávži 2 has the greatest potential for inferences about details of site structure (Fig. 3) because of its low post-depositional disturbance, exact find location data, and favorable soil type. For a variety of reasons, the other sites are not as well suited to intra-site studies. The Rastklippan site, located on a rocky islet and consisting of a hut floor on a small patch of soil deliberately restrained with piled-up stones, was partly destroyed by negligent digging prior to excavation. At Devdis I, Aksujavri, and Vuopaja, sandy soil has not preserved any direct signs of housing. Furthermore, while the exact find location was recorded at Mávdnaávži 2, find locations at the other four sites were only recorded to within half- or one-meter squares.

Low preventive site maintenance is indicated at Mávdnaávži 2 by a hearth-related pattern of discrete activity areas or "drop zones" with arrowhead manufacturing waste, including broken and intact arrowheads and performs, as well as increased numbers of small retouch flakes and chips. A similar pattern is discernible at Rastklippan and Devdis I (Fig. 4), although at Rastklippan, the hut floor and waste were deliberately covered with a layer of clean sand and new hearth stones, which suggests later "cleaning up" of the site for re-use (Knutsson, 2005). The hearth-related pattern is further evidenced at Mávdnaávži 2 by conjoins between burnt basal parts of arrowheads found in the inside hearth and their

Table 1
Radiocarbon dates from the studied sites. Data from Hood (2012), Manninen and Knutsson (2011) and Manninen and Tallavaara (2011). A = direct date from a burnt reindeer (*Rangifer tarandus*) bone, B = the only identified species within the same concentration of burnt bone is reindeer.

Lab. no.	Site	Dated sample	BP	calBC, 2σ
T-1343	Devdis I	Charcoal, indet. species	6575 ± 150	5759–5221
Tua-7194	Aksujavri	Burnt bone, *Rangifer tarandus*[B]	6650 ± 30	5631–5526
Ua-40900	Mávdnaávži 2	Charcoal, *Pinus sylvestris*	6580 ± 38	5616–5478
Hela-963	Mávdnaávži 2	Burnt bone, *Rangifer tarandus*[B]	6455 ± 45	5484–5327
Ua-40897	Vuopaja	Burnt bone, *Rangifer tarandus*[A]	6526 ± 39	5607–5380
Ua-3656	Rastklippan	Charcoal, *Pinus sylvestris*	6540 ± 75	5626–5363
Ua-3654	Rastklippan	Charcoal, *Pinus sylvestris*	6410 ± 75	5508–5223
Ua-3655	Rastklippan	Charcoal, *Pinus sylvestris*	6355 ± 75	5483–5081

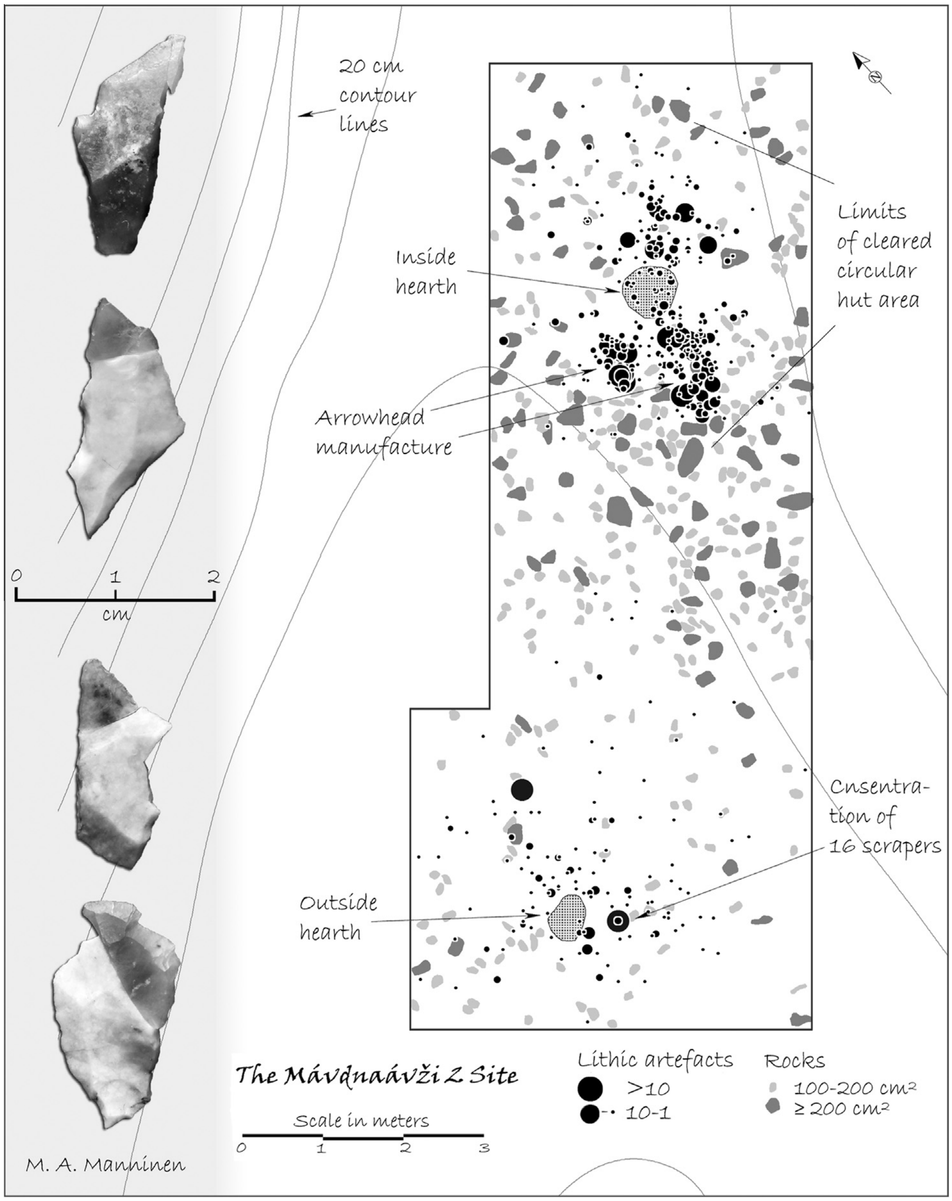

Fig. 3. The Mávdnaávži 2 site. On the right, the hearth-related spatial distribution of lithic artifacts. Retouch flakes and unburnt tips of arrowhead performs are concentrated to the southwest of the inside hearth, while burnt basal parts are concentrated within the hearth area. On the left, refitted arrowhead retouch flake (top) and arrowhead performs consisting of conjoins between unburnt tips and burnt bases.

unburnt tips that broke off during manufacture and were found next to the hearth (Fig. 3). Feature discreteness is especially clear at Mávdnaávži 2, where individual sitting places can be discerned next to tool production waste inside the dwelling and where a tight concentration of sixteen scrapers was found in the hearth-related outdoor activity area. At Aksujavri and Vuopaja, the pattern is less clear, but arrowheads and waste from arrowhead manufacture do coincide with concentrations of burnt bone (Fig. 4; Hood, 1988).

Unfortunately, the generally poor preservation of organic materials in the study area prevents inferences concerning the size, content, and location of food processing debris, as only small fragments of burnt bone are found in the excavations. None of the bone fragments from Rastklippan and Devdis I have been identified by species, but some information on hunted species can be retrieved from fragments of burnt bone at the other sites. At Mávdnaávži 2 and Aksujavri, the bones identified belonged to reindeer (*Rangifer tarandus*), while at Vuopaja, in addition to reindeer bones, bones of European elk/moose (*Alces alces*) have been identified.

The sites show no evidence of house structures other than light ground-surface dwellings. The circular or elliptical hut foundations at Mávdnaávži 2 and Rastklippan are approximately 3.5 meters wide. This size and shape are analogous to the single-family dwellings (usually for 4–8 persons) of many ethnographically known northern hunter–gatherer groups, such as the Skolt Saami (Nickul, 1948; Paulaharju, 1921) and the Mistissini Cree (Tanner, 1979). This is not to say that the size and shape of the floor indicates cultural affiliation. Rather, it seems likely that body mechanics, similar environment, and anticipated mobility led to equifinality in house structures. In an ethnographic survey, Binford (1990) also found a tendency linking circular and elliptical ground plans and dwellings erected directly on the ground surface with greater mobility. The estimate of 4–8 inhabitants in Mávdnaávži 2 and Rastklippan also roughly corresponds with the smallest group sizes

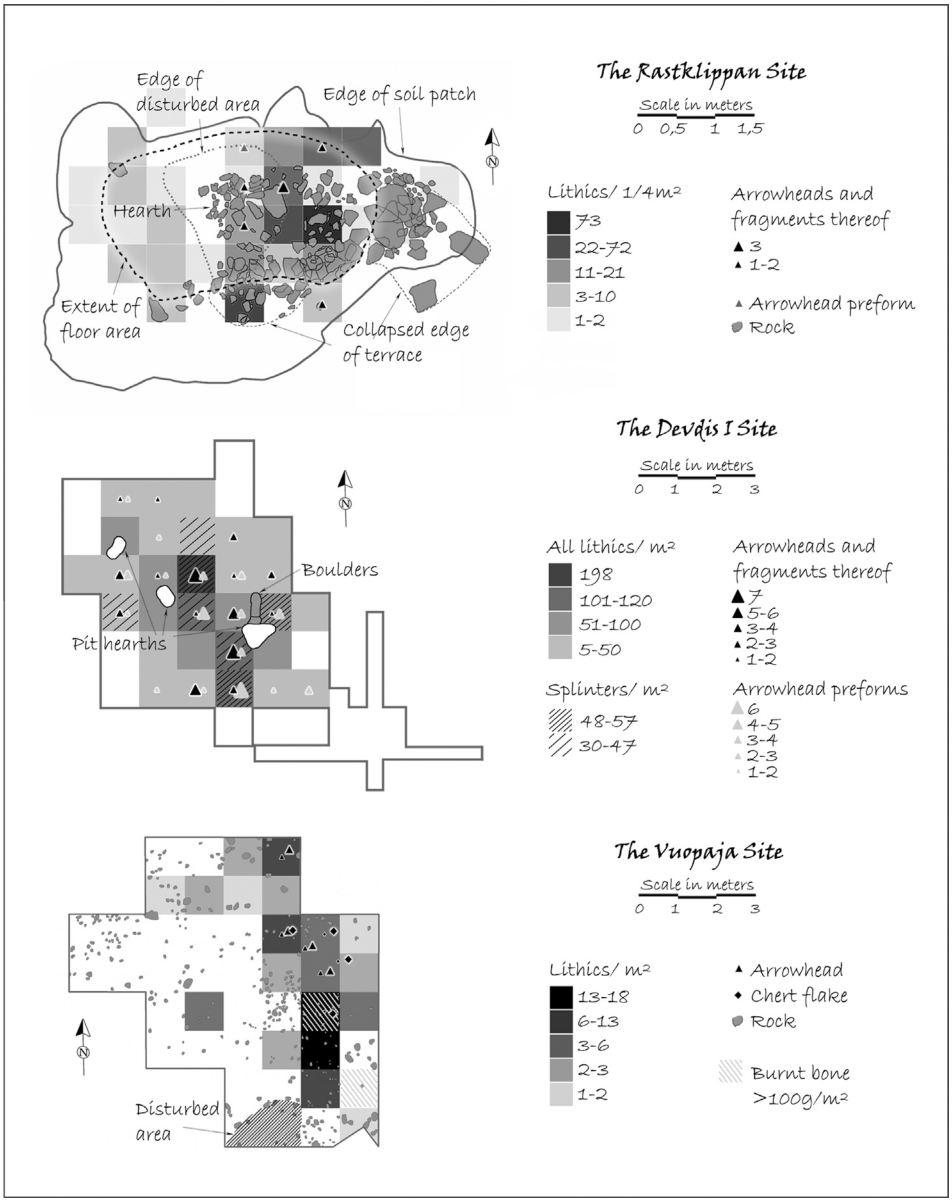

Fig. 4. Structural features and spatial distributions of lithic artifacts at the Rastklippan, Devdis I, and Vuopaja sites. Not included are the 674 artifacts that were collected prior to excavation from the disturbed area surrounding the Rastklippan hearth and for which more exact find location data do not exist. The Devdis I and Vuopaja site maps are based on Helskog (1980, Fig. 29) and Seppälä (1994). Note the difference in the scales.

(8–10 individuals) among ethnographically known hunter–gatherers, such as the Weagamow Ojibwa and the Kusk Ingalik, during the most dispersed phases of their annual cycle (Binford, 2001:Table 8.01).

In addition to group size, site structure and the spatial organization inside the Rastklippan and Mávdnaávži 2 dwellings can be used to evaluate group composition. In a worldwide survey of ethnographic and archaeological data, Grøn found that spatial behavior inside small dwellings is highly structured and tends to follow a bipartite division of space according to gender. In single-hearth one-family dwellings, there tends to be a clear division into male and female sides (Grøn, 1989, 2003). This type of division appears to also be reflected in the distribution of arrowhead manufacturing waste inside the Rastklippan and Mávdnaávži 2 dwellings, which suggests gendered division of space and labor and consequently the presence of both sexes at these sites. Together with the small discrete artifact clusters, the signs of a gendered division of space point to small, residentially highly mobile family units, rather than single-sex task groups.

Raw material composition

To study the organization of lithic raw material use, we divided each site assemblage into analytical nodules according to visual raw material characteristics. We found that each assemblage represents 5–9 raw materials (Table 2). The method is a variation of Minimum Analytical Nodule analysis (Larson and Kornfeld, 1997). We found division at the raw material level to be sufficient for these sites, which, on the basis of site structure, represent at most a few short occupations and a variety of raw materials. Therefore, we did not attempt any further division into smaller nodules according to intrinsic differences within a raw material type. We also did not use a size cutoff; instead, we included all lithic artifacts in the analysis to prevent data loss in assemblages in which artifact size is markedly small.

The results indicate a pattern of each site having one or two relatively large analytical nodules (72–1181 artifacts) and 4–7 small nodules (1–17 artifacts). In 26 cases, an analytical nodule is represented by less than 10 artifacts, and in 11 of these 26 cases, the

Table 2
The composition of analytical nodules by site. Fgs = fragments, ORPcs = other retouched pieces, % ret = percentage of retouched artifacts. Nodule descriptions: MN1 = light grey (Porsanger?) chert, MN2 = white vein quartz, MN3 = green (fuchsite) quartzite, MN4 = light grey fine-grained chert/quartzite, MN5 = white coarse-grained quartzite, MN6 = black chert, MN7 = greyish-brown banded quartzite, MN8 = white fine-grained quartzite, MN9 = dark brown pumice, RN1 = translucent fine-grained white & grey quartzite, RN2 = grey/white banded quartzite, RN3 = beige chert, RN4 = opaque grey quartzite, RN5 = opaque white quartzite, DN1 = light grey yellowish chert/quartzite, DN2 = dark grey chert/quartzite, DN3 = white vein quartz, DN4 = dense grayish blue chert/quartzite, DN5 = opaque fine-grained white chert/quartzite, DN 6 = translucent white fine-grained chert/quartzite, DN7 = black chert/quartzite, DN8 = grey lustrous chert/quartzite, DN9 = rock crystal, AN1 = milky white vein quartz, AN2 = dark grey (Kvenvik) chert, AN3 = grey (Kvenvik?) chert, AN4 = light grey chert with lighter bands, AN5 = rock crystal, AN6 = bluish grey chert, AN7 = dark grey banded rhyolite, AN8 = grey/white banded quartzite, VN1 = white vein quartz, VN2 = grey chert with dark hairlines, VN3 = grey quartzite, VN4 = grayish white opaque quartzite, VN5 = grayish white quartzite with white dots. Note that there are slight changes in the composition of the Mávdnaávži 2 nodules in comparison to earlier classification (Manninen, 2009, Fig. 16.3).

	Flakes&fgs	Cores	Scrapers	Points&fgs	ORPcs	Total	% ret
Mávdnaávži 2							
MN1 (chert 1)	677			21	28	726	6.6
MN2 (quartz)	170	1	14			185	7.6
MN3 (quartzite 1)	13		4			17	23.5
MN4 (quartzite 2)	5		1			6	16.7
MN5 (quartzite 3)	3					3	0
MN6 (chert 2)	1					1	100
MN7 (quartzite 4)			1			1	100
MN8 (quartzite 5)			1			1	100
MN9 (pumice)						1	0
Total	869	1	21	21	28	941	7.4
% of Whole assemblage	92.3	0.1	2.2	2.2	3.0		
Rastklippan							
RN1 (quartzite 1)	920	12	1	8	20	961	3.1
RN2 (quartzite 2)	1			7		8	87.5
RN3 (chert)	0			2		2	100
RN4 (quartzite 3)	0			2		2	100
RN5 (quartzite 4)	0			1		1	100
Total	921	12	1	20	20	974	4.2
% of whole assemblage	94.6	1.2	0.1	2.0	2.0		
Devdis 1							
DN1 (chert/quartzite 1)	1114	6	8	17	36	1181	5.2
DN2 (chert/quartzite 2)	241	6	3	7	7	264	6.4
DN3 (quartz)	9					9	0
DN4 (chert/quartzite 3)	4			2		6	33.3
DN5 (chert/quartzite 4)				6		6	100
DN6 (chert/quartzite 5)	4			1		5	20
DN7 (chert/quartzite 6)	4					4	0
DN8 (chert/quartzite 7)			1	1		2	100
DN9 (rock crystal)	2					2	0
Unknown				3		3	0
Total	1378	12	12	37	43	1482	6.2
% of whole assemblage	93.0	0.8	0.8	2.5	2.9		
Aksujavri							
AN1 (quartz)	464	9	6			479	1.3
AN2 (chert 1)	227	1	2	11	1	242	5.4
AN3 (chert 2)	14					14	0
AN4 (chert 3)	1			3		4	75
AN5 (rock crystal)	3					3	0
AN6 (chert 4)	0			1		1	100
AN7 (rhyolite)	0			1		1	100
AN8 (quartzite)	1					1	0
Unidentified	7					7	0
Total	717	10	8	16	1	752	3.3
% of whole assemblage	95.3	1.3	1.0	2.1	0.1		
Vuopaja							
VN1 (quartz)	62	2	5		3	72	4.2
VN2 (chert)	2			4	2	8	75
VN3 (quartzite 1)	2					2	0
VN4 (quartzite 2)			1			1	100
VN5 (quartzite 3)	1					1	0
Total	67	2	6	4	5	84	17.9
% of whole assemblage	79.8	2.4	7.1	4.8	6.0		

nodules consist of only retouched pieces. The percentage of retouched artifacts per nodule also shows a clear bimodal pattern (Table 3). A plausible explanation for this pattern is that large nodules represent on-site manufacture and small nodules consist of tools and blanks produced elsewhere and brought to the sites as parts of portable toolkits (see Larson, 1994; Larson and Kornfeld, 1997; Tallavaara, 2005).

For many of the analytical nodules, the source of the raw material is unknown. Therefore, distances to raw material sources cannot be determined with equal degrees of confidence for each

Table 3
The percentage of retouched artifacts by analytical nodule.

%	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80	81–90	91–100
Number of cases	8	2	1	1	0	0	0	2	1	10

site. As noted before, vein quartz sources have the largest geographical coverage in the area, and quartz may, therefore, have been procured from locations close to the sites. In contrast, many of the other raw materials have comparatively restricted source areas.

The closest known sources for quartzite/brecciated quartz similar to the Rastklippan nodule RN1 are some 30 km from the site (Holm, 1991, p. 24). The distance from the Devdis I site to a source of macroscopically similar chert/quartzite as nodule DN2 is only slightly longer (35 km) (Halinen, 2005, p. 27). Sources for most of the chert in the Aksujavri assemblage (Kvenvik chert) lie some 100 km from the site (Hood, 1992, pp. 101–120, 142). However, there remains a possibility that these raw materials derive from unknown sources located closer. The situation is clearer at Mávdnaávži 2 and Vuopaja, where the geological boundary between the exposed and chertless Paleoproterozoic and Archaean bedrock and the younger chert-bearing formations of the Barents Sea coast makes it possible to define minimum distances of 60 and 150 km to sources of chert (Hood, 1992; Manninen, 2009). In addition, green (fuchsite) quartzite similar to nodule MN3 is not known from any other sites within a 15-km radius of Mávdnaávži 2, and pumice is exotic to the whole region but is found as waterborne pieces on the Barents Sea coastline (Bøe, 1999).

The picture we obtain from the analytical nodules thus supports the impression given by the site structure. The raw material composition, small assemblage sizes and the transportation of raw material and tools over considerable distances all suggest high mobility and embedded and direct raw material acquisition. The fact that at Vuopaja only chert points and a few relatively large chert flakes were found suggests that the site represents a point in the mobility round at which coastal good-workability raw material had been exhausted and totally converted to points and flake blanks. At Mávdnaávži 2, no more than a couple of chert cores—possibly only a single core—were brought to the site, reduced there, and transported elsewhere. At Rastklippan, Devdis I, Vuopaja, and Aksujavri, there are small analytical nodules composed almost entirely of arrowheads and arrowhead fragments, a pattern that suggests retooling and gearing up, i.e., that broken or defective points manufactured elsewhere were discarded and new points were made on site (cf. Binford, 1980; Larson, 1994). In addition, ready-made scrapers and scraper blanks of fine-grained quartzite of unknown origin were brought in and used at Mávdnaávži 2 and Vuopaja.

Otherwise, the scrapers suggest an inclination toward the use of locally available raw material because at Mávdnaávži 2, Aksujavri, and Vuopaja, they are mostly made of quartz. Diverging from this picture, however, at Devdis I and Rastklippan, all scrapers are within large analytical nodules that also contain a large part of the arrowhead manufacturing waste. This pattern is consistent with the fact that the proportion of quartz in site assemblages increases linearly with the distance to the closest known source of fine-grained raw material (Fig. 5).

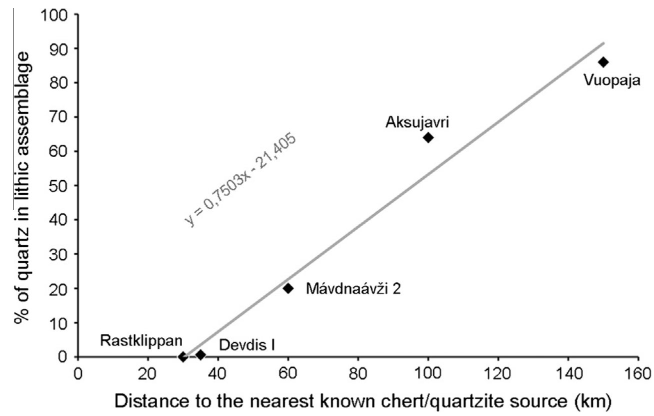

Fig. 5. The relationship between the percentage of quartz in a site inventory and the distance to the closest known source of high-quality raw material (the correlation coefficient of the linear trendline $r = 0.99$). Note that at Aksujavri, a geological formation with possible chert sources is also found closer to the site. However, the presence of chert in the formation has not been confirmed (Hood, 1992, p. 96).

The mobile toolkit

The site assemblages are divided into four main artifact categories: flakes (and flake fragments), flake cores, scrapers on flake, and arrowheads on flake (Fig. 6). In addition, there is a heterogeneous group of retouched pieces and fragments, which includes arrowhead performs, a few microliths (e.g., Manninen, 2005: Fig. 8), flake knives, and other indeterminate tools and rejected/discarded pieces.

The lithic production is based on variable core forms used to produce unstandardized flakes (Table 4). Although some flakes are long and narrow, there is no evidence of systematic blade or blade flake production. The recovered cores are small, with maximum dimensions less than 50 mm, which suggests that the shortest acceptable flakes were less than 20 mm in length (e.g., Helskog, 1980, Figs. 26 and 27). The flake lengths rarely exceed 40 mm, with only a few exceptions in the Rastklippan and Devdis I assemblages. Flakes have also been used as cores to produce smaller flakes (Fig. 6m). Both platform cores and bipolar-on-anvil cores are present, but bipolar reduction is rare and used exclusively on quartz, while most of the cores and flakes, regardless of raw material, represent platform reduction. There are also some relatively large quartz platform flakes in the material that in the Mávdnaávži 2 assemblage are in the same overrepresented size class as quartz scrapers (Manninen, 2009, Fig. 16.4), suggesting that quartz flakes produced elsewhere, although not necessarily far from the site, were brought in to make scrapers.

The arrowheads are all made of non-quartz flake blanks of irregular sizes and shapes and are between 13.5 and 37.7 mm in length, with an average thickness of 3.4 mm. An inverse correlation between point length and the distance to the closest known raw material source (Fig. 7) suggests an intensification of raw material use with increasing distance to the source, i.e., a classic distance decay situation (cf. Henry, 1989; Newman, 1994; see also Hood, 1994).

The average scraper thickness in the assemblages is 8.6 mm and, apart from two chert scrapers in the Aksujavri assemblage, they are all made of quartz or quartzite. However, there is a difference between the quartz and the quartzite scrapers in that the scrapers in the quartz group are thicker. The quartz scrapers have an average thickness of 10 mm, whereas the average thickness of the scrapers in the quartzite group is 7.7 mm. The greater quartz scraper thickness is most likely due to the proneness of quartz to

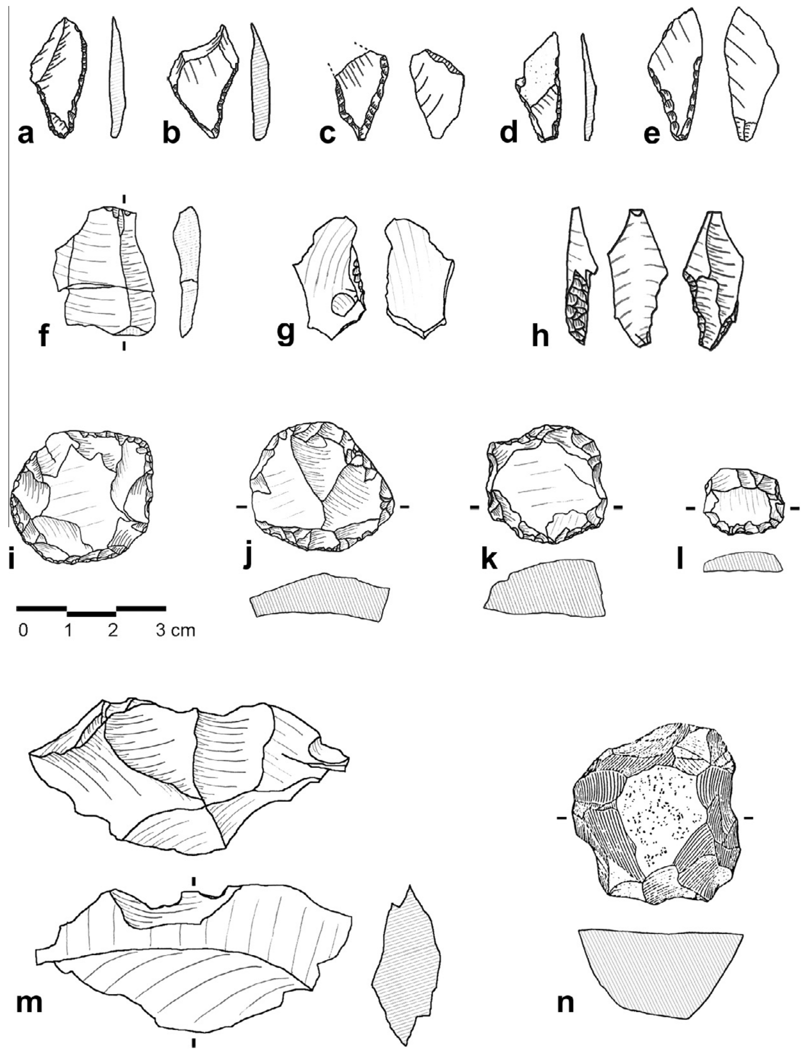

Fig. 6. Typical artifact categories at oblique point sites: (a–e) arrowheads, (f–h) blanks, performs, and rejects, (i–l) scrapers, (m–n) cores. Examples from Vuopaja (b and i), Mávdnaávži 2 (d, j–l), Devdis I (e and n), Aksujavri (c), and Rastklippan (a, f–h, m). Core (n) from Helskog (1980).

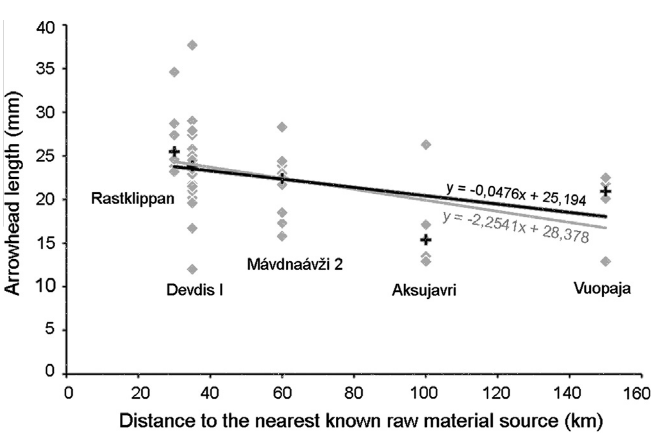

Fig. 7. The lengths of arrowheads (gray diamonds) and the median lengths of arrowheads (black crosses) by site in relation to the distance to a known source of arrowhead raw material, with linear trendlines (lengths of arrowheads, $r = -0.43$; median lengths of arrowheads, $r = -0.62$). Only the arrowheads of raw materials from known source areas are included in the graph. Note that at Aksujavri, a geological formation with possible chert sources is also found closer to the site. However, the presence of chert in the formation has not been confirmed (Hood, 1992, p. 96).

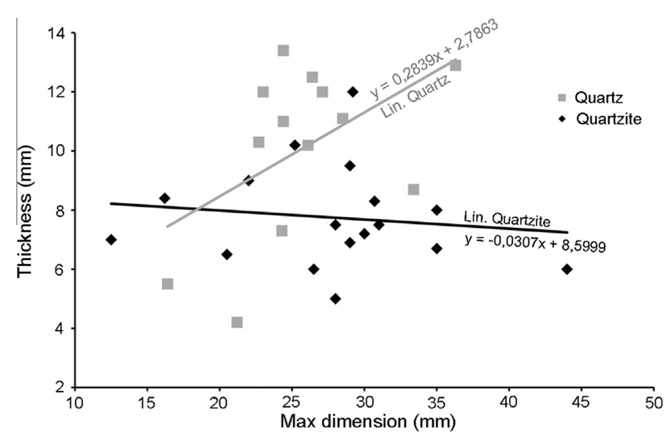

Fig. 8. The relationship between scraper thickness and maximum outline dimension in quartz ($n = 13$) and quartzite ($n = 17$) scrapers (linear trendlines, quartz $r = 0.50$, quartzite $r = -0.10$). Data from Mávdnaávži 2, Devdis I, Rastklippan, and Vuopaja. Data on Aksujavri are not available.

fragment, due to its fragility and heterogeneity. Tallavaara et al. (2010) found that these properties can be counterbalanced up to a point with raw material-specific design choices, most notably

Table 4
Core types.

	Core type	Total
Mávdnaávži 2		
Quartz (MN2)	Bipolar-on-anvil	1
Total		1
Rastklippan		
Quartzite (RN1)	Core-on-flake	6
Quartzite (RN1)	Irregular	6
Total		12
Devdis		
Chert /quartzite (DN2)	Single platform	5
Chert /quartzite (DN1)	Core-on-flake	7
Total		12
Aksujavri		
Quartz (AN1)	Bipolar-on-anvil	7
Quartz (AN1)	Bipolar-o-a fragment	2
Quartzite (AN8)	Core-on-flake	1
Total		10
Vuopaja		
Quartz (VN1)	Bipolar-on-anvil	2
Total		2

by producing relatively thick platform flakes or by using bipolar-on-anvil reduction. In line with these results, Manninen and Tallavaara (2011) found that, in general, the thickness of oblique points made of quartz increases with the point length, while the same type of points made of chert do not exhibit a similar correlation. The quartz scrapers discussed here seem to reflect the same principle of increasing blank thickness. The thickness of quartz scrapers increases with the maximum outline dimension, whereas the quartzite scraper thickness tends to remain the same regardless of the other dimensions (Fig. 8).

Discussion

The results leave little room for doubt that the studied sites represent mobile groups and short occupation spans. The analyses described above provide overwhelming evidence of anticipated and actual mobility. The bipartite division of space inside dwellings suggests occupation by family units rather than single-sex task groups and thus points toward a settlement configuration with frequent residential moves. The patterns of raw material use and the raw material composition also suggest high residential mobility. Although some of the sites may represent logistic camps, we would not expect distances of up to 150 km to sources of arrowhead raw material unless the residential camps were also frequently moved or the raw material was procured indirectly (cf. Binford, 1980). The latter alternative, however, is not likely because of the linear distance decay pattern in arrowhead size, the high raw material diversity, and the presence of several good-workability raw materials in small proportions in the discard assemblages alongside proportionally large analytical nodules—a combination that indicates movement through large territories and retooling with raw material deriving from close by sources (cf. Ingbar, 1994). Although the operational chains were simple, stone tool production and use were obviously not expedient or opportunistic. Instead, the technology included curation of cores and tools and the transportation of raw material and tools over long distances.

High residential mobility, however, does not seem to have caused much of the type of economizing behavior that could be expected in a situation in which lithic materials of relatively higher workability are low in abundance. Although formal blade production is often perceived as an economizing strategy used as a response to low availability of good-quality raw material (but see Eren et al., 2008; Jennings et al., 2010), the absence of blades at the studied sites and the marked drop in blade production in the area next to the discussed sources of coastal chert indicate that in this case, formal blades were not a favorable strategy in the long-distance residential mobility pattern. Instead, both the local and non-local raw materials indicate production based on informal flakes. In fact, a comparison between oblique points made of quartz and chert shows that quartz points in general were oriented more formally in relation to the blank than points made of chert (Manninen and Tallavaara, 2011). Hence, and possibly somewhat counterintuitively, production using widely available lower-workability raw material was in this technological context *more* formal than production using better-workability raw material of low abundance.

We also lack evidence of intensified use of tools and bipolar-on-anvil exhaustion of cores made of low-abundance raw materials, patterns that could indicate a maximization of non-local raw material (cf. Bousman, 1993; Goodyear, 1993; Kelly, 1988). The oblique point design does not allow rejuvenation after breakage, and therefore arrowheads cannot be used to evaluate rejuvenation intensity, but the scrapers made of non-local raw materials do not seem to have been any more extensively re-sharpened than the ones made of local materials. Furthermore, although bipolar reduction was not used on the raw materials of better flakeability and controllability, there are some bipolar cores of quartz. This suggests that bipolar reduction, which is known to reduce the fragmentation of quartz flakes during detachment (Callahan et al., 1992; Tallavaara et al., 2010), was instead employed to increase the utility of vein quartz.

All in all, there are only two patterns apparent in the results that can be readily connected with economizing. These two patterns are the generally small size of the lithic artifacts and the way raw materials of better workability, when in low abundance, were reserved for arrowhead manufacture, while tools requiring larger blanks, most notably scrapers, were in most cases made of raw materials abundant at the sites.

A plausible explanation for many of the characteristics of the technology presented above can thus be found in the properties of the widely available raw quartz material. The more formal nature of point production in quartz follows from the way most quartz points are oriented perpendicular to the flake blank. As noted by Manninen and Tallavaara (2011), this orientation helps to achieve a sustainable edge in the fragile raw material, whereas points made of more resilient raw materials can be oriented more freely and, when needed, also in ways that enhance raw material conservation. The production of relatively thick platform flakes, the use of bipolar reduction, and the use of flake blanks in a way that decreased the risk of failure suggest that the undesired properties of quartz were compensated for by favorable technological choices.

Because the localized raw materials of better workability were nevertheless preferred when available, we suggest that the flake-based technology is a solution that continues to culturally reproduce the margin-retouched point tradition while balancing organizational dimensions that increase the utility of quartz and those that maximize the utility of the intermittently available raw materials of better flakeability and controllability. This type of strategy, in which the properties of the raw material of lower workability strongly influence the overall technology, deviates from situations in which a low abundance of high-workability raw material leads to formalization and to the use of diverse coping strategies. We suggest that the reason for this deviation is a diversification of the raw material base that takes place when the cost of the technology based on raw material of good flakeability and controllability becomes too high in relation to the time needed to fulfill dietary needs.

Raw material diversification as an adaptive strategy

In view of group survival, it is clear that the placement and size of the foraging range are strongly linked to the availability of food resources. Therefore, the availability of vital nutrients also has a decisive influence on the availability of lithic raw materials, and shifts in the availability of food resources may lead to a situation in which lithic technology needs to be reorganized. In the most pronounced cases, the cost of comparatively higher-quality raw material, i.e., raw material of good flakeability and predictability needed for the successful execution of a technological concept, can increase to a point at which an overall shift to a simplified technology based on raw material of lower workability becomes a viable solution. This type of circumstances may occur, for example, when there are shifts in the size or location of the foraging range due to changes in subsistence and settlement organization or when new areas are colonized. Lithic technology in this type of situation can be expected to undergo modifications designed to make efficient use of lower-workability raw material.

From an economics perspective, the widening of the raw material resource base to include raw materials that are easily procured but require a simplification of the established technology can be regarded as a type of asset allocation: investments are distributed to reduce risk in the event of a decline in a particular part of the investment portfolio. In this sense, raw material diversification is comparable to subsistence resource diversification, a set of practices that form a food procurement strategy that "either by exploiting a wider range of plant and animal species or by exploiting broader and more varied areas, reduces the risk of catastrophic shortages" (Halstead and O'Shea, 1989, p. 4; see also Colson, 1979; Flannery, 1969; Hayden, 1981). In a similar way, in situations in which the availability of lithic raw materials of good workability becomes uncertain, the risk of remaining without suitable raw material can be reduced in the long term by changing the technology in a way that is less demanding on raw material and consequently includes raw materials such as quartz in the class of raw materials that, when randomly picked up, yield a usable piece more often than not.

Because of the system-scale change in technology, raw material diversification should be regarded as an adaptive strategy. The main difference between adaptive strategies and coping mechanisms is in the scale and duration of change. Coping can be defined as a short-term response to occasional and immediate declines in resources, whereas adapting means a change in the rules of resource acquisition as well as in the systems within which these rules operate (Davies, 1993; see Dincauze, 2000, pp. 75–77 for similar arguments). It is not unusual for coping mechanisms to develop into adaptive strategies over time because, in principle, short-term responses to change use the same range of strategies that are applied in the case of long-term changes (Berkes and Jolly, 2001; Davies, 1993; Dincauze, 2000, pp. 75–77).

For example, formal lithic technologies that optimize raw material use are perceived as adaptations to raw material scarcity, while the exhaustion of cores of costly raw material by using bipolar hammer-on-anvil reduction can be considered a coping mechanism. This is also the difference between raw material substitution (e.g., Ricklis and Cox, 1993) and raw material diversification as it is defined here. Although raw material substitution also entails the use of alternative raw materials, it is a short-term response that does not affect the overall technological organization and is utilized only when access to better-quality raw material is temporarily severed. However, because the difference between coping and adaptation is mostly in the scale and duration of the response, raw material substitution and diversification should not be perceived as fixed alternatives but rather as parts of an organizational continuum.

In the process of raw material diversification, the whole technology, including manufacturing sequences and artifact types, is modified to conform to the properties of the alternative or lower-quality raw material (Fig. 9). In the changed situation, the new technological concept is also used to a large degree when raw materials suitable for the execution of the former technology are encountered. It is important to note, however, that because lithic raw material use and artifact traditions are dictated by both physical and social environments, it follows that there is no easily quantifiable threshold beyond which formal reduction strategies that are costly in raw material quality are replaced by less formal strategies and raw material diversification.

In situations in which the diversification of the raw material base leads to marked technological simplification, it is likely that some technological traits are lost as the technology evolves into a new set of operational chains (cf. Riede, 2006). Raw material diversification can therefore lead to a loss of culturally acquired skills and have effects on technology that seem similar to those of demographic fluctuations (cf. Henrich, 2004). In the case of raw material diversification, however, the loss of skills cannot be considered maladaptive. We would also expect those parts of a technological tradition that need not be changed to be maintained in the changed situation—at least initially.

Raw material diversification and the properties of quartz

Returning to the lithic technology present at the studied sites, we suggest that easily accessible vein quartz was the lower-workability raw material that influenced the technological choices in this case. Quartz has disadvantages that make it a less desirable tool stone than chert or fine-grained quartzite (Callahan et al., 1992; Cotterell and Kamminga, 1990, p. 127; Mourre, 1996). For example, a quartz core can be considered less reliable than a core of chert, as there is a higher probability of a quartz core failing to produce suitable tool blanks when needed. The fragility and poor controllability of the raw material also means that a quartz core

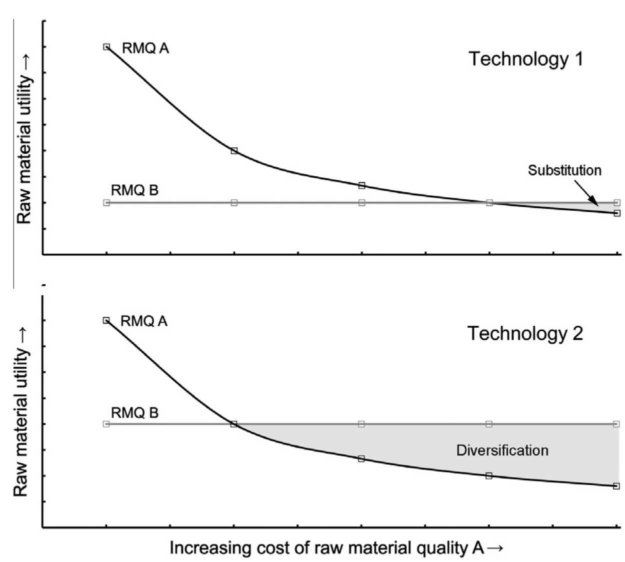

Fig. 9. Hypothetical model of the utility of localized high-quality raw material (RMQ A) and widely available low-quality raw material (RMQ B) in relation to the cost of the higher-quality raw material when used in formal (1) and informal (2) lithic technology. Technology 1 makes efficient use of the high-quality raw material as long as its cost does not get too high. In this technology, the low-quality raw material is seldom used and only as a last resort, as its utility is low in a formal technology. The informal technology 2 is adapted to the properties of the low-quality RMQ B and therefore increases its utility in relation to RMQ A, especially when the cost of the higher-quality raw material increases.

contains more waste than a core of comparable size made of a more resilient and predictable raw material and therefore carries a higher transportation cost (Tallavaara et al., 2010).

However, because sources of raw material of good flakeability and controllability are located only in restricted parts of the study area, a technological solution adapted to vein quartz, such as, in this case, the use of selected flake blanks, directly reduced the risk of ending up without suitable tool stone and relaxed constraints on mobility posed by the use of specific localized raw materials. It also decreased the time needed for searching for and procuring lithic raw material and thus increased the time available for other tasks, most notably food procurement.

If flake blanks are produced at the raw material source and only the best are selected, the risk of fatal failure when using raw materials with intrinsic flaws is considerably reduced (Brantingham et al., 2000). Scrapers are particularly easily produced from almost any raw material, as they can be made of thick flakes, their working edges are retouched, and they usually do not need to be as reliable and readily replaceable as arrowheads. A technology based on the use and transportation of flake blanks is therefore advantageous when raw materials such as quartz are included in the raw material base, and as shown by Kuhn (1994; see also Surovell, 2009, pp. 142–150), such a technology can also have advantages for mobile groups in terms of low carrying costs when using raw materials of better workability.

Adapting the production of margin-retouched points to the properties of vein quartz made it possible to develop an arrow technology that allowed the use of a diverse set of raw materials without the need to change the operational chains or hafting mechanisms when shifting from one raw material grade (sensu Callahan, 1979) to another. However, in addition to the disadvantages of a quartz core in comparison to more predictable raw materials, obvious risks are also present in carrying quartz flakes fit for oblique points or oblique points made of the same raw material. Carrying such artifacts made of quartz is more risky than carrying corresponding artifacts of chert or quartzite because an un-retouched working edge, such as the edge of an oblique point made of a fragile raw material is particularly prone to breakage. This also explains why oblique points made of quartz are rare at sites at which raw materials of better controllability are present. Because of the critical role of arrowheads for group survival during encounter hunting, in arrowhead production, a preference for the most resilient and easily controllable raw material available is to be expected.

We therefore suggest that the way different organizational dimensions and design criteria intersect in the oblique point technology is strongly determined by the properties of vein quartz. At the same time, we emphasize that other organizational dimensions and environmental factors, such as the intermittent availability of better-quality raw material and the socially transmitted margin-retouched arrowhead template, are also reflected in the outcome. We further suggest that this technology represents the effect that the emergence of a long-distance inland–coast mobility pattern with limited access to sources of raw material of good flakeability and controllability had on local lithic traditions.

However, it must be stressed that raw material diversification is related to the cost of raw material acquisition and therefore does not require changes in settlement configuration, although it can occur together with both decreased and increased mobility. The process of diversification during the advancement of a colonization front, for example, can also lead to a total exclusion of raw material of better workability from the raw material base if access to localized sources of better-workability raw material decreases with increasing distance. In other cases, depending on the physical and social environments, an adaptation to quartz can therefore take substantially different forms. For example, a widely known case in which pronounced differences in technology, in addition to other possible reasons, could be explained by raw material diversification is the dominance of core and flake tools in Middle and Late Pleistocene East and Southeast Asia, as opposed to the expected hand axes and Levallois technology (Lycett and Bae, 2010). In this case as well, the simpler technology is characterized by the use of quartz and other low-quality raw materials (e.g., Brantingham et al., 2000; Huang and Knutsson, 1995; Norton et al., 2009).

It is also important to note that as the properties of vein quartz make the execution of elaborate technological concepts particularly difficult, raw material diversification most likely has a more pronounced effect on lithic technology in situations in which quartz in particular gains importance in the raw material base, compared with situations in which the raw material base is extended to include raw materials of lower but still comparatively high quality. A good example of the latter, known from Upper Paleolithic Central Europe at the Magdalenian to Federmesser/Azilian transition, is the transition from elaborate blade technology that utilized distinct high-grade flints to a simplified blade technology that used a large variety of coarser but still high-quality raw materials (Bodu and Valentin, 1997; De Bie and Caspar, 2000, pp. 112–113). In this case as well, the simplification of technology and the widening of the raw material base permitted larger foraging ranges and was associated with an increase in residential mobility (Bodu and Valentin, 1997; Valentin, 2008a, 2008b).

Conclusions

In this paper, we have explored the effects of an inverse correlation between raw material availability and raw material workability on the organization of stone tool production technology. We have discussed the roles of raw material properties and related raw material diversification in hunter–gatherer organizational strategies.

Our results provide support for views that promote the use of a bottom-up approach, i.e., working up from details, in the study of hunter–gatherer adaptations (e.g., Bamforth, 2009; Chatters, 1987). By exploring independently several different organizational dimensions, including settlement configuration, group size and composition, raw material procurement and use, and reduction technology, we have been able to better grasp the ways in which these dimensions intersect in the studied case and infer some of the underlying reasons for these intersections.

Our results are consistent with the view (Manninen, 2009; Manninen and Tallavaara, 2011) that the Late Mesolithic spread of margin-retouched point technology into the interior of northernmost Norway, Finland, and later Sweden was connected to long-distance mobility that resulted from a major shift in the size and location of foraging ranges.

Our results are also consistent with the findings of earlier studies that suggest that when lithic technological organization is viewed as an intersection of many varying dimensions, the properties and availability of raw materials can be considered the most important determinants in how these dimensions intersect within any organizational context (e.g., Andrefsky, 1994a,b; Bamforth, 1986; Brantingham et al., 2000; Dibble et al., 1995; Kuhn, 1991). However, our material exemplifies a situation in which a low abundance of raw material of good flakeability and controllability does not lead to intensification through formal lithic production or to a pronounced use of other economizing and coping strategies. Instead, our results are consistent with studies that indicate that in certain situations, flake-based and informal technologies are advantageous for groups with high residential mobility (cf. Eren et al., 2008; Jennings et al., 2010; Kuhn, 1994; Prasciunas, 2007; Surovell, 2009).

We suggest that in the studied case, instead of formalization, the high cost of raw material of good workability led to the use of a diversified raw material base, i.e., a broadened spectrum of lithic raw material grades, including a high-abundance raw material of poor working quality. In the studied area in northernmost Europe, the widely available vein quartz gained importance as an organizational determinant because of the high cost of localized raw materials of good workability and predictability when foraging ranges were expanded into areas where only raw material of low predictability and flakeability was available.

Although resource diversification is a widely used concept in the study of human adaptation and the variability in lithic raw material properties is universally accepted, the diversification of the raw material base as an explanatory factor in lithic technological change has been little explored. We suspect that adaptation through a widening of the raw material base to include raw materials that require alteration of the habitual technological concepts has also taken place in many other instances in prehistory but is more readily observable than usual in the material presented here. This is due to the relative rapidity of the process in the case presented here and the pronounced differences between quartz and the raw materials of better workability, in comparison to cases in which adaptation to alternative raw materials was more gradual and the differences in raw material workability were less severe.

Acknowledgments

We thank the two reviewers (Tom Jennings and an anonymous reviewer) for their insightful comments, which helped to considerably improve the quality of this paper. We would also like to thank Esa Hertell, Tuija Rankama and Miikka Tallavaara for their valuable comments on earlier versions of the manuscript. Parts of this research were carried out with generous financial support provided by the Finnish Cultural Foundation, the Finnish Graduate School in Archaeology (M.M.), and the Swedish–Finnish Cultural Foundation (K.K.).

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jaa.2013.12.001. These data include Google maps of the most important areas described in this article.

References

Åhman, E., 1967. Riksantikvarieämbetets norrlandsundersökningar IV. Petrografisk översikt av Umeälvsmaterialet. Fornvännen 62, 8–11.
Andrefsky Jr., W., 1994a. Raw-material availability and the organization of technology. Am. Antiq. 59 (1), 21–34.
Andrefsky Jr., W., 1994b. The geological occurrence of lithic material and stone tool production strategies. Geoarchaeol.: Int. J. 9, 375–391.
Andrefsky Jr., W., 2009. The analysis of stone tool procurement, production, and maintenance. J. Archaeol. Res. 17, 65–103.
Bamforth, D.B., 1986. Technological efficiency and tool curation. Am. Antiq. 51, 38–50.
Bamforth, D.B., 2009. Top-down or bottom-up?: Americanist approaches to the study of hunter–gatherer mobility. In: McCartan, S.B., Schulting, R., Warren, G., Woodman, P. (Eds.), Mesolithic Horizons. Papers presented at the Seventh International Conference on the Mesolithic in Europe, Belfast 2005, vol. I. Oxbow Books, Oxford, pp. 81–88.
Baugh, T.G., Ericson, J.E., 1994. Prehistoric Exchange systems in North America. Plenum Press, New York.
Berkes, F., Jolly, D., 2001. Adapting to climate change: social-ecological resilience in a Canadian western arctic community. Conserv. Ecol. 5 (2), 18.
Bettinger, R.L., Eerkens, J.W., 1999. Point typologies, cultural transmission, and the spread of bow-and-arrow technology in the prehistoric great basin. Am. Antiq. 64, 231–242.
Binford, L.R., 1979. Organization and formation processes: looking at curated technologies. J. Anthropol. Res. 35, 255–273.
Binford, L.R., 1980. Willow smoke and dog's tails: hunter–gatherer settlement systems and archaeological site formation. Am. Antiq. 45, 4–20.
Binford, L.R., 1990. Mobility, housing, and environment: a comparative study. J. Anthropol. Res. 46, 119–152.
Binford, L.R., 2001. Constructing Frames of Reference. An Analyti cal Method for Archaeological Theory Building Using Ethnographic and Environmental Data Sets. University of California Press, Berkeley, Los Angeles, London.
Binford, L.R., 2002 [1983]. In Pursuit of the Past. Decoding the Archaeological Record. University of California Press, Berkeley, Los Angeles, London.
Bjerck, H.B., 2008. Norwegian mesolithic trends. A review. In: Bailey, G., Spikins, P. (Eds.), Mesolithic Europe. Cambridge University Press, Cambridge, pp. 60–106.
Blades, B.S., 2001. Aurignacian Lithic Economy: Ecological Perspectives from Southwestern France. Kluwer Academic/Plenum Pub., New York.
Bleed, P., 1986. Optimal design of hunting weapons. Am. Antiq. 51, 737–747.
Bodu, P., Valentin, B., 1997. Groupes à Federmesser ou Aziliens dans le sud et l'ouest du Bassin parisien. Propositions pour un nouveau modèle d'évolution. Bulletin de la Société préhistorique française 94, 341–348.
Bøe, P., 1999. Stein som råstoff. Ottar 225, pp. 3–12.
Bousman, C.B., 1993. Hunter–gatherer adaptations, economic risk and tool design. Lithic Technol. 18, 59–86.
Brantingham, P.J., Olsen, J.W., Rech, J.A., Krivoshapkin, A.I., 2000. Raw material quality and prepared core technologies in Northeast Asia. J. Archaeol. Sci. 27, 255–271.
Callahan, E., 1979. The basics of biface knapping in the eastern fluted point tradition: a manual for flintknappers and lithic analysts. Archaeol. Eastern North Am. 7 (1), 1–179.
Callahan, E., Forsberg, L., Knutsson, K., Lindgren, C., 1992. Frakturbilder. Kulturhistoriska kommentarer till det säregna sönderfallet vid bearbetning av kvarts. TOR 24, 27–63.
Chatters, J.C., 1987. Hunter–gatherer adaptations and assemblage structure. J. Anthropol. Archaeol. 6, 335–375.
Colson, E., 1979. In good years and in bad: food strategies of self-reliant societies. J. Anthropol. Res. 35, 18–29.
Cotterell, B., Kamminga, J., 1990. Mechanics of Pre-industrial Technology. Cambridge University Press, Cambridge.
Davies, S., 1993. Are coping strategies a cop out? Institute of Development Studies Bulletin 24, 60–72.
De Bie, M., Caspar, J.-P., 2000. Rekem, a Federmesser Camp on the Meuse River Bank. Leuven University Press, Leuven.
Dibble, H.L., Roth, B., Lenoir, M., 1995. The use of raw materials at Combe-Capelle Bas. In: Dibble, H.L., Lenoir, M. (Eds.), The Middle Paleolithic Site of Cornbe-Capelle Bas (France). The University Museum Press, Philadelphia, pp. 259–287.
Dincauze, D.F., 2000. Environmental Archaeology: Principles and Practice. Cambridge University Press, Cambridge.
Domanski, M., Webb, J.A., Boland, J., 1994. Mechanical properties of stone artefact materials and effect of heat treatment. Archaeometry 36, 177–208.
Elston, R.G., Kuhn, S.L. (Eds.), 2002. Thinking Small: Global Perspectives on Microlithization. Archeol. Pap. Am. Anthropol. Assoc. 12.
Eren, M.I., Greenspan, A., Sampson, C.G., 2008. Are upper paleolithic blade cores more productive than middle paleolithic discoidal cores? A replication experiment. J. Hum. Evol. 55, 952–961.
Flannery, K., 1969. Origins and ecological effects of early domestication in Iran and the near east. In: Ucko, P.J., Dimbleby, G.W. (Eds.), The Domestication and Exploitation of Plants and Animals. Aldine Publishing Co, Chicago, pp. 73–100.
Gamble, C.S., Boismier, W.A. (Eds.), 1991. Ethnoarchaeological Approaches to Mobile Campsites: Hunter–Gatherer and Pastoralist Case Studies. International Monographs in Prehistory Ethnoarchaeological Series 1, Ann Arbor.
Gifford, D.P., 1980. Ethnoarchaeological contributions to the taphonomy of human sites. In: Behrensmeyer, A.K., Hill, A.P. (Eds.), Fossils in the Making: Vertebrate Taphonomy and Paleoecology. University of Chicago Press, Chicago, pp. 93–106.
Goodyear, A.C., 1993. Tool kit entropy and bipolar reduction: a study of interassemblage lithic variability among Paleo-Indian Sites in the Northeastern United States. North Am. Archaeolog. 14 (1), 1–23.
Gould, R.A., 1971. The archaeologist as ethnographer: a case from the Western Desert of Australia. World Archaeol. 3 (2), 143–177.
Gould, R.A., Saggers, S., 1985. Lithic procurement in central Australia: a closer look at Binford's idea of embeddedness in archaeology. Am. Antiq. 50 (1), 117–136.
Grøn, O., 1989. General spatial behaviour in small dwellings: a preliminary study in ethnoarchaeology and social psychology. In: Bonsall, C. (Ed.), The Mesolithic in Europe. Papers Presented at the third International Symposium, Edinburgh 1985. John Donald Publishers Ltd., Edinburgh, pp. 99–105.
Grøn, O., 2003. Mesolithic dwelling places in south Scandinavia: their definition and social interpretation. Antiquity 77, 685–708.
Grydeland, S.-E., 2000. Nye perspektiver på eldre steinalder i Finnmark – En studie fra indre Varanger. Viking LXIII, 10–50.
Grydeland, S.-E., 2005. The Pioneers of Finnmark – from the earliest coastal settlements to the encounter with the inland people of Northern Finland. In: Knutsson, H. (Ed.), Pioneer Settlements and Colonization Processes in the Barents Region. Vuollerim Papers on Hunter–Gatherer Archaeology 1, pp. 43–77.
Hagen, O.E., 2011. Overgangen ESA II – ESA III på Nordkalotten – naturforutsetninger og kulturell endring. MA thesis, University of Tromsø. <http://hdl.handle.net/10037/3978>.
Halinen, P., 2005. Prehistoric Hunters of Northernmost Lapland. Settlement Patterns and Subsistence Strategies. Iskos 14.

Halstead, P., O'Shea, J., 1989. Introduction: cultural responses to risk and uncertainty. In: Halstead, P., O'Shea, P. (Eds.), Bad Year Economics: Cultural Responses to Risk and Uncertainty. Cambridge University Press, Cambridge, pp. 1–7.
Hayden, B., 1981. Subsistence and ecological adaptations of modern hunter/gatherers. In: Harding, R.S.O., Teleki, G. (Eds.), Omnivorous Primates. Gathering and Hunting in Human Evolution. Columbia University Press, New York, pp. 344–421.
Helskog, K., 1980. Subsistence-Economic Adaptations to the Alpine Regions of Interior North Norway. PhD Dissertation. University of Wisconsin-Madison. University Microfilms, Ann Arbor, Michigan.
Henrich, J., 2004. Demography and cultural evolution: how adaptive cultural processes can produce maladaptive losses: the Tasmanian case. Am. Antiq. 69 (2), 197–214.
Henry, D., 1989. Correlations between reduction strategies and settlement patterns. In: Henry, D., Odell, G. (Eds.), Alternative Approaches to Lithic Analysis. Archaeological Papers of the American Anthropological Association 1, Washington, pp. 139–155.
Hertell, E., Tallavaara, M., 2011a. High mobility or gift exchange – early mesolithic exotic chipped lithics in Southern Finland. In: Rankama, T. (Ed.), Mesolithic Interfaces. Variability in Lithic Technologies in Eastern Fennoscandia. Monographs of the Archaeological Society of Finland 1, pp. 11–41. <http://www.sarks.fi/masf/masf_1/masf_1.html>.
Hertell, E., Tallavaara, M., 2011b. Hunter–gatherer mobility and the organization of core technology in mesolithic North-Eastern Europe. In: Rankama, T. (Ed.), Mesolithic Interfaces. Variability in Lithic Technologies in Eastern Fennoscandia. Monographs of the Archaeological Society of Finland 1, pp. 95–110. <http://www.sarks.fi/masf/masf_1/masf_1.html>.
Hesjedal, A., Damm, C., Olsen, B., Storli, I., 1996. Arkeologi på Slettnes. Dokumentasjon av 11.000 års bosetning. Troms Museums Skrifter XXVI.
Hesjedal, A., Ramstadt, M., Niemi, A.R., 2009. Undersøkelsene på Melkøya: Melkøyaprosjektet – kulturhistoriske registreringer og utgravninger 2001 og 2002. Tromura, Kulturvitenskap 36. <http://munin.uit.no/handle/10037/2437>.
Holm, L., 1991. The Use of Stone and Hunting of Reindeer. Archaeology and Environment 12. University of Umeå, Umeå.
Hood, B.C., 1988. Undersøkelse av en steinalderboplass ved Aksujavri, Kautokeino kommune, Finnmark. In: Engelstad, E., Holm-Olsen, M. (Eds.), Arkeologisk feltarbeid i Nord-Norge og på Svalbard 1986. Tromura kulturhistorie 14, pp. 23–31.
Hood, B.C., 1992. Prehistoric Foragers of the North Atlantic: Perspectives on Lithic Procurement and Social Complexity in the North Norwegian Stone Age and the Labrador Maritime Archaic. PhD Dissertation, Department of Anthropology, University of Massachusetts, Amherst. <http://scholarworks.umass.edu/dissertations/AAI9219445>.
Hood, B.C., 1994. Lithic procurement and technological organization in the stone age of West Finnmark, North Norway. Norweg. Archaeol. Rev. 27, 65–85.
Hood, B.C., 2012. The empty quarter? Identifying the mesolithic of interior Finnmark, North Norway. Arctic Anthropol. 49 (1), 105–135.
Huang, Y., Knutsson, K., 1995. Functional analysis of middle and upper palaeolithic quartz tools from China. TOR 27, 7–46.
Ingbar, E.E., 1994. Lithic material selection and technological organization. In: Carr, P.J. (Ed.), The Organization of North American Prehistoric Chipped Stone Technologies. International Monographs in Prehistory Archaeological Series 7, pp. 45–56.
Jennings, T.A., Pevny, C.D., Dickens, W.A., 2010. A biface and blade core efficiency experiment: implications for Early Paleoindian technological organization. J. Archaeol. Sci. 37, 2155–2164.
Jones, K.T., 1993. The archaeological structure of a short-term camp. In: Hudson, J. (Ed.), From Bones to Behavior. Ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains. Center for Archaeological Investigations Southern Illinois University at Carbondale Occasional Paper 21, pp. 101–114.
Kankaanpää, J., Rankama, T., 2005. Early Mesolithic pioneers in Northern Finnish Lapland. In: Knutsson, H. (Ed.), Pioneer Settlements and Colonization Processes in the Barents Region. Vuollerim Papers on Hunter–Gatherer Archaeology 1, pp. 109–161.
Kelly, R.L., 1988. The three sides of a biface. Am. Antiq. 53, 717–734.
Kelly, R.L., 1995. The Foraging Spectrum: Diversity in Hunter–Gatherer Lifeways. Smithsonian Institution Press, Washington and London.
Kelly, R.L., Poyer, L., Tucker, B., 2005. An ethnoarchaeological study of mobility, architectural investment, and food sharing among Madagascar's Mikea. Am. Anthropolog. 107 (3), 403–416.
Kent, S., 1991. The relationship between mobility strategies and site structure. In: Kroll, E.M., Price, T.D. (Eds.), The Interpretation of Archaeological Spatial Patterning. Plenum Press, New York and London, pp. 33–59.
Knutsson, K., 2005. Rastklippan och historiens mening. Ekologi, socialt minne och materiella diskurser. In: Engelmark, R., Larsson, T.B., Rathje, L. (Eds.), En lång historia: Festkrift till Evert Baudou på 80-års dagen. Archaeology and Environment 20. University of Umeå, Umeå, pp. 235–259. .
Knutsson, K., Knutsson, H., 2014. Pressure and punched blades in non-flint materials: Chaine Opératoire analysis of Middle Mesolithic Blade Assemblages from Central Sweden. In: Arias, P. (Ed.), Proceedings of the Eight Conference of the Mesolithic in Europe, Santander, Spain 14–18 September 2010.
Kuhn, S.L., 1991. "Unpacking" reduction: lithic raw material economy in the Mousterian of west-central Italy. J. Anthropol. Archaeol. 10, 76–106.
Kuhn, S.L., 1994. A formal approach to the design and assembly of mobile toolkits. Am. Antiq. 59, 426–442.
Larson, M.L., 1994. Toward a holistic analysis of chipped stone assemblages. In: Carr, P.J. (Ed.), The Organization of North American Prehistoric Chipped Stone Tool Technologies. International Monographs in Prehistory Archaeological Series 7, pp. 57–69.
Larson, M.L., Kornfeld, M., 1997. Chipped stone nodules: theory, method, and examples. Lithic Technol. 22, 5–18.
Lycett, S.J., Bae, C.J., 2010. The Movius Line controversy: the state of the debate. World Archaeol. 42 (4), 521–544.
Manninen, M.A., 2005. Problems in dating inland sites—lithics and the mesolithic in Paistunturi, Northern Finnish Lapland. In: Knutsson, H. (Ed.), Pioneer Settlements and Colonization Processes in the Barents region. Vuollerim Papers on Hunter–Gatherer Archaeology 1, pp. 29–41.
Manninen, M.A., 2006. Mesoliittiset asumuksenpohjat Pohjois-Lapissa. Huomioita liikkumisesta ja asumuksista. Arkeologipäivät 2005, 106–117.
Manninen, M.A., 2009. Evidence of mobility between the coast and the inland region in the Mesolithic of Northern Fennoscandia. In: McCartan, S.B., Schulting, R., Warren, G., Woodman, P. (Eds.), Mesolithic Horizons, vol. I. Oxbow Books, Oxford, pp. 102–108.
Manninen, M.A., Knutsson, K., 2011. Northern inland oblique point sites – a new look into the late mesolithic oblique point tradition in eastern Fennoscandia. In: Rankama, T. (Ed.), Mesolithic Interfaces – Variability in Lithic Technologies in Eastern Fennoscandia. Monographs of the Archaeological Society of Finland 1, pp. 143–175. <http://www.sarks.fi/masf/masf_1/masf_1.html>.
Manninen, M.A., Tallavaara, M., 2011. Descent history of mesolithic oblique points in eastern Fennoscandia – a technological comparison between two artefact populations. In: Rankama, T. (Ed.), Mesolithic Interfaces – Variability in Lithic Technologies in Eastern Fennoscandia. Monographs of the Archaeological Society of Finland 1, pp. 177–211. <http://www.sarks.fi/masf/masf_1/masf_1.html>.
Mourre, V., 1996. Les industries en quartz au paleolithique. Terminologie, méthodologie et technologie. Paléo 8, 205–223.
Nelson, M.C., 1991. The study of technological organization. In: Schiffer, M.B. (Ed.), Archaeological Method and Theory 3. University of Arizona Press, Tuscon, pp. 57–100.
Newman, J.R., 1994. The effects of distance on lithic material reduction technology. J. Field Archaeol. 21 (4), 491–501.
Newman, K., Moore, M., 2013. Ballistically anomalous stone projectile points in Australia. J. Archaeol. Sci. 40, 2614–2620.
Nickul, K., 1948. The Skolt Lapp Community Suenjelsijd During the Year 1938. Nordiska Museet: Acta Lapponica V. Hugo Gebers Förlag, Stockhoilm.
Nordgulen, Ø., Andresen, A., 2008. The Precambrian. In: Ramberg, I.B., Bryhni, I., Nottvedt, A., Rangnes, K. (Eds.), The Making of a Land – Geology of Norway. Trondheim, Norsk Geologisk Forening, pp. 62–119.
Norton, C.J., Gao, X., Feng, X., 2009. The East Asian middle paleolithic reexamined. In: Camps, M., Chauhan, P. (Eds.), Sourcebook of Paleolithic Transitions. Springer, New York, pp. 245–254.
Odell, G.H., 2003. Lithic Analysis. Springer, New York.
Odner, K., 1966. Komsakulturen i Nesseby og Sør-Varanger. Universitetsforlaget, Tromsø/Oslo/Bergen.
Olofsson, A., 2003. Pioneer Settlement in the Mesolithic of Northern Sweden. Archaeology and Environment 16. University of Umeå, Umeå.
Panja, S., 2003. Mobility strategies and site structure: a case study of Inamgaon. J. Anthropol. Archaeol. 22, 105–125.
Parry, W., Kelly, R., 1987. Expedient core technology and sedentism. In: Johnson, J., Morrow, C. (Eds.), The Organization of Core Technology. Westview Special Studies in Archaeological Research. Westview Press, Boulder, pp. 285–304.
Paulaharju, S., 1921. Kolttain mailta. Kansatieteellisiä kuvauksia Kuollan-Lapista. Kirja, Helsinki.
Prasciunas, M.M., 2007. Bifacial cores and flake production efficiency: an experimental test of technological assumptions. Am. Antiq. 72 (2), 334–348.
Rankama, T., 2003. The colonisation of northernmost Finnish Lapland and the inland areas of Finnmark. In: Larsson, L., Kindgren, H., Knutsson, K., Loeffler, D., Åkerlund, A. (Eds.), Mesolithic on the Move. Oxbow Books, Exeter, pp. 684–687.
Rankama, T., Kankaanpää, J., 2011. First evidence of eastern Preboreal pioneers in arctic Finland and Norway. Quartär 2011, 183–209.
Rasic, J., Andrefsky Jr., W., 2001. Alaskan blade cores as specialized components of mobile toolkits: assessing design parameters and toolkit organization. In: Andrefsky, W., Jr. (Ed.), Lithic Debitage: Context, Form, Meaning. University of Utah Press, Salt Lake City, pp. 61–79.
Ricklis, R.A., Cox, K.A., 1993. Examining lithic technological organization as a dynamic cultural subsystem: the advantages of an explicitly spatial approach. Am. Antiq. 58, 444–461.
Riede, F., 2006. Chaîne Opératoire, Chaîne Evolutionaire? Putting Technological Sequences into an Evolutionary Perspective. In: Gravina, B. (Ed.), Technologies: Changing Matter, Changing Minds. Archaeological Review from Cambridge 21, pp. 50–75.
Schanche, K., 1988. Mortensnes – en boplass i Varanger. En studie av samfunn og materiell kultur gjennom 10.000 år. MA thesis, University of Tromsø. <http://munin.uit.no/handle/10037/3316>.
Seppälä, S.-L., 1994. Inari 13 Vuopaja. Kivi- ja varhaismetallikautisen asuinpaikan kaivaus 13.6.-18.7.1994. Excavation Report on Archive, National Board of Antiquities, Department of Archaeology, Helsinki.

Skandfer, M., 2003. Tidlig, nordlig kamkeramikk. Typologi-kronologi-kultur. PhD Dissertation, University of Tromsø. <http://www.ub.uit.no/munin/handle/10037/284>.

Surovell, T.A., 2009. Toward a Behavioral Ecology of Lithic Technology: Cases from Paleoindian Archaeology. The University of Arizona Press, Tucson.

Tallavaara, M., 2005. Arkeologisen kiviaineiston nodulianalyysi. Sovellusesimerkki Rääkkylän Vihin kampakeraamsen ajan asuinpaikan piikivimateriaaliin. Muinaistutkija 2/2005, pp. 14–23.

Tallavaara, M., Manninen, M.A., Hertell, E., Rankama, T., 2010. How flakes shatter: a critical evaluation of quartz fracture analysis. J. Archaeol. Sci. 37, 2442–2448.

Tanner, A., 1979. Bringing Home Animals. Religious Ideology and Mode of Production of the Mistassini Cree Hunters. C. Hurst & Company, London.

Torrence, R., 1989. Retooling: towards a behavioral theory of stone tools. In: Torrence, R. (Ed.), Time, Energy and Stone Tools. Cambridge University Press, Cambridge, pp. 57–66.

Valentin, B., 2008b. Magdalenian and Azilian lithic productions in the Paris Basin: disappearance of a Programmed Economy. Arkeotek J. 2 (3), 1–54.

Valentin, B., 2008a. Jalons pour une paléohistoire des derniers chasseurs (XIVe-VIe millénaire avant J.-C.). Cahiers Archaéologiques de Paris 1.

Whallon, R., 2006. Social networks and information: non-"utilitarian" mobility among hunter–gatherers. J. Anthropol. Archaeol. 25 (2), 259–270.

Woodman, P., 1993. The Komsa culture. A re-examination of its position in the stone age of Finnmark. Acta Archaeol. 63, 57–76.

Woodman, P., 1999. The early postglacial settlement of Arctic Europe. In: Cziesla, E., Kersting, T., Pratsch, S. (Eds.), Den Bogen spannen…Festschrift für Bernhard Gramsch zum 65. Geburstag, Teil 1. Beitrage zur Ur- und Frugeschichte Mitteleuropas 20. Beier & Beran, Weissbach, pp. 292–312.