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University of Bergen Archaeological Series

The Stone Age Conference in Bergen 2017

Dag Erik Færø Olsen (ed.)

UNIVERSITY OF BERGEN

12

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Preface

This anthology is based on contributions presented as part of *The Stone Age Conference in Bergen 2017 – Coast and Society, research and cultural heritage management*. The conference was co-organized by the Department of Archaeology, History, Cultural Studies and Religion (AHKR) at the University of Bergen and the Department of Cultural History at the University Museum of Bergen (UM). The organizing committee included Dag Erik Færø Olsen (leader) and Tina Jensen Granados from AHKR, together with Leif Inge Åstveit and Knut Andreas Bergsvik from UM.

The Stone Age Conference in Bergen 2017 was the third instalment of the "Stone Age Conference" series to be organized in Norway. The first conference was held in Bergen in 1993 (Bergsvik *et al.* 1995) and the second in Molde in 2003. The purpose for the 2017 conference in Bergen was to gather archaeologists with common interest in the Norwegian Stone Age and from all parts of the national Stone Age community. Several prominent research communities exist in Norway today and representatives from all University departments and from the majority of the County Municipalities was gathered to share current results and to discuss common issues and strategies for future research.

Since the last conference in 2003, the cultural heritage management in Norway has made large quantities of new archaeological data accessible for research. Such extensive new data has provided new methodological and theoretical challenges and opportunities which is reflected in the scope of research published within the last 20 years.

The Stone Age Conference in Bergen 2017 wanted to reflect the new empirical, theoretical and methodological diversity, and to highlight how these developments could be integrated into the cultural heritage management and within future research. The conference was structured by current themes and approaches and divided into five main sessions (including a poster session) and seven session themes (see Sessions and papers at the end of this volume).

An increasing association with the *natural scientific approaches* was one important theme of the conference focusing on research on climate change, aDNA and new and improved methods for analysis and dating. Related to this was the general theme *technology* were studies on raw material and technological studies are used in mobility- and network analysis.

Managing and utilizing the large quantities of data generated over the last two decades was the basis for the themes *demography* and *subsistence changes*. The theme *methodological developments* included increasing digitalization and how this is used in rescue archaeology, with challenges and new possibilities. The conference also wanted to explore aspects of *ritual communication* where various forms of expressions, such as rock art, could elaborate and increase our understanding of several of the other main themes mentioned.

During the three days of the conference a total of 46 15 minutes presentations addressed various topics and aspects within the seven session themes. All sessions were led by session leaders and three of the conference sessions were introduced by key note speakers.

After the conference, it was decided to publish an anthology, inviting all participants to contribute including the poster participants. The publication was to be in the University of Bergen Archaeological Series, UBAS, and with Dag Erik Færø Olsen as editor of the anthology. Ten papers were submitted from all the sessions and is representative of the topics presented and discussed during the three-day conference. The papers included in this volume are organized mainly geographically starting with Northern Norway moving southwards.

Kenneth Webb Vollan focuses on housepit sites in Arctic Norway using radiocarbon dates for distinguishing reuse or occupational phases. He presents a method for analysing dates following the Bayesian approach and shows that the housepits were reused to a much larger degree than previous acknowledged.

Skule Spjelkavik and *Axel Müller* explores similar topics in their paper about quartz crystal provenance. By using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) they were able to compare debitage from the Early Mesolithic settlement site Mohalsen I at the island Vega with samples from 19 known sources in Norway. This is especially interesting since there are no known quartz crystal occurrences at Vega and was consequently brought from the main land or other areas. This study shows the potential for using this method, even though no clear parallel to the Mohalsen debitage could be identified in the analysed material.

Jan Mangerud and *John Inge Svendsen* explores colonization processes from a geological perspective. They document how an ice sheet margin presented a physical barrier across the Oslofjord preventing human immigration until the onset of the Holocene, providing an interesting backdrop for discussing aspects of colonization processes in the Early Mesolithic.

Arne Johan Nærøy discusses the use of tools and behaviour patterns based on use-wear analysis of quartz assemblage from the site 16 Budalen in Øygarden, Hordaland County. He is able to distinguish two individuals operating at the site suggesting spatially segregated work operations. Nærøy shows through this study the potential for functional analysis of lithic material from settlement sites.

Astrid Nyland, Kidane Fanta Gebremariam and *Ruben With*'s contribution represents both the new technological and methodological developments and the interdisciplinary nature of archaeology today. This paper explorers the potential for using pXRF for regional provenance analysis of greenstone adzes in western Norway. This study revisits an older interpretation of the division of this region into two social territories in the Middle and Late Mesolithic. The results show that the method is robust and well suited for studying green stone and the authors can also largely confirm the original interpretations based on distribution networks of Mesolithic adzes.

Birgitte Skar discusses the early postglacial migration into Scandinavia based on aDNA studies on two Early Mesolithic Norwegian skeletons. Skar's results confirms the recent interpretation of a second migration into Norway from the Northeast thus contributing to the overall narrative of the colonization of Norway.

Almut Schülke revisits the topic of Mesolithic burial practises in Norway based on new data from recent excavations. Schülke highlights that human remains are often found at settlement sites, opening for discussions of various relationships between the living and the dead and human-nature engagement.

Krister Eilertsen presents results from an excavation of an Early Neolithic hut in Rogaland, Southwestern Norway. He discusses classical interpretative challenges where the lithic material and ^{14}C-datings are not comparable. Eilertsen emphasise the importance of not dismissing difficult results but rather try to find an answer to the differences in light of a wider analysis of the area including various natural and cultural processes. He is thus able to explain the contrasting data and provide new insight into settlement patterns and economy at the start of the Neolithic.

Dag Erik Færø Olsen reviews the rock shelters in the mountain regions of Hardangervidda and Nordfjella. The previous interpretation of these settlement sites as primarily from the Late Neolithic and onwards is discussed based on a reclassification of archaeological material. The results show that rock shelters have been used from at least the Middle Mesolithic and in some cases with an intensification and stronger continuity after 2350 BC.

Gaute Reitan discusses the chronological division of the Mesolithic based on new data from excavations the last 20 years. Reitan presents a revised chronology for the Mesolithic in Southeast Norway dividing each of the three main phases into two sub-phases, adding two new phases to Egil Mikkelsen's original from 1975.

Acknowledgements

On the behalf of the organizing committee, we would like to thank all participants of *Steinalderkonferansen i Bergen 2017* for sharing their knowledge and for the discussions that followed at the conference. We also want to express our gratitude to the conference key note speakers, Prof. Kjel Knutsson (Dep. of Archaeology and Ancient History, Uppsala University), Assoc. Prof. Per Persson (Dep. of Archaeology, Museum of Cultural History, University of Oslo) and Prof. Charlotte Damm (Dep. of Archaeology, History, Religious Studies and Theology, The Arctic University of Norway) for introducing three of the conference sessions. This gratitude is also extended to five session leaders, Assoc. Prof. Arne Johan Nærøy (Museum of Archaeology, University of Stavanger), Prof. Marianne Skandfer (The Arctic University Museum of Norway), Assoc. Prof. Birgitte Skar (Dep. of Archaeology and Cultural History, NTNU University Museum), Prof. Hans Peter Blankholm (Dep. of Archaeology, History, Religious Studies and Theology, The Arctic University of Norway) and Prof. Almut Schülke (Dep. of Archaeology, Museum of Cultural History, University of Oslo).

During the three-day conference the committee received assistance from voluntary students from The University of Bergen and they provided valuable help during the conference.

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The editor of this anthology would further like to express gratitude to all the anonymous peer reviewers whose valuable comments and insights has made this publication possible.

Last, but not least, thank you to the authors of this anthology for the patience and work on the papers that make out this volume.

Dag Erik Færø Olsen and Tina Jensen Granados – Oslo 2021

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Kenneth Webb Berg Vollan

Dwellings as population proxies? Identifying reuse of coastal Stone Age housepits in Arctic Norway by means of Bayesian modelling of radiocarbon dates

Almost for a century, the archaeological record of the coastal Stone Age housepit sites in Arctic Norway has been at the centre of attention in many archaeological studies of this region. Although housepit reuse is occasionally recognised in particular cases, the theme does not get the proper attention it deserves. Since the early 1990s, an increasing number of radiocarbon samples have been dated, and the most recent excavations provide ^{14}*C-dates from single dwelling structures in quantities not formerly seen. Frequently, the radiocarbon determinations from one housepit prove to be widely spread in time, and hint towards the possibility of reuse. Here I contribute to the subject by outlining a formal method for analysing radiocarbon dates to detect episodes of housepit reuse, and by presenting the first estimation of the magnitude of the phenomena on a larger scale. Radiocarbon dates from three large-scale excavation projects, conducted between 1991 and 2010, are modelled following the Bayesian approach, and the chronological relationship between the dates is evaluated by statistical testing. The analysis reveals that housepit reuse is far more common than hitherto acknowledged, consequently each housepit can represent multiple household generations.*

Introduction

For decades, the Stone Age housepits on the coast of Arctic Norway have been of major interest for archaeologists working in the region, perhaps because they offer a physically perceptible fixed point for relating the archaeological record to past households and societies. In the few attempts to estimate prehistoric population sizes, both on single sites and in larger regions, the housepits have functioned as the key proxy (Andreassen 1985, p. 235–250, E. Helskog 1983, p. 150, K. Helskog 1984, p. 65–66, Schanche 1994, p. 175–177, Simonsen 1996, p. 118–122). The line of arguments behind the traditional estimation method consists of several stages. First, estimates of the number of housepits (supposedly) contemporaneous or used within the same chronological phase were made. Often, shoreline dating forms the basis for suggesting relative chronological order and relations between housepits. It follows the principle that housepits higher above present sea level are older than housepits on lower levels, and those on the same height levels are approximately of the same age or relatively close in time (e.g. Helskog 1984, Simonsen 1996). Secondly, one proposes how many households the contemporary housepits were inhabited by, and estimate the average number of individuals per household. Estimation of household size is often based on a combination of ethnographic information and housepit floor size. Finally, the population size estimate is the product of multiplying the number of individuals in a household with the number of households represented by the housepits. The same reasoning also lies behind estimations of population sizes in other regions with different culture-historical contexts (e.g. Müller *et al.* 2016, p. 134, 164, Birch-Chapman *et al.* 2017, p. 5; see also Hassan 1981, p. 72–75, Schacht 1981, p. 125–126, and references therein).

A major concern with this method is that it virtually disregards the possibility of housepit *reuse*. This is the main topic in this paper. I attempt to utilise radiocarbon dates from three large-scale excavation projects (Fig. 1) to detect housepit reuse, and to estimate the magnitude of the phenomenon. Does housepit reuse occur frequently or only in exceptional cases? The data source is restricted to the radiocarbon samples and the information about their archaeological contexts. An important aspect of this article is to develop a formal method for utilising that specific data to detect reuse; therefore, emphasis is put on methodological issues. Consequently, at this stage there will be little room for identifying spatio-temporal patterns and discussing possible explanations of the results in a cultural-historical context. The analysis aims at giving a minimum estimation, more than an exhaustive picture of housepit reuse. Nonetheless, the analysis will offer a more solid foundation for assessing whether reuse has an impact on our understanding of Stone Age housepits as a demographic proxy.

The housepits are often well visible on the ground surface and occur in relatively high numbers along the coast. The term *housepit* is applied to designate the archaeological remains of houses where the floor is situated below the ground level, often referred to as semi-subterranean houses or pit houses. The floor depth varies from a few centimetres to over half a meter, and the size from below eight m^2 to around 50 m^2. Often there are wall mounds surrounding the floors; the wall height can vary from a few centimetres up to half a meter (Engelstad 1988). On the coastal sites, the housepits tend to cluster and often forming rows following shoreline ridges or terraces. A typical site contain from five to twenty-five housepits. They have been radiocarbon dated back to around 7000 BC (Skandfer *et al.* 2010, p. 82–115), and as late as the early Iron Age (Skandfer 2012, p. 158–162). However, the majority of housepits are dated between 5000 BC and BC/AD.

The traditional application of housepits as a demographic proxy reflects a view on housepits as closed chronological units; they represent *one* dwelling structure inhabited by *one* household generation. However, recent resource management excavations, and especially their radiocarbon dating programs, provide chronological information making it reasonable to systematically assess the archaeological record related to Stone Age housepits (see also Hood and Helama 2010). Since the early 1990s, an increasing amount of samples from housepits has been ^{14}C-dated. Frequently, the ^{14}C-dates prove to be widely spread in time, indicating that many of the housepits have a far more complex use-history than captured by the traditional housepit-proxy approach.

To deal with the archaeological complexity that often follows from situations where multiple, chronologically spread occupations unfold within the same area, I regard it as useful to replace the term *housepit* with *dwelling plot*. Dwelling plot is the area upon where a dwelling structure is erected – the dwelling footprint (Fretheim 2017). The term helps to differentiate between

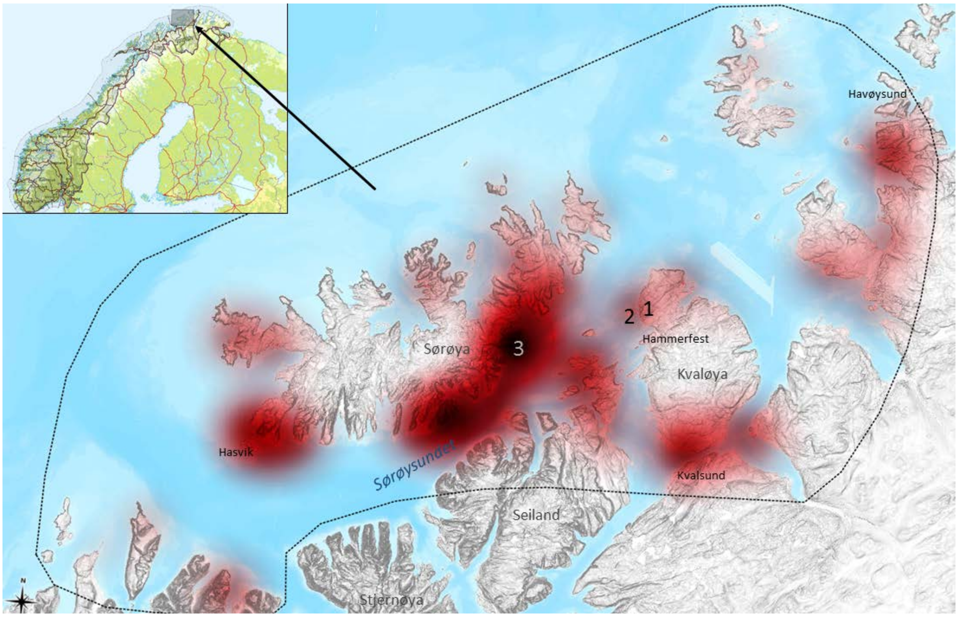

***Figure 1**: Map of the Sørøysund region and adjacent areas, western Finnmark. Within the map area there are more than 1400 recorded Stone Age housepits, the light to dark red colouring on the map indicates density of recorded housepits from low to high. The dotted line indicates the boundary for the density analysis. The numbers mark the locations of the excavation projects providing data for the reuse analysis; 1=Fjellvika/Skjærvika; 2=Melkøya; 3=Slettnes. They are situated in areas with a varying density of housepits. Scale 1:400 000. Background map © Kartverket.*

the dwelling structure and the area it is built upon, the plot. Moreover, this makes it easier to envision that multiple dwelling structures could have occupied the same plot at chronologically separate periods, and to acknowledge the concept of reuse. Besides, the dwelling plot term embraces all types of dwellings, including tents and lean-tos built on the ground surface, and not only the semi-subterranean houses normally associated with housepits. Here, dwelling plot *reuse* refers to situations when a new dwelling structure is erected on the same plot where an earlier dwelling once stood, and where the interval between the two episodes of dwelling habitation indicates that they cannot represent the same household generation.

Sites and data selection

From the three selected excavation projects, the compilation of analysis data is restricted to seven coastal sites in western Finnmark (see Fig.1). These are (1) Fjellvika and Skjærvika on Kvaløya (Gil *et al*. 2005, Henriksen and Valen 2009, 2013), (2) Sundfjæra and Normannsvika on Melkøya (Hesjedal 2009), and (3) three sites from Slettnes on Sørøya, Slettnes III, IV, and V (Damm *et al*. 1993, Hesjedal *et al*. 1993, 1996). In the excavation reports, all the sites except Slettnes III are sectioned into smaller units, but here the subdivisions are merged. As such, each larger site includes a variety of structure types (e.g. house remains, activity areas, graves and slab-line pits) distributed at different levels above the present shoreline. Chronologically, the structures range from Early Stone Age and well into the Iron Age, some even to modern times (Fig. 2).

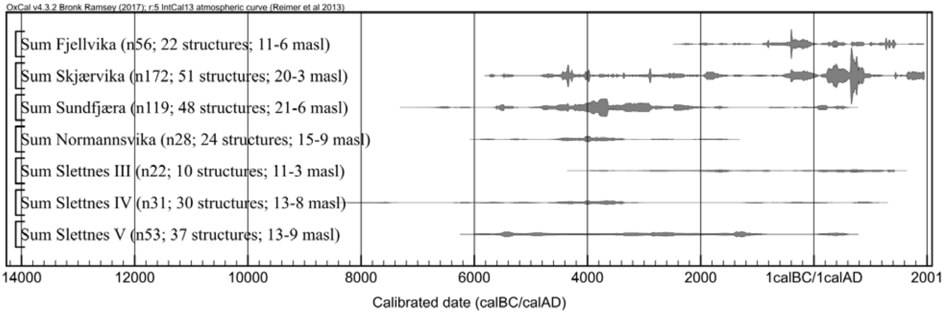

***Figure 2**: Summed probability distribution (SPD) of all ^{14}C-dates from each site, indicating the span of human activity. Note that four ^{14}C-dates from Normannsvika are excluded from the SPD, because they are not related to site occupation. Behind the site names is the number of ^{14}C-dates, the number of excavated structures on the site, and the range in meters above sea level of these structures.*

The reuse analysis concerns only the Stone Age dwelling plots (supplemental Table 1). In this paper, to be defined as *Stone Age*, there must be at least one ^{14}C-date indicating that the dwelling plot was established before BC/AD. Once it is determined that a plot was established in the Stone Age, all its ^{14}C-dates relating to dwelling habitation are included in the reuse analysis, even those younger than BC/AD. Dwelling plots only containing ^{14}C-dates younger than BC/AD are labelled *too young* and excluded from the analysis.

Figure 3 displays the number of excavated dwelling plots on each site and the years of excavation. The third column give the number of dwelling plots labelled too young and those that lack ^{14}C-dates associated with a dwelling habitation. Stone Age dwelling plots containing only one ^{14}C-date associated with a dwelling habitation are shown in the fourth column. For these dwelling plots, the ^{14}C-dates cannot display potential reuse, thus they are excluded from the analysis. The number of dwelling plots included in the reuse analysis is displayed in the second last column, i.e. those with two or more ^{14}C-dates representing dwelling habitation, and the last column shows how many ^{14}C-dates that sums up to be. Because Figure 3 is based on a re-evaluation of the relationships between dwelling plots and radiocarbon samples, the number of ^{14}C-dates associated with each dwelling plot might differ slightly from how it is presented in the excavation reports.

Site name	**Excavation year**	**Excavated**	**Too young, or none ^{14}C-dates**	**With one ^{14}C-date**	**Two or more ^{14}C-dates**	**^{14}C-dates in reuse analysis**
Fjellvika	2009–10	9	5	0	4	20
Skjærvika	2009–10	26	11	4	11	40
Sundfjæra	2001–02	19	0	4	15	56
Normannsvika	2001–02	13	2	7	4	9
Slettnes III	1991–92	9	2	1	6	15
Slettnes IV	1991–92	13	6	5	2	4
Slettnes V	1966, 1991–92	20	8	3	9	25
Total		109	34	24	51	169

***Figure 3**: Table of data from the sites included in the reuse analysis. In the two last columns, the table presents the number of dwelling plots and ^{14}C-dates from each site that are included into the reuse analysis. It also shows the number of excavated dwelling plots and how many that are unsuitable for the analysis. For more detailed description of table, see text.*

A total of 282 dated samples were obtained during excavation of housepit structures (supplemental Table 2), of which 169 are *strongly associated with dwelling habitation* (see below) in the 51 dwelling plots accepted into the reuse analysis. There are 165 ^{14}C-determinations on charcoal, three on crust from ceramics, and one on a sample containing marine shells (*Mytilus edulis* and *Patellidae*). The charcoal in 123 of the dated samples is identified as deriving from short-lived species (mainly *Betula*, *Sorbus*, *Prunus*, *Salix*, *Populus*). One sample contained larch (*Larix*) that did not grow naturally in the study area and must originate from driftwood. For the remaining 41 radiocarbon determinations on charcoal, the sample taxa are unidentified, and all except one are from the Slettnes sites. The conventional radiocarbon dating method was used on 63 samples, while 106 were dated by accelerator mass spectrometry (AMS), which gives a more precise age determination.

Selection criteria: radiocarbon samples representing dwelling habitations

It is important to remember that radiocarbon dates essentially date the sample, not the sample context. Therefore, in every case one must assess the sample material and the relations between samples and their contexts (Waterbolk 1971, p. 15–16, Bayliss 2015, p. 688–690). When exploring dwelling plot reuse by means of ^{14}C-dates, evaluating the associations between contexts and past events is paramount. As a guideline for this study, radiocarbon samples from contexts interpreted as floor layers, and features situated in these floor layers, are presumed to represent dwelling habitation, unless the stratigraphy or context indicate otherwise. Floor areas are commonly defined by being semi-subterranean, or a cleared area, often surrounded by wall mounds or a line of stones (e.g. Engelstad 1988, Skandfer 2012, Fretheim 2017). The floor layers often contain lithic debris, charcoal, ash and organic matter. Sometimes this is more blended into the natural beach gravel than accumulated in solid cultural layers. Samples procured from hearths integrated into the floor layers are considered particularly reliable when dating a dwelling habitation.

Samples from contexts probably deposited in the floor area of a dwelling after its abandonment, and from pits cutting floor layers, are considered weakly related, or not related at all to dwelling habitation. In the case of survey test pitting the conditions are poorer, compared to excavation situations, for interpreting the contexts the samples are obtained from, so there might be a greater risk for blending sample material from chronologically different deposits. Given this, the association between test pit samples and dwelling habitations are here categorized as weak, and thus excluded from the reuse analysis.

Charcoal in wall areas can have several possible explanations. In the excavation reports, some of the samples obtained from wall areas or outside the dwellings are interpreted as refuse dumps from dwelling hearths. Potentially, charcoal in wall areas can derive from wooden structure elements. If the dwelling plot was reused, the charcoal originally could have been deposited in the floor area, but later re-deposited in the wall when the plot was prepared for a new superstructure. Alternatively, charcoal mixed into wall material could have been deposited during an earlier period of open-air activities, when there was no functioning dwelling structure on the plot (Fretheim 2017, p. 76–89). In addition, the wall could have been built upon an older cultural layer, or, as suggested in the excavation report from Slettnes (Hesjedal *et al.* 1993, p. 113, 163), the wall material might have been taken from neighbouring housepits or other, earlier activity areas. Since the origin of wall-samples is difficult to interpret, all the ^{14}C-dates from the wall areas are excluded from this reuse analysis. I do not consider samples from features and cultural layers outside the dwelling plots as directly related to a dwelling habitation. This also applies for sampled features or deposits associated with a dwelling by the excavators, which is often the case for abutting middens, heaps of fire-cracked rocks and nearby open-air hearths and cooking pits.

Radiocarbon dates as data: critical issues

There are critical issues concerning ^{14}C-dates as a source. Depending on the archaeological situation, some are more relevant than others (see Bayliss 2015). Along with the effect of the wiggles in the calibration curve, which is described below, sample materials and sampling routines are the factors with the highest potential for obscuring the reuse analysis. Marine material and the reservoir effect is one of the critical issues concerning the sample material. There is one sample representing dwelling habitation on Slettnes IV containing marine shells. For reservoir correction I use a ΔR value of 13 ± 40, which is the weighted average of two correction estimates on whale bones (Mangerud *et al.* 2006) and one on *Mytilus edulis* (Mangerud 1972). The correction samples are from two different locations, both approximately 40 km away from Slettnes (supplemental Figure 1). Due to high δ^{13}C-values in the three crust samples taken from ceramics found at Slettnes V, indicating a considerable content of marine mammal lipids, corrections were made by the radiocarbon laboratory following a standard procedure of reducing the radiocarbon age by 440 years (Oppvang 2009, p. 85).

A different issue regards the old wood effect, including driftwood. Only one sample consists of charcoal identified as a long-lived species, driftwood of larch. However, since the sample dates to the same habitation episode as a charcoal sample of birch from the same dwelling plot, it is accepted into the reuse analysis. If the larch sample alone represented a habitation episode, it would have been excluded from the reuse analysis because it potentially has a much higher ^{14}C-age than the deposits it is associated with. Regarding the Slettnes sites, where all the charcoal samples lack wood species identification, it is difficult to evaluate if the old-wood effect has an impact on the reuse analysis of the Slettnes sites, or to what degree.

Another issue concerning particularly the Slettnes excavations is charcoal sampling routine. The formerly used conventional radiocarbon dating method required a large amount of material for measuring the ^{14}C-age (Bayliss 2009, p. 125). At the Slettnes excavations in 1991 and 1992, for the samples to be large enough for conventional radiocarbon dating, charcoal fragments with a relatively wide horizontal distribution occasionally were gathered into the same bag. This increases the risk of blending charcoal from chronologically separate depositions into the same sample, but it is difficult to estimate the actual impact this has on the analysis results. At the time of the Melkøya excavations in the early 2000s, both sampling routines and stratigraphic documentation had improved significantly. Smaller amounts of charcoal were required for conventional radiocarbon age measurements, and dating by AMS had become much cheaper and thus more available as a dating method (Bronk Ramsey *et al.* 2004, Bayliss 2009, p. 125–126). At Melkøya, there was an explicit strategy to obtain samples from stratigraphic profiles and with a limited spatial distribution, and to secure detailed documentation of their contexts (Hesjedal *et al.* 2009, p. XI). This was followed up in the later projects at Skjærvika and Fjellvika. It is important to note that even with smaller samples from distinct contexts, there is still a risk of mixing charcoal related to chronologically different activities (Ashmore 1999). Nonetheless, I consider the risk generally lower compared to larger samples containing more widely distributed material.

Bayesian modelling of radiocarbon dates

Bayesian modelling (Buck *et al.* 1996) provides a formal statistical framework for combining radiocarbon dates with information about stratigraphic relationships between the dated samples. The basic principle behind the modelling algorithms in calibration software, such as OxCal (Bronk Ramsey 2009a) and BCal (Buck *et al.* 1999), are based on Bayes theorem, which is probabilistic and can be expressed as *standardised likelihoods x prior beliefs = posterior beliefs* (Buck *et al.* 1996, p. 19–21, Bayliss 2009, p. 127–129, Hamilton and Krus 2018, p. 189–190). Transferred to an archaeological situation, the calibrated radiocarbon dates form the standardized likelihoods, and prior beliefs are the existing knowledge about the archaeological contexts of the dates, which indicates their relative chronological order. The archaeological information is used to constrain the calibrated radiocarbon dates, and the new, constrained age estimates are the posterior beliefs, or the modelled dates (Bronk Ramsey 2009a, Bayliss 2011, p. 19–35).

How a model is structured should reflect the archaeological questions to which it is meant to respond. In a site-specific context, the relative chronological order of stratigraphy, features, and deposits often form the basis of the model structure (e.g. Macsween *et al*. 2015, Richards *et al*. 2016, Card *et al*. 2018). Following this approach, the ^{14}C-dates from the seven study sites are arranged in stratigraphic site-models. In many ways, the model structures resemble a Harris matrix. If a group of contexts can be sorted in a relative chronological order, the samples can be modelled in a sequence, according to that order (Bronk Ramsey 1995, p. 463). Samples from relatively older deposits should date earlier than samples from younger deposits. If two samples are procured from the same context and strongly associated in time, e.g. charcoal from the same burning event, then the radiocarbon ages should calibrate approximately to the same dates.

By constraining the ^{14}C-dates in models, the chronological precision level is potentially enhanced, which improves the ability to estimate the timing of archaeological events, the tempo of change and duration of phases (Whittle *et al.* 2011). Important to note, the method also provides a framework for formal analysis, as opposed to informal eye-balling of calibration results, which has generally been the case in Norwegian Stone Age research (see however E. Helskog 1983, K. Helskog and Schweder 1989). When narratives of the past are based on visual inspection of calibration results alone, it has been shown that archaeologists generally assume archaeological events or phases to start earlier, last longer and end later than what is plausible (Bayliss *et al.* 2007, p. 8–9, 25). Concerning the issue in this paper, Bayesian modelling should be a beneficial approach when using the radiocarbon dates to define dwelling habitation episodes and detect reuse.

I use the calibration program OxCal v4.3 (Bronk Ramsey 1995, 2001, 2009a) to model the data analysed in this article. For all dates, the IntCal13 (Reimer *et al.* 2013) calibration curve is applied, except for the sample of marine shells from Slettnes, which is calibrated using the Marine13 curve (Reimer *et al.* 2013). Modelled dates and statistical estimations based on these dates are given in italics, and have been rounded outwards to the nearest five years and refer to the calendar BC/AD scale.

The models can be diagnosed to see if there is good agreement between the radiocarbon dates and the model. The most important is the model agreement index, A_{model} (Bronk Ramsey 2009a, p. 356–357). For each date there is also calculated an individual agreement index A, which measures the agreement between the posterior distribution (the modelled date) and the (unmodelled) calibrated radiocarbon date. These values are used to calculate an overall agreement index, $A_{overall}$, for the model as a whole (Bronk Ramsey 1995, p. 429). For all the agreement indices, the value should stay above 60%. If the A_{model} and $A_{overall}$ values are below 60%, there could be a problem with the model. Lower values for the individual dates indicate that it might be an outlier of some kind (Bronk Ramsey 2009b). Re-deposition and post-depositional mixing of deposits (Schiffer 1987, Bailey 2007, p. 204–207) might cause a collapse of the law of superimposition (Brantingham *et al.* 2007, p. 517). When residues from one event are blended into a context related to a chronologically different event, it can affect how well the ^{14}C-dates fits the relative chronological order of a stratigraphic sequence.

The site-models

The reuse analysis presented here is based on carefully selected ^{14}C-dates, yet all the radiocarbon dates are included in the Bayesian models for each site. This is to ensure that the models are as robust as possible, and to prevent the selected data from being disentangled from its larger context. The models do not only provide an overall impression of the sites' occupation histories; they also function as a powerful tool when evaluating the radiocarbon dates in relation to each other and to the site deposits: the integrity of contexts and stratigraphic layers. Is the relative order of layers chronologically sound? What is the age difference between discrete layers in a stratigraphic sequence? Do the deposits represent single archaeological events or are they an aggregation of material from chronologically different episodes?

Model building is a dynamic process that often involves a repetitive procedure of modelling-evaluation-re-modelling (Bayliss 2007, p. 4–5). For each model, there are site-specific challenges that need to be handled, and the procedures can be repeated several times before the final model is reached. There will always be an element of interpretation when structuring models according to stratigraphic information, and sometimes hypothesis testing is exactly the point of modelling. Here, however, I aim at defining and detecting occasions of dwelling plot reuse on a rather large dataset. Therefore I have had an explicit strategy of keeping the models as simple as possible (see Bayliss and Bronk Ramsey 2004), and to accept limitations in the available archaeological information. If the stratigraphic relations between samples appear unclear in the report and field documentation, no constraints are added based on ambiguous interpretations of how the relations could have been.

In each of the site-models for Fjellvika, Skjærvika and Sundfjæra (supplemental Figure 2–4), all radiocarbon dates are grouped within a single phase. Each phase represents the site-occupation, irrespective of duration. The ^{14}C-dates from Normannsvika are structured into three sequential phases (supplemental Figure 5). The first phase contains dates from layers covered by transgression sediments, the second contains the dates related to site occupation after the Tapes-transgression maximum, which is when the dwelling plots were used, and the third phase contains charcoal samples from the turf covering the site. The ^{14}C-dates from Slettnes are structured into three separate, chronologically overlapping phases, which respectively represent the occupation of the sites III, IV and V (supplemental Figure 6). In all models, within the phases representing larger site occupations, radiocarbon dates from single archaeological features are arranged into distinct groups (e.g. dwelling plot). If there is information about the relative chronological order of samples belonging to the same structure, they can be constrained. For example, by sequencing samples from the top and bottom layers in a hearth, or samples from hearths stacked in different floor layers.

All the site-models in this study have acceptable agreements; the A_{model} values from the models of Fjellvika, Skjærvika, Sundfjæra, Normannsvika and Slettnes are respectively 97%, 80%, 94%, 90%, and 97%. In addition, the $A_{overall}$ values are above 60%. Five of the dwelling plots included in the reuse analysis, two from Skjærvika and three from Sundfjæra, contain ^{14}C-dates returning poor agreement when modelled in a sequence according to their stratigraphic order. For three of the plots, the reuse analysis demonstrates that the date estimates of the misfit samples overlap other date estimates representing dwelling habitation on the same plot. This indicates that the stratigraphic sequences are disturbed, possibly due to post-depositional processes. Since they have no impact on the final analysis results, the misfit dates from these three plots are kept in the models.

The fourth plot (one from Skjærvika) contains six floor samples, which are modelled in a sequence of four stratigraphic levels. Also, here post-depositional mixing of deposits might explain why the radiocarbon age of two samples are inconsistent with the relative chronological order of the stratigraphic layers. However, both are kept in the model and each represents their own habitation episode. Consequently, the reuse analysis counts four episodes of dwelling habitation on the plot. If both samples were removed, the analysis would still conclude that the plot was reused, but only once. A third floor sample from this plot, which is approximately thousand years older than the other floor samples, is removed from the floor sequence because its large offset prevents the model analysis to run appropriately. It is also excluded from the reuse analysis.

The low agreement in the fifth dwelling plot (from Sundfjæra) is caused by two samples from a hearth; the sample from the top layer dates earlier than the sample from the bottom layer. The latter sample dates to the same time as a third sample representing dwelling habitation in the plot. Possibly, the relative stratigraphic order is disturbed due to mixing of the hearth deposits, or one of the hearth dates could be an outlier. Both samples from the hearth are kept in the model and the reuse analysis. If it were possible to demonstrate that the sample from the top of the hearth provided an older date than expected because of contamination or other incidents affecting the reliability of the date, it would have been removed. Then the reuse analysis would have counted one habitation episode on the dwelling plot.

The reuse analysis

The reuse analysis is based on two operations. First, it is statistically determined how many dwelling habitation episodes the dated radiocarbon samples represent for each plot. The chronological relationships between the ^{14}C-dates are evaluated by X^2-testing (Ward and Wilson 1978), which defines whether two or more ^{14}C-dates are statistically consistent or not (Bronk Ramsey 1995, p. 429). If consistent, the ^{14}C-dates possibly relate to events occurring contemporaneously or relatively close in time. If the test fails, the dates probably relate to events from chronologically different habitation episodes (see also Steele 2010, p. 2020–2021, Wicks *et al.* 2016, p. 11). When two or more ^{14}C-dates from the same dwelling plot are from chronologically different episodes, i.e. not statistically consistent, it is taken as a signal of reuse. Important to note, the X^2-test works on the uncalibrated radiocarbon ages.

The second operation of the analysis is therefore to apply the site-models for assessing the results from the X^2-tests. This is done by combining the posterior distributions (the modelled dates) of the samples with statistically consistent ^{14}C-ages, i.e. the samples that probably represent the same habitation episode. The combine function in OxCal can be used on dates that are relatively close in time, and expected to refer to the same event (such as a dwelling habitation episode). If the overall agreement of the combination (A_{comb}) is above 60%, the assumption that the ^{14}C-dates represent one habitation episode is strengthened. If the A_{comb} shows poor agreement, it might indicate that the ^{14}C-dates represent a long-term regular use of the dwelling plot, or that it was reused within a relatively short interval.

If two ^{14}C-dates from the same plot are chronologically adjacent or marginally overlapping, but still prove to be statistically inconsistent with each other, it could possibly be a result of long-term regular use. Nonetheless, in a situation like that, the X^2-analysis will find two habitation episodes. Again, the modelled dates can be used for evaluating the X^2-test results, both by combining and by estimating the interval between the episodes. I have done this on all dwelling plots where the X^2-test indicates two habitation episodes. In archaeological studies, the average age-at-death of a human normally is well below 60 years, and only a few individuals lived longer (see Chamberlain 2006, p. 81–92 and references therein). Therefore, if the minimum range of the estimated interval between the dwelling habitation episodes is more than 60 years, this is taken as a sign of reuse.

The shape of the calibration curve is a known concern when it comes to radiocarbon dating (e.g. Ames 2012, p. 176–178, Williams 2012, p. 581–583). When ^{14}C-dates hit a plateau in the calibration curve, the probability distribution can exhibit a wide chronological range and give a false impression of longevity. This could affect the reuse analysis directly. If two or more dates from the same dwelling plot, but from different contexts deposited during chronologically separate habitation episodes, hit the same plateau, there is good chance that the X^2-test will find the ^{14}C-dates to be statistically consistent. Potentially, the plateau effect can disguise that there were considerable time-gaps between the dated events, and that the dwelling plot had multiple habitation episodes. The larger the standard error is for the ^{14}C-measurements, the larger is the risk that reuse episodes are blurred out. By using Bayesian modelling it is possible to partly deal with such issues.

Analysis results: Reuse of Stone Age dwelling plots

As Figure 3 displays, 51 dwelling plots are suitable for the reuse analysis, and from these there are 169 ^{14}C-dates associated with dwelling habitation. One hundred of these dates are from hearth contexts, and 67 are from other features mounted in floor layers or from the floor layers themselves. Additionally, two of the plots in Fjellvika have one sample each that offers a *terminus post quem* (tpq) for their third and last dwelling habitation episodes. In dwelling plot 23, the tpq-date is taken from the turf layer found under one of the stones in a tent-ring, and above the floor-layer of an earlier dwelling structure. The tpq-date in dwelling plot 24 is from a similar context, but the upper dwelling is a post AD 1650 structure with turf walls.

Running the X^2-test on the ^{14}C-determinations from their respective dwelling plots returns signals of reuse in 39 plots (Fig. 4, also see supplemental Figures 7–11), whereof 18 have three or more habitation episodes. For 20 dwelling plots, the X^2-test finds that the ^{14}C-dates represent two habitation episodes. The posterior distributions from the site-models are applied to evaluate the chronological relationship between episode one and two in each of these plots (Supplemental Table 3). For 14 of these plots, the estimated interval between habitation episode one and two exceeds 100 years (*95.4% probability*). Thus, the modelled dates substantiate that these plots probably have been reused. For three dwelling plots (from Slettnes), the modelled dates of episode one and two, as defined by the X^2-test, are slightly overlapping. For each plot, the estimated interval between the modelled dates are *0–690 years, 0–760 years*, and *0–785 years* (*95.4% probability*). Although the ^{14}C-dates indeed could represent two habitation episodes separated by an interval potentially spanning hundreds of years, this also opens up the possibility that the ^{14}C-dates represent only one episode of habitation. Since the ^{14}C-dates can be interpreted in both directions, the dwelling plots can be catorized as ambiguous (Fig. 4).

There is a similar situation for the remaining four plots (two from Sundfjæra, one from Normannsvika, and one from Slettnes), where the X^2-test indicates two habitation episodes. Here the modelled dates from episodes one and two do not overlap, but the shortest interval between the episodes is estimated from 35 to 55 years (*95.4% probability*). Given this, the interval estimations make it possible to suggest that the ^{14}C-dates represent long-term, regular use of the plots. The plots have therefore been re-categorised as ambiguous. However, the upper range of the interval estimations lies between 360 and 635 years (*95.4% probability*). Hence, dwelling plot reuse is still a plausible interpretation. Note that for all the 21 dwelling plots where the X^2-test indicates two habitation episodes, the intervals in the models are estimated to exceed a minimum of 95 years at *68.2% probability*.

In 12 dwelling plots, the X^2-test indicates that the ^{14}C-dates represent only one dwelling habitation episode. When combining the modelled dates from each of these plots, all return an A_{comb} value above the threshold of statistical consistency and substantiates the probability that the ^{14}C-dates represent one episode of dwelling habitation. However, for two plots individual modelled dates are in poor agreement with the overall combine result, which indicate that the ^{14}C-dates might represent two habitation episodes, or a phase of long-term regular use. Hence, the two plots (both from Sundfjæra) are added to the ambiguous-category. As displayed in the three last columns in Figure 4, in 32 dwelling plots both the X^2-test and the Bayesian models evidently indicate reuse. Nine dwelling plots fall into the ambiguous-category, which holds the plots for which it is problematic to distinguish reuse from a long-term dwelling habitation. Lastly, in ten plots the ^{14}C-dates are consistent with only one habitation episode.

Sites	X^2-test		Adjusted according to models		
	Reused	Not reused	Reuse confirmed	Ambiguous	No-reuse confirmed
Fjellvika	4	0	4	0	0
Skjærvika	9	2	9	0	2
Sundfjæra	10	5	8	4	3
Normannsvika	2	2	1	1	2
Slettnes	14	3	10	4	3
Total	39	12	32	9	10
			(63%)	(18%)	(20%)

***Figure 4**: Table of dwelling plot reuse. The first two columns display the reuslts of the X^2-testing on the uncalibrated radiocarbon ages. The last three columns show the final result of the reuse analysis, after the modelled dates is analysed to evalute the X^2-tests. See text for further description.*

The best data quality, in terms of number of dated samples per plot and precision of radiocarbon age measurements, is found at the Fjellvika and Skjærvika sites. It is also here that the highest proportion of reuse is identified. Concerning the Melkøya project, the data quality for Normannsvika is notably poorer than for Sundfjæra. From Normannsvika there are fewer ^{14}C-dates and dwelling plots suitable for the reuse analysis, and almost none of the charcoal samples are related stratigraphically. This might explain why the magnitude of dwelling plot reuse is considerably lower in Normannsvika compared to the other sites. However, it should be noted that on a general level there probably are between-site differences, which cannot be explained solely by the data situation. The analysis results of the Slettnes sites, belonging to the third and oldest developmental project, fits well with the general picture. This might imply that sample material and changes in sampling routine is not significantly affecting the results. The reuse trend is relatively consistent on all sites, despite the varied data quality, and the chronological and topographical differences. This offers strength to the analysis results.

Discussion

Important to note, this analysis probably gives a *minimum* estimation of the frequency of dwelling plot reuse. Radiocarbon samples and information about their stratigraphic and contextual relationships are the only data source applied in the reuse analysis. In addition, the analysis is based on a careful selection of samples, only including those reasoned to be strongly associated with dwelling habitation. Moreover, only 37 of the 51 analysed dwelling plots are fully excavated. By dating more samples or by adding information from other types of data, the analysis can be further developed. For instance, if there are stacked floor layers and/or dwelling features (e.g. walls, hearths), if chronologically distinct artefact types and technologies from different periods are found in the same dwelling plot, or if the artefact material does not match the ^{14}C-dates, this could be indications of dwelling plot reuse. Nevertheless, the analysis presented above demonstrates that reuse of Stone Age dwelling plots is a frequently occurring phenomenon.

Of the 31 dwelling plots with three or more dates, the analysis identifies 18 plots with three or more habitation episodes. Thus, it is not unusual for dwelling plots to have been reused multiple times. The available data does not allow for going much deeper into detecting trends about how many times or how intensively dwelling plots have been reused. Still, they indicate variation. Two dwelling plots respectively contain eight and nine ^{14}C-dates that represent dwelling habitation, the analysis detects six separate habitation episodes in each. On the other hand, for two of the dwelling plots containing four and five ^{14}C-dates, the X^2-test finds only one habitation episode. This illustrates that the amount of reuse should be expected to vary, and that it often is crucial to have a certain amount of ^{14}C-dates from different contexts to be able to outline an adequate use-history of a dwelling plot.

The length of the intervals between dwelling habitation episodes can vary from hundred years to over a millennia. This clearly has implications for the reliability of shoreline dating, which is based on the assumption that housing structures generally were placed close to the contemporary shoreline (Bjerck, *et al*. 2008, Fig. 5.3, Henriksen and Valen 2013, Fig. 5.2). Possibly, shoreline dating might indicate approximately when a dwelling plot first were established, but, if the dwelling plot were reused multiple times, the shoreline dating method does not necessarily provide valid date estimates for all dwelling habitation episodes. Thus, since the chronological distribution of habitation episodes related to a dwelling plot can be spread over large timespans, one should be cautious not to put too much emphasis on assumptions about the relative chronological order of dwelling features based on their height above sea level. Still, at a coarser level shoreline dating might be useful. When areas at different height-levels on a site are topographically divided, for example by a steep slope, it appears in most cases of the analysed sites that all habitation episodes related to dwelling plots at the higher level are earlier than those at the lower level. However, within each height-level area it becomes problematic to differentiate dwelling plots chronologically according to height above sea level.

In relation to this, stability of site attractiveness can be viewed as a parameter mediating/constraining dwelling plot reuse. Attractiveness is a term combining several factors, such as landing conditions for boats, social aspects (e.g. closeness to kin, or renowned hunters), resource availability (e.g. closeness to reliable fishing areas, fuel), and other environmental conditions (e.g. drainage, windiness). If the attractiveness of a site, or a certain area on a site, remains stable over long periods of time, it should be expected that this particular area are occupied by residential groups more often compared to areas less attractive or only temporarily attractive. This also implies the prediction, which should fit most archaeologists' intuitive assumption, that dwelling plot areas at height-levels where the shoreline has remained stable for centuries are probably reused more frequently than plots at height-levels with more rapidly regressing shorelines. Furthermore, due to accumulation of residential activities within the same area over time, reuse could possibly be more common on smaller sites (or areas), where there is room only for a limited number of dwelling plots, than on larger, equally attractive sites.

When it comes to the spatio-temporal distribution of dwelling plot reuse, further investigation of the results is necessary before formally demonstrating any potential prominent patterns. At this stage the results seems to suggest that reuse is a general trend occurring more or less regularly. However, within certain periods markedly fewer episodes of reuse are identified. In the period between c. 3400–3000 cal. BC there is only one reuse episode, and in the periods between c. 1800–1500 and 1000–500 cal. BC there are two, or possibly only one in each. Although the significance of these observations is uncertain, since the analysed data are from a restricted number of sites, it is worth noting that these periods roughly coincides with times when human activity in the larger region seems to have been relatively low. The two first period follows a marked drop in the summed probability distribution of radiocarbon dates from northern Norway (Jørgensen 2018, Fig. 5), suggested to reflect demographic downturns (Jørgensen 2018, Damm *et al.* 2019). This fits with an assumption that periods with a higher population density within a given area should result in more dwelling plot reuse than periods with lower population density.

The last period has not been associated with particular demographic fluctuations on a larger scale. Further investigation is needed in order to suggest whether the reuse pattern of the last two millenniums BC is an artefact of the data, or if it echoes demographic changes on a more local scale, or changes in land-use or mobility strategies. It seems reasonable to assume that populations practicing high residential mobility will produce more dwellings than more sedentary populations. However, one must also consider that sedentary people might have dwellings at special camps. Theoretically, several parameters can affect the spatio-temporal distribution and magnitude of dwelling plot reuse, and not necessarily in straightforward ways. Here I have touched upon a few, which seems particularly relevant for this study.

Dwelling plot reuse can have a significant impact on the integrity of the associated archaeological record, including the dwelling feature (see also Binford 1982). Only in a few exceptional cases are there possible to distinguish traces of multiple dwelling features on the same plot. Even when a dwelling plot has been reused several times, the archaeological documentation are normally conceptualised as a representation of only one dwelling feature. Generally, there is a floor area of certain size and shape (and depth when it comes to semi-subterranean dwellings) surrounded by a set of walls, and with some other accompanying elements (e.g. hearths). This begs the question, to which dwelling habitation episode(s) does the feature attributes (and artefacts, for that matter) relate? If floor size functions as a proxy for household size, it is important to explicitly state which habitation episode(s) the floor size are associated with – it could be the last, the first, or, perhaps all – and preferably why.

The results presented in this paper clearly illustrate that the relationship between number of dwelling plots and population size is a complex matter. One dwelling plot can represent multiple household generations belonging to chronologically different periods. Consequently, before the Stone Age dwelling plots are applied as a demographic proxy, the link between the dwelling plots at hand and the population they are expected to represent ought to be carefully evaluated, both methodologically and theoretically. Doing this potentially will provided more reasonable population size estimates. Here I have presented a formal method for utilizing the growing radiocarbon assemblage to outline the use-life of Stone Age dwelling plots, which can aid in estimating more precise population sizes. Nevertheless, further research on dwelling plot reuse, and on the impact that reuse in general can have on the archaeological record is needed.

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Supplemental Materials

For supplemental material accompanying this article, visit https://doi.org/10.18710/AQ1AQJ. Note that OxCal-codes for the site-models are also available.

Supplemental Figure 1: Reservoir correction of sample containing marine material.

Supplemental Figure 2: Bayesian site-model of radiocarbon dates from Fjellvika.

Supplemental Figure 3: Bayesian site-model of radiocarbon dates from Skjærvika.

Supplemental Figure 4: Bayesian site-model of radiocarbon dates from Sundfjæra.

Supplemental Figure 5: Bayesian site-model of radiocarbon dates from Normannsvika.

Supplemental Figure 6: Bayesian site-model of radiocarbon dates from Slettnes.

Supplemental Table 1: Dwelling features documented on the sites used in this article.

Supplemental Table 2: Radiocarbon dates included in the Bayesian models.

Supplemental Table 3: Results of X^2-tests.

Supplemental Table 4: Interval lengths between habitation episodes.

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Skule O. S. Spjelkavik and Axel Müller

As clear as crystal? An attempt at sourcing hydrothermal quartz crystals from the Early Mesolithic site 'Mohalsen-I', Vega Island, Norway using LA-ICP-MS and SEM-CL

This article describes an attempt at sourcing hydrothermal quartz crystals from the Early Mesolithic site Mohalsen-I by comparing four pieces of debitage with quartz crystal samples from 19 known quartz crystal occurrences in Norway. Through identifying a possible source, the hope was that we could shed light on mobility patterns and raw material procurement strategies in the research area. The samples were analysed using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) and scanning electron microscopy cathodoluminescence (SEM-CL). Through analysing SEM-CL images and the chemical composition of five samples from the Berglia-Glassberget occurrence in Lierne, we found similar structural features and chemical concentrations of selected trace elements in the samples. This indicates that the method is a viable approach to sourcing hydrothermal quartz crystals from archaeological contexts. However, no clear parallel for the samples from Mohalsen-I was discovered, indicating that the source is not among the quartz crystal occurrences analysed here. The research conducted will serve as a basis for potential future investigations and as a reference for similar studies.

Introduction

This article aims to highlight the findings from a recent provenance study of quartz crystal debitage from the Early Mesolithic site Mohalsen-I (see Fig. 1) on Vega Island, Norway (Spjelkavik 2016, Müller *et al.* 2018). The site was first excavated in 1974 (Alterskjær 1975, 1985), and later as a rescue excavation in 2012 and 2013 due to intensive aeolian erosion of the area (Lorentzen 2013, 2014). Though flint clearly dominates as the chosen lithic raw material on the site, a relatively large amount of quartz crystal tools, blades and debitage was collected. The flakes clearly show that they stem from large single quartz crystals (> 5 cm in size), which can be found only in a few Norwegian mineral occurrences. This sparked an interest in the provenance of the crystals. Where have these crystals been collected? Can they hint at possible trading, mobility patterns and lines of interaction?

With the increasing focus on varying migration patterns relating to the pioneer settlement of the Norwegian coast (see Kleppe 2014), it is interesting to consider the role of the settlement traces on Vega Island. As the inland ice sheet in this area would have been considerably closer to the contemporary coastline than further south and north in Norway (see Fig. 4), it seems unlikely that the mountainous regions would have been utilised to the same extent as the high mountain plateaus of western (Bang-Andersen 2003) and central Norway (Breivik and Callanan 2016). As the presence of an 'obligatory' small amount of quartz and quartz crystal on Early Mesolithic coastal sites in western Norway often is interpreted as the result of high mountain expeditions (Waraas 2001, p. 103), the relatively high amount of quartz crystal on the Mohalsen-I site warrants further inspection. There are few known Early Mesolithic sites along the coast of Nordland (see Breivik 2016) – could the quartz crystal debitage serve as a proxy to indicate inland mobility in this period? The main objective of this paper is thus to establish whether it is possible to trace quartz crystal debitage from an archaeological assemblage to a possible source, and to briefly investigate the role of quartz crystal in Early Mesolithic assemblages in central Norway.

The study combines scanning electron microscopy (SEM), scanning electron microscopy cathodoluminescence (SEM-CL) and laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) analyses to investigate the petrography and geochemical composition of quartz crystal samples from the site, compared with samples from known natural quartz crystal occurrences in central, western and southern Norway. The premise for the study is that structural traits, such as growth zoning and other internal structures of the crystals visualised by SEM-CL, combined with trace elemental analysis will provide a 'signature' or 'fingerprint' for each quartz crystal site. The internal textures and trace element content are unique to the crystals, which come from the same occurrence because they reflect the formation conditions and the crystal growth history at this site. A recent provenance study of quartz grains in marine sediments off the coast of Spitsbergen (Müller and Knies 2013) has revealed the potential in using LA-ICP-MS, SEM and SEM-CL for this purpose. Provenance studies of hydrothermal quartz (crystals formed by low to moderate temperature [50 to 600 °C] precipitation from an aqueous fluid) in archaeological research have seemingly not been attempted before, though attempts have been made to source pegmatitic (magmatic) quartz (e.g. Halavínová and Přichystal 2008, ten Bruggencate *et al.* 2013).

Mohalsen-I – an Early Mesolithic site on Vega Island, Norway

There are few Early Mesolithic sites in this part of Norway (see overview in Breivik 2016). This makes the sites on Vega Island interesting with respect to the earliest settlement phase of Norway and the development of adaptation and mobility in the Early Mesolithic. Because of the high level of isostatic rebound in the area and distance to the mainland (approximately 20 km), Vega Island has been referred to as an excellent 'laboratory' for Stone Age research (Bjerck 1989, p. 45). In the following, I will give a brief presentation of the Mohalsen-I site and the geology of Vega Island.

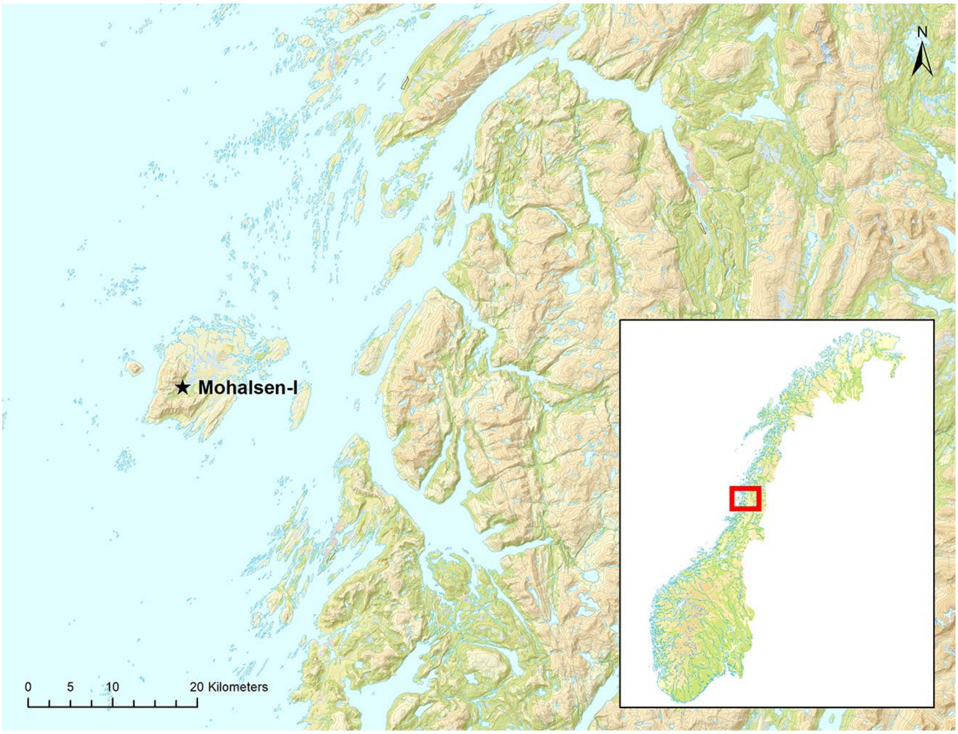

***Figure 1**: Map showing the location of the Mohalsen-I site. Map by Skule O. S. Spjelkavik.*

The Early Mesolithic landscape

Vega Island is situated 20 km off the Norwegian coast, near the town of Brønnøysund, approximately 110 km south of the polar circle (Fig. 1). It covers an area of 108 km^2 and comprises a small mountain range on the south-west side of the island, while the rest is dominated by a strand flat – a flat erosion surface typical of the coastal areas in this part of Norway (Holtedahl 1998). However, due to isostatic uplift since the Last Glacial Period, the island would have been considerably smaller at the time Mohalsen-I was in use (Fig. 2).

During the Early Mesolithic (9500–8000 BC), the island would have mainly consisted of the steep mountains Røsstinden (737 m.a.s.l.), Trollvasstinden (801 m.a.s.l.) and Vegtindan (661 m.a.s.l.). Areas suitable for habitation would primarily have consisted of a small brim of land along the base of the mountain chain, in addition to Vegdalsskaret – a rocky mountain pass crossing the island east to west between Røsstinden and Vegtindan. It is probable that the shoreline during the Early Mesolithic habitation phase at Mohalsen-I would have been situated around 70–80 m.a.s.l. This is based on an interpretation of the surrounding landscape, and the theory that the sites were oriented towards the marine environment and located close to natural harbours (Bjerck 1990). Under these conditions, the site would have been located on a low, rocky point, in a wide northeast facing bay, with a small skerry in the waters just east of the site (Fig. 2). The waters around Vega Island, today dominated by skerries and islets, would have been open and exposed to winds from nearly every direction.

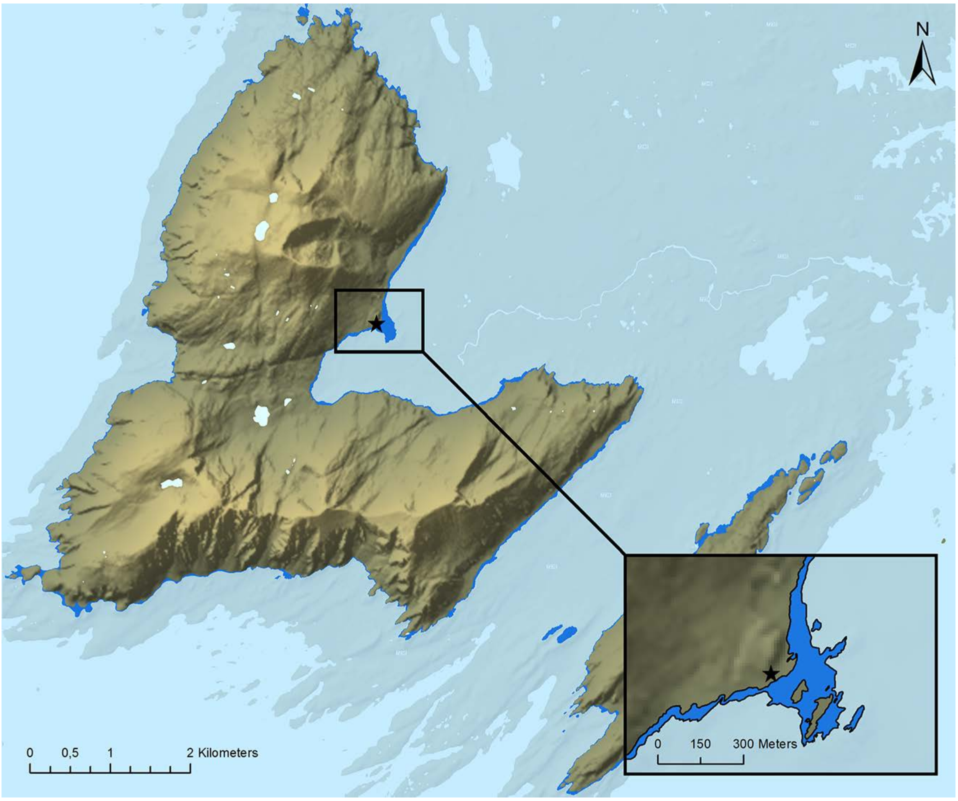

***Figure 2**: Map showing Vega Island with sea level positioned at 80 m.a.s.l. and 75 m.a.s.l. (marked with dark blue). The Mohalsen-I site is marked with a star. Map by Skule O. S. Spjelkavik.*

The geology of Vega

The bedrock of Vega is dominated by granodiorite and granite of the Ordovician (c. 475 Ma) Vega intrusive complex in the south, and marble, schist and gneiss of the Caledonian Uppermost Allochthon in the north (Marko *et al.* 2014). During the Early Mesolithic, only the parts of the island consisting of granodiorite, and to some extent the marble and calc-silicate (contact-metamorphosed marble when the granodiorite melt emplaced), would have been above sea level. The rest would have been inundated by seawater and out of reach. Hydrothermal veins, which could have produced quartz crystals > 5 cm, do not occur on Vega Island. This suggests that the hydrothermal quartz crystals on Mohalsen-I originate from somewhere else.

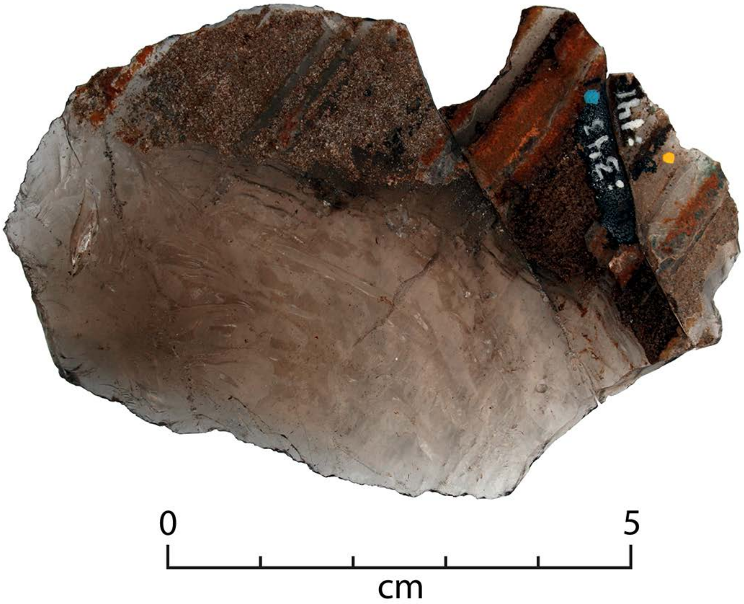

Figure 3*: T25950:416, 343 and 141. Example of quartz crystal informal tool from Mohalsen-I. The flakes have been glued together as part of the research related to a recent master's thesis by Sæther (2017). Photo: Skule O. S. Spjelkavik.*

Quartz crystals could, however, have been found in moraine sediments, especially the large north–south-oriented terminal moraine located on the western central part of the island (Andersen *et al.* 1981, Fjalstad 1990). The excavations in 2012 and 2013 indicated that the site itself is situated on moraine sediments (B. Skar pers. comm.), though this is not indicated by the geological survey of the area. Moraines and beach deposits around Mohalsen-I could thereby constitute possible sources for lithic raw materials in the area. However, since large quartz crystals are rare in general, it is very unlikely that such large crystals occur in the moraine material on Vega Island.

Finds and radiocarbon dates

The compiled archaeological material collected from the site during the excavations in 1974, 2012 and 2013 consists of 7025 artefacts, mainly lithic debitage. Several Early Mesolithic diagnostic finds were discovered – such as single-edged points, burins, waste material from flake-adze production, and unifacial blade cores with acute striking angles. Flint (81.1%) was clearly the preferred raw material for tool production, but quartz crystal (9.6%) seems to have been favoured as well (Fig. 3). The remaining 9.3% of the finds consisted of various quartzites, vein quartz and some unclassified sedimentary rocks. Following a *chaîne opératoire*-analysis conducted by Sæther (2017), it was established that the site had been visited on several occasions and the material indicated that it was a multi-purpose dwelling site, as opposed to a butchering site or similar site resulting from a short-term stay.

Radiocarbon dating of charcoal collected from both the 1974 and 2012/2013 excavations confirms the typological dating, placing the activity at site between the EM2 and MM1 chronozone. The charcoal samples from the 2012 and 2013 excavations consisted of willow (*Salix*) and were dated to 9110–8460 cal. BC (2σ) (Ua-46949) and 9140–8620 cal. BC (2σ) (Ua-46947) (Lorentzen 2013, 2014). The samples from 1974 consisted of both willow (*Salix*) and small amounts of oak (*Quercus*) and the results of the dating had a considerably larger standard error: 9440–7825 cal. BC (2σ) (T-1807) and 8170–7040 cal. BC (2σ) (T-1808) (Alterskjær 1985). All dates have been recalibrated using OxCal v4.4.4. with the IntCal20 calibration curve (Ramsey 2009, Reimer et al. 2020).

Methods and materials

The geochemical analysis of the quartz crystal samples was conducted using LA-ICP-MS, whereas SEM and SEM-CL were used to produce electron and CL images of quartz crystal sections prepared as 300 µm thin sections mounted on standard glass slides (4.8 × 2.4 × 0.2 cm). The methods performed are presented below in general terms only (for further details on methodology, see Müller 2000, Müller *et al.* 2008, Müller and Knies 2013). Laboratorial details concerning the SEM and LA-ICP-MS instruments, and the reference materials utilised, are provided in Müller *et al.* (2018).

Samples

A total 23 quartz samples were prepared and analysed for this study. Four of these were selected from the lithic material retrieved from the excavations at Mohalsen in 2013 and consisted of micro-flakes. This was done to avoid destroying pieces that are more vital and disturb further research on the finds. On the basis of current knowledge, 15 hydrothermal quartz crystal occurrences in Norway were selected to serve as comparative material and as potential sources of the samples from Mohalsen-I. These chosen quartz occurrences cover most of the known Norwegian sites, which produced hydrothermal quartz crystals with sizes of > 5 cm. The archaeological finds from Mohalsen-I indicate that some of the quartz crystals utilised would have had a length greater than 5 cm, which is a relatively uncommon feature of quartz crystals occurring Norway (Mindat 2019 and references therein). Fourteen of the samples were kindly provided by Torgeir T. Garmo from his private mineral collection. The five remaining samples were collected at Berglia-Glassberget in Lierne, Trøndelag by Axel Müller in 2012 (see Müller *et al.* 2018 for occurrence description).

The sites Netoseter, Lyngeshø and Valdres were most likely covered by the inland ice sheet during the occupation phase at Mohalsen-I but were still included in the study as they were located close to the ice sheet margin. The Berglia-Glassberget occurrence was most likely covered by ice as well (see Fig. 4). However, since there exists an uncertainty regarding the extent of the ice sheet in this area (see Hughes *et al.* 2016), the samples from this occurrence were included in the study.

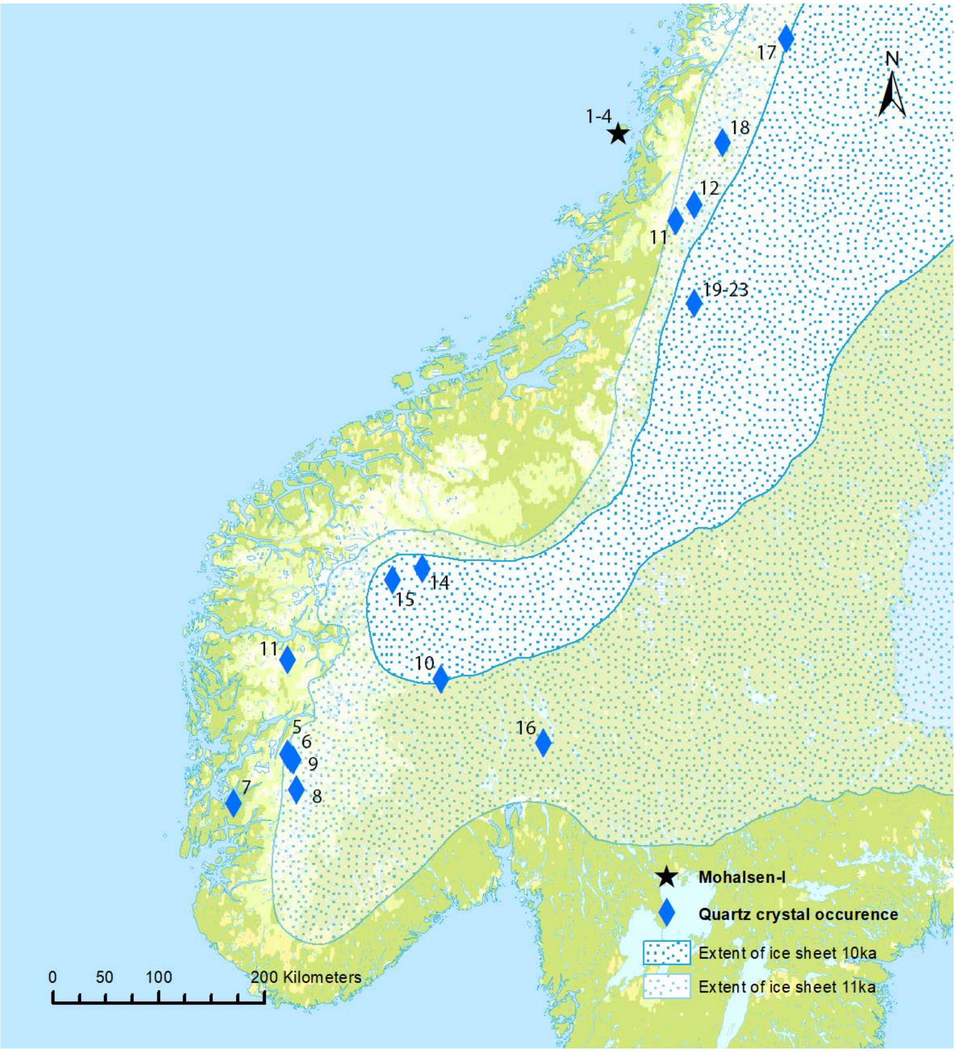

***Figure 4**: Map showing the quartz crystal occurrences analysed in this study. The numbers correspond to sample number (see Fig. 5). The extent of the ice sheet is after Hughes et al. (2016). Map by Skule O. S. Spjelkavik.*

During LA-ICP-MS analysis, the laser beam ablates the quartz sample over a raster of 300 × 150 µm with a depth varying between 40 and 100 µm. The quartz samples were thus prepared as special 300 µm-thick polished sections mounted on standard glass slides. The samples were prepared in Bochum, Germany, by Dettmar Dissection Technology GmbH.

For sake of clarity, the samples will hereafter be referred to by serial number (s.nr.), not corresponding museum ID number (T-number) or NGU number (see Fig. 5).

Sample nr.	NGU-nr.	Museum nr. (Tnr.)	Site	County
1	84751	T26109:581	Mohalsen-I, Vega	Nordland
2	84752	T26109:590	Mohalsen-I, Vega	Nordland
3	84753	T26109:591 (a)	Mohalsen-I, Vega	Nordland
4	84754	T26109:591 (b)	Mohalsen-I, Vega	Nordland
5	84777		Endenut	Hordaland
6	84779		Nibbenut	Hordaland
7	84780		Etne	Hordaland
8	84781		Svandalsflona	Telemark
9	84782		Matskorhæ	Hordaland
10	84783		Valdres	Oppland
11	84784		Vikafjell	Sogn og Fjordane
12	84785		Børgefjell	Nordland
13	84786		Bjørhusdal	Nord-Trøndelag
14	84787		Lyngveshøa	Oppland
15	84788		Netoseter	Oppland
16	84789		Hurdal	Akershus
17	84790		Nasafjell	Telemark
18	84791		Hattfjelldal	Nordland
19	84792		Lierne	Nord-Trøndelag
20	84793		Lierne	Nord-Trøndelag
21	84794		Lierne	Nord-Trøndelag
22	84795		Lierne	Nord-Trøndelag
23	84796		Lierne	Nord-Trøndelag

Figure 5*: List of samples analysed in this study.*

Scanning electron microscopy

A SEM scans the surface of a specimen with a beam of accelerated electrons. In order to avoid interference from air molecules and other disturbances, the specimen is placed in a vacuum chamber. The intensity of the electrons reflected from the sample surface is measured by a secondary electron detector and used to produce images with a magnification of 20× to 20,000×. In addition to producing 3D images of the specimen surface by detecting secondary electrons, it is possible to detect areas of varying chemical content by detecting higher energy backscattered electrons (BSE). This result in images where areas composed of atoms of relatively high mean atomic number are bright, and darker in areas where the mean atomic number is lower (Frahm 2014).

In this study, the thin sections were investigated using an LEO 1450VP SEM, with an attached INCA energy-dispersive X-ray spectrometer (EDS), in order to document and identify (chemically) micro-inclusions (< 100 µm) of other minerals that may occur in the quartz crystals investigated. The type of micro-inclusion provides an additional criterion for distinguishing different provenance areas.

Scanning electron microscopy cathodoluminescence

The SEM-CL detector records photons (visible and invisible light) emitted from the sample when the electron beam hits and interacts with the sample surface. The energy (wavelength) of the detected photons is then translated into greyscale images. Contrasting grey-shades in SEM-CL images are caused by the heterogeneous distribution of various lattice defects, such as oxygen and silicon vacancies in the quartz crystal or broken bonds, and lattice-bound trace elements (Boggs and Krinsley 2006).

CL imaging of quartz crystals reveals structural traits relating to crystallisation, deformation and fluid-driven overprint (alteration) (Müller *et al.* 2018). Typical structures are micro-scale (< 1 mm) growth zoning, which can be compared to growth rings in a tree (though they do not indicate age in the same way). SEM-CL also reveals alteration structures and different quartz generations, such as crystal twinning and sub-grain formation, which are not visible on images produced by optical microscopy or BSE. These structures give insight into the growth and alteration history of quartz crystals. Additionally, the CL colour of quartz has been used to study its geological provenance (Boggs and Krinsley 2006). In archaeometric research, CL imaging has been applied to petrographic analyses of a wide range of materials (Szczepaniak 2014).

Laser ablation inductively coupled plasma mass spectrometry

ICP-MS instruments can be utilised for a variety of purposes in archaeology – such as raw material sourcing, determining isotopic ratios and age determination (Neff 2017). In LA-ICP-MS studies, the sample is placed in a near-vacuum chamber and ablated by a laser beam in order to free small particles from the sample surface. These particles (in our case quartz crystal fragments) are transported by an Ar–He gas mixture to the mass spectrometer where they are ionised into a plasma in order to determine the elemental composition of the sample by counting the ions with a detector.

LA-ICP-MS can determine element concentrations down to ppb (parts per billion), which makes it a high-precision tool for detecting trace elements (elements which make up less than 0.1% of the composition of a mineral or rock). One of the method's benefits for archaeologists is that it requires no sample preparation, which means that artefact samples can be analysed without being visibly destroyed. It will, however, leave a trace of the raster pattern of the laser beam, in our case 300 × 150 × 50 µm, though this is barely visible to the naked eye. Six LA-ICP-MS analyses were performed per sample along profiles across the quartz samples. The sampling spots were specifically located in different, CL-visualized growth zones in order to reveal possible chemical variations within the crystal.

In this study, LA-ICP-MS was used to analyse the concentrations of Li, Be, B, Al, P, Ti, Ca, Na, K, Mn, Fe and Ge, which are the most common trace elements found in natural quartz samples (e.g. Götze 2009). Six analyses were performed on each quartz crystal to reveal possible intra-crystal trace element variations. The analyses were conducted at the laboratories of NGU, using an Element 1 double-focusing sector field ICP-MS from Finnigan MAT. The results were processed in Microsoft Excel, using logarithmically scaled bivariate plots.

Results

The results are presented in the two following sections, one describing the structures visualised by SEM-CL in the quartz investigated, while the other focuses on the trace element content of quartz crystals.

Characterisation of cathodoluminescent structures in quartz crystals

Two of the quartz crystals analysed from Mohalsen-I (samples 1 and 4) revealed distinct structural traits that could be used in provenance studies. Sample 1 has an intense luminescent crystal core with weakly contrasted growth zoning (Fig. 6). The crystal margin shows strongly contrasted primary growth zoning with low CL intensity. In addition to this, tiny (< 200 µm) bright luminescent sub-crystals occur along the growth zone which separates the bright crystal core and the dull margin. Secondary structures include sporadic micro-fractures, healed with non-luminescent quartz. Similar to sample 1, sample 4 has a crystal core with strong CL intensity and weakly contrasted growth zoning and crystal twinning. Only a small part of the crystal edge is preserved in the sample, but the visible remains show weakly contrasted growth zoning with a low CL intensity. The visible secondary structures are similar to those of sample 1.

Samples 2 and 3, on the other hand, displayed a low CL intensity with no visible growth zoning. The CL images revealed a large amount of dull luminescent secondary quartz along and around healed micro-fractures. This secondary overprint is so strong that only a small volume of primary, more intense luminescent quartz is preserved. In general, the features are typical for quartz of igneous origin, and particularly for pegmatite quartz. However, the high abundance of these secondary, dark grey structures in both samples is not typical for pegmatitic quartz. These structures were likely enhanced by low-grade metamorphism or exposure to artificial heating, such as a bonfire.

Megacrystic (> 3 cm) pegmatite quartz is very abundant in Norway, in particular in South-Norway (e.g. Müller *et al.* 2017). Therefore, it is extremely challenging to trace the origin of these two pegmatite quartz samples, as their features are very similar, and it will not be possible to distinguish them from quartz from different Norwegian pegmatite localities. However, pegmatite quartz does not occur in the bedrock on Vega Island.

All hydrothermal crystals investigated from the 15 Norwegian quartz occurrences show distinct primary growth zoning of various patterns.

Sample 7 from Etne, sample 9 from Matskorhæ, sample 13 from Bjørhusdal and sample 14 from Lyngveshø have, in general, similar structures to that of sample 1 from Mohalsen-I: an intense luminescent crystal core, with weakly contrasted growth zoning overgrown by dull luminescent growth zones with strong contrast. However, hydrothermal samples from the Norwegian mainland do not have the distinct sub-crystals or the same type of secondary micro-fractures healed with non-luminescent quartz.

The remaining mainland samples displayed variable CL intensity and contrasted growth zoning, which is different to samples 1 and 4 from Mohalsen-1.

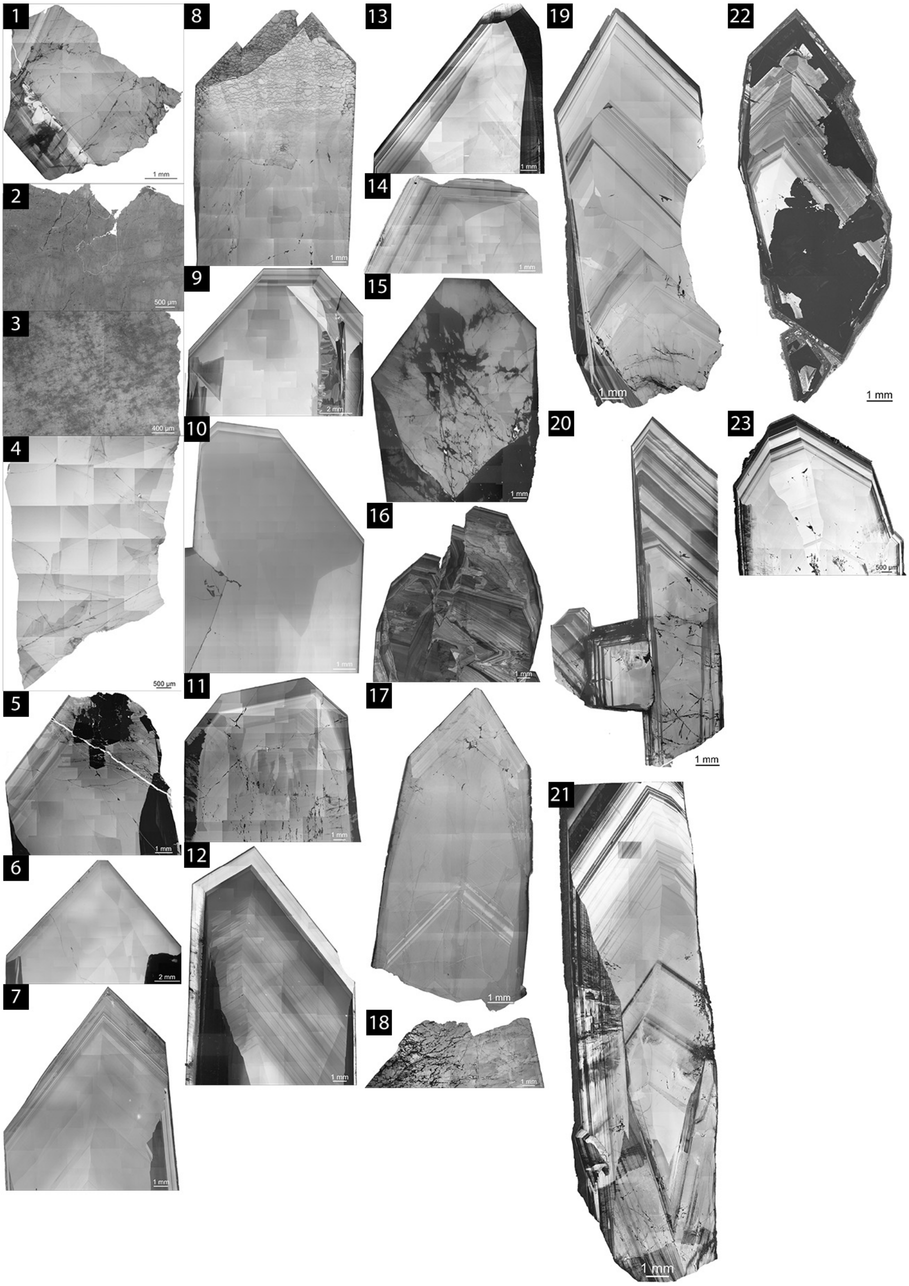

Figure 6*: SEM-CL images of the quartz crystal analysed. Numbers correspond to sample numbers in Fig. 5. 1) Mohalsen-I, Nordland, 2) Mohalsen-I, Nordland, 3) Mohalsen-I, Nordland, 4) Mohalsen-I, Nordland, 5) Endenut, Hordaland, 6) Nibbenut, Hordaland, 7) Etne, Hordaland, 8) Svandalsflona, Telemark, 9) Matskorhæ, Hordaland, 10) Valdres, Oppland, 11) Vikafjell, Sogn og Fjordane, 12) Børgefjell, Nordland, 13) Bjørhusdal, Nord-Trøndelag, 14) Lyngveshøa, Oppland, 15) Netoseter, Oppland, 16) Hurdal, Akershus, 17) Nasafjell, Telemark, 18) Hattfjelldal, Nordland, 19–23) Berglia-Glassberget, Lierne, Nord-Trøndelag.*

The structural composition of the Lierne samples (s.nr. 14–19) all displayed similar characteristics: a high CL intensity in the crystal core and clearly delimited crystal edge, with highly contrasted growth zoning. Hydrothermal quartz of different origin is different in terms of structure. Thus, the cathodoluminescent structure seems to be indicative for a certain hydrothermal occurrence.

Quartz chemistry

All samples were successfully analysed using LA-ICP-MS to detect concentrations of common trace elements in quartz crystals. Ti, Al, Li and Ge were selected for further analysis, as these elements displayed a high degree of variation between the different occurrences (see appendix for detection limits (LOD) for each element).

Concentrations of Ti, Al, Li and Ge were similar for samples 1 and 4 from Mohalsen-I (Fig. 7a–7c and appendix). Sample 1 contained on average 6.3 ± 1.0 ppm Li, 1.9 ± 0.2 ppm Ge, 15.1 ± 1.9 ppm Al and 1.0 ± 0.6 ppm Ti. Sample 4 had 2.8 ± 0.4 ppm Li, 1.6 ± 0.1 ppm Ge, 16.9 ± 2.0 ppm Al and 1.0 ± 0.4 ppm Ti. This indicates that both quartz crystals could stem from the same quartz occurrence. Samples 2 and 3 contained a similar content of Li and Ge to samples 1 and 4, but their Al and Ti content were significantly higher.

Sample 9 from Matskorhæ contained similar, though somewhat lower, levels of Ti (0.6 ppm on average) and Ge (1.0 ppm on average) to samples 1 and 4. The Al (23.2 ppm) and Li (6.3 ppm) content had a relatively large standard variation (21.5 ppm and 5.7 ppm respectively), which means that the levels are within the range of samples 1 and 4 from Mohalsen-I. Additionally, the sample from Nibbenut (s.nr. 6) contained similar concentrations of Li (3.6 ± 2.3 ppm), Ge (1 ± 0.3 ppm), Al (14.3 ± 8.6 ppm) and Ti (0.54 ppm) to those of samples 1 and 4 from Mohalsen-I (see above and appendix).

The five samples from Lierne (s.nr. 19–23) displayed similar geochemical composition, with relatively high concentrations of Li and Al compared to the other samples. Sample 23 displayed spikes of Li and Al concentrations, resulting in a high standard deviation of the average measurement of the elements in this sample. The spikes could be explained by a large internal variation in chemical content. Additionally, there was some overlap in Li/Al content with the sample from Lyngveshøa (s.nr. 14): 129.5 ± 37.6 ppm Li and 1217.4 ± 517.7 ppm Al in the Lyngveshøa sample (s.nr. 14); and 78.3 ± 95.13 ppm Li and 558.3 ± 697 ppm Al for all the Lierne samples (s.nr. 19–23). However, the Lyngveshøa sample (s.nr. 14) displayed consistently higher concentrations of Li and Al, whereas the Lierne samples had a considerably higher degree of variation.

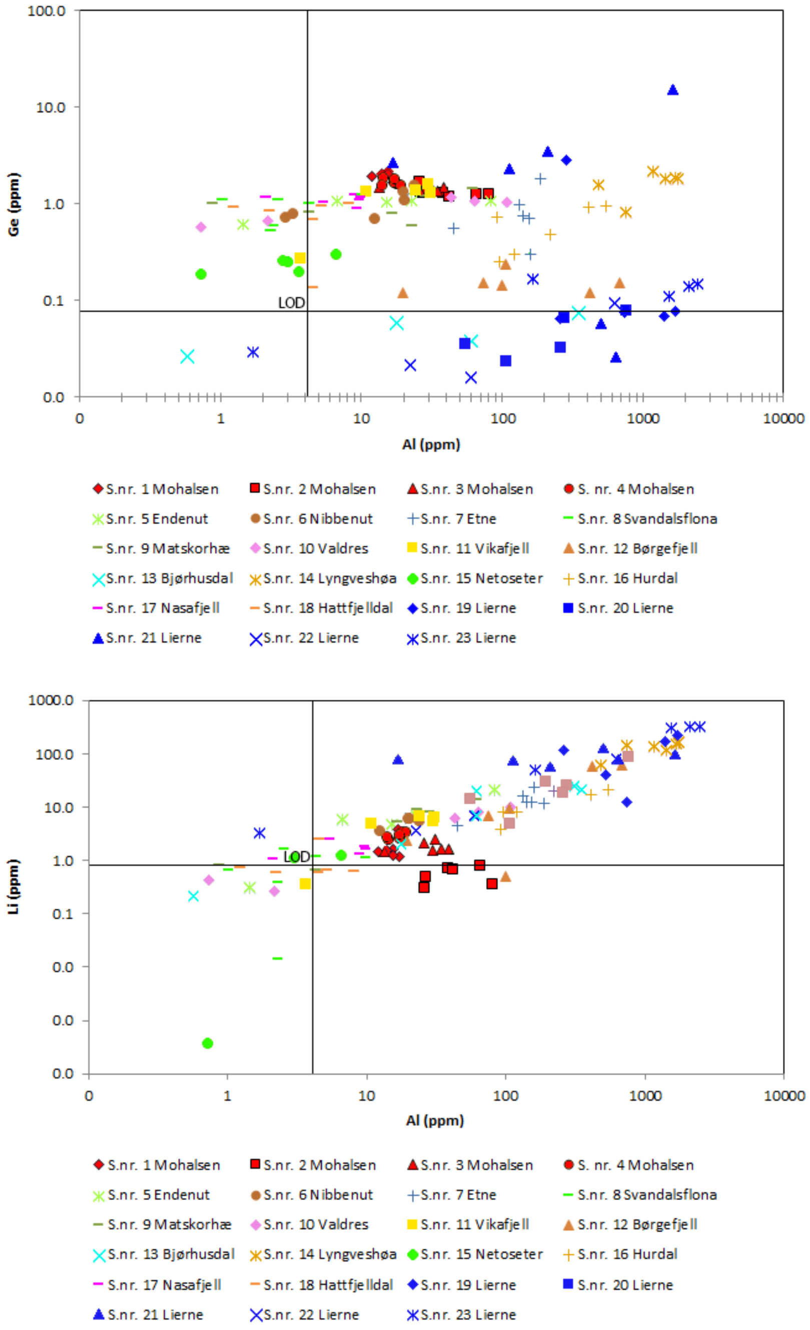

Figure 7: *a) Bivariate plot showing Ge/Al content of quartz crystals analysed, b) bivariate plot showing Li/Al content of quartz crystals analysed,*

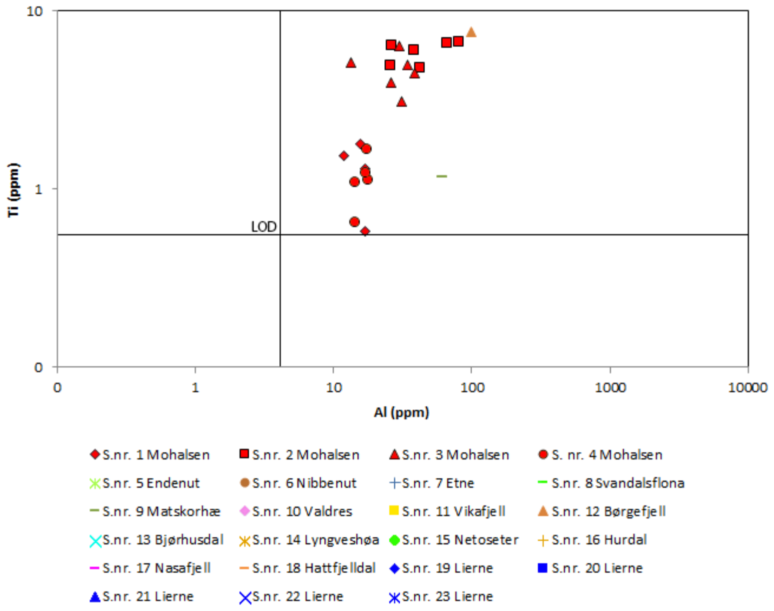

Figure 7 (continued): *c) bivariate plot showing Ti/Al content of quartz crystal analysed. LOD is marked in all plots with black lines.*

Discussion

Hydrothermal quartz crystal provenance studies – a viable approach?

The results from the LA-ICP-MS and SEM-CL analyses of the samples from Mohalsen-I (s.nr. 1–4) and selected quartz crystal outcrops (s.nr. 5–23), did not indicate a possible source for the quartz crystals from Vega Island. However, the concentrations of Al, Ti, Li and Ge in the samples (see Fig. 7a–7c) indicate that samples 1 and 4 formed under similar conditions and may come from the same quartz crystal occurrence. There were some structural and chemical similarities between samples 1 and 4, and sample 9, from Matskorhæ, but the results did not provide clear evidence to suggest this occurrence as a possible source.

Although the study was not able to detect a source for the quartz crystals used at Mohalsen-I, within a reasonable certainty, the method proved able to separate different hydrothermal quartz crystal occurrences. The five samples from Lierne displayed similar structural characteristics and geochemical composition, indicating that linking archaeological material to a known quartz crystal site is possible. However, there are several difficulties relating to such attempts. Many of these are 'classical' problems in provenance studies. First of all, it can be challenging to determine which sources were known and which were not in the period in question, and there is always the possibility that the sources which were utilised are depleted and thus not visible for us today. Furthermore, the material could have been found in redeposited sediments, such as riverbanks or moraines, or in areas outside national borders or area of investigation. Lastly, the internal geochemical variation in a quartz crystal occurrence could be too big to establish a secure 'signature' of the source (Andrews and Doonan 2003).

It is often said that it is easier to establish where a lithic material is not from than to establish a secure provenance (Andrews and Doonan 2003). As Shackley (1998, p. 261) puts it:

> ‘One of the most misused terms in archaeometry is the word “sourcing”. Archaeologists most often use it, and unfortunately, archaeometrists do too. Besides the grammatical problems with the word, it implies that whatever is submitted to the archaeometrist will return with a bona fide and certified source provenience that is not probabilistic at all, but confidently determined. I’m certainly not the first to say this, but I will reiterate that nothing is ever really “sourced”.’

To mitigate some of these ‘pitfalls’, it is important to establish consistent sampling methodology and cooperation with geologists. In a review of lithic sourcing methods, Shackley (2017) presents eight steps to follow in provenance studies, which serve as a valuable guide to secure high-quality data collection. These guidelines could serve as a useful framework for future studies.

Another problem in provenance studies of archaeological artefacts is the use of destructive methods. In this study, thin sections were prepared of quartz crystal micro-debitage. This was done in order not to disturb refitting studies and other analyses of the material, such as use–wear analysis. Because so little of the crystal edge was preserved, it was difficult to assess the structural characteristics of the samples from Mohalsen-I. In relation to sourcing quartz crystals by combining petrography and geochemistry, this is a clear disadvantage. It must be a goal for future studies to include pieces where it can be confirmed that the crystal edge, and preferably parts of the crystal core, is preserved.

However, several instruments are being developed for fieldwork, making rock and mineral characterisation more accessible and less cost demanding than before. Portable SEMs are now being developed, with a high relevance for archaeological fieldwork. Relating to quartz crystals, this development is not as clear-cut. In order to establish the structural ‘signature’ of each occurrence, by characterising CL intensity and primary and secondary structures, we are so far dependent on producing thin sections for SEM-CL analysis.

The archaeological context – quartz crystals as a raw material and indication of mobility

Small amounts of quartz crystal seem to be present at several Early Mesolithic sites in western Norway (Waraas 2001). In central Norway, the tendency seems to be the same, with quartz crystal tools and debitage being present in small amounts at 91 of 261 Early Mesolithic sites listed by Breivik (2016), which were briefly analysed in relation to this article (6 of the total 267 listed sites were not available in online databases). This amounts to 35% of the sites, and quartz crystal is present in both coastal and inland assemblages. Most of the inland sites in the mountainous regions of Romsdal, Sunndal and Tafjord contained quartz crystal, whereas the picture was more varied on the coastal sites. The high mountain site Langfjelldal in Norddal County stands out with an assemblage dominated by quartz crystal (71%) (Ramstad 2014).

Waraas’ (2001, p. 102) explanation for this tendency is that the large amount of quartz crystal on mountain sites in western Norway could be explained by the manufacture of tools which were brought back to the coast at the end of the hunting expedition. This will create a pattern where the high mountain sites contain a large amount of quartz crystal debitage, whereas the coastal sites will only have tools and little waste material. However, it is interesting to note that seemingly few other raw materials have been utilised in these areas, such as milky quartz or quartzite and other sedimentary rock types. This could be explained by the special characteristics of quartz crystals. The important role of these alluring crystals among native peoples in various regions has been well documented in ethnographic accounts (e.g. Ball 1941, see also Broadbent 1979, p. 53). The symbolic and imagined magical capabilities of quartz crystals could well have been an important selective criterion in the Early Mesolithic, as both Waraas (2001) and others (Bang-Andersen 1998, Ramstad 2014) have pointed out.

However, it is difficult to assess both symbolic aspects and patterns of mobility from the Mohalsen-I assemblage, when no source has yet been identified. It seems unlikely that the quartz crystals in question have been found locally on Vega Island, indicating that they have been brought there by people. Following Binford's (1979) idea of 'embedded procurement', the raw material could have been collected during seasonal mobility routes or shorter hunting expeditions. In a pioneer phase, it seems unlikely that larger quarries or outcrops were exploited. This is supported by Nyland's (2016) recent work concerning rock quarries in southern Norway. She found no quarries that could be dated to the Early Mesolithic with reasonable certainty, though several appear during the Middle and Late Mesolithic. A chert quarry in Melsvik in Finnmark, however, seems to have been utilised by pioneer groups in the Early Mesolithic (Cerbing *et al.* 2019) – though somewhat later than the main occupation phase at Mohalsen-I. However, through the short analysis above it seems reasonable to conclude that the quartz crystals on Vega Island must have been found in nearby mountainous areas, such as the Lomsdal–Visten area, indicating utilisation of the inland area in the region.

Conclusion

The method applied here has a great potential to shed light on procurement strategies and mobility patterns in archaeological research. By examining four quartz samples from the Early Mesolithic site Mohalsen-I on Vega Island using SEM-CL and LA-ICP-MS, it was established that two of the samples (s.nr 2 and 3) were pegmatitic quartz, whereas the other two samples (s.nr. 1 and 4) consisted of hydrothermal quartz. This was based on a combination of interpretation of SEM-CL images and geochemistry. Samples 2 and 3 were probably exposed to artificial heating, most likely a bonfire or low-grade metamorphisation. Samples 1 and 4 displayed similar levels of the trace elements Al, Ti, Li and Ge (see Fig. 7a–7c), indicating that they stem from the same quartz crystal occurrence.

Hydrothermal quartz crystals were collected from 15 different occurrences in central and southern Norway, but none of these showed similar characteristics to the hydrothermal quartz crystal samples from Mohalsen-I (s.nr. 1 and 4) and thus no likely source could be established. However, after a short review of the occurrence of quartz crystals in Early Mesolithic assemblages in central Norway, it seems reasonable to conclude that a nearby mountainous region on the mainland, such as the Lomsdal–Visten area, is a possible source. Unfortunately, there are no quartz crystal occurrences yet known in this area containing > 5 cm quartz crystals.

Despite the negative results from the attempt to source the quartz crystal samples from Mohalsen-I, the study yielded positive results in relation to establishing a methodology for the purpose. The five samples from the Berglia-Glassberget occurrence in Lierne displayed similar structural characteristics and trace element concentrations to each other, indicating that the method is a viable approach to sourcing hydrothermal quartz from archaeological contexts. However, in a future development of this line of research, there is clearly a need for a more thorough sampling to address the issue of intra-site chemical variability of a source.

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Appendix

Table showing trace element data of analysed samples expressed in ppm. LOD for the selected elements are shown below each element. Averages and standard deviations are included as well.

Site/occurrence		Li7(LR)	Be9(LR)	B11(LR)	Mn55(LR)	Ge74(LR)	Rb85(LR)	Sr88(LR)	Na23(MR)	Al27(MR)	P31(MR)	K39(MR)	Ca44(MR)	Ti47(MR)	Fe56(MR)
	LOD	0,78	0,45	1,41	0,17	0,07	0,10	0,03	7,94	4,21	5,02	20,41	6,32	0,54	0,51
S.nr. 1 Mohalsen	581-A	3,73	0,45	1,41	0,17	1,65	0,10	0,06	114,30	16,84	5,02	20,41	6,32	1,31	0,51
	581-B	1,47	0,45	1,41	0,17	1,91	0,10	0,10	7,94	12,00	5,02	20,41	6,32	1,53	0,51
	581-C	1,66	0,45	1,41	0,21	2,20	0,10	0,05	7,94	15,53	5,02	20,41	6,32	1,81	0,51
	581-D	1,20	0,45	1,41	0,49	1,74	0,10	0,06	7,94	17,05	5,02	20,41	6,32	0,58	0,51
	581-E	1,51	0,45	1,45	0,31	2,07	0,10	0,07	7,94	13,92	5,02	20,41	6,32	0,54	0,51
	581-F	1,22	0,45	1,41	0,17	2,04	0,10	0,04	7,94	15,45	5,02	20,41	6,32	0,54	0,51
	average	1,80	0,45	1,42	0,25	1,93	0,10	0,06	25,67	15,13	5,02	20,41	6,32	1,05	0,51
	STD	0,96	0,00	0,02	0,13	0,21	0,00	0,02	43,42	1,91	0,00	0,00	0,00	0,57	0,00
S.nr. 2 Mohalsen	590-A	0,78	0,45	1,41	0,27	1,65	0,10	0,10	7,94	26,16	5,02	20,41	6,32	4,95	0,62
	590-B	0,78	0,45	1,46	0,20	1,23	0,10	0,10	7,94	82,13	5,02	20,41	6,32	6,67	1,25
	590-C	0,78	0,45	1,41	0,30	1,24	0,10	0,08	7,94	66,41	5,02	26,33	6,32	6,61	0,51
	590-D	0,78	0,45	2,22	0,38	1,29	0,10	0,20	7,94	38,84	5,02	20,41	6,32	5,99	0,51
	590-E	0,78	0,45	1,41	0,20	1,17	0,10	0,08	7,94	42,53	5,02	20,41	6,32	4,77	0,51
	590-F	0,78	0,45	1,59	0,23	1,27	0,10	0,10	7,94	26,65	5,02	20,41	6,32	6,33	0,51
	average	0,78	0,45	1,58	0,26	1,31	0,10	0,11	7,94	47,12	5,02	21,40	6,32	5,89	0,65
	STD	0,00	0,00	0,32	0,07	0,17	0,00	0,04	0,00	22,56	0,00	2,42	0,00	0,84	0,30
S.nr. 3 Mohalsen	591a-A	2,56	0,45	1,41	0,17	1,47	0,10	0,06	17,05	31,18	5,02	20,41	6,32	3,12	0,51
	591a-B	1,43	0,45	1,41	0,21	1,48	0,10	0,05	7,94	13,37	5,02	20,41	6,32	5,15	0,51
	591a-C	1,52	0,45	1,41	0,22	1,39	0,10	0,06	7,94	30,02	5,02	20,41	6,32	6,41	0,51
	591a-D	1,62	0,45	1,41	0,17	1,49	0,10	0,04	7,94	38,83	5,02	20,41	6,70	4,49	0,51
	591a-E	1,64	0,45	1,41	0,24	1,34	0,10	0,05	7,94	34,68	5,02	20,41	6,32	5,01	0,51
	591a-F	2,10	0,45	1,41	0,25	1,36	0,10	0,05	7,94	26,09	5,02	20,41	6,32	3,99	0,51
	average	1,81	0,45	1,41	0,21	1,42	0,10	0,05	9,46	29,03	5,02	20,41	6,38	4,69	0,51
	STD	0,43	0,00	0,00	0,03	0,07	0,00	0,01	3,72	8,80	0,00	0,00	0,16	1,12	0,00
S. nr. 4 Mohalsen	591b-A	3,24	0,45	1,41	0,17	1,59	0,10	0,04	7,94	18,13	5,02	20,41	6,32	1,13	0,51
	591b-B	2,35	0,45	1,41	0,21	1,81	0,10	0,05	7,94	14,54	5,02	20,41	6,32	0,64	0,51
	591b-C	2,67	0,45	1,59	0,17	1,55	0,10	0,06	7,94	14,37	5,02	20,41	6,32	1,09	0,51

Site/occurrence		Li7(LR)	Be9(LR)	B11(LR)	Mn55(LR)	Ge74(LR)	Rb85(LR)	Sr88(LR)	Na23(MR)	Al27(MR)	P31(MR)	K39(MR)	Ca44(MR)	Ti47(MR)	Fe56(MR)
	591b-D	2,54	0,45	1,41	0,18	1,62	0,10	0,03	7,94	17,39	5,02	20,41	6,32	1,23	0,51
	591b-E	3,30	0,45	1,41	0,25	1,53	0,10	0,04	7,94	19,44	5,02	20,41	6,32	0,54	0,51
	591b-F	2,87	0,45	1,44	0,21	1,76	0,10	0,06	7,94	17,53	5,02	20,41	6,32	1,67	0,51
	average	2,83	0,45	1,44	0,20	1,64	0,10	0,05	7,94	16,90	5,02	20,41	6,32	1,05	0,51
	STD	0,38	0,00	0,07	0,03	0,11	0,00	0,01	0,00	2,03	0,00	0,00	0,00	0,41	0,00
S.nr. 5 Endenut	84777-A	21,40	0,45	1,41	0,54	1,07	0,10	0,07	7,94	83,50	10,57	20,41	7,75	0,54	0,87
	84777-B	4,81	0,45	1,41	0,28	1,05	0,10	0,10	7,94	15,26	5,02	20,41	6,32	0,54	0,51
	84777-C	6,24	0,45	1,41	0,27	1,19	0,10	0,07	7,94	20,74	5,02	20,41	6,32	0,54	0,51
	84777-D	6,82	0,45	1,41	0,34	1,09	0,10	0,13	7,94	22,63	5,02	20,41	6,32	0,54	0,51
	84777-E	5,85	0,45	1,41	0,24	1,09	0,10	0,06	7,94	6,76	5,02	20,41	6,32	0,54	0,51
	84777-F	0,78	0,45	1,41	0,37	0,61	0,10	0,07	7,94	4,21	5,15	20,41	6,32	0,54	0,51
	average	7,65	0,45	1,41	0,34	1,01	0,10	0,08	7,94	25,51	5,97	20,41	6,56	0,54	0,57
	STD	7,07	0,00	0,00	0,11	0,20	0,00	0,03	0,00	29,34	2,26	0,00	0,58	0,00	0,15
S.nr. 6 Nibbenut	84779-A	3,37	0,45	1,41	0,43	0,69	0,10	0,10	7,94	12,71	5,02	20,41	6,32	0,54	0,53
	84779-B	5,83	0,45	1,41	0,27	1,08	0,10	0,10	7,94	20,54	5,02	20,41	6,32	0,54	0,51
	84779-C	5,85	0,45	1,41	0,30	1,34	0,10	0,07	7,94	20,10	5,02	20,41	8,51	0,54	0,51
	84779-D	5,23	0,45	1,41	0,26	1,53	0,10	0,09	7,94	24,08	5,02	20,41	6,32	0,54	0,51
	84779-E	0,78	0,45	1,41	0,47	0,79	0,10	0,07	7,94	4,21	7,46	20,41	6,32	0,54	0,51
	84779-F	0,78	0,45	1,41	0,28	0,70	0,10	0,03	7,94	4,21	5,02	20,41	6,32	0,54	0,51
	average	3,64	0,45	1,41	0,33	1,02	0,10	0,08	7,94	14,31	5,43	20,41	6,69	0,54	0,51
	STD	2,39	0,00	0,00	0,09	0,36	0,00	0,03	0,00	8,65	1,00	0,00	0,89	0,00	0,01
S.nr. 7 Etne	84780-A	4,38	0,45	1,41	0,58	0,57	0,10	0,03	7,94	45,24	5,02	20,41	6,32	0,54	0,51
	84780-B	11,59	0,45	1,41	0,22	1,83	0,10	0,03	7,94	187,21	5,02	20,41	6,32	0,54	0,51
	84780-C	15,84	0,45	1,41	0,34	0,97	0,10	0,05	7,94	132,33	5,02	20,41	6,32	0,54	0,51
	84780-D	12,59	0,45	1,41	0,21	0,71	0,10	0,03	7,94	154,49	5,02	20,41	6,32	0,54	0,51
	84780-E	12,49	0,45	1,41	0,31	0,76	0,10	0,06	7,94	140,25	5,02	20,41	6,32	0,54	0,51
	84780-F	23,93	0,45	1,41	0,24	0,31	0,10	0,08	7,94	159,92	5,21	20,41	6,32	0,54	0,51
	average	13,47	0,45	1,41	0,32	0,86	0,10	0,05	7,94	136,57	5,05	20,41	6,32	0,54	0,51
	STD	6,37	0,00	0,00	0,14	0,52	0,00	0,02	0,00	48,59	0,08	0,00	0,00	0,00	0,00
S.nr. 8 Svandalsflona	84781-A	0,78	0,45	1,41	0,58	0,59	0,10	0,03	7,94	4,21	5,02	20,41	6,32	0,54	0,51
	84781-B	0,78	0,45	1,41	0,29	0,53	0,10	0,06	7,94	4,21	5,02	20,41	20,47	0,54	0,51
	84781-C	1,14	0,45	1,41	0,29	1,25	0,10	0,05	7,94	9,50	5,02	20,41	6,32	0,54	0,51
	84781-D	1,61	0,45	1,41	0,33	1,12	0,10	0,05	7,94	4,21	5,02	20,41	6,99	0,54	0,51

Site/occurrence		Li7(LR)	Be9(LR)	B11(LR)	Mn55(LR)	Ge74(LR)	Rb85(LR)	Sr88(LR)	Na23(MR)	Al27(MR)	P31(MR)	K39(MR)	Ca44(MR)	Ti47(MR)	Fe56(MR)
	84781-E	0,78	0,45	1,41	0,24	1,10	0,10	0,09	7,94	4,21	5,02	20,41	11,66	0,54	0,51
	84781-F	1,20	0,45	1,41	0,37	1,01	0,10	0,10	7,94	4,21	5,02	20,41	7,12	0,54	0,51
	average	1,05	0,45	1,41	0,35	0,93	0,10	0,06	7,94	5,09	5,02	20,41	9,81	0,54	0,51
	STD	0,34	0,00	0,00	0,12	0,30	0,00	0,03	0,00	2,16	0,00	0,00	5,60	0,00	0,00
S.nr. 9 Matskorhæ	84782-A	8,89	0,45	1,41	0,17	0,60	0,10	0,07	7,94	23,10	5,02	20,41	6,32	0,54	0,51
	84782-B	5,14	0,45	1,41	0,20	0,81	0,10	0,07	7,94	16,65	5,02	20,41	6,32	0,54	0,51
	84782-C	14,11	0,45	1,41	0,24	1,46	0,10	0,09	7,94	62,17	5,02	20,41	6,32	1,16	0,51
	84782-D	8,22	0,45	1,41	0,21	1,22	0,10	0,10	7,94	28,79	5,02	20,41	6,32	0,54	0,51
	84782-E	0,81	0,45	1,41	0,26	1,02	0,10	0,07	7,94	4,21	5,02	20,41	6,32	0,54	0,51
	84782-F	0,78	0,45	1,41	0,27	0,82	0,10	0,08	7,94	4,31	5,02	20,41	6,32	0,54	0,51
	average	6,33	0,45	1,41	0,22	0,99	0,10	0,08	7,94	23,21	5,02	20,41	6,32	0,64	0,51
	STD	5,17	0,00	0,00	0,04	0,31	0,00	0,01	0,00	21,50	0,00	0,00	0,00	0,25	0,00
S.nr. 10 Valdres	84783-A	9,97	0,45	1,41	0,22	1,03	0,10	0,03	7,94	109,22	5,02	20,41	9,42	0,54	0,51
	84783-B	6,12	0,45	1,41	0,25	1,19	0,10	0,03	7,94	43,31	5,27	20,41	6,32	0,54	0,51
	84783-C	8,01	0,45	1,41	0,27	1,08	0,10	0,03	7,94	63,73	5,02	20,41	6,32	0,54	0,51
	84783-D	0,78	0,45	1,41	0,23	0,57	0,10	0,05	7,94	4,21	5,02	20,41	6,32	0,54	0,51
	84783-E	0,78	0,45	1,41	0,27	0,68	0,10	0,04	7,94	4,21	5,02	20,41	20,49	0,54	0,51
	84783-F	0,78	0,45	1,41	0,29	0,58	0,10	0,07	7,94	4,21	5,02	20,41	11,10	0,54	0,51
	average	4,41	0,45	1,41	0,26	0,85	0,10	0,04	7,94	38,15	5,06	20,41	9,99	0,54	0,51
	STD	4,16	0,00	0,00	0,02	0,27	0,00	0,02	0,00	42,86	0,10	0,00	5,52	0,00	0,00
S.nr. 11 Vikafjell	84784-A	1,74	0,45	1,41	0,17	0,34	0,10	0,03	7,94	4,21	5,09	20,41	6,32	0,54	0,51
	84784-B	6,52	0,45	1,41	0,27	1,35	0,10	0,08	7,94	24,42	5,02	20,41	6,32	0,54	0,51
	84784-C	6,10	0,45	1,41	0,25	1,26	0,10	0,03	7,94	31,18	5,02	20,41	6,32	0,54	0,51
	84784-D	5,32	0,45	1,41	0,45	1,58	0,10	0,09	7,94	30,14	5,02	20,41	6,32	0,54	0,51
	84784-E	4,64	0,45	1,41	0,26	1,34	0,10	0,04	7,94	11,04	5,02	20,41	6,32	0,54	0,51
	84784-F	0,78	0,45	1,41	0,34	0,27	0,10	0,08	7,94	4,21	5,02	20,41	6,32	0,54	0,51
	average	4,18	0,45	1,41	0,29	1,02	0,10	0,06	7,94	17,53	5,03	20,41	6,32	0,54	0,51
	STD	2,37	0,00	0,00	0,10	0,56	0,00	0,03	0,00	12,57	0,03	0,00	0,00	0,00	0,00
S.nr. 12 Børgefjell	84785-A	59,52	0,45	1,41	0,17	0,12	0,10	0,22	7,94	422,32	5,02	20,41	6,32	0,54	0,51
	84785-B	59,88	0,45	1,41	0,39	0,15	0,10	1,51	7,94	684,44	5,02	20,41	17,21	0,54	0,51
	84785-C	2,35	0,45	1,41	0,38	0,12	0,10	0,04	7,94	19,55	5,02	20,41	6,32	0,54	0,51
	84785-D	9,34	0,45	1,41	0,34	0,24	0,10	0,04	7,94	105,22	5,02	20,41	6,32	0,54	0,51
	84785-E	6,97	0,45	1,41	0,30	0,15	0,10	0,03	7,94	74,34	5,02	20,41	8,58	0,54	0,51
	84785-F	0,78	2,21	1,41	1,11	0,14	0,10	0,17	64,82	99,98	5,02	20,41	12,26	7,68	64,47

Site/occurrence		Li7(LR)	Be9(LR)	B11(LR)	Mn55(LR)	Ge74(LR)	Rb85(LR)	Sr88(LR)	Na23(MR)	Al27(MR)	P31(MR)	K39(MR)	Ca44(MR)	Ti47(MR)	Fe56(MR)
	average	23,14	0,74	1,41	0,45	0,15	0,10	0,34	17,42	234,31	5,02	20,41	9,50	1,73	11,17
	STD	28,49	0,72	0,00	0,33	0,04	0,00	0,58	23,22	262,45	0,00	0,00	4,43	2,92	26,11
S.nr. 13 Bjørhusdal	84786-A	20,24	0,45	1,41	0,38	0,04	0,10	0,07	7,94	61,55	5,02	20,41	6,32	0,54	0,51
	84786-B	6,97	0,45	1,41	0,36	0,04	0,10	0,12	7,94	60,71	5,02	20,41	21,90	0,54	0,51
	84786-C	2,06	0,45	1,41	0,21	0,06	0,10	0,06	7,94	17,83	5,02	20,41	20,56	0,54	1,99
	84786-D	0,78	0,45	1,41	0,40	0,03	0,10	0,08	7,94	4,21	6,48	20,41	6,32	0,54	0,51
	84786-E	24,66	0,45	1,41	0,31	0,00	0,10	0,04	7,94	316,71	11,19	20,41	6,32	0,54	0,51
	84786-F	20,99	0,45	1,41	0,36	0,08	0,10	0,03	7,94	347,95	5,02	20,41	8,55	0,54	0,51
	average	12,62	0,45	1,41	0,34	0,04	0,10	0,07	7,94	134,83	6,29	20,41	11,66	0,54	0,76
	STD	10,55	0,00	0,00	0,07	0,03	0,00	0,03	0,00	154,99	2,47	0,00	7,47	0,00	0,60
S.nr. 14 Lyngveshøa	84787-A	143,86	0,45	1,41	0,41	0,82	0,10	0,08	7,94	749,32	5,02	20,41	6,32	0,54	0,51
	84787-B	59,91	0,45	1,41	0,37	1,59	0,10	0,04	7,94	482,01	5,02	20,41	6,32	0,54	0,51
	84787-C	139,66	0,45	1,41	0,37	2,16	0,10	0,03	7,94	1171,25	5,02	20,41	6,32	0,54	0,51
	84787-D	115,95	0,45	1,41	0,34	1,80	0,10	0,09	7,94	1442,28	5,02	20,41	6,32	0,54	0,51
	84787-E	162,92	0,45	1,56	0,41	1,84	0,10	0,04	7,94	1761,90	6,24	20,41	18,27	0,54	0,51
	84787-F	154,71	0,45	1,41	0,44	1,86	0,10	0,09	7,94	1698,07	5,02	20,41	6,32	0,54	0,51
	average	129,50	0,45	1,44	0,39	1,68	0,10	0,06	7,94	1217,47	5,22	20,41	8,31	0,54	0,51
	STD	37,65	0,00	0,06	0,04	0,46	0,00	0,03	0,00	517,71	0,50	0,00	4,88	0,00	0,00
S.nr. 15 Netoseter	84788-A	0,78	0,45	1,41	0,54	0,22	0,10	0,08	7,94	4,21	5,02	20,41	6,32	0,54	0,51
	84788-B	0,78	0,45	1,41	0,34	0,18	0,10	0,06	7,94	4,21	5,02	20,41	6,32	0,54	0,51
	84788-C	1,06	0,45	1,41	0,35	0,24	0,10	0,03	7,94	4,21	5,02	20,41	6,32	0,54	0,51
	84788-D	1,18	0,45	1,41	0,25	0,29	0,10	0,05	7,94	6,74	5,02	20,41	6,32	0,54	0,51
	84788-E	0,78	0,45	1,41	0,47	0,19	0,10	0,03	7,94	4,21	5,02	20,41	6,32	0,54	0,51
	84788-F	0,78	0,45	1,41	0,31	0,25	0,10	0,03	7,94	4,21	5,02	20,41	6,32	0,54	0,51
	average	0,89	0,45	1,41	0,38	0,23	0,10	0,05	7,94	4,63	5,02	20,41	6,32	0,54	0,51
	STD	0,18	0,00	0,00	0,11	0,04	0,00	0,02	0,00	1,03	0,00	0,00	0,00	0,00	0,00
S.nr. 16 Hurdal	84789-A	3,76	0,45	1,41	0,17	0,74	0,10	0,06	7,94	91,49	5,02	20,41	6,32	0,54	0,51
	84789-B	16,83	0,45	1,41	0,35	0,94	0,10	0,14	7,94	413,65	5,02	20,41	6,32	0,54	0,51
	84789-C	7,99	0,45	1,41	0,32	0,30	0,10	0,06	7,94	121,19	7,85	20,41	6,32	0,54	0,51
	84789-D	7,87	0,45	1,41	0,26	0,25	0,10	0,04	7,94	95,74	5,02	20,41	16,62	0,54	0,51
	84789-E	20,85	0,45	1,41	0,31	0,97	0,10	0,22	7,94	545,31	5,02	20,41	6,32	0,54	0,51
	84789-F	19,92	0,45	1,41	0,33	0,49	0,10	0,06	7,94	221,99	7,58	20,41	6,32	0,54	0,51
	average	12,87	0,45	1,41	0,29	0,61	0,10	0,10	7,94	248,23	5,92	20,41	8,04	0,54	0,51

Site/occurrence		Li7(LR)	Be9(LR)	B11(LR)	Mn55(LR)	Ge74(LR)	Rb85(LR)	Sr88(LR)	Na23(MR)	Al27(MR)	P31(MR)	K39(MR)	Ca44(MR)	Ti47(MR)	Fe56(MR)
	STD	7,22	0,00	0,00	0,07	0,31	0,00	0,07	0,00	189,88	1,40	0,00	4,20	0,00	0,00
S.nr. 17 Nasafjell	84790-A	2,45	0,45	1,41	0,37	1,05	0,10	0,05	7,94	5,13	5,02	20,41	6,32	0,54	0,51
	84790-B	1,06	0,45	1,41	0,29	1,16	0,10	0,03	7,94	4,21	5,02	20,41	11,68	0,54	0,51
	84790-C	1,83	0,45	1,41	0,17	0,90	0,10	0,04	7,94	9,30	5,02	20,41	6,32	0,54	0,51
	84790-D	1,31	0,45	1,41	0,38	1,23	0,10	0,03	7,94	8,51	9,40	20,41	15,84	0,54	0,51
	84790-E	1,71	0,45	1,41	0,26	1,10	0,10	0,04	7,94	9,32	5,02	20,41	6,32	0,54	0,51
	84790-F	1,61	0,45	1,41	0,27	1,17	0,10	0,04	7,94	9,57	7,95	20,41	8,80	0,54	0,51
	average	1,66	0,45	1,41	0,29	1,10	0,10	0,04	7,94	7,67	6,24	20,41	9,21	0,54	0,51
	STD	0,48	0,00	0,00	0,08	0,12	0,00	0,01	0,00	2,37	1,94	0,00	3,88	0,00	0,00
S.nr. 18 Hattfjelldal	84791-A	2,45	0,45	2,79	0,17	0,14	0,10	0,03	7,94	4,62	5,25	20,41	6,32	0,54	0,51
	84791-B	0,78	0,45	1,41	0,32	0,68	0,10	0,03	7,94	4,56	6,14	20,41	6,32	0,54	0,51
	84791-C	0,78	0,45	1,41	0,30	0,95	0,10	0,04	7,94	5,25	6,27	20,41	6,32	0,54	0,51
	84791-D	0,78	0,45	1,41	0,33	0,84	0,10	0,05	7,94	4,21	5,02	20,41	6,32	0,54	0,51
	84791-E	0,78	0,45	1,41	0,41	0,93	0,10	0,03	7,94	4,21	5,02	20,41	6,32	0,54	0,51
	84791-F	0,78	0,45	1,41	0,31	1,01	0,10	0,07	7,94	8,24	5,02	20,41	33,63	0,54	0,97
	average	1,06	0,45	1,64	0,31	0,76	0,10	0,04	7,94	5,18	5,45	20,41	10,87	0,54	0,59
	STD	0,68	0,00	0,57	0,08	0,33	0,00	0,02	0,00	1,54	0,59	0,00	11,15	0,00	0,19
S.nr. 19 Lierne	84792-A	25,97	0,45	1,41	0,24	2,83	0,10	0,06	7,94	284,33	5,02	20,41	6,32	0,54	0,51
	84792-B	217,87	0,45	1,41	0,22	0,08	0,10	0,12	7,94	1707,56	5,02	20,41	6,32	0,54	0,51
	84792-C	115,27	0,45	1,41	0,63	0,07	0,10	0,14	7,94	260,63	5,02	20,41	11,53	0,54	0,51
	84792-D	41,13	0,45	1,41	0,28	0,07	0,10	0,03	7,94	521,45	5,34	20,41	6,32	0,54	0,51
	84792-E	12,53	0,45	1,41	0,27	0,08	0,10	0,03	7,94	742,22	10,01	20,41	13,90	0,54	0,51
	84792-F	165,18	0,45	1,41	0,27	0,07	0,10	0,03	7,94	1408,90	5,02	20,41	6,32	0,54	0,51
	average	96,33	0,45	1,41	0,32	0,53	0,10	0,07	7,94	820,85	5,91	20,41	8,45	0,54	0,51
	STD	83,54	0,00	0,00	0,15	1,13	0,00	0,05	0,00	604,91	2,02	0,00	3,39	0,00	0,00
S.nr. 20 Lierne	84793-A	24,33	0,45	1,41	0,17	0,07	0,10	0,09	7,94	278,09	6,71	20,41	6,32	0,54	0,51
	84793-B	14,15	0,45	1,41	0,40	0,07	0,10	0,09	7,94	55,69	7,23	20,41	6,32	0,54	0,51
	84793-C	4,77	0,45	1,41	0,28	0,07	0,10	0,05	7,94	109,04	8,17	20,41	6,32	0,54	0,51
	84793-D	18,12	0,45	1,41	0,25	0,07	0,10	0,04	7,94	262,56	5,42	20,41	6,95	0,54	0,51
	84793-E	83,86	0,45	1,41	0,36	0,08	0,10	0,03	7,94	775,47	8,12	20,41	45,43	0,54	0,51
	84793-F	28,71	0,45	1,41	0,36	0,07	0,10	0,14	7,94	196,26	6,98	20,41	6,32	0,54	0,51
	average	28,99	0,45	1,41	0,30	0,07	0,10	0,07	7,94	279,52	7,11	20,41	12,94	0,54	0,51
	STD	28,13	0,00	0,00	0,09	0,00	0,00	0,04	0,00	257,82	1,02	0,00	15,92	0,00	0,00
S.nr. 21 Lierne	84794-A	96,81	0,45	1,41	0,17	15,03	0,14	0,15	7,94	1634,26	5,02	20,41	6,32	0,54	0,51

Site/occurrence		Li7(LR)	Be9(LR)	B11(LR)	Mn55(LR)	Ge74(LR)	Rb85(LR)	Sr88(LR)	Na23(MR)	Al27(MR)	P31(MR)	K39(MR)	Ca44(MR)	Ti47(MR)	Fe56(MR)
	84794-B	59,27	0,45	1,41	0,28	3,45	0,10	0,07	7,94	210,58	5,02	20,41	6,32	0,54	0,51
	84794-C	79,06	0,45	1,41	0,32	0,07	0,10	0,07	7,94	643,31	5,21	20,41	13,74	0,54	0,51
	84794-D	128,05	0,45	1,41	0,46	0,07	0,21	0,18	7,94	505,14	5,02	20,41	6,32	0,54	2,10
	84794-E	76,50	0,45	1,41	0,28	2,29	0,10	0,10	7,94	112,07	5,02	20,41	22,56	0,54	0,51
	84794-F	80,04	0,45	1,41	0,38	2,71	0,10	0,10	7,94	16,71	5,02	20,41	6,32	0,54	0,51
	average	86,62	0,45	1,41	0,32	3,94	0,13	0,11	7,94	520,35	5,05	20,41	10,26	0,54	0,77
	STD	23,54	0,00	0,00	0,10	5,61	0,04	0,04	0,00	595,39	0,08	0,00	6,72	0,00	0,65
S.nr. 22 Lierne	84795-A	0,78	0,45	1,41	0,41	0,29	0,10	0,04	7,94	4,21	5,02	20,41	21,37	0,54	0,51
	84795-B	0,78	0,45	1,41	0,38	0,07	0,10	0,06	7,94	4,21	5,02	20,41	6,32	0,54	0,51
	84795-C	6,79	0,45	1,41	0,38	0,07	0,10	0,03	7,94	59,77	5,89	20,41	29,78	0,54	0,51
	84795-D	3,69	0,45	1,41	0,39	0,07	0,10	0,05	7,94	22,42	5,02	20,41	6,32	0,54	0,51
	84795-E	80,00	0,45	1,41	0,29	0,09	0,10	0,03	7,94	633,19	5,02	20,41	6,32	0,54	0,51
	84795-F	0,04	0,45	1,41	0,26	0,08	0,10	0,03	7,94	4,21	5,02	20,41	11,40	0,54	0,51
	average	15,35	0,45	1,41	0,35	0,11	0,10	0,04	7,94	121,34	5,17	20,41	13,59	0,54	0,51
	STD	31,77	0,00	0,00	0,06	0,09	0,00	0,01	0,00	251,68	0,36	0,00	9,86	0,00	0,00
S.nr. 23 Lierne	84796-A	0,78	0,45	1,41	0,56	0,70	0,10	0,04	7,94	4,21	5,02	20,41	6,32	0,54	0,51
	84796-B	50,58	0,45	1,41	0,23	0,17	0,10	0,05	7,94	163,97	5,02	20,41	6,32	0,54	0,51
	84796-C	316,18	0,45	1,41	0,26	0,14	0,10	0,07	9,60	2104,79	7,52	20,41	6,32	0,54	0,51
	84796-D	319,32	0,45	1,41	0,42	0,15	0,10	0,15	7,94	2471,34	5,02	20,41	6,32	0,54	0,51
	84796-E	297,21	0,45	1,41	0,37	0,11	0,10	0,11	7,94	1549,65	5,02	20,41	6,32	0,54	0,51
	84796-F	3,22	0,45	1,41	0,40	0,07	0,10	0,03	7,94	4,21	5,02	20,41	6,32	0,54	0,51
	average	164,55	0,45	1,41	0,37	0,22	0,10	0,07	8,22	1049,70	5,44	20,41	6,32	0,54	0,51
	STD	161,48	0,00	0,00	0,12	0,24	0,00	0,05	0,68	1127,37	1,02	0,00	0,00	0,00	0,00
Lierne all	average	78,37	0,45	1,41	0,33	0,97	0,11	0,07	8,00	558,35	5,73	20,41	10,31	0,54	0,56
	STD	95,13	0,00	0,00	0,10	2,82	0,02	0,04	0,30	697,01	1,29	0,00	8,82	0,00	0,29

Jan Mangerud and John Inge Svendsen

The Scandinavian Ice Sheet as a barrier for Human colonization of Norway

Several times during the Last Ice Age, the ice sheet covered only mountain areas so that it theoretically was possible for humans to colonize coastal areas of Norway. The last time this happened prior to the Last Glacial Maximum (LGM: 26,000–19,000 years ago) was during the Ålesund Interstadial, 38,000–34,000 years ago. However, no traces of human presence have been found from these ice-free intervals. Following the LGM, it was not until the Bølling Interstadial (14,700–14,000 years ago) that ice-free areas were large enough to host a potentially permanent human population. Some archaeologists previously considered that people arrived at the west coast of Norway this early, but most scientists now reject this hypothesis. An ice sheet margin that crossed Oslofjorden formed a physical barrier that probably prohibited human immigration this early. The oldest documented traces of humans show that they settled the coast during the first centuries after the onset of the Holocene 11,600 years ago, at a time when the shrinking ice sheet still covered the interior of Norway. The ice margin was located in the lowlands in eastern Norway until 10,500 years ago. Based the available data we assume that the entire Scandinavia became ice-free 10,000–9500 years ago.

Introduction

Ice sheets have from time to time formed barriers for human expansion, not at least to northwest Europe. For a couple of hundred thousand years this was the case for the Neanderthals (*Homo neanderthalensis*). However, it is unknown whether they established themselves in Scandinavia even during the warmest interglacials when climate was warmer than today. Modern humans (*Homo sapiens sapiens*) first migrated to Western Europe 40,000–30,000 years ago, at a time when the Eurasian Ice Sheet was significantly smaller than during the Last Glacial Maximum (LGM), which occurred about 10,000 years later (Hughes *et al.* 2016). The exact ice sheet extent during this initial colonization phase of modern humans in Europe is poorly known, but during the Ålesund Interstadial, 38,000–34,000 years ago, much of the western coast of Norway was ice free and remnants of reindeer and a rich sea-bird fauna have been found in caves (Larsen *et al.* 1987, Valen *et al.* 1996, Mangerud *et al.* 2010). Subsequently, when the Scandinavian Ice Sheet grew to its maximum extent during the LGM 26,000–19,000 years ago, all of Norway was encapsulated in thick glacial ice (Fig. 1). The final colonization of Norway first became possible when the ice sheet started to melt, and the ice margin had retreated from the outer coast. This has been much discussed in the archaeological literature (e.g. Bang-Andersen 2003, Breivik 2014, Glørstad 2016, Solheim and Persson 2018.), but in this paper we will only provide an updated synthesis from a geological point of view.

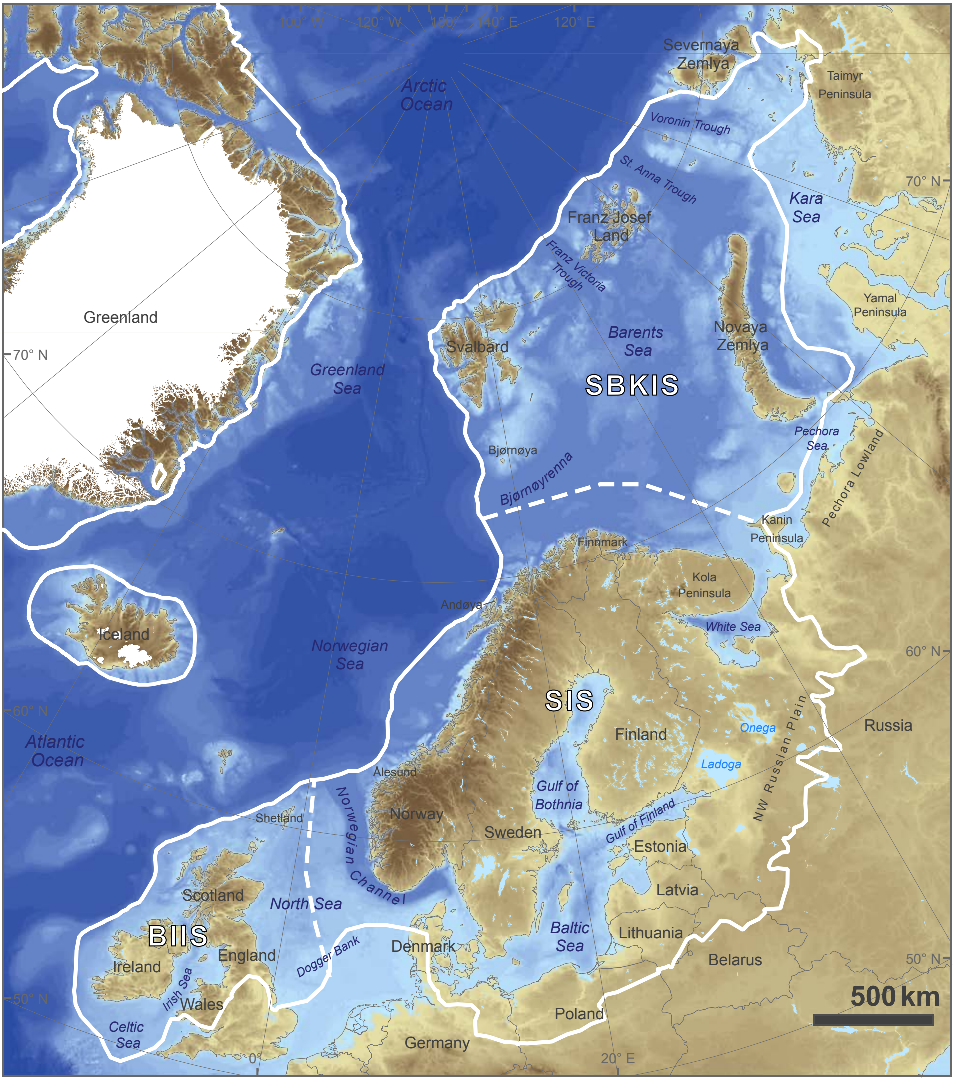

***Figure 1**: The maximum extent of the Eurasian Ice Sheet during the Last Glacial Maximum (LGM). The boundary is not synchronous around the ice sheet; it is about 26,000 years old in the west and some 17,000 years in the east. BIIS – the British-Irish Ice Sheet; SIS – the Scandinavian Ice Sheet; SBKIS – the Svalbard-Barents Sea-Kara Sea Ice Sheet. The approximate LGM ice boundaries (white lines) are shown also for Iceland and Greenland. Modified from Hughes et al. (2016).*

All ages in this paper are given in calendar years; more specifically radiocarbon dates (^{14}C yrs) are cited as calibrated ages, using the IntCal13 calibration curve (Reimer *et al.* 2013). We adhere to the convention in geological sciences that ages are given as years before the present (BP), where "present" means AD 1950. Ice core ages are counted from the year 2000 (B2k) (Andersen *et al.* 2006), but we have subtracted 50 years so that also ice-core years (BP) are given relative to the year 1950.

Background – geological subdivision of time

During the last interglacial, from approximately 130,000 to 117,000 years BP, the climate was as warm as our present interglacial, the Holocene. In Western Europe, this period is referred to as the Eemian, named after the Eem River in the Netherlands were deposits from this interglacial was first described (Mangerud 1991). For global correlations, geologists commonly use the isotope stratigraphy in sediment cores from the deep sea: Marine Oxygen Isotope Stages (MIS). According to this nomenclature the last interglacial is termed MIS 5e (Fig. 2). The Last Ice Age (MIS 5d-2; 117,000–11,600 years BP) followed this global warm interlude. In Western Europe, the Last Ice Age is named the Weichselian from the German name for the Polish river Vistula where the ice-sheet limits were mapped for the first time. The climate, and thus the size of the former ice sheets, varied considerably during the Weichselian. For some mild interstadial periods, notably MIS 5c and 5a, most of the Eurasian Ice Sheet melted away (Fig. 2). The next period with the formation of large ice sheets occurred during MIS 4, 75,000–58,000 years BP, when Norway once again became completely ice-covered. Following this cold spell, the ice sheets retreated considerably at the transition to the MIS 3 period and large areas of land became ice-free. The climate varied also during MIS 3 (58,000–25,000 years BP), and during the mildest periods the ice cover may have been confined to the mountain areas.

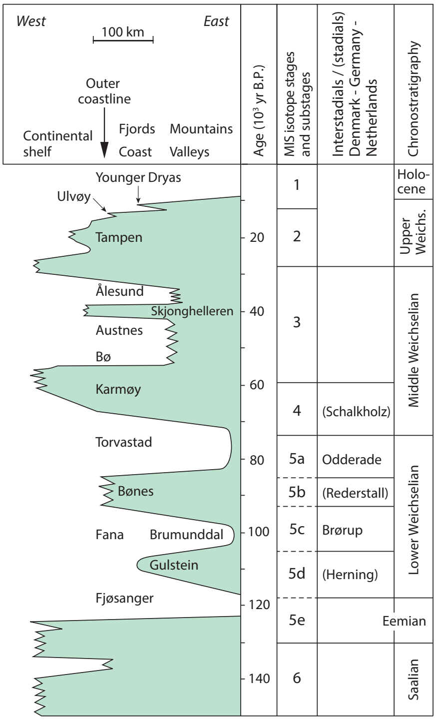

***Figure 2**: The fluctuations of the western flank of the Scandinavian Ice Sheet through the entire last Ice Age, the Weichselian. The green curve shows schematically the position of the ice margin, i.e. how the glacier expanded from the mountains through the valleys and fjords to the continental shelf in the west. The coast of western Norway was apparently ice-free during most of the last 120,000 years. Only during the Marine Isotope Stages (MIS) 4 and 2 was the coast covered for longer periods. Names on the curve represent sites in Norway. MIS – Marine Isotope Stages. Modified from Mangerud et al. (2011).*

Around 30,000 years BP, the ice sheets once again started to grow. Most ice sheets and glaciers on Earth now expanded to their maximum extent during the Last Ice Age, and the culmination of this global ice-growth period is generally termed the Last Glacial Maximum (LGM). However, in northern Russia and Siberia the development was different. Here the ice sheet had its maximum extent during the foregoing MIS 4 glaciation (75–58,000 years ago) and during the LGM this vast region along the northern rim of the Eurasian continent remained essentially ice free (Svendsen *et al.* 2004). Global sea level is a measure of how much ice is stored on land, i.e. the total volume of ice sheets and glaciers overall on Earth. During the LGM, between 26,000–19,000 years BP, the global sea level was at its lowest and lay 125–130 m below present sea level (Clark *et al.* 2009). The term LGM is often used to denote this period with global sea-level low stand. However, different sectors of an ice sheet did not reach their maximum extent at the same time, and the term LGM may also be used locally to indicate when the ice sheet in a particular area had its maximum extent.

During the Weichselian the British-Irish and Scandinavian ice sheets reached their maximum extent between 26,000–19,000 years BP. At this time, the ice sheet margin formed an insurmountable barrier for human expansion across northwestern Eurasia, all the way from southern England through Germany and eastwards to Russia (Fig. 1). The maximum extent was not synchronous; in the west, the British Ice Sheet reached its maximum extent about 26,000 years BP, whereas the Scandinavian Ice Sheet advanced to its maximum position in Russia almost 10,000 years later. The pattern and timing of the ice margin retreat is not well documented along the former ice margin, and details of the withdrawal are in many areas highly uncertain. The most recent reconstruction of the build-up and decay of the last Eurasian Ice Sheet were provided by Hughes *et al.* (2016) who also presented the uncertainties in age and position of the ice sheet margins. This synthesis includes a full database of published radiocarbon and other numerical dates that were used to reconstruct the large-scale history of the Eurasian Ice Sheet.

The last ice remnants in Scandinavia melted away during Early Holocene, between 10,000 to 9000 years BP, whereas the much larger ice sheet over North America survived until about 6000 years BP. These ages thus represent the physical end of the ice age on each of these continents. The boundary between the Pleistocene and the Holocene has recently been defined chronostratigraphically by a stratotype located at a depth of 1492.45 m in the GRIP2 ice core from Greenland (Walker *et al.* 2009). In this core the abrupt and major climate warming is identified from changes in the oxygen isotope composition in the ice. By counting annual layers in the ice core, this boundary is found to have an age of 11,653 years BP with a counting uncertainty of maximum 99 years (Rasmussen *et al.* 2006). According to stratigraphical rules, boundaries for lower-hierarchical stratigraphical units, such as the Weichselian/Holocene and the Younger Dryas/Preboreal, are defined by the same stratotype, as long as these latter units are considered as chronostratigraphic units. Formally, this means that the Last Ice Age in Europe, the Weichselian, ended when the ice margin started to retreat from the Ra Moraines around Oslofjorden and the Halsnøy-Herdla Moraine in Hordaland, i.e. at a time when almost all of Norway was still covered by glacier ice (Fig. 3).

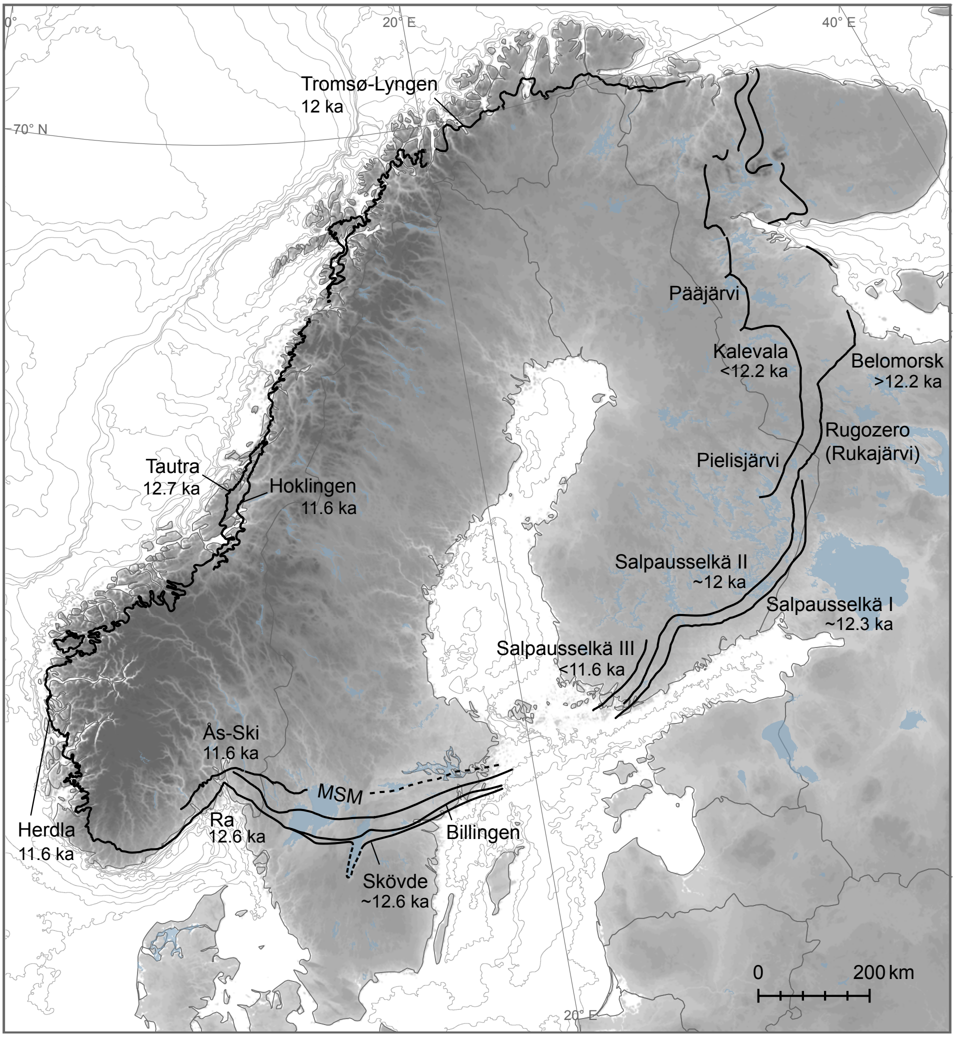

***Figure 3**: The Younger Dryas (YD, 12,700-11,600 cal ka BP) moraines around the Scandinavian Ice Sheet. Selected ages of named moraines are given in thousand years (ka). Note that some moraines were formed during early YD whereas others at the very end of YD. Modified from Mangerud et al. (2016).*

The initial ice retreat after the LGM started around 20,000 years BP, but the first major warming in northwest Europe occurred only at the start of the Bølling interstadial (named after the lake Bølling Sø in Denmark), about 14,700 years BP. A colder episode, named Older Dryas, occurred around 14,000–13,800 years BP, before the climate again became milder in the Allerød interstadial (named from a village in Denmark) between 13,800 and 12,700 BP. The period covering the entire time span between 14,700 and 12,700 BP is often referred to as the Bølling-Allerød interstadial, regardless of the small and short-lived climate coolings that occurred in the middle of this period. During this time, Ice Age humans migrated into northern Germany and Denmark (Fischer *et al.* 2013) and during the YD even into south-western Sweden, close to the Norwegian boundary (Schmitt and Svedhage 2015).

In northwest Europe, the Bølling-Allerød interstadial ended with an abrupt and major climate cooling that represents the start of the Younger Dryas stadial (or chronozone). Nathorst (1870, 1893 cited Mangerud 2021) found leaves of the mountain flower Dryas octopetala (Eng., mountain avens; Norw., reinrose) in layers of clay in southern Sweden and Denmark and Nathorst interpreted them as evidence of a cold climate with a treeless landscape. Later it was discovered that this cold Dryas period was interrupted by milder periods and the youngest Dryas leaves were found in a layer of clay that lay above the Allerød peat, leading Hartz (1912 cited Mangerud 2021) to introduce the name the Younger Dryas as designation of the last cold spell of the ice age in Europe. The Greenland interstadial 1/stadial 1 boundary, approximately corresponding with the Allerød/Younger Dryas boundary, is dated to 12,846 ± 138 years BP in the Greenland ice cores (Rasmussen *et al.* 2006) and to 12,737 ± 31 years BP in a lake core from Kråkenes in western Norway (Lohne *et al.* 2013, 2014), which is one of the best dated sediment cores covering the late glacial period in Europe. The two ages overlap within one standard deviation, but the ice-core chronology and calibrated radiocarbon years are not necessarily identical. It is also well known that there are geographical time lags in climate changes, and that the biological and physical processes that had an imprint on the studied archives have different response times. Thus, the dating of a climate event in a stratigraphical sequence may give different ages. The end of the Younger Dryas is defined by the Pleistocene/Holocene boundary, described above. This transition is dated to 11,653 ± 50 years BP in the ice cores (Rasmussen *et al.*, 2006) and 11,535 ± 58 years BP in the mentioned lake core from Kråkenes in western Norway (Lohne *et al.* 2013, 2014).

Opening of southwestern Norway

Southwestern Norway was the first part of the country that offered suitable environmental conditions in a sufficiently large area for a more permanent human occupation. There are ^{10}Be exposure dates that suggest that the Island Utsira was ice-free as early as 20,000 years BP (Svendsen *et al.* 2015). However, radiocarbon dates from the Norwegian Channel suggest that deglaciation of Utsira did not occur until about 18,500 years BP (Sejrup *et al.* 2016). We now suspect that the ^{10}Be exposure dates, from samples taken from ice-transported boulders, overestimate the real ages by about 2000 years. This can be explained by some inheritance of ^{10}Be from an earlier ice-free period when the bedrock was exposed (Briner *et al.* 2016). Recent radiocarbon dates of marine foraminifers indicate that southern Karmøy became permanently ice-free at around 18,000 years BP, i.e. shortly after the deglaciation of the Norwegian Channel (Vasskog *et al.* 2019). However, there are indications that the radiocarbon ages of marine samples older than the Bølling (14,700 years BP) are overestimated by more than thousand years (Brendryen *et al.* 2020). Anyway, most of Boknafjorden was probably ice-free by 15,000 years BP (Briner *et al.* 2014, Gump *et al.* 2017).

A classical locality for the discussion of when the first humans arrived in Norway is a site from Blomvåg in Øygarden, west of Bergen; the research history for this site is given in Mangerud *et al.* (2017). Extensive excavations in 1941–1942 uncovered a rich fauna of marine shells, bones of a bowhead whale, harp seal, reindeer, and many sea birds. The Blomvåg beds are now dated with more than 20 radiocarbon dates, demonstrating that these strata were deposited during the period 14,800–13,330 years BP and subsequently not overrun by ice. As a matter fact, the fauna is similar to that found from Mesolithic sites in western Norway (Lie 1986, 1990). The finding of reindeer and the fauna composition have been used as arguments in favour of human presence, i.e. that the animals are prey that have been hunted and utilized by humans. There were also some pieces of flint found together with the animal remains, which some archaeologists have argued were worked by humans, but presently most archaeologists disprove these as artefacts and rather consider them result of natural processes (Bjerck 1994, Eigeland 2012, Eigeland and Solheim 2012, Fischer 2012, Mangerud *et al.* 2017).

After the outer coastal areas, including Blomvåg, became deglaciated, the ice margin continued to retreat inwards in the fjords until the late Allerød, about 12,700 years BP. At that time most of the coast and fjord landscape in southwestern Norway was ice-free (Mangerud *et al.* 2017) and the landscapes were covered with a vegetation consisting of grass, herbs and small shrubs (Paus 1989, Birks 2015). However, so far undisputable traces of pre-Holocene human occupation have not been found anywhere in Norway. If the lack of finds means that humans did not colonize the coast until the early Holocene, it means that the first humans arrived more than 3000 years after the ice front receded from the Blomvåg site. This delay can possibly be explained by the persistent existence of an ice barrier across Oslofjorden, so that western Norway remained isolated from the ice-free areas in Sweden and Denmark that hosted a human population prior to the Holocene period (Fischer *et al.* 2013, Glørstad 2016, Mangerud *et al.* 2017). During the entire Bølling-Allerød-Younger Dryas interval, the ice margin crossed Oslofjorden, and there was no land bridge from Sweden to western Norway (Hughes *et al.* 2016). One should also keep in mind that the relative sea level at that time was considerably higher on both the Swedish and Norwegian side of Oslofjorden. Humans would have to cross at least 200 km of open water, either in boat or on winter ice, whether they came from Sweden, Denmark, or a dry land area of the present North Sea. Such a crossing may have been possible, and it was previously argued that humans followed reindeer herds as new areas became ice-free. As mentioned above, the reindeer remnants found at Blomvåg were earlier interpreted in this way. However, the fact that no reliable artefacts have been uncovered makes this hypothesis highly uncertain.

The younger Dryas glacial re-advance

At the onset of the cold Younger Dryas about 12,700 years BP, or probably slightly before (Lohne *et al.* 2007), the Scandinavian Ice Sheet started to re-grow and the ice front expanded over large areas that had been ice-free during the foregoing Allerød period. How fast the ice front expanded, and how large the area that was inundated by the advancing ice front, is difficult to estimate because the waxing ice sheet removed most of the deposits from the foregoing ice-free period. The re-advance is best documented in the Hordaland area in western Norway, where the ice front expanded more than 50 km and it reached the maximum position (the Herdla-Halsnøy Moraine, Fig. 3) at the very end of the Younger Dryas, 11,600 years BP (Mangerud *et al.* 2016). A re-advance of the ice margin is also described along the west coast of Oslofjorden (Bergstrøm 1999, Romundset *et al.* 2019) suggesting that the ice front advanced along the entire coastline from Hordaland to Oslofjorden.

In eastern areas, the ice sheet behaved differently; in Finland and eastern Sweden there was a general retreat interrupted by small re-advances or halts of the ice margin during the Younger Dryas as seen from the belt of moraines in Figure 3 (Johnsen and Ståhl 2010). Thus, the outermost ice-front position in these areas dates to the onset of the Younger Dryas, 12,700 years BP, opposite to Western Norway where the outermost ice front position was reached at the very end of the Younger Dryas. The Oslofjorden area might represent an intermediate position; scientists have for decades considered that the large Ra Moraines were formed during the middle part of the Younger Dryas, 12,650 to 12,350 years BP, and that the Ski Moraine further inland represents the end of the Younger Dryas (Fig. 3) (Sørensen 1979, Mangerud *et al.* 2018). This interpretation is based on a several radiocarbon dates from marine shells. However, new dates suggest that the Ra Moraines are younger than previously assumed (Romundset *et al.* 2019). Based on the available data one cannot ignore the possibility that the ice margin remained at the Ra Moraine until the end of the Younger Dryas period.

Northern Norway

It is well documented that the northern part of the island Andøya (located 69 °N) became ice-free and that vegetation established there as early as 22,000 years BP, but this was a very small area of the island (Vorren *et al.* 2013). It is possible that some mountain summits in Norway became ice-free earlier, or even remained ice-free throughout the Last Glacial Maximum as nunataks, but no other place in Norway is proven with radiocarbon dates to be ice-free as early as Andøya. However, one has to keep in mind that Andøya was an isolated ice-free "island" along an ice-sheet margin stretching from Svalbard to the North Sea (Hughes *et al.* 2016).

A pathway from Russia and along the northern coast of Norway started to open about 14,000 years BP, when the northern tip of Varangerhalvøya and some islands became ice-free (Romundset *et al.* 2017). However, further east the ice probably still reached the Barents Sea at that time (Hughes *et al.* 2016) and a full pathway did not open until late Allerød. At that time, and indeed much earlier, humans lived north of the Arctic Circle on the Russian mainland, and thus an early migration to northern Norway is feasible (Hufthammer *et al.* 2019). Concerning the lack of known dwelling sites, one must consider that to the east of the White Sea, that remained ice free during the LGM, the relative sea level has been below the present from today and at least back to 20,000 years BP. Late glacial and early Holocene dwelling sites may therefore be located on the floor of the Barents Sea (Pechora Sea) along the Russian mainland.

The Holocene

Direct radiocarbon dating of the oldest dwelling sites in Norway has been difficult because most of the organic material is degraded, but there appears to be a general agreement that humans made their entrance during the first few centuries of the Holocene (Glørstad 2016). The Pauler 1 site, located shortly west of the Ra Moraine near the city of Larvik on the western shore of Oslofjorden, is shore-line-dated to 11,200 years BP or slightly later (Jaksland and Persson 2014).

A very fast warming, which led to rapid melting of the ice sheet, started at the Younger Dryas/Holocene transition. However, the pattern and timing of the retreat of the ice-sheet margins are poorly known and the progress in knowledge is extremely slow because only a couple of geologists are working on such problems in Norway. We assume that in the end, the ice sheet split up in different ice masses, located in individual mountain areas, but it is not documented how and when this happened. We will describe only a few examples where data are available.

The Younger Dryas ice sheet reached the outermost coast only at short stretches in Hordaland and Nordland (Fig. 3) and the entire coast along Norway, from Oslofjorden to the Russian border, was therefore open for human migrations only 100–200 years after the onset of the

Holocene. The main hindrance for human movement would be the Oslofjorden area where the ice margin for centuries ended in the fjord and where relative sea levels were up to 220 m higher and produced a wide fjord, which humans would have to cross in order to reach the west coast of Norway. It can also be mentioned that all other fjords that early immigrants would have to cross were wider than at present because of the higher relative sea levels.

We have recently obtained a very precise age for the deglaciation of the Mjøsa area (near the town of Lillehammer) in eastern Norway (Mangerud *et al.* 2018). Basal lake sediments with pioneer vegetation that must have lived close to the ice margin were dated to 10,500 years BP; this age fits into an up-dated deglaciation chronology of eastern Norway (Fig. 4). At that time there was still a contiguous ice sheet across central Norway, stretching from the Jotunheimen Mountains in the west to the Swedish border in the east. An important feature with this ice is its location south of the water shed between southeast Norway and Trøndelag (to the north). This was because it inherited the ice-surface pattern from the Last Glacial Maximum when the ice divide (the summit of the ice sheet) was located south of the present water divide. The ice sheet during this stage of the deglaciation therefore formed a major dam across the valleys of Østerdalen and Rendalen leading to the formation of a huge ice-dammed lake (Nedre Glomsjø) between the ice sheet and the watershed to Trøndelag (near Røros). About 10,500 years BP, or slightly later, this lake drained catastrophically under the ice (Høgaas and Longva 2016) and caused a sudden local sea-level rise of about 35 m in the almost closed Romeriksfjorden (Longva and Thoresen 1991, Longva 1994,). This must have been a catastrophic event for humans if they had settled in this area to the east and north of Oslo.

The last ice remnants in eastern Norway survived as a belt across the country well south of the present-day water shed and highest mountains. This pattern, with ice-dammed lakes between the ice and the watershed, continued northwards in Sweden. Here the ice remnants were located east of the watershed (Regnell *et al. 2019).* Hughes *et al.* (2016) have therefore reconstructed the last ice remnants south of the watershed in eastern Norway and east of the watershed in much of Sweden. When this ice finally melted is not dated, but it was probably between 10,000– and 9500 years BP. The western end of this last ice mass was located differently as glacial striations suggest that the ice margin retreated towards the highest mountains and that the last remnants from the ice age survived in the Jotunheimen mountains (Sollid 1964, Bergersen and Garnes 1983, Hughes *et al.* 2016).

Some prominent moraines around the head of Hardangerfjorden have been used to reconstruct an active remnant of the ice sheet on the western part of the mountain plateau Hardangervidda (Anundsen and Simonsen 1967). These moraines are now dated to 10,900 years BP, using well dated shorelines (Mangerud *et al.* 2013). The ice cap that formed these moraines sent outliers that reached and calved in Osafjorden and Eidfjorden, the innermost branches of Hardangerfjorden. In an ongoing project, we have found that also some ice-marginal deposits in Modalen, northeast of Bergen, were formed 10,900 years BP showing that a remnant of the ice sheet survived on the mountain plateau Stølsheimen, south of Sognefjorden (Mangerud *et al. 2019).*

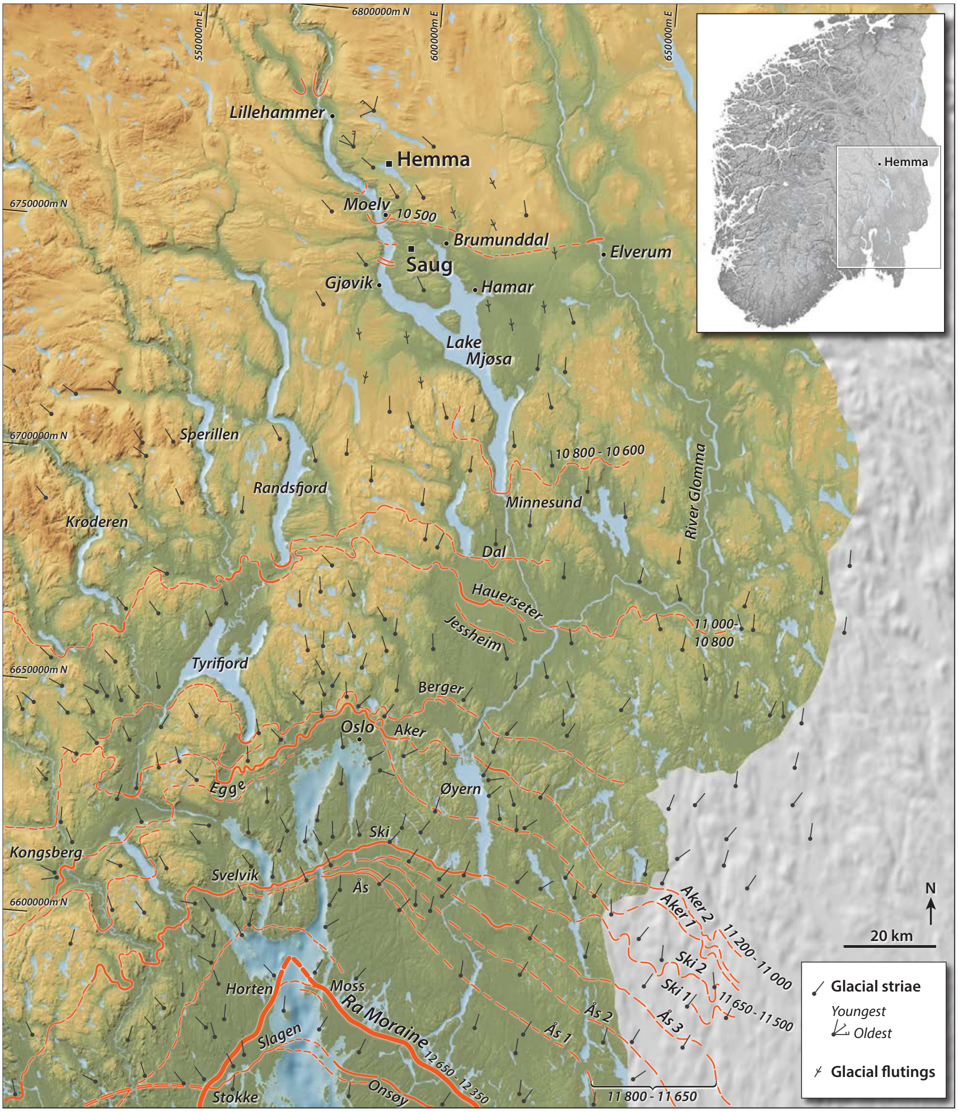

***Figure 4**: The deglaciation of eastern Norway. Red lines show named ice-margin positions and assumed ages for the moraines. Modified from Mangerud et al. (2018).*

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Arne Johan Nærøy

The Spatial Context of Technology in the Middle Neolithic – a use-wear study on quartz

Prehistoric hunter-gatherer settlement sites were arenas for technological practices as the daily and physical context where technological processes took place. In this perspective, archaeological analyses of site contexts are directed towards understanding technological processes, the use of tools and where these activities were performed at the sites.

Middle Neolithic sites in western Norway exhibit a varied used of raw materials for lithic tools, particularly with quartz and quartzite knapped using bipolar technique. The paper discusses a site from Øygarden, Hordaland County, western Norway, dated to the Middle Neolithic, with a use-wear analysis of the quartz assemblage as a point of departure. The focus is directed at understanding functional properties of the tool assemblage and the spatial context of technological practices reflected by the distribution of the artefact assemblage.

The use-wear analysis extends the understanding of the behavioural pattern of the site where two individuals performed both similar and different work operations. Quartz tools are associated with one of the individuals. The distribution of the tools suggests several spatially segregated work operations linked in a continuous process. The study directs attention to the lack of, and potential for, functional studies on Norwegian site assemblages.

Introduction

In our effort to analyse and interpret spatial activity patterns of prehistoric hunter-gatherer sites, we try to understand technological processes in a broad sense as the procurement and processing of raw materials, the production and use of tools and how these features change through time. Furthermore, the spatial context in which these processes takes place is important for our understanding of the hunter-gatherer way of life and the interplay between members of social groups. In hunter-gatherer societies, technology and technological processes are interwoven and integrated with many facets of social, cultural and ideological life. In this context, the settlement site was a central arena for processes of technological change or stability; it was the daily and physical scene where technological processes occurred in an interplay between the inhabitants.

The sites with their archaeologically visible features, are spaces that were organised according to specific sets of rules pertaining to both ideological and cultural aspects such as world view (the dwelling as a reflection of and organised as cosmos, Grøn 2000) and gendered activity patterns

(Nærøy 2000, Jarvenpa and Brumbach 2006). These spaces were also social, cultural and ideological spaces open for social negotiation and change through the manipulation of material objects such as lithic tools, their production, use and discard. A detailed understanding of the relation between the technological processes and the structural features of a site is therefore important in order to understand prehistoric hunter-gatherer lifeways. In the present context, a use-wear analysis of lithic tools combined with spatial patterns of the lithic assemblage was seen as useful for such an analysis.

The point of departure for a discussion of these issues is a spatial and use-wear analysis performed twenty years ago on the lithic assemblage from a coastal site from the Middle Neolithic (Nærøy 2000). This was an analysis of the complete assemblage of quartz, which was the dominant raw material at the site. It is important to bear in mind that the term Neolithic as far as western Norway is concerned, is to a large extent a chronological term. The Early and Middle Neolithic A and B (4000–3400 cal. BC and 3400–2350 cal. BC, Bergsvik 2012, Prescott 2012) were characterised by sedentary/semi-sedentary hunter-gatherer populations with a knowledge of, but with no substantial practice of husbandry and agriculture (Hjelle *et al*. 2006, Prescott 2012).

Use-wear analysis of tools is an important method for understanding and interpreting the lithic assemblages at prehistoric hunter-gatherer sites. The method is, however, a time-consuming process and, in Norwegian archaeology, few studies have been performed on non-flint raw materials. The question is why this is so and how functional studies can improve possibilities for interpreting prehistoric hunter-gatherer sites. The present paper is, however, primarily a case study of a specific prehistoric hunter-gatherer space discussing processes of spatial and social patterning.

Site 16 Budalen, Øygarden, Hordaland, Western Norway

Site description

Site 16 Budalen was situated in a protected bay on the island of Oni in Øygarden municipality, on the outer coast of Hordaland County (Nærøy 1994, 2000) (Fig. 1a and b). The area was surveyed, and the site was excavated as part of a rescue excavation project. The finds were deposited on an irregular surface with coarse sand, stones and boulders on top of the bedrock. The lack of structural features makes it impossible to determine whether this was an open-air site or if there had been some form of dwelling. The central site area, however, was cleared for larger stones.

The distribution of artefacts covered approximately 60 square metres (Figures 2 and 3). The site was covered by 25 cm turf covering a 15 cm layer of lighter sand mixed with decomposed organic plant material, small stones, charcoal and artefacts. Below this was brownish sand mixed with gravel, charcoal and artefacts. These two artefact-bearing layers were excavated in three 5 cm spits in squares of 50 x 50 cm. The soil was water-sieved with a mesh size of 4 x 4 mm. However, excavation spit 2 was sieved through a 2 x 2 mm mesh due to the presence of large amounts of microdebitage.

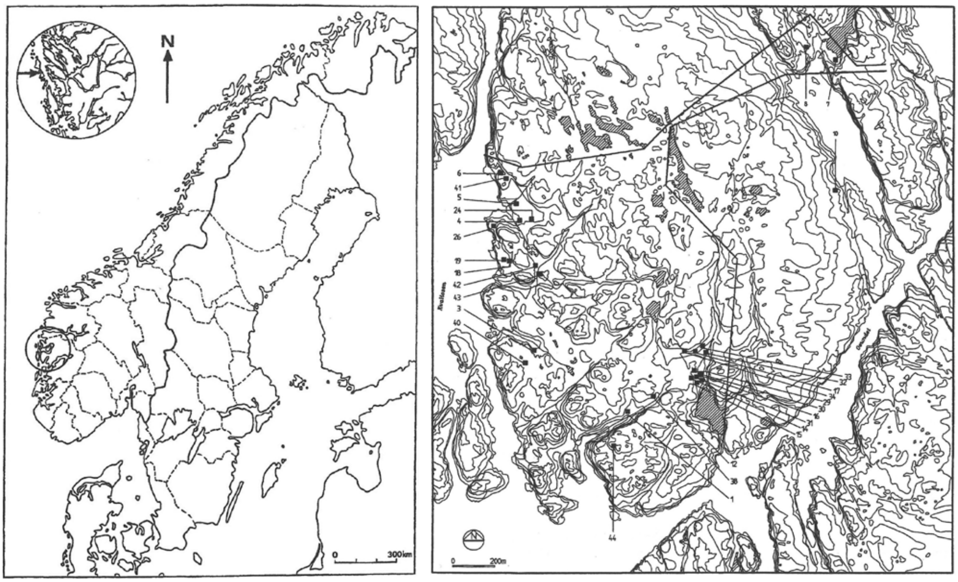

Figure 1*: Map of Kollsnes, Øygarden, Hordaland, Western Norway.*

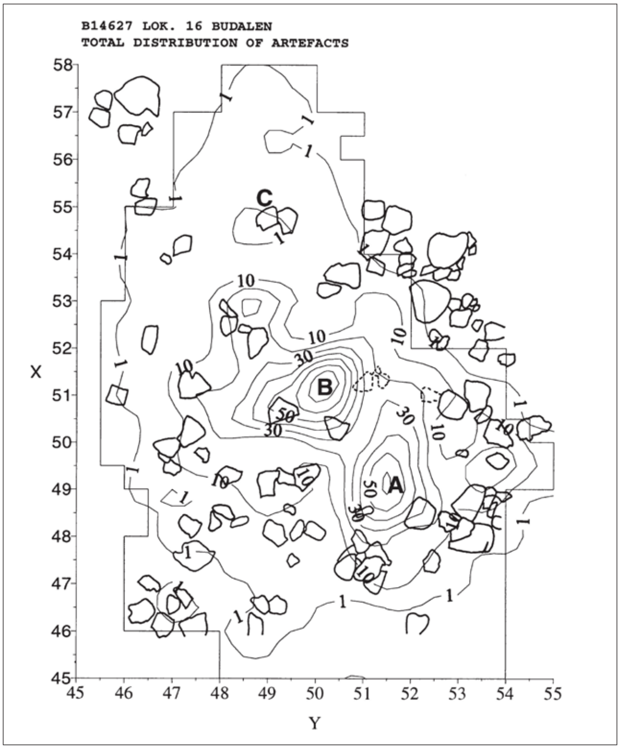

Figure 2: *Site 16 Budalen, Øygarden, Hordaland, Western Norway – artefact distribution on site plan (Elevated stones above the excavated surface are indicated, cf. photo on Fig. 2. Contoured distribution with intervals 1, 10, 20, 30 etc.).*

***Figure 3**: Site 16 Budalen, Øygarden, Hordaland, Western Norway – photo of excavated site surface (scale 1 m) (photo: Arne Johan Nærøy).*

A contextual assessment of the site concluded that the site represented an in-situ situation with primary deposited lithic debris. The site is seen as evidence of the remains of a single-phased, isolated functional and technological activity.

Lithic assemblage and typological dating

The recovered lithic assemblage consists of 3369 artefacts, Figure 4. Notable is the low number of formal tool types: a few projectile points in the form of four fragmented slate points, two pressure-flaked points and one tanged arrowhead. The morphologically defined small tools (26 pieces) only counts for 0.8 per cent of the total lithic inventory. An important issue as far as the technology is concerned, is the dominant use of quartz, which accounted for almost 80 per cent of the lithic waste. The quartz is predominantly reduced using a bipolar technology. However, we must bear in mind that the initial reduction of larger pieces of quartz may have been platform reduction. The quartz is highly likely from local sources as the bedrock contains many quartz ores (Nærøy 1994).

There are no traces of the Early Neolithic cylindrical core technology performed on rhyolite. Only four fragments of rhyolite were recovered at the site. This underlines the change in reduction technique that took place from the Early to the Middle Neolithic. The cylindrical technique was used to a large extent in the production of tanged arrowheads and small tools. The slate points and a tanged flint arrowhead may well be typologically dated to the Middle Neolithic. Their spatial location at the site may, however, indicate a deposition prior to the main activity phase in the Middle Neolithic. The pressure-flaked points are of a later date in

B-14627 SITE 16 BUDALEN	
Morphological type	**Number**
Blade	7
Flake	3291
Misc. core with one platform	1
Bipolar core	11
Other core	2
Tanged arrowhead, A-type	1
Pressure-flaked point, preform	1
Pressure-flaked point, triangular	1
Slate point, fragment	1
Slate point, pointed-oval section	2
Slate point, triangular section	1
Retouched flake	20
Retouched blade	2
Grinding stone, fragment	1
Hammer stone for knapping	4
Pumice with abrading traces	7
Flint nodule	4
Water-rolled flint flake	7
	3369

B-14627 SITE 16 BUDALEN	
Raw material	**Number**
Other	15
Rock crystal	2
Flint	516
Gneiss	1
Quartzite	41
Quartz	2779
Pumice	7
Rhyolite	4
Slate	5
	3369

Figure 4: *Site 16 Budalen, Øygarden, Hordaland, Western Norway – artefact catalogue and distribution of raw materials (Nærøy 1994, 140).*

the Late Neolithic or Bronze Age and secondary intrusions. Water sieving of the excavated soil through a 2 x 2 mm mesh did not document the presence of small, pressure-flaked lithic debris from the production of pressure-flaked projectile points.

The composition of the tool inventory, the technology employed and the raw material composition date the assemblage to the Middle Neolithic (Nærøy 1994, 2000). A closer dating to Middle Neolithic A or B is however, difficult to establish. The local sea-level displacement curve (Krzwinsky & Stabell 1984) does not contradict this; the site is located at 9–9.5 m.a.s.l. indicating an age later than 4400 cal. BC.

Use-wear analysis on quartz debris

The use-wear analysis performed on the site assemblage was based on the methodology and definitions of use-wear patterns developed by Knutsson (1988a, 1988b). In addition to experimentally testing the formation of these patterns of use-wear on quartz, the lithic assemblage from site 16 Budalen was analysed searching for similar use-wear formations (Nærøy 2000). Figures 5.1–5.5 illustrate use-wear patterns identified on quartz tools from site 16 Budalen conforming to use-wear patterns defined by Knutsson.

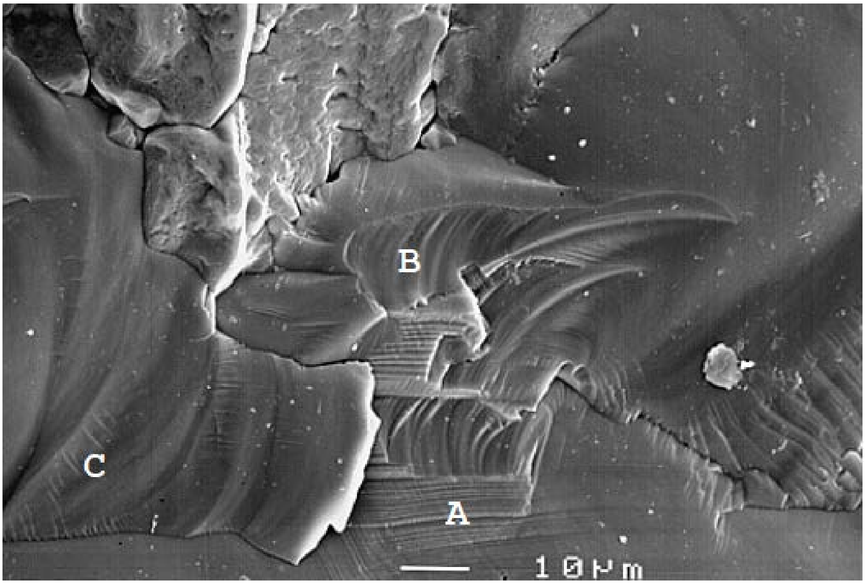

***Figure 5.1**: Fracture plane features on freshly knapped quartz: A/ flat and vertical cleavage planes, B/ conchoidal breakage and C/ ripples.*

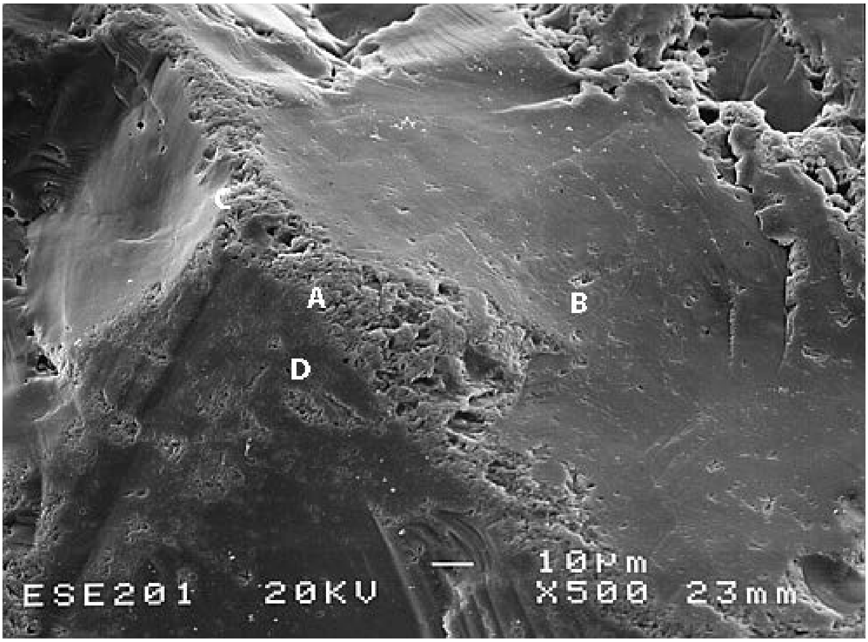

***Figure 5.2**: Use-wear formation on tool B14627/55.2: A/ broken-up ridges, B/ impact pits, C/ smoothing and D/ striations.*

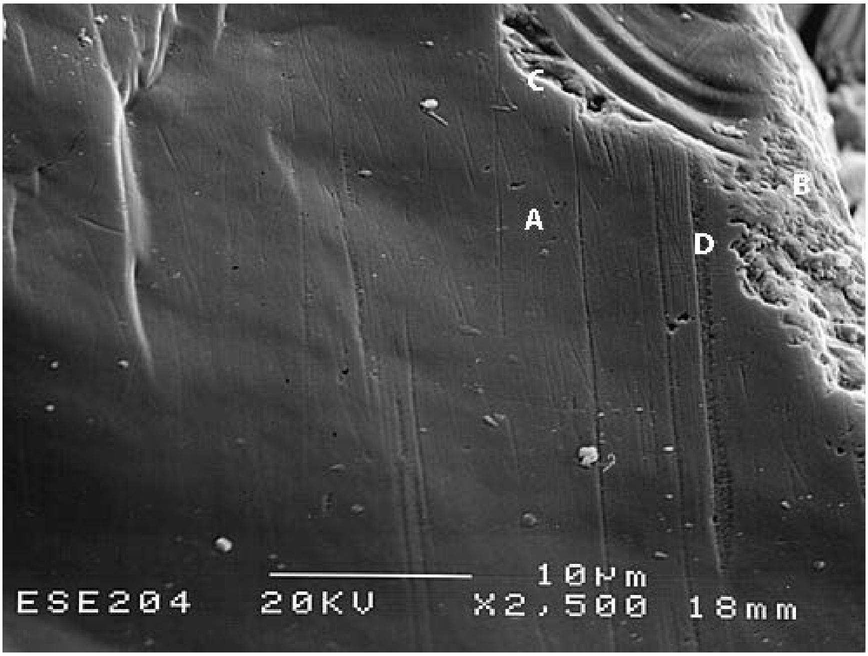

***Figure 5.3**: Use-wear formation on tool B14627/55.2: A/ narrow plastic deformations, B/ edge rounding, C/ smoothing, D/ abrasion area.*

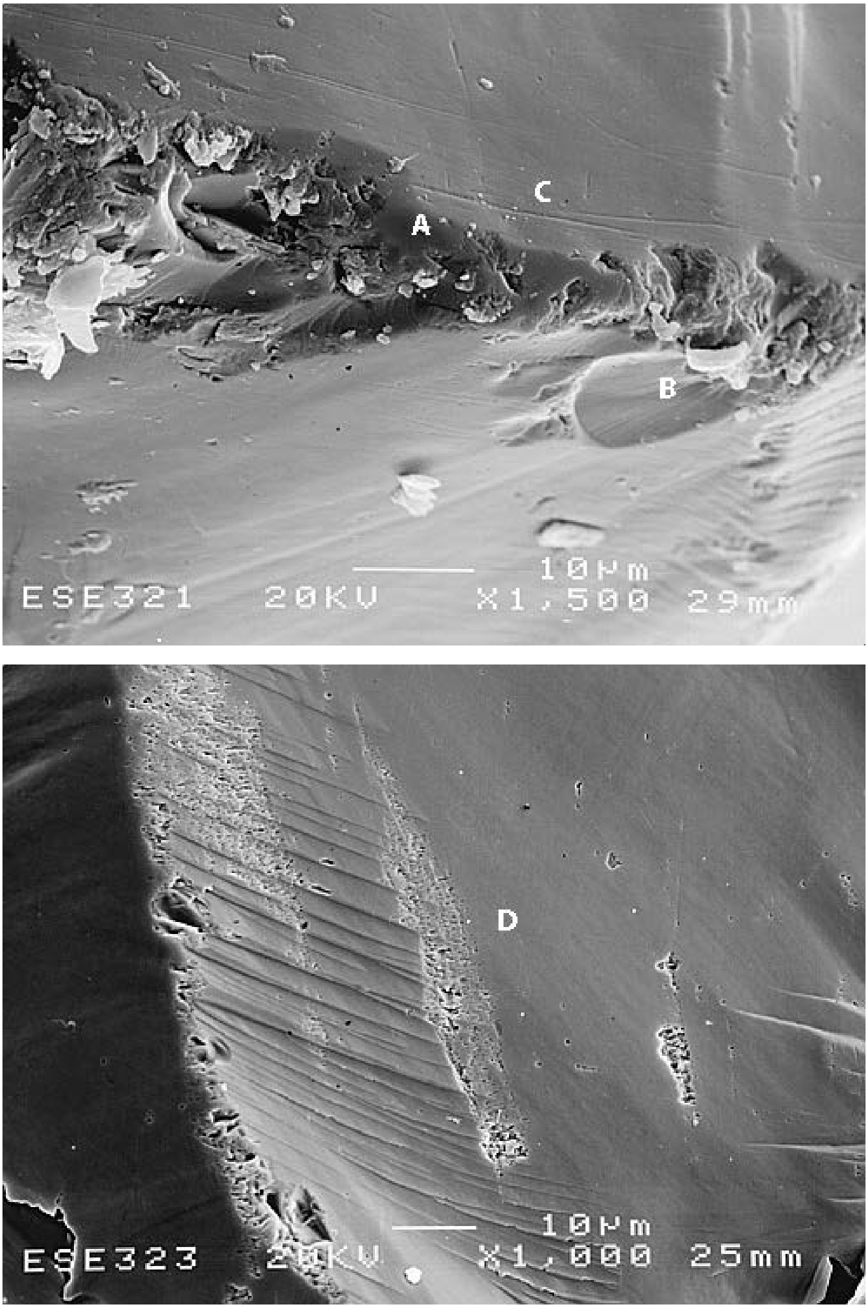

Figure 5.4: *Use-wear formation on tool. B14627/78.1 A/ flake scars, B/ slight edge rounding, C/ straight-sided striations, impact pits.*

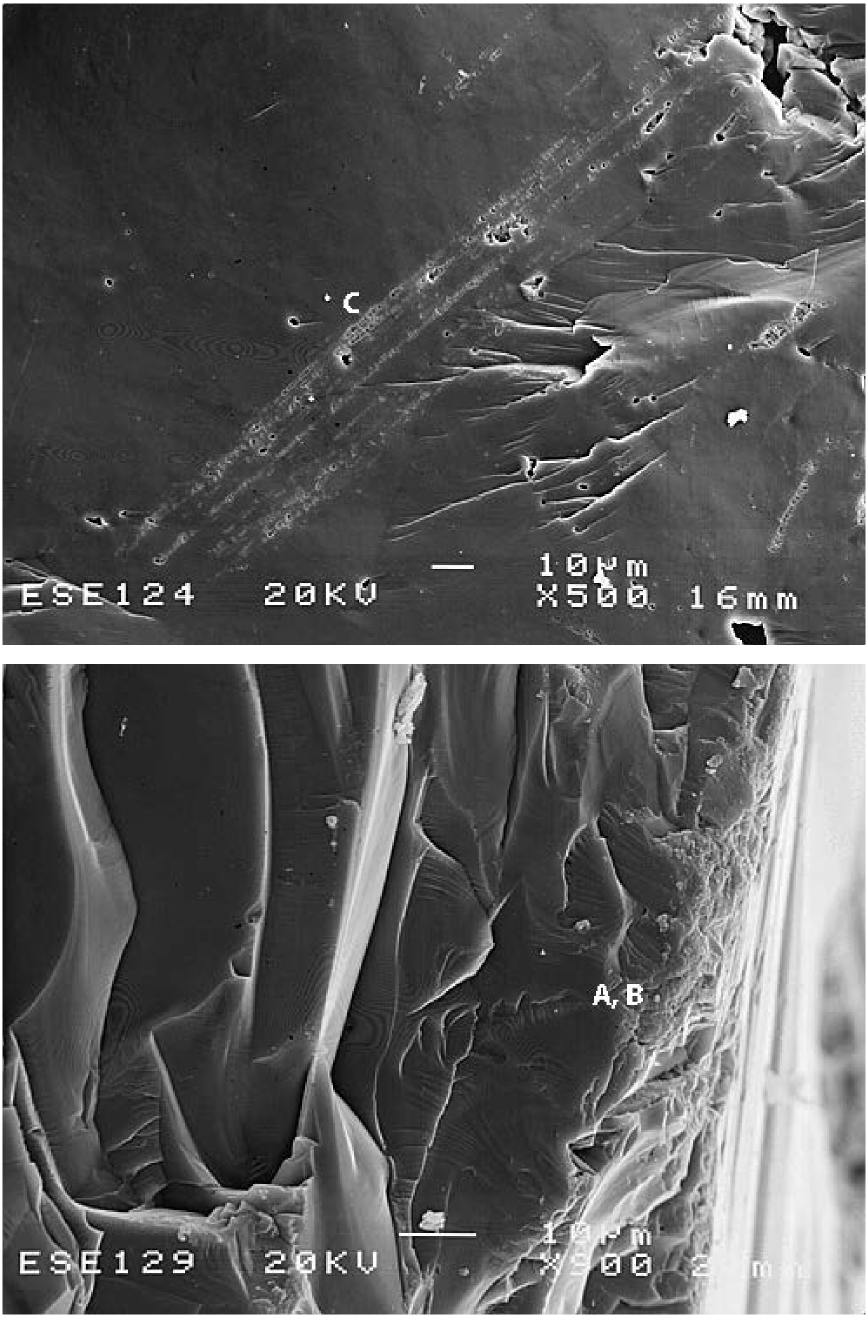

***Figure 5.5**: Use-wear formation on tool. B14627/78.1 A/ flake scars, B/ broken up ridges, C/ straight-sided striations, impact pits and D/ slight edge rounding.*

In the analysis, the following steps were taken (Nærøy 2000). Initially, all the flakes from excavation spits 1 and 2 with dimensions larger than 1 cm were investigated for edges, which could have been used. This was a subjective operation but had to be weighed against scanning all the material in light microscope, which was not possible. Small fragments are difficult to handle and were excluded from analysis. This resulted in 308 artefacts, representing 9 per cent of all finds and 11 per cent of the quartz, being selected and subsequently scanned in a light microscope, Figure 6. The scanning indicated that 24 artefacts were used and seven possibly used. Light microscopy was used to perform use-wear analysis on these 31 artefacts. Furthermore, a scanning electron microscope was used to document use-wear features on some of these tools. The use-wear analysis in the light microscope resulted in the identification of 14 used tools of quartz whereas secure identification of use could not be identified on 17 of the artefacts. This almost doubled the number of lithic tools from the site. The types of use-wear on the tools indicate work primarily on wood and bone, but also hide.

Use-wear analysis site 16 Budalen – scanning light microscope		
Indication	**No. artefacts**	**Percentage**
Used	20	6.5
Used/eroded	4	1.3
Used?	6	1.9
Used?/eroded	1	0.3
Not used	96	31.2
Not used/eroded	176	57.1
Unknown	5	1.6
SUM	308	99.9

Figure 6*: Site 16 Budalen, Øygarden, Hordaland, Western Norway – results from initial scanning of quartz artefacts in light microscope.*

Site interpretation

Formation processes

What consequences does the use-wear analysis on the quartz debris seen in context of the spatial distribution of the lithic debris, have for the interpretation of the site activities and the site as a whole? Based on the contextual evaluation, a close relation between the work activities taking place at the site and the place of deposition of the lithic debris was initially suggested for the site. To reach this conclusion, the analysis of the lithic debris was based on the model of primary and secondary refuse patterns (Schiffer 1976) using size sorting of the debitage from the lithic knapping process as an archaeological parameter. Additionally, a visual comparison of distributional patterns based on experimental but also archaeological spatial patterns from single lithic reduction locations, was made (Nærøy 2000). The lithic debris was sorted in three size classes (<10 mm, 10–40 mm, >40 mm). The spatial co-occurrence and location in similar concentrations of all three-size classes argued for the preservation of complete reduction processes in primary deposited contexts at the site. Traceable refuse disposal patterns of the lithic debris such as distinct distribution or concentration of larger pieces of lithic waste, dense concentrations of debris in peripheral parts of the site or associated with dwelling structures ("wall effect") were not identified. It was concluded that the lithic waste including both waste products and tools, was discarded at the location of use in primary contexts.

The distribution of the lithic debris at the site may be given a "classical" interpretation in terms of a small prehistoric hunter-gatherer location with the preserved remains of two primary knapping and work areas. A slight horizontal variation in the composition of tools used and discarded suggests differences in the activities being performed in the two work areas. Furthermore, the quartz debris was distributed evenly between the two main concentrations of finds, but the individual pieces identified as being used through the use-wear analysis were located in one of these. This implies that the quartz analysis expanded the interpretation further, indicating a differentiation in activities between these two work areas and the individuals performing these activities.

Tool use and space

The use-wear analysis of the quartz and a macroscopic evaluation of fracture patterns in terms of fracture type and direction on tools (Andrefsky 2005) from other raw materials linked to the distributional analysis showed several significant features (Nærøy 2000). The number of tools increased through the use-wear analysis compared to the morphologically defined classification. This was no surprise since use-wear on quartz tools does not have to be visible to the naked eye or even at low magnifications in a light microscope. The identified tools are also a minimum number of tools. This is among other factors due to surface features on the quartz which were believed to be the result of soil erosional processes, which may have destroyed use wear features on the objects (Knutsson 1988b: fig. 85a, Nærøy 2000: fig. 4.23). These added tools underlined the importance of the reduction of quartz as a tool-producing activity.

USE-WEAR ANALYSIS OF ARTEFACTS OF QUARTZ FROM SITE 16 BUDALEN			
ARTEFACT B14627/	**MOVEMENT**	**HARDNESS**	**MATERIAL**
55.2	CUT	MEDIUM	WOOD
60.1	CUT	MEDIUM	WOOD
105.1	CUT	MEDIUM	WOOD–BONE
216.5	CUT	MEDIUM?	WOOD<–>SHELL
749.1	CUT–PLANE	MEDIUM	WOOD
85.3	INCISE (CUT?)	MEDIUM	WOOD–BONE
138.1	INCISE	MEDIUM–HARD	WOOD–BONE
491.1	INCISE	MEDIUM	WOOD
1102	INCISE	MEDIUM–HARD	WOOD–BONE
1199	INCISE	MEDIUM	WOOD–BONE/ANTLER
78.1	SHAVE–PLANE	MEDIUM–SOFT	WOOD
106.1	SHAVE–PLANE	MEDIUM	WOOD–BONE
413.3	PLANE–SCRAPE	MEDIUM	WOOD–BONE
200.1	SCRAPE	SOFT	WOOD–BONE

Figure 7*: Site 16 Budalen, Øygarden, Hordaland, Western Norway – results from use-wear analysis of quartz tools based on light microscopy and scanning electron microscopy.*

The use-wear analysis identified the raw materials being worked by the quartz tools as primarily being in a range between wood and bone for eight tools with four tools being used on wood, Figure 7. One tool had indications of being used on shell and one on antler. The patterns of use-wear features were consistent and might be interpreted within the framework of production and maintenance of equipment with constituent parts of wood and/or bone. Furthermore, tool motions on tools where it was possible to identify, formed a varied picture with identification of tools for cutting and incising but also occurrences of shaving/planing and scraping. The spatial distribution also suggested differentiated locations of the tool used, Figures 8 and 9. Incising tools were primarily located in the central area B, which also was true for a few shaving/planing tools. The cutting tools were, however, located in a small area to the west, outside the central lithic depositional area. Scraping tools were distributed evenly across the site. On a hypothetical level, if these tools were bound together in a continuous work process, then cutting raw material was performed outside the central area of work, whereas further processing occurred in the central work area. This could indicate a dynamic work process where single work operations linked together in a work process were performed on different places at the site.

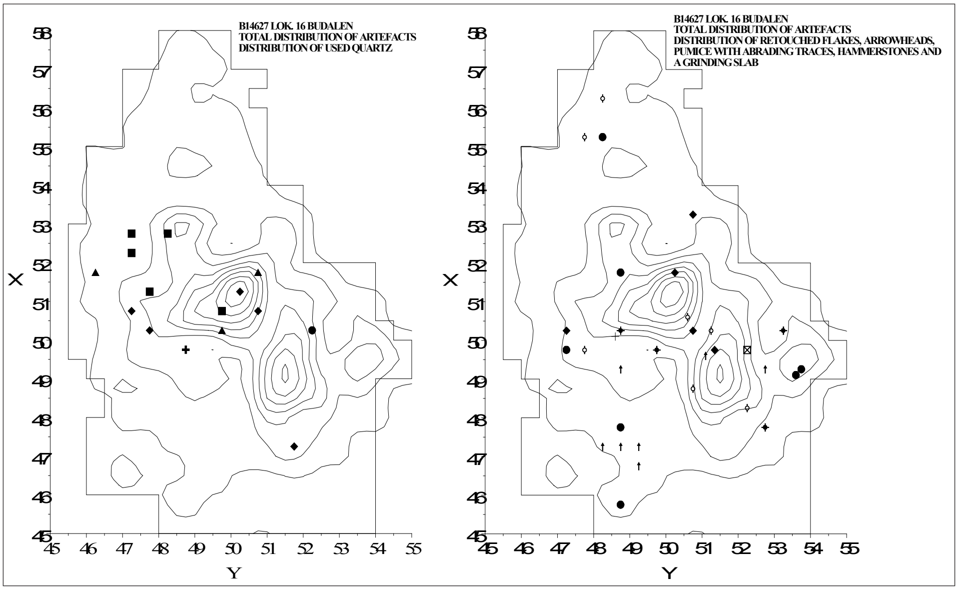

Figure 8: *Site 16 Budalen, Øygarden, Hordaland, Western Norway – distribution of typologically defined tools (right) and tools defined through use-wear analysis of quarts (left).*

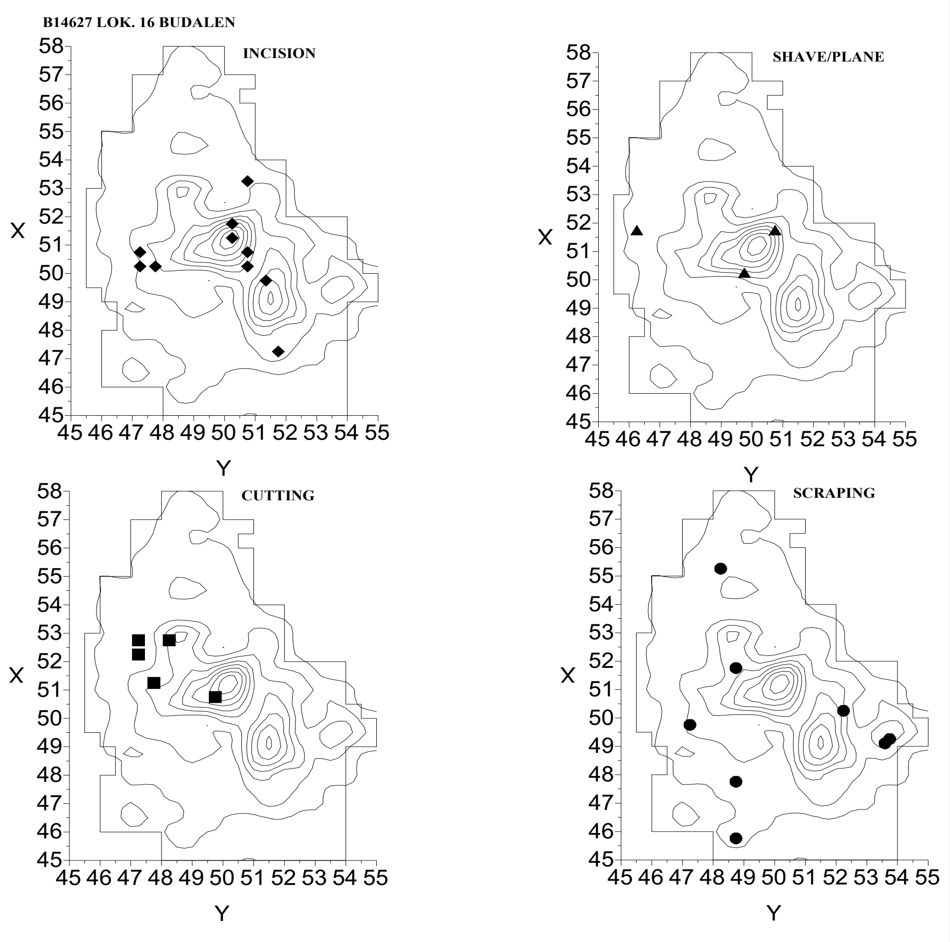

***Figure 9**: Site 16 Budalen, Øygarden, Hordaland, Western Norway – distribution of tool movements for tools of quartz and flint with identifiable tool motions.*

The added tools from the quartz analysis resulted in a greater differentiation of the work processes at the site than could be seen by the morphological classification of the lithic tool inventory. This differentiation was present both in terms of tool types and in relation to the spatial distribution of the activities at the site. This composition and use of tools at the site were governed by several factors. The site was a specific resource utilization event within a larger settlement pattern. The subsistence objective and group mobility conditioned the composition and organization of the group and their activities. This concerned features such as the structuring of the site, the activities performed on the site and the technology employed, i.e. production, use, maintenance and selection of tools and raw materials. In this context, it is of interest to evaluate if the selection of tools discarded on the site represent specific types of tools adapted to the situation or a general set of tools (tool kit; Andrefsky 2005).

To evaluate this in a comparative perspective, Figure 10 presents the distribution of morphologically defined tools from a series of Middle Neolithic sites from coastal Hordaland. These are sites dated within the Middle Neolithic A/B (4000–2200 cal. BC). They are not directly comparable in terms of representing parts of a specific settlement system. However, they are a selection of sites in a coastal area presumably of different types, characters and functions. Figure 10 illustrate that site 16 differs significantly from all the other sites with a low percentage of tools in relation to the total number of artefacts. It is important also to bear in mind that close to 50 per cent of the tools on site 16 have been detected by use wear analysis. This makes the number of tools relatively higher than for the other sites. These differences between the sites may be chronological features but the figure still represent a comparison of a variation of tool sets between coastal sites. The inclusion of artefact classes such as pottery, grinding tools and hammer stones are not directly comparable to the lithic assemblage. They are, however, an important group of artefacts to note on a presence /absence dimension and insignificant in number and percentage.

Site	**Budalen 16**	**Kotedalen 14**	**Kotedalen 15**	**Bjorøy 4 str. 20**	**Bjorøy 4 str. 19**	**Bjorøy 4 str. 30**	**Bjorøy 4 str. 34**	**Austvik IV**
Ret. flake/blade	**0,65**	**2,0**	**2,3**	**1,9**	**2,6**	**3,4**	**1,9**	**8,2**
Arrowhead	**0,1**	**0,9**	**1,1**	**0,4**	**1,2**	**1,1**	**0,7**	**0,9**
Grind. stone, frg.	**0,02**	**0,5**	**0,4**	**0,3**	**0,4**	**0,3**	**0,5**	**0,6**
Adze/chisel		**0,03**	**0,08**	**0,2**	**0,3**	**0,08**	**0,2**	**0,4**
Borer		**0,01**		**0,2**	**0,2**	**0,04**	**0,06**	
Hammer stone	**0,01**			**0,2**		**0,3**	**0,2**	**0,5**
Grinder						**0,04**		
Net sinker		**0,006**					**0,3**	
Pumice, abrading	**0,2**			**0,2**	**0,1**	**0,6**	**0,3**	**1,2**
Pottery, frg.		**0,1**	**0,1**	**1**	**0,06**	**0,08**	**2,4**	
Sum % tools	**0,98**	**3,07**	**3,9**	**4,4**	**4,86**	**5,94**	**6,56**	**11,8**
Sum no. tools	39	115	125	128	139	188	300	536
Sum artefacts	3350	960	3909	3241	2360	3277	7781	15671

Figure 10: *Percentage distribution of tools on coastal Middle Neolithic sites, Hordaland, Western Norway. Numbers collected from Nærøy 2000, tab. 4.2.1, Kotedalen (Olsen 1992), Bjorøy (Kristoffersen, K. 1994), Austvik (Kristoffersen, S. 1990).*

The low number and variation of tools on site 16 strengthens the impression of a specific kind of resource utilization episode. The technology used to solve tasks performed at the site is by the utilization of locally extracted and used quartz. In a technological perspective and related to the subsistence and settlement pattern, it would be important to evaluate whether these tools where of an expedient or curated character, i.e. the degree of mobility involved in the procurement of raw materials as well as the production, use and maintenance of the tools (Rasic and Andrefsky 2001).

Curated vs expedient assemblages

Technologically, the transition from the Early to the Middle Neolithic in western Norway represents the final phase in the use of platform cores to produce regular blades (Olsen 1992, Nærøy 1993, Bergsvik 2012). The Early Neolithic use of rhyolite using cylindrical technique to produce blades for tools such as projectile points and scrapers disappears at the transition to the Middle Neolithic. This was an important technological change in the lithic assemblages and was related to processes of change in terms of subsistence and social and cultural patterns. Analytically and methodologically, the change in raw materials and percussion technique from the Early to the Middle Neolithic is demanding. This concerns both understanding differences in morphological and technological traits and in terms of tool functions identifiable on the different types of raw materials. The technology in its broadest sense, as the sum of interrelated work activities at site 16 Budalen, was different from previous Neolithic and Mesolithic site assemblages in the area. The character and intention of the lithic reduction as an aspect of this had moved away from the blade-producing, single and double platform reduction directed at producing specific tools such as projectile points. Specific retooling activities such as replacing lithic edges on projectiles, characteristic of both Mesolithic and Early Neolithic sites are not evident in the lithic material. In this context, it is suggested that the reduction of quartz at site 16 Budalen was of a more expedient character than the more technically precise reduction of blades on cylindrical platform cores on rhyolite. Expedient technologies implies manufacture of tools on the spot for imminent use and with less formal technological and technical precision utilising local raw materials. This is opposed to a curated technology where tools involving more complex technologies and techniques are manufactured in anticipation of future use, transport and maintenance in time and space (Binford 1973, Bamforth 1986). This is despite the fact that blanks and tools from platform/bipolar reduction of quartz as other types of raw materials have been transported between sites in technological and adaptive strategies including movement of people, raw materials and tool blanks between sites (Knutsson *et al*. 2016). The feature of expediency in the lithic assemblage and technology is underlined by the fact that these tools were produced using locally available quartz as opposed to the regional character of the rhyolite transported to Øygarden from Bømlo in the southern part of Hordaland County (Alsaker 1987). These features stand out as important in terms of the activities performed and the purpose of the site in a larger settlement system.

The need for use-wear analyses

The present small-scale study of quartz implements from site 16 Budalen is one of few use-wear studies of Norwegian Stone Age assemblages. It was intended to illustrate the possibilities for such studies on Norwegian Stone Age material. The difficulty in performing use-wear studies on quartz is reflected by the few studies summarised by Clemente Conte *et al.* (2015, p. 62) in a publication discussing the general status of use-wear studies (Marreiros *et al.* 2015). The lack of use-wear studies may be due to a number of reasons. It is a time-consuming method based on a long period of individual training to develop experience-based knowledge. It is based on costly equipment. Furthermore, Norway does not have a tradition of performing functional studies of this type. Additionally, due to cultural heritage management legislation, studies on lithic material cannot be financed through excavation projects. Use-wear studies are primarily defined as research, which must be financed through research grants difficult to obtain. Functional studies should however be prioritised. This is due to the number and contextual qualities of Mesolithic and Neolithic lithic material available for study and that lithic artefacts in most cases are the only artefactual evidence at our disposal for the interpretation of prehistoric hunter-gatherer sites.

Conclusion

The use-wear analysis of the quartz assemblage from site 16 Budalen resulted in an increased in-depth understanding of site activities and structure through the identification of 14 tools in the quartz assemblage. This is a low number of tools but on a relative scale in terms of the size of the lithic assemblage and the site activity pattern, important, especially considering the spatial distribution.

The structural and functional characteristics of site 16 Budalen fit with a model of the Middle Neolithic in terms of being a logistically-based seasonal camp for a semi-sedentary population located in inner coastal areas. Logistic movements took place and site 16 Budalen can be seen as evidence of utilisation of outer coastal resources. Site distributional patterns and functional evidence suggests the presence of two individuals. A continuous and spatially diversified work process was hypothesised where tools of different function were used on different parts of the site. Site 16 Budalen is, in such a context, evidence of the range and use of sites on the coast in the Middle Neolithic, from large settlement sites to small utility sites.

Furthermore, at the time the use-wear analysis was performed, use-wear patterns identified both on experimental and original artefacts argued for the general applicability of the method and the validity of its criteria and definitions of use-wear patterns on western Norwegian Stone Age material.

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Astrid J. Nyland, Kidane Fanta Gebremariam and Ruben With

Challenging an old theory – Portable X-ray fluorescence (pXRF) analyses of greenstone adzes in Rogaland, southwestern Norway

Abstract

The first large scale regional provenance analysis of greenstone and diabase adzes in western Norway was undertaken forty years ago. The study identified two social territories, which have been central in Norwegian archaeology ever since. Concerns have later been raised regarding the validity of the results due to the dominance of descriptive macroscopic methods, mostly based on visual examinations, used to identify the different rock types. To evaluate the older study, we have undertaken portable X-Ray Fluorescence Spectroscopy (pXRF) analyses of greenstone adzes distributed in Rogaland County, southwestern Norway. However, there are also challenges pertaining to this type of surface-confined analytical technique, such as effects of patination, surface depositions, surface geometry and spectral interferences. Methodological rigorousness and proper documentation are thus vital in order to produce valid data suited for inter- and intra-group comparative lithic provenance studies. Acknowledging the concerns raised, we describe our procedure, including the process of selecting suitable parameters and measures taken regarding the computation and replicability of the measurement results. Our preliminary results suggest that pXRF is indeed a capable non-destructive method for studying the provenance of greenstone adzes. It may also prompt further research into the exploitation of rock, place and identity in the Mesolithic.

Introduction

Was the region of Rogaland in southwestern Norway really a part of a larger southern social territory in the Mesolithic? In the early 1980s, Asle Bruen Olsen and Sigmund Alsaker (1984) argued the existence of two social territories along the west coast of southern Norway. They based their theory on a primarily visual-based provenance study of about 1000 adzes made from greenstone and diabase from two particular quarries (Fig. 1) (Olsen and Alsaker 1984). Our paper presents the preliminary results of a pilot study utilizing portable X-Ray Fluorescence Spectroscopy (pXRF) to analyse 80 Mesolithic adzes from Rogaland County in order to confirm or refute the hypothesis presented in the 1980s (cf. Olsen 1981, Olsen and Alsaker 1984, Alsaker 1987). The central source in the suggested southern social territory was a large quarry at the islet Hespriholmen, 2 km west of the island Bømlo, providing greenstone for adze production in the region of Hordaland and Rogaland counties. In the northern territory, the quarries 'Stakaneset I–V' at the headland Stakalleneset 200 km further north in the county of Sogn and Fjordane, provided rock in a similar manner. The notion of two coexisting social territories has since been central to the understanding of the Mesolithic and Neolithic on the western coast of South Norway (e.g. Olsen 1992, Bergsvik 2002, 2006, Bergsvik and Olsen 2003, Bjerck 2008, Nyland 2016, 2017). However, since most of the identification of rock types was done macroscopically, concerns have lately been raised as to whether the greenstone distribution pattern is indeed valid and as wide as suggested (Bergsvik 2006, p. 120).

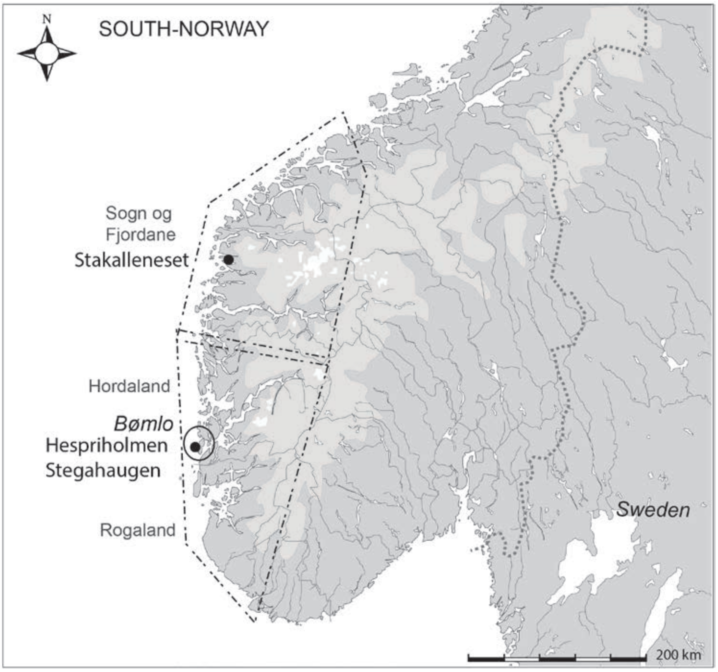

***Figure 1**: Map with place names mentioned in the text and the two suggested social territories by Olsen and Alsaker (1984). Illustration: Astrid J. Nyland.*

Visual methods are often criticized for being too subjective and unreliable (e.g. Crandell 2006, Gauthier *et al.* 2012a, Olausson *et al.* 2012). To address this, pXRF, a fast, non-intrusive and non-destructive method was applied to identify the geochemical signature of the greenstone from the quarries at Hespriholmen and Stegahaugen, another quarry located on the nearby island of Bømlo. In turn, this method was used to re-examine the greenstone adze distribution in the southwestern part of the southern social territory, i.e. focusing on the county of Rogaland (see Fig. 1). The determination of the multi-elemental composition of lithic objects is vital for studying provenance and exploitation of raw material sources. Among the successful analytical techniques for such analyses are inductively coupled plasma mass spectrometry (ICP-MS), neutron activation analysis (NAA) and electron microprobe analysis (EMPA) (Luedtke 1979, Cackler *et al.* 1999, Frahm 2012, Speer 2014a, Speer 2014b, Simpson and Dussubieux 2018). Nevertheless, the need to access advanced instruments, combined with the time required for analysis, the cost incurred and the destructive nature of some of the methods have limited the number of objects studied, but this has also encouraged the development of more accessible and non-destructive methods (cf. Tykot 2016). The pXRF approach has thus given us the means to examine more objects non-destructively, in a relatively short time and at low cost. Our study is the first large regional provenance study of Mesolithic adzes using portable X-Ray Florescence Spectroscopy (pXRF) in Norway.

Multi-elemental analysis based on pXRF can thus potentially be a very useful tool. Used in provenance studies, results could have wide-ranging implications for our understanding and interpretation of prehistoric social relations and societal organization (e.g. Pétrequin 2017, Simpson and Dussubieux 2018). However, there are challenges pertaining to surface-confined analytical techniques like pXRF, such as the effects of patination, surface depositions, surface geometry and spectral interferences. The determination of light elements and the need for matrix-matched calibration are also often encountered difficulties. Methodological rigorousness and proper documentation are vital in order to produce valid data suited for inter- and intra-group comparative provenance studies on lithic materials. For example, an ongoing debate questions whether it is a reliable method for provenance studies at all (e.g. Hancock and Carter 2010, Grave *et al.* 2012a, Frahm 2013, Frahm and Feinberg 2013, Speakman and Shackley 2013). One also asks whether such studies are reliable if they only produce self-contained data for isolated research projects, only internally compatible, and thus non-replicable (Speakman and Shackley 2013). Due to the noted problems with variation in accuracy, sensitivity and precision of employing pXRF, the necessity of methodological rigorousness has been advocated to make sure one produces valid data suited for comparative studies in general (Tykot 2016). Moreover, since pXRF is a non-intrusive method, efforts should be made to explore the potential for applying the method, as it offers possibilities to analyse prehistoric artefacts without destruction. Continuous testing including a wider range of measured rock types contributes to consolidating the method. Besides obsidians (e.g. Frahm 2012), pXRF has also been applied in provenance studies on mafic stones and cherts (Gauthier *et al.* 2012b, Grave *et al.* 2012b, Mehta *et al.* 2017). The selection of heavier elements for the analysis has provided promising results in some of the cases where weathering and patination on the artefacts is a factor that can affect the measurements considerably.

The tacit contract of archaeological interpretation is that we trust in each other's data. Acknowledging the concerns raised to the validity of pXRF data, establishing a sound procedure for our measurements was thus an objective in the pilot study presented in this paper. In the following, we will therefore describe our procedure, including the process of selecting suitable parameters to maximize the validity of the data and replicability of our results. We will present our preliminary findings and some implications that can be further explored in future research. However, we will commence by outlining the older study as an explanation and contrast to our study and results.

Research history – the background to the pilot pXRF study

The greenstone discussed in this article is a metamorphic igneous rock with a massive fine-grained texture, lacking slate structure, phenochrysts and gas voids (geologist H. Furnes in Olsen and Alsaker 1984). In the greenstone at Hespriholmen, 0.1–1 mm epidote lines are visible in the deposit (Fig. 2), yet the rock is relatively homogeneous. Its greenish hue is derived from its content of chlorite, epidote and/or amphibolite. The greenstone investigated was mainly procured at Hespriholmen but also at Stegahaugen, located on the main island of Bømlo. Both quarries tap into a larger greenstone deposit surfacing in more than one place within the Bømlo area but made during one geological event (described by geologists as deposits of 'pillow lava'). There is greenstone at the other islets surrounding Hespriholmen too, but the texture is too coarse and the stone contains too much epidote to be suitable for making adzes (Kolderup 1925). The islets have also been surface-surveyed but no traces of prehistoric quarrying were found (Alsaker 1981, 1987). The sites are located about 13 km apart as the crow flies, yet the quarry on the islet of Hespriholmen was by far the most intensely exploited. Based on topography (measurements of the depth of the scars on the rock face), and the remaining waste piles on the islet and on the sea floor just below the main quarries, Alsaker (1981, 1987) estimated that around 400 m^3 greenstone had been quarried at the site.

***Figure 2**: Picture of the greenstone with epidote lines in the quarry at Hespriholmen. Photo: Astrid J. Nyland.*

The potentially wide range of distribution of rock from Hespriholmen was discovered in the early 1940s. At this time, the geochemical signatures of rock samples from the quarry, alongside two adzes found at Lego in Rogaland about 93 km south of the Hespriholmen quarry, were found to match (Fægri 1944). In the 1960s, Graham Clark (1965) pointed out the vast potential that lay in an extended provenance study of greenstone in western Norway. Following up on this in the late 1970s, Sigmund Alsaker initiated a large-scale study of adzes from the southwestern coast (Alsaker 1982, Olsen and Alsaker 1984, Alsaker 1987). Alsaker's study is the present study's point of departure, and his methodological choices are our reasons for retesting the older hypothesis.

Sigmund Alsaker initially selected adzes and flakes for sampling based on the artefacts' visual appearances. According to Alsaker (1987, p. 33), four visual criteria characterize greenstone from Hespriholmen: the rock has to be homogeneous (1), be without voids from gas bubbles, or phenocrystals (2), the colour should be close to 'Munsell 4.2/1 – olive grey' (3), and the rock should contain hair-thin lines of epidote (4). Altogether 86 samples of greenstone from various contexts were then geochemically analysed for trace elements using XRF (Alsaker 1987, p. 15) (Fig. 3). Forty of these came from adzes found at sites on the west coast and fjord landscapes of southern Norway (Alsaker 1987, p. 57–58). Nine of the 40 adzes came from Rogaland County. Twenty-four of the 89 samples came from flakes from workshop sites located at the island of Bømlo. The rest of the samples came from four other greenstone deposits in Norway, located further south and north on the western coast, in central and northern Norway (Alsaker 1987, p. 37). The results were presented in triangular discrimination diagrams portraying the content of Titanium (Ti), Yttrium (Y), and Zirconium (Zr) (Alsaker 1987 (with references)).

***Figure 3**: Picture of adze with drilled holes after sampling nearly 40 years ago. Photo: Astrid J. Nyland.*

Together, these samples created a frame of reference, identifying variation between greenstone sources and the signature of greenstone from the Bømlo area, from the quarries of Hespriholmen and Stegahaugen. Compared to the sampled adzes, the analyses demonstrated that these clustered within the same area in the Titanium-Yttrium-Zirconium (Ti-Y-Zr) discrimination diagram. Based on this, Alsaker (1987, p. 58) argued that his visual criteria were verified, and with that, their applicability to identifying greenstone through a visual analysis. Hence, out of

2209 visually inspected adzes from the Mesolithic and Neolithic, 736 were visually determined as greenstone from Hespriholmen. Pertaining to our investigation of adzes from Rogaland County, 268 adzes (32 %) allegedly originated from Hespriholmen (Alsaker 1987, p. 55). The distribution of these adzes supported then the interpretation of a social territory covering Rogaland, Hordaland and parts of Sogn og Fjordane in the Mesolithic and Neolithic. Due to the intrusive nature of the sampling procedure (Fig. 3), it is understandable that the number of sampled Mesolithic and Neolithic adzes was kept to a minimum. Nevertheless, that only nine of these adzes were geochemically analysed is potentially problematic. Since then, the developments in the X-ray detectors, optics and associated electronics have progressively also improved leading to ever-increasing sensitivity of pXRF to the elemental determinations even when compared to benchtop XRF instruments used in the 1980s and later. Although smaller samples are now required for benchtop XRF, pXRF enables measuring without any intrusive sampling at all.

In the early 2000s, Knut Andreas Bergsvik (2006) pointed out some problems with Alsaker's analyses. For one, the results had not been sufficiently described and presented, making it hard for later researchers to evaluate them. Secondly, some of the previous identifications were proved false by an isotope study of the content of Strontium (Sr) and Niobium (Nb) isotope levels. Bergsvik (2006, p. 121–23) had thus selected 12 Neolithic adzes from Hordaland and Sogn og Fjordane counties, as well as samples from the two mentioned greenstone quarries, to test the listed visual criteria for greenstone from Hespriholmen. However, the results showed that only two out of 12 tested adzes actually originated at Hespriholmen, or rather, Bømlo. Testing other adzes macroscopically, too, and examining the slate structure of the rock in particular, Bergsvik (2006, p. 120–22) demonstrated that using visual criteria was not a fail-safe method to identify greenstone from Hespriholmen. Consequently, doubts arose as to whether the distribution analysis of adzes in Rogaland could be trusted. Hence, the current pXRF project, measuring the trace elemental composition of 83 adzes and adze fragments from the county of Rogaland, was undertaken. These include several of the Mesolithic adzes previously classified as greenstone by Alsaker, as well as artefacts from newer excavations.

Methodology

The rock and tested adzes

The adzes selected for this study are from the collections of the Museum of Archaeology, University of Stavanger, Norway. They are all typologically classified as Middle and Late Mesolithic adzes with rounded cross-sections and pointed or butted necks. The surface preparation of the adze bodies varies between being fully or partly pecked and ground, but the edge is always carefully ground and polished. The rock type in all of the adzes had previously been recorded as greenstone in the museum's database. As noted earlier, visual and macroscopic identification is challenging, so some of the adzes could have been misidentified in the first place. Moreover, even if all the adzes are greenstone, they may not originate from the same quarry or source.

The surface of greenstone is highly susceptible to post-depositional weathering processes. When exposed to soil acidity, water, sun or air, the greenstone will start to weather, that is, to shed minerals and develop a patina. This is an obvious problem when measuring surface properties of ancient artefacts. The pXRF depth of penetration is affected by the sample matrix's elemental composition, its density and the applied X-ray energy of excitation, often within a range of a few micrometres. Therefore, a selective sampling strategy of the adzes measured has been adapted with a wide range of tests, including measurements to demonstrate the variation found between non-weathered and weathered samples collected at one particular source (Fig. 4). Furthermore, to reduce the possibilities of variation due to weathering, which could affect measurements, mostly polished parts of the adze, which are relatively less affected by patina formation, were measured in our study. In addition to the adzes investigated, measurements were taken on reference samples, including both weathered (W) and non-weathered (N), directly from sources in the Bømlo area, from Hespriholmen, Stegahaugen and a now destroyed workshop site called Løvegapet, located directly east of Hespriholmen. We could therefore establish a solid frame of reference for comparison with the results from the adze measurements.

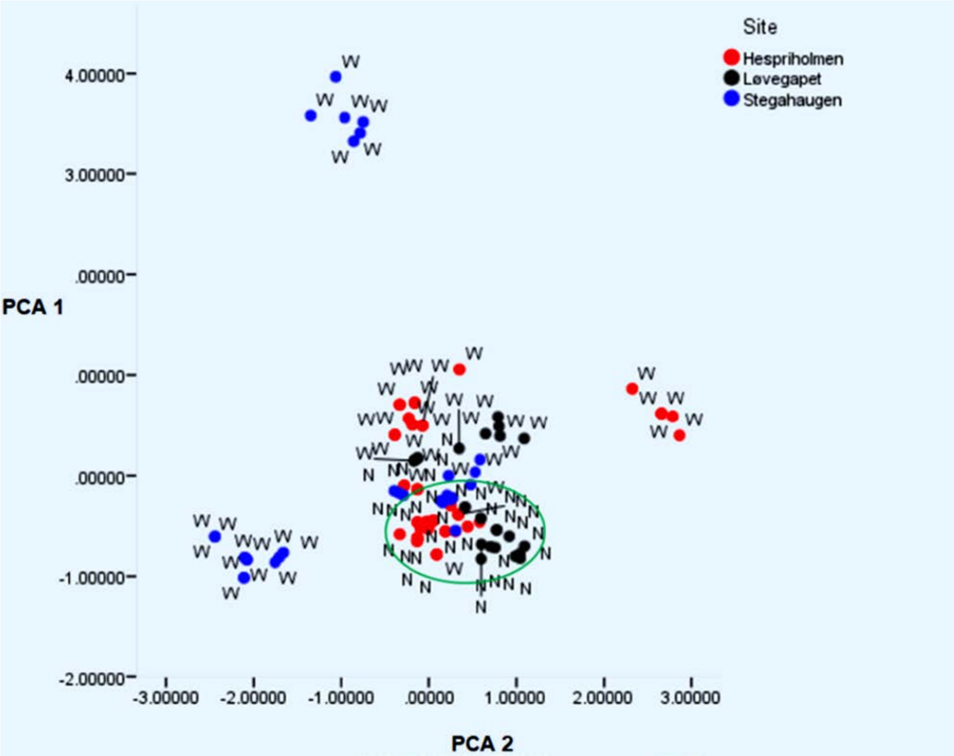

***Figure 4**: Score plot diagram showing weathered (W) and non-weathered (N) samples from Bømlo area (Hespriholmen, Stegahaugen and Løvegapet), PC1 (56.5%) and PC2 (21.8%). Illustration: Kidane Fanta Gebremariam.*

Instrumentation

A Bruker Tracer III-SD portable XRF instrument was used to carry out the measurements. The instrument is fitted with a silicon drift detector (SDD) that allows fast and sensitive measurements. It has a Rhodium (Rh) anode (2W tube) and can allow an application of a maximum of 30μA current at 40 kV voltage and 55μA at 15 kV. The operator has the option of manually inserting one out of four different filters or none at all, depending on the elements of interest being targeted. Count rates of more than 100,000 cps can be acquired, allowing the detection of trace concentrations of even light elements up to magnesium. The resolution is 145 eV at FWHM (full width at half maximum) for Ka of manganese. The alloy calibration can be tested using a stainless steel duplex 2205 check sample supplied by the manufacturer, but it is not straightforward to calibrate the instrument for the intended lithic analysis as it demands matrix-matched standard materials. Data correction schemes and calibration may vary between devices from different manufacturers, even between devices of different series. This can produce non-compatible measurements. We therefore employed the same instrument for all our measurements, and in this case, we analysed the net count, raw data that was not calibrated to an external standard. A primary focus in this paper is thus the testing of the capability of the semi-quantitative data collected from a portable-XRF for the aforementioned greenstone provenance study.

For this study, S1PXRF (version. 3.8.30) was used to control experimental parameters (voltage, current, time) as well as for spectrum collection and storage ARTAX (version 15) was used for processing of the spectra collected, such as element identification, peak deconvolution using Bayesian method, net peak area calculation, and export of the computation results. To present the semi-quantitative data from the pXRF measurements, a relative percentage based on the net peak areas was used after element identification and deconvolution. The relative percentages computed for the sample measurements based on the net peak areas were used to numerically compare elemental concentrations and employed in the multivariate data analysis. This approach is intended to simplify the conversion to more problematic quantitative units. It is applied in the context of non-obsidian lithic material studies that can be affected by surface weathering similar to the samples we have examined (Grave *et al.* 2012b). Our results are, therefore, only internally comparable, but at a later stage, the results will be calibrated with closely matrix-matched standard reference materials. That will make it possible to make comparisons of the data with measurements taken by other researchers working with similar objects.

Method and procedure

As mentioned, concerns have been voiced against the application of pXRF in provenance studies. The critics point to variable accuracy, precision and, in particular, the difficulties in measuring heterogeneous materials (e.g. Frahm 2012, Tykot 2016). Testing archaeological artefacts without intrusive methods is well worth exploring, but needs a stringent procedure. The precision and accuracy of spot testing on the surface of an artefact, employing pXRF is naturally lower than laboratory-based testing on bulk samples with sampling and subsequent sample preparations. Bulk sample testing provides the general elemental composition of the homogenized material of the sample in question, covering representative components of the sample from all parts, not only those confined to the surface. However, spot testing does give us the average elemental composition of the measured areas subjected to the possible weathering and heterogeneity of the artefact surface.

Before starting the study, measurements were undertaken with a variety of filters and without a filter to experience how to maximize the detectability of selected elements. Parameters such as durations of measurements were considered, too. We then chose to measure smooth, flat surfaces with as little weathering as possible and homogeneous texture. In order to partly make up for variations arising from any other heterogeneity and surface confinement, we chose to take five to six measurements per stone adze or flake, increasing the accuracy and precision of the analysis. All samples were measured at 40 kV and 30μA current, without the use of filters, and vacuum for an acquisition duration of 120 seconds. This gives enhanced sensitivity to heavier elements that can be used as geomarkers, while also allowing for measurement of lighter elements. The spots where measurements were taken were all documented on photographs to ensure the replicability of the measurements (Fig. 5).

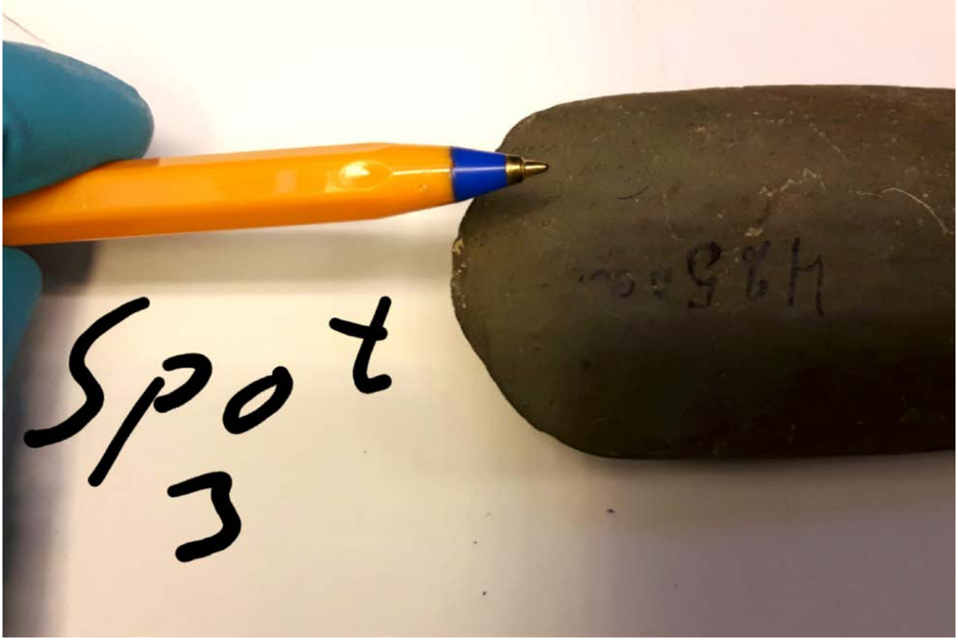

***Figure 5**: Photo documentation of test spots. Photo: Ruben With.*

Some sample measurements were repeated in order to check whether the measurements changed over time, and to assess the effect of time on the measurement of elements from different samples. As to the latter, differences in the effect of prolonging the time on the intensities of the elements on different samples were noted, though there is a generally increasing trend with time (Fig. 6). The enhancement with extended time was more predominant for strontium and zirconium in both samples tested compared to that of yttrium, rubidium and niobium. With regards to the sensitivity of the method, these can imply and reflect the accuracy and precision of the measurements.

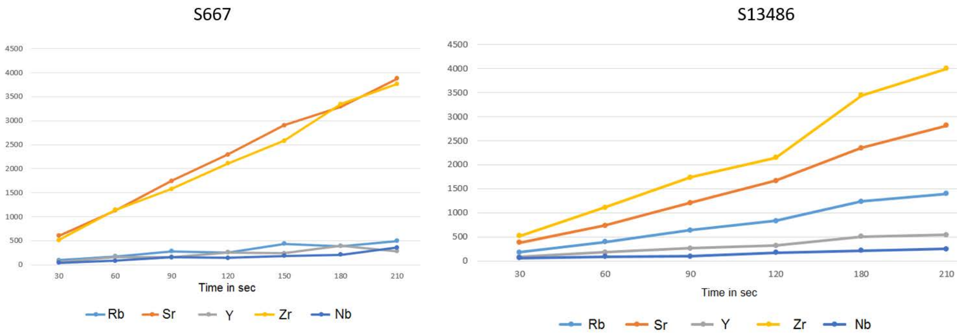

***Figure 6**: Effect of time of measurement on the intensities of pXRF peaks for some of the elements used in the provenance study. The sample used in this case are S13486 and S6667. They show clear variations in the pattern of peak intensities for the five elements, and thus their respective computed net peak areas, are observed for the different samples. Illustration: Kidane Fanta Gebremariam.*

There is variation in the precision of the measurements from sample to sample. A mean value of the elemental composition of each object was therefore computer generated from the five to six measurements, based on the peak areas of the respective detected and selected elements (listed below with their element symbol and number). Net integrated peak areas of potassium (K, 19), calcium (Ca, 20), titanium (Ti, 22), vanadium (V, 23), manganese (Mn, 25), iron (Fe, 26), copper (Cu, 29), zinc (Zn, 30), gallium (Ga, 31), rubidium (Rb, 37), strontium (Sr, 38), yttrium (Y, 39), zirconium (Zr, 40), niobium (Nb, 41), tin (Sn, 50) and lead (Pb, 52), were calculated with ARTAX software and later converted to relative percentages. The quantitative results were then subjected to multivariate analysis (Principal Component Analysis (PCA)) using Statistical Package for the Social Sciences (SPSS) software version 25. Non-rotated PCA was used in the analysis. This has been instrumental for analysis of the data and visual display of the results in a simplified manner.

Results

Ti, V, Rb, Sr, Y, Zr, and Nb were used in the PCA of the greenstone adzes, as most of them are used as geomarkers in lithic analysis and have been shown to be successful for determining sources for artefacts like obsidian tools and ceramic fragments (Tykot 2002, Little *et al.* 2011, Speakman and Shackley 2013). This also proved to be successful for greenstone. Hence, our analyses indicate that pXRF is indeed suitable for non-destructive analysis of the composition of greenstone objects. We can geochemically compare measurement results from distributed artefacts without intrusive sampling. An apparent benefit is our possibility of establishing a sound frame of reference: the presumed source of origin of the greenstone (see Fig. 4 and 7). Several groups are differentiated, allowing for a wider effect of weathering based on the measured results on samples from the Bømlo area. We also identified clusters and tendencies in the employment of more than one greenstone source for Mesolithic adze production in Rogaland County (Fig. 7).

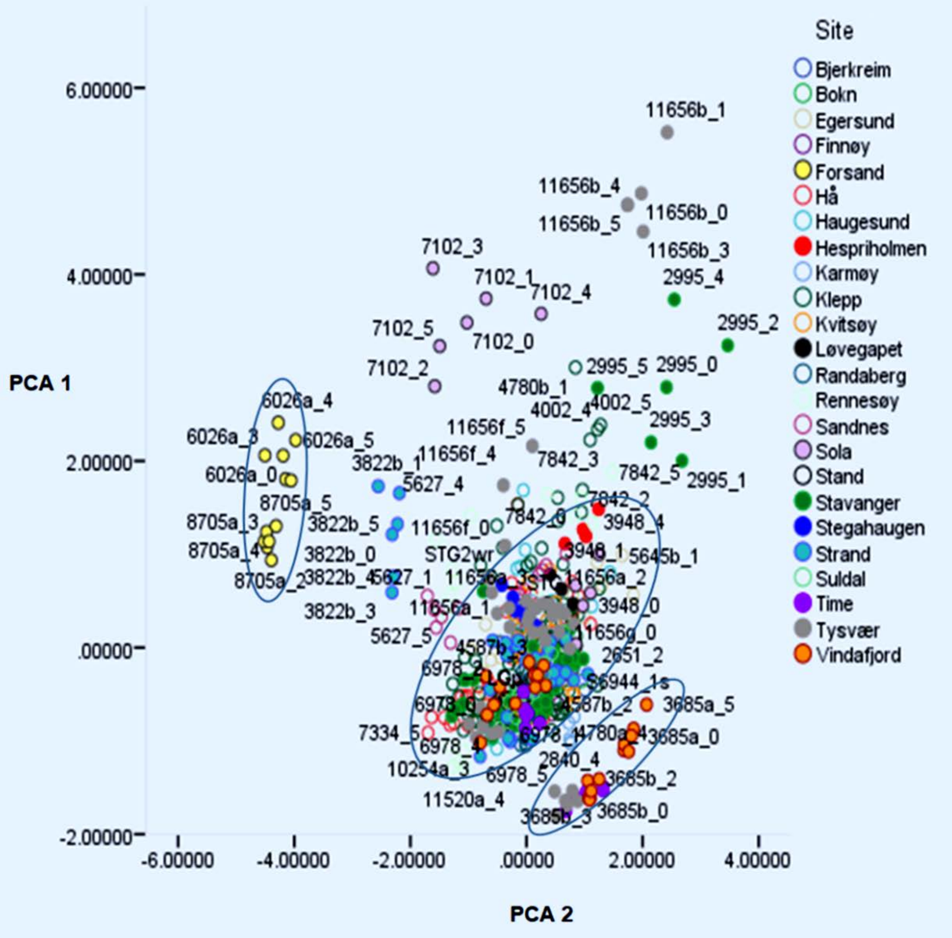

Figure 7: All results displayed together in diagram marking clusters of other sources. The score plot from the measurements on the adze samples and reference samples (PC1 (44.4%) and PC2 (19.8%)). Greenstone from the Bømlo area, including Hespriholmen, Stegahaugen and the workshop site Løvegapet, are found within the circle in the middle. Two groups are encircled marking other sources of greenstone exploited in Rogaland, upper left, and lower right corner. Illustration: Kidane Fanta Gebremariam.

The PCA score plot shows some differentiation in the geochemical composition of the Bømlo area samples from a few other potential sources. The majority of the source materials used in the adzes is traced to the Bømlo area (central encircled cluster). Some samples from Time, Tysvær and Vindafjord (circle in lower right area) appear to have similar composition, yet are distinct from the Bømlo area samples. Two samples from Forsand (circle upper left area) form another distinct separation from the source from which we have reference samples. Our results thus demonstrate that among the tested adzes, greenstone from Hespriholmen was a dominant source. Overall, the visual analyses of the 1980s are more or less supported by the pXRF analyses we conducted. However, our results give rise to new questions of a more cultural-historical nature.

Discussion and implications of our finds

We could not statistically distinguish between greenstone from the Hespriholmen and Stegahaugen quarries using pXRF. However, neither the XRF analyses on ground samples from the 1980s, nor the isotope analyses of the early 2000, managed to distinguish between them either. As mentioned, the greenstone was most likely made during the same geological event. Still, archaeological investigations show a varied scale of exploitation of the two quarries, where Hespriholmen seems to have been more intensely used than Stegahaugen. Although Hespriholmen probably dominated, both were in use from the Middle Mesolithic to the Middle Neolithic (Olsen and Alsaker 1984, Alsaker 1987, Bergsvik and Olsen 2003, Nyland 2016). Hence, there seems to have been something about greenstone from the Bømlo area that caused the inhabitants of southwestern Norway to prefer rock from this place. The continuous use of Hespriholmen might have started as a predictable source for high quality raw material, yet after a millennium, and even after the transgressing sea threatened to drown the site as the sea rose, people continued to return and quarry this deposit (Nyland 2017). Even today, one may only land a boat at the islet of Hespriholmen if the weather is calm; the sea and weather around the islet are treacherous. Perhaps the latter was a reason for establishing a quarry at the safer and more accessible quarry on the main island, at Stegahaugen.

Our main result shows that the exploitation and distribution of greenstone adzes from Bømlo was indeed wide (Fig. 8). Nevertheless, even if all the greenstone adzes from Rogaland are truly from the Bømlo area, they comprise only one third of all the recorded Mesolithic adzes in Rogaland. That said, no other extensively used quarries similar to the large quarries at Hespriholmen or Stegahaugen are known in Rogaland. The results demonstrated that other sources of green rock similar to the greenstone must also have been exploited during the Middle and Late Mesolithic. Knowing the geographical location of these adzes may help us to delimit new areas of where to survey for new adze quarries, if this kind of information is pursued and expanded. Another question for future research is whether the use of greenstone that was so similar to Hespriholmen might have been an intentional strategy. Could there have been restrictions on access to greenstone from the Bømlo area? If so, could a green adze represent the same as Bømlo greenstone in a socio-cultural setting?

The confirmed distribution of Mesolithic adzes indicates that the quarry, or indeed the Bømlo area, probably did function as a node in a social territory. Throughout the Mesolithic, the Hespriholmen quarry also physically developed a monumental character. In an area where there were no other enduring human-made structures, these persisting scars made by previous generations could, over time, have come to materialize a mythical past and ancestors (Nyland 2016, 2017). Hence, in addition to confirming the theory presented in the 1980s, our pXRF study also indicates that we should explore the fact that there can be more to rock than meets the eye.

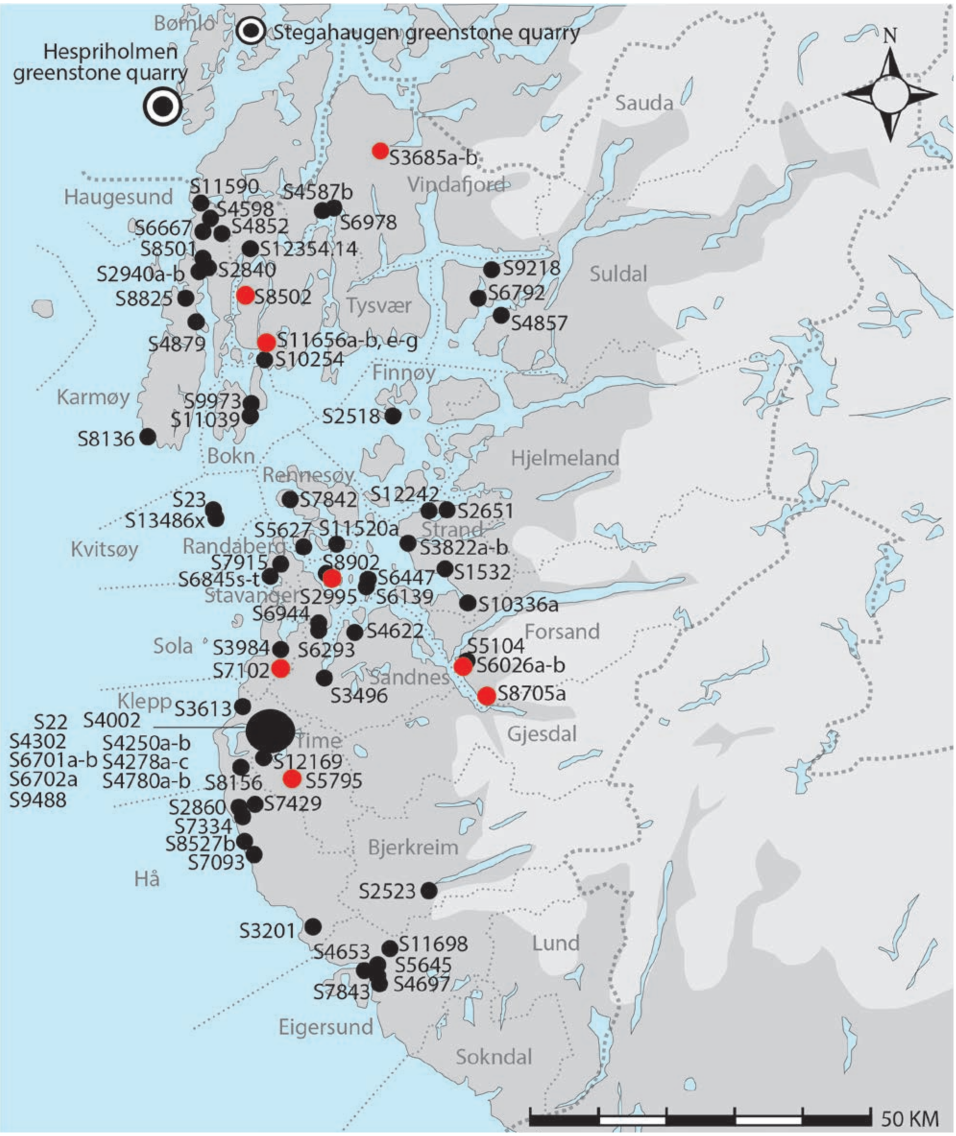

Figure 8*: Distribution map of the measured adzes. The ones that are most likely not made of Bømlo greenstone are marked with red. Illustration: Astrid J. Nyland.*

Final remarks

There has been a growing trend in the last decade to use methods and approaches from the natural, 'hard' sciences to analyse archaeological material. This interest in applying scientific methods can be seen, for example, by the number of pages in the annual volume of the Journal of Archaeological Science, which has increased five times over the last two decades: from 600 pages in 1990, to around 1200 in the year 2000, to around 3400 in 2015. Advances in technology provide archaeology with an expanding empirical base for interpreting and gaining insight into past human lives and societies. New techniques enable more aspects of the archaeological record to become part of archaeological considerations. The new advances in technology have made it possible for archaeologists to demonstrate and establish relations between sources and sites with more certainty than before. Since the results are used to validate sometimes lofty theories, our trust in the validity, or refutation, of identified relations and empirical data is thus of outmost importance. This trust is often founded on our confidence in the applied methods, but it requires that we acknowledge the challenges and problematic aspects associated with these new methods and techniques, too. In this article, we hope that the technique we used and the methodical generation of our results are transparent. As pertains to our point of departure, pXRF did prove to us to be a powerful tool, offering suitable data to challenge old truths and theories. With reference to future research, we are in the process of comparing and contrasting the results from the portable instruments with a more sensitive and accurate analytical method: Inductively Coupled Plasma-Mass Spectrometry (ICP-MS), which can be used for comparisons with the XRF results from reference samples of the known sources. However, that will be the topic of another paper. Furthermore, and perhaps even more important, the patterns revealed will be put to use to write more histories of the past (Nyland 2021).

Acknowledgements

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Birgitte Skar

Mobility and material culture in the Middle Mesolithic of Fennoscandia – validating the input from biomolecular studies

Similarities in late-glacial lithic technology (direct percussion) of western Europe and the oldest counterparts of Scandinavia appearing around 11,700 BP have sustained arguments for an early postglacial migration from northwestern Europe into Scandinavia including coastal areas of northern Norway. However, another lithic technology (pressure blade), occurring in Fennoscandia around 10,300 BP, indicates contacts with groups in the east and potentially a second and east-west migration deriving from the Russian mainland.

aDNA studies of some of the oldest coastal human individuals from Europe, represented by two Norwegian skeletons (9500 BP) unveiled admixture of southern hunter gatherer (SHG) and eastern hunter gatherer (EHG), descended from isolated Glacial refugia. The Norwegian samples show dominance of EHG while contemporary samples from Gotland show a dominance of SHG ancestry. Isotopic markers of a diet consisting of more than 80% marine protein deriving from the highest level of the food chain sustain the importance and likely attraction of marine mammal resources. The biomolecular results underpin a second migration into Norway from northeast c. 10,300 BP, likely over the Cap of the North. Recent lithic studies covering larger parts of Central Scandinavia and Russia, however, provide a more fine-tuned narrative of networks and pulses of migration.

Introduction

In 2018 an article was published in *PLOS Biology* (Günther *et al.*) presenting the results of biomolecular studies of aDNA and stable isotope of some the oldest known human individuals from coastal Europe. The analyses of these individuals found in Norway and Sweden suggests that the first human settlers on the Scandinavian Peninsula followed two distinct migration routes.

There is consistent evidence of a human presence in the Scandinavian Peninsula from around 11,700 years ago on the Swedish west coast and from 11,500 cal. BP along the Norwegian coast (Breivik 2016, Appendix B). Similarities between stone tool artefacts and technology found in Scandinavia and those seen in Western Europe suggests that people deriving from the North West European Ahrensburg culture were the first to enter this part of Scandinavia. Approximately a millennium later, a new technology resting on specialized blade production from conical cores was introduced in Fennoscandia and on the west Scandinavian Peninsula.

Based on meticulous studies of technology and radiocarbon dates it has been suggested (Sørensen *et al.* 2013) that east european groups migrated into present day northern Finland and Norway from the northeast, around 10,300 cal. BP.

The genetic studies comprise seven Scandinavian hunter-gatherers dated to be 9500–6000 years old. The analysis indicates that migrations into the Scandinavian Peninsula most likely followed two routes; one from central Europe and one about a millennium later from the Northeast: from Russia, via Finland and further down along the Norwegian Atlantic Coast (Günther *et al.* 2018). The biomolecular analysis thus underpins the initial stone technological studies. Further studies (Kashuba *et al.* 2019) strengthen the evidence of an association between the introduction of technological innovations and human demographic processes involving admixture during the Middle Mesolithic. The two groups EHG and WHG are suggested to have met and mixed in Scandinavia, creating a genetically diverse population.

Stable isotope analysis gives an input to understanding the resource base of these Middle Mesolithic people (Skar *et al.* 2016, Günther *et al.* 2018, S1). The genetic studies also give comprehensive information on the physical nature of the analyzed people, this will however not be a focus in the present article.

In this article, we will seek to investigate how this new and independent information on the Middle Mesolithic population can be integrated in studies of cultural development together with material culture studies. Aspects of mobility will be at the core of the discussion, but also further lines of enquiry are suggested.

The setting – environmental trajectories

The environmental trajectories in early postglacial Scandinavia and part of Northern Europe have been described in a recent chapter in vol.1 of 'The Early Settlement of Northern Europe' (Skar and Breivik 2018, p. 1–18).

The environmental development during the timeframe from the preboreal period 11,500 cal. BP until the subatlantic arround 4500 cal. BP can in many respects best be understood as an aftermath of the Weichselian. It represents a period of dramatic landscape changes in Scandinavia and Northern Europe; the final melt down of continental glaciers, isostatic land uplift and sea-level fluctuations, as well as alternation between a dammed and open Baltic Sea (Skar and Breivik 2018). While the general trend during this period is gradual heating, three marked early Holocene cold events, at c. 10,300 cal. BP, 9200 cal. BP and 8200 cal. BP that can be traced in climate reconstructions from the Greenlandic Ice cores (Björck *et al.* 2001, Rasmussen *et al.* 2007, Seppä *et al.* 2007, Manninnen *et al.* 2018) with effects throughout large areas in Europe would have had impact on both marine, lacustrine and terrestrial ecosystems. The inland ice still lingered in the interior of Northern Scandinavia, and the area covered by the Fennoscandian Ice sheet was not completely ice-free until c. 8700 cal. BP (Patton *et al.* 2017, see also Mangerud and Svendsen in this volume). Around 10,300 cal. BP a shortlived cold period has been documented particularly in the Fennoscandian areas to have had eco-dynamic repercussions, also potentially influencing demography and for a while halting the beginning spread of human population towards northwest from Russia and Finland (Manninen 2014, Manninen *et al.* 2018).

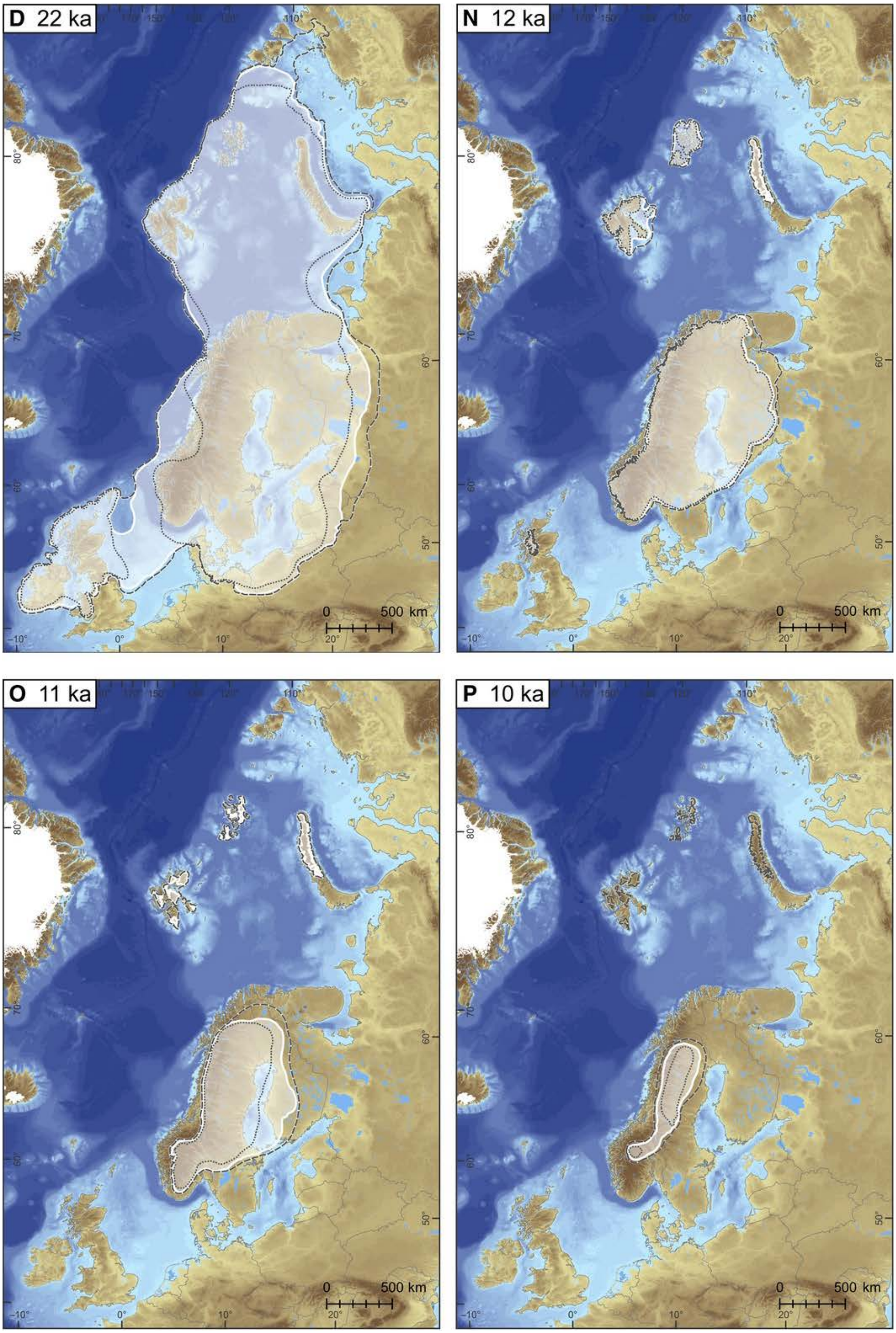

Figure 1: Timeslice reconstruction of the extent of the Eurasian ice sheet from Late Glacial Maximum (LGM) to the 10000 cal BP. Dates are expressed in calibrated years BP. After Hughes et al. 2016, Figure 6. The datasets are available for download at https://doi.pangaea.de/10.1594/PANGAEA.848117. Reprinted with permission.

In most parts of Europe, Early Holocene coastal areas are now inundated, resulting in early postglacial shore-bound settlement being submerged. Due to the great thickness of the ice sheet, the Scandinavian Peninsula underwent rapid isostatic land uplift, parallel with sea-level rise, as the weight from the ice diminished during the Late-glacial meltdown. This has resulted in elevated ancient shorelines in larger parts of central and northern Scandinavia (Schmitt *et al.* 2009, Schmitt and Svedhage 2015, Breivik 2016, Skar and Breivik 2017). A more characteristic development on the west and southern coast of Norway and Sweden is, however, that at least boreal coastlines were eroded and covered by the Tapes transgression occurring between 9000–6000 BP (i.e. c. 8200–4900 cal. BC) (Svendsen and Mangerud 1987). Some parts of the ancient Norwegian coast from this period remain inundated today, and can be compared with the situation in other parts of Europe (Bjerck 2008, Nymoen and Skar 2011). These factors have important repercussions for our ability to reconstruct middle Mesolithic settlement along larger parts of the coastline.

The environmental trajectories of the Baltic Sea are also mutable. The subject is addressed in many publications latest by Påsse and Daniels (2015). The Baltic Ice Lake had already by the Boreal period been though several phases of transformations, from a long phase during the Late Glacial as a dammed freshwater basin through a dramatic drainage episode towards the end of Younger Dryas (11,700–11,600 cal. BP), that caused the waterlevel to drop approximately 25 meters during the course of 1–2 years. The following period – the Yoldia Phase – was brackish/saline where the basin was connected to the North Sea towards the northwest lasting until approximately 10,700 BP. A new tilting caused by the diminishing inland ice led to a new damming called the Ancylus Lake stage (Tikkanen and Oksanen 2002, Skar and Breivik 2017). This is the period of particular relevance to the present study. Areas previously inundated emerged from the sea, and former dry land became submerged. Approximately 8500 cal. BP, the conditions again turn back to marine, marking the transition to the Littorina Sea stage. During this period the southern Baltic, up to approximately the Stockholm-south Finland area, would experience transgressions.

These climatic and eustatic changes would have had a contemporary impact on both ecosystems and humans, in addition to our ability to relocate archaeological sites from the Boreal period. The question is, however, to which degree the pioneer societies were resilient to the very dynamic nature grid conditions, as suggested by some authors (Breivik *et al.* 2018). Perhaps particularly the alterations in the Baltic Sea and substitution of biomass between saltwater, brackish and freshwater ecosystems would have affected the human impression of stability or instability of resource access in this region. The tilting around 10,700 cal. BP may also to a lesser degree have affected the terrestrial biomass, at times demanding longer periods of vegetation recovery, and thus influencing grazing areas for large ungulates and other sources of prey. The question of migration roads particularly in the Fennoscandian areas has recently been discussed in an article by Kleppe (2018) who suggests a delay in the first pioneer migration from the south along the northwest coast of Norway due to calving ice and subsequent tectonic activity in the earliest Holocene from Northern Trøndelag to southern Troms. Instead, he suggests that the first pioneers of western Fennoscandia would have derived from the northeast already during the Preboreal period. However, Kleppe's (2018) comprehensive and thought-provoking studies do not comprise an analysis of the actual material culture remains on the settlement sites. The question is to which extent the natural circumstances that took place from 11,600–11,400 cal. BP, and would clearly have affected the terrestrial ecosystem, would also have influenced a highly marine oriented occupation entering contemporaneously or a bit later.

On the east side of the Baltic, we have the earliest settlement in southern Finland 11,100 cal. BP (Tallavaara *et al.* 2010, Tallavaara and Seppä 2011, Rankama and Kankaanpää 2011). The Baltic sites represent a Post-Swiderian technology deriving from the east. Settlement sites and radiocarbon dates suggest a climatic setback caused by the 10,300 cal. BP cold event, thus indicating two pulses of migration into northeastern Fennoscandia (Tallavaara *et al.* 2014, Manninen *et al.* 2018), of which the Sujala assemblage (c. 10,300 cal. BC) represents the earliest (Rankama and Kankaanpää 2018). The Baltic Sea would have been at the Ancylus stage and thus a freshwater basin during this period while the Coast of Norway represented extensive areas of relatively sheltered archipelago rich in marine resources. In the inland areas of Southern Norway and Sweden as well as in Finland east and north of the ice-cover, the ice was gradually giving way to vegetation and thus providing grazing resources for large ungulates (Tallavaara *et al.* 2014, Kleppe 2018).

Further east, north of the Ural mountains late Paleolithic sites have been found on the northern coast. These sites have a very wide specter of dates – the oldest from 43,000 cal. BP (Pitulko *et al.* 2004). More recent data on deglaciation and archeological documentation exists from for example Pymva Shor cover the period 26,300–11,600 BP (Hughes *et al.* 2016, Stroeven *et al.* 2016; Östlund 2018). Some early Mesolithic sites that are contemporary to the North Scandinavian sites have been documented on the Kola Peninsula and the coast of the White Sea. Although such a scenario does open the possibility of very early Holocene migration from the northeast into western Fennoscandia, we presently lack a more detailed knowledge of the chronology of these sites (Hartz *et al.* 2010, Günther *et al.* 2018, S1).

Material culture indications of mobility during the middle Mesolithic in Middle and Northern Scandinavia

The lithic material

During the last years, an impressive amount of work has been done analyzing lithic materials with a particular focus on the spread of the middle Mesolithic narrow blade technology in Scandinavia (e.g. Sørensen *et al.* 2013, Damlien 2016, Damlien *et al.* 2018, Guinard 2018, Manninen *et al.* 2018, Rankama and Kankaanpää 2018, Sørensen 2018). It has been argued that producing long narrow blades from conical blade cores by pressure or lever is a technology that has its point of departure in 'Post-Swiderian' hunter-gatherer lithic traditions dated to approximately 11,500 cal. BP on the Russian plain (Sørensen *et al.* 2013). This technology is found on sites belonging to the Butovo/Veretye inland forager groups (Damlien *et al.* 2018). Around 10,300 cal. BP this technology spread as earlier mentioned from the east to northern Finland north of the Scandinavian Ice Sheet where it can be found on the Sujala site and in the Varangerfjord area (Rankama and Kankaanpää 2018). Sørensen *et al.*'s (2013) analysis is based on a chronological trend from east to west in the materials. They argue that technology spread primarily because of intergroup communication along the Norwegian west coast towards the south, while there may have been a route south of the Scandinavian Ice Sheet back towards the east. The spread of this so-called conical core pressure blade technology (CCPBC) was suggested to have taken a different route slightly later and more directly via the Baltic towards Bornholm and southern Scandinavia, where the lack of platform preparation on the cores distinguishes it from the chaine operatoire of the northern version.

In their 2018 article Damlien, Kjällquist and Knutsson (p.110–112) diversify Sørensen *et al.* (2013) initial interpretation of a potential eastern migration. In line with Tallavaara *et al*'s studies (2014) the authors suggest that there must have been at least two and possibly more pulses of eastern migration. Their studies are underpinned by a large amount of radiocarbon dated and analyzed sites along an east-west gradient from Russia to Norway (Damlien *et al.* 2018, Appendix 5.1). Based on the lithic technological studies the first expansion (10,500–10,300 cal. BP) did not reach further into Norway than the Varangerfjord area. A second and more massive migration, resulting in many dated sites and a substitution of the old direct percussion technology with the new indirect and pressure technologies, happened after 10,150 cal. BP in Central Sweden and inland Norway. This expansion can be linked to the meltback of the Fennoscandian Ice Sheet, where eastern foragers would have investigated the recently opened areas also south of the Ice sheet. The re-examination of the narrow blade technology from the deep pit at the Huseby Klev site in Bohuslän on the westcoast of Sweden dated to c.10,040–9610 cal. BP can indeed be taken to underpin such a scenario (Kashuba *et al.* 2019). On the southwest coast of Norway, the earliest dates of the CCPBC technology are dated to 9600 cal. BP (Damlien *et al.* 2018, p. 111)

The settlement record and thus the database for the above mentioned studies do not have entire geographical coverage. Particularly on the southern and large parts of the western Norwegian coastlines the earlier mentioned effects of the tapes transgression, which peaks around 7700 cal. BP and the Storegga tsunami (8250–8100 cal. BP) have superimposed middle Mesolithic sites (Prøsch-Danielsen 2006). A number of known sites in key areas in northern and western central Norway where analysis has just started will help filling in the knowledge gaps concerning the mentioned hypothesis. Still the accomplished lithic analysis does give a remarkably detailed understanding of demographic processes that took place during this approximately 500–1000 years of the Boreal period.

The bone material

A similar route around the Cap of the North has been suggested for the so-called specialized 'shaft-wedge-splinter' technique used in bone industry (Bergsvik and David 2014). It has been suggested that the production of bone tools at the two cave sites Viste and Sævarhelleren (c. 9000–8000 cal. BP) consisted of a combination of fracturing techniques (shaft-wedge-splinter) and abrasive techniques (drilling, sawing, scraping and grinding). This mode of production clearly distinguishes northeastern European (Post-Swiderian) tradition of producing bone tools from the southern Maglemose tradition (David 1999). The authors argue that the industry developed between 10,000 and 9000 cal. BP partly as a result of eastern technological influences, and partly from regional innovations and adjustments related to an increased focus on a marine economy during this period. Later studies (Mansrud and Persson 2018) have recognized this technology in contemporary settlement deposits along the Oslo Fjord. The linkage between the bone technology and the CCPBC is related to the use of slotted bone tools during this period. In terms of chaine operatoire the grinding, polishing and even decoration of bone tools can also be related to grinding and polishing as we find it in ground stone axes and hatchets (Bergsvik and David 2017). Unfortunately, the archaeological record in the northern and central part of Scandinavia only seldom provides us with organic remains. Compared to the lithic record, which is rich – the organic record is often very fragmented or burnt if at all existing. The lack of preservation may very well limit our insight into fine-grained studies of regional expressions and indications of direct contact between groups that one can imagine such a material would have entailed (David and Kjällquist 2018).

The above-mentioned analyses supplemented by extensive investigations of demographic dynamics and climate change based on radiocarbon dates (Tallavaara *et al.* 2014, Manninen *et al.* 2018) are presently the most comprehensive studies that seek on the basis of archaeological material to underpin a hypothesis of migration and knowledge transfer from Post-Swiderian hunter-gatherer groups in Russia into Scandinavia during the Middle Mesolithic.

Migration, mobility, cultural encounters and social development

A general review of other aspects of material culture remains help fill in the picture and illustrate innovations and cultural changes that are introduced during the approximately 500–1000 years from the first transformation observed in change of archery and cutting tools. These changes may have been inspired by or introduced as a result of cultural encounters.

Rock art in northern Norway clearly predates rock art in the east by several thousand years and is thus likely in its origin a western tradition. A relatively large amount of the polished rock art has been shoreline dated to the period between 11,200 and 9000 cal. BP (Gjerde 2010, p. 386, fig. 275). The naturalistic polished art found in the Ofoten and Steigen areas illustrating different types of prey, can be taken to represent arenas of ritual practice for the pioneer groups that first arrived in this landscape. The interpretation of rock arts role as a material culture expression is challenging but can most directly be associated with descriptions of hunting scenes and communication with the other world in a context of rite of passage (Gjerde 2010). Whether the rock art is also a manifestation of power in terms of demarcation of territory in a type of intergroup communication is less clear. One can assume, however, that rock art sites and imageries are meant to communicate and it is interesting that the early stages of this material culture expression overlaps in time with the above mentioned transformations in other material culture. Does the rock art have a role in the interplay between groups in this northern region of Norway where meetings between eastern and western groups would likely have taken place?

Human ritual deposits are not present until this time in Scandinavia. We have close to a thousand archaeological sites from the Early Mesolithic in Norway alone, but so far no indications of intentional burial or other ritual deposition of the dead during this period. The DNA and isotope analyzed individuals from Hummervikholmen (Sellevold and Skar 1999, Nymoen and Skar 2011, Skar *et al.* 2016, Günther *et al.* 2018 S1), Stora Förvar (Lindqvist and Possnert 1999, Günther *et al.* 2018 S1) and Stora Bjers (Arwidsson 1979, Günther *et al.* 2018: S1) are among the oldest individuals found in Scandinavia (9732–8553 cal. BP). The earliest dated skeletal remains are, however, from the northeastern Skagerrak area. A female from Österöd from the Swedish west coast is dated to c. 10,200 BP (Ahlström and Sjögren 2009), and the human remains from Huseby Klev are dated to 10,040–9619 cal. BP (Nordqvist 2005, bilaga 1, Kashuba *et al.* 2019). Whether the Huseby Klev human findings represents a grave/ritual deposit, can also be debated.The burial practice varies considerably between these localities. The Middle Mesolithic graves cover a spectrum from cave burials adjacent to settlement deposits like Stora Förvar on Gotland to open-air graves on lakeshores, like for example Kams or Stora Bjers on Gotland (Grünberg 2000, p. 260f, Martinsson-Wallin 2011, Apel *et al.* 2018), or Hummervikholmen in Søgne, which is situated on the contemporary beach. Even bodies deposited in an inland lake like Bredgård, Hanaskede, Västergötland (Jonsson and Gerdin 1997) (c.10,000 BP), and possibly the individual found on Kyrkjetangen, Bønes in Bergen (c. 8500 cal. BP) exist (Hufthammer, pers. com.). The somewhat younger (c. 7900–7600 cal. BP) sacrificial site of Kanaljorden, Östergötland (Hallgren 2011) where several individuals were decapitated and the heads put on poles in a contemporary lake presently stands out as unique. The most common body pose varies from a dorsal position to a squatting position. Grave goods and the use of ochre is a frequent but not always present phenomenon. Several but not all indicate violence as a cause of death.

The very fragmented record of ritual deposition of humans in the Middle Mesolithic of Scandinavia provides us with highly dissimilar traditions. One can thus conclude that burial or ritual depositions of the dead appears to be a newly introduced cultural characteristic of this period, as can also be observed in the east on for example the expansive grave sites of Olenii Ostrov (c. 10,000–8400 cal. BP) (Jacobs 1995). However, one cannot attribute this ritual tradition entirely to potential migrating Post-Swiderian groups arriving with a complete and uniform ritual practice. Perhaps the practice of burial is rather inspired by cultural encounters and admixture, further reflecting the contemporary society's group organization and finally stimulated by a gradually more stable regional belonging. Underlining the ritual aspects of society is the introduction of polished and often decorated hatchets of bone, antler or ground stone. Such artefacts can also carry anthropomorphic traits and they rather resemble procession weapons than part of a working tool-kit. This is a type of artefact that is introduced and lasts for a very long time as part of the middle and late Mesolithic inventory. The oldest directly dated example of hatchets is a decorated bone hatchet from Hidra on the south Norwegian coast (9850 cal. BP) (Nymoen and Skar 2011).This type of artefact is rarely found in settlement deposits, but more often as stray finds in association with water, potentially as part of ritual activity (Glørstad 1999, 2010, p. 231). The chaine operatoire of producing such hatchets have a counterpart in the Post-Swiderian axe and club inventory (Oshibkina 1997, Zhilin 2006, Hartz *et al.* 2010, Anttiroiko 2015).

Several authors have underlined a beginning regionalization and regional belonging as well as a diversification of foraging strategies as an accelerating process from the late Early Mesolithic and into the Middle Mesolithic (Damlien 2016, Nyland 2016, Skar and Breivik 2017, Boethius 2018, Mansrud and Persson 2018, Nilsson *et al.* 2018). The Scandinavian settlement record displays a variety of site types and documents exploration of both the coast and the inland. A common denominator is, however, resource exploitation taking its point of departure in repeated returns to base localities along the coast displaying particularly stable and favorable sources of food. While semi-long distance resources for example in the inland, reachable along watersystems, provide periodic supplement and raw materials like skin, antler and bone (Mansrud and Persson 2018, Mjærum 2018). The growing record of semi-subterranean and larger dwelling structures indicates settlement of longer duration and intensity, as does the finding of potential assembly sites (Fretheim 2017, Gjerde and Skandfer 2018). This all ads to the picture of emerging regional belonging and a beginning semi-sedentism, towards the end of the Middle Mesolithic.

The stone quarries have been interpreted as nodal points for social encounters and redistribution of raw material and axes, within quite clear social territories. The oldest in Norway are dated to approximately 10,000 cal. BP (Nyland 2016) While quarrying of raw material for cutting equipment can be dated back to the final stages of the Preboreal (at the latest 10,500 cal. BP) (Niemi 2015) at least in northern Norway. Quarrying from particular sources of quality raw material where it is easily accessible has a long tradition going back into the late Paleolithic in northern Europe. But on the Scandinavian peninsula this tradition starts during the Late Preboreal/Early Boreal period and can be seen in context with a potential population supplement and the introduction of a more regionally confined lifestyle (Nyland 2016).

The general trend is that the Middle Mesolithic society becomes more complex during this period and that influx of eastern inspired cultural traditions plays a part.

The input from aDNA and stable isotopes

The aDNA analysis (Günther *et al.* 2018) was based on deep sequencing of seven Scandinavian individuals directly dated between 9500 cal. BP and 6000 cal. BP from Norway and Sweden (Günther *et al.* 2018). The analysis draws its conclusions based on comparative studies of 36 complete mitochondrial genomes from European Mesolithic humans. The comparative sample comprises seven earlier published individuals from Sweden (Motala), Latvia, Spain, Luxembourg, Italy, Hungary, Georgia and Ukraine, France, Germany and Russia.

The analysis includes three Norwegian samples Hummervikholmen 1 and 2 from Søgne on the south coast and Steigen from Nordland in addition to four Swedish samples: three from Stora Förvar (SF9, SF11, SF12) and one from Stora Bjers (SBj) all on Gotland. The Hummervikholmen individuals derive from a submerged locality, a grave-site that was deposited on land prior to the Tapes transgressions. While the Steigen individual that has a 3000 year younger date derives from a cave-site. The three individuals from Stora Förvar were also found in a cave site, while the Stora Bjärs individual is from an open air site.

Stable carbon and nitrogen isotope data for the Scandinavian humans has been analyzed (Günther *et al.* 2018, S1). The Norwegian samples show values between –14.2‰ and–13.5‰ for δ 13C, og 18.2–20.5‰ for δ 15N. This indicates a very large intake of marine mammal protein both at Hummervikholmen and in Steigen. The isotope signatures are so high that they only compare to more recent populations living off almost 100% marine diets (Skar *et al.* 2016). The life history data from two of the Norwegian individuals (Hum 1 and Steigen) suggests that their diet has not changed significantly throughout their lifespan. (Günther *et al.* 2018, S1). The Stora Förvar samples have considerably lower values between –18.8‰ and –16.4‰ for δ 13C og 9.8–12.9‰ for δ 15N. The Nitrogen isotope values indicate a diet consisting of freshwater fish like pike and perch or possibly migrating seal (Günther *et al.* 2018, S1). This is not surprising considering that the individuals lived on Gotland during the Ancylus Lake stage.

The dates have been corrected for marine reservoir effect. At Hummervikholmen and Steigen where individuals lived from an almost 100% marine diet 380 +/-30 radiocarbon years have been subtracted from the 14C date, following Mangerud *et al.* (2006) (Günther *et al.* 2018). As Hummervikholmen is positioned on the Skagerak coast in southern Norway this is the absolute maximum correction, while for Steigen which is much further north this value is probably closer to the truth. There are nine radiocarbondates from five human skeletal elements from Hummervikholmen, the calibrated (95.4 probability) is approximately 9500–9300 cal. BP. For the Steigen individual there was only one radiocarbon date, with a 2Σ range of app. 6000–5800 cal BP. The Stora Förvar dates fall between a 2Σ range approximately 9000–8500 cal. BP having subtracted 300 year for freshwater reservoir effect (Apel *et al.* 2018).

A Principal component analysis (PCA) demonstrates that the contemporary Mesolithic hunter gatherers fall into markedly distinct groups; the Scandinavian hunter gatherers being a clear admixture of the two well-defined different Western and Eastern hunter-gatherer groups. The results from the DNA analysis thus indicate that Fennoscandia was colonized from two definite groups and from two directions before 9500 cal. BP. One group from the south that is related to the West-European Hunter gatherers (WHG) and one group from the East, related to the Eastern European hunter-gatherers (EHG), the admixture (SHG) originating in Scandinavia. What may surprise us is that hunter-gatherers from Southern Norway are genetically more like the EHG compared to the central and east Scandinavian contemporary hunter-gatherers–these showing a larger genetic similarity with the western hunter-gatherers (WHG). The results from analyzing human DNA from chewed birch bark pitch mastics representing three different individuals from the deep pit trench at Huseby Klev (Kashuba *et al.* 2019), further underlines this pattern.

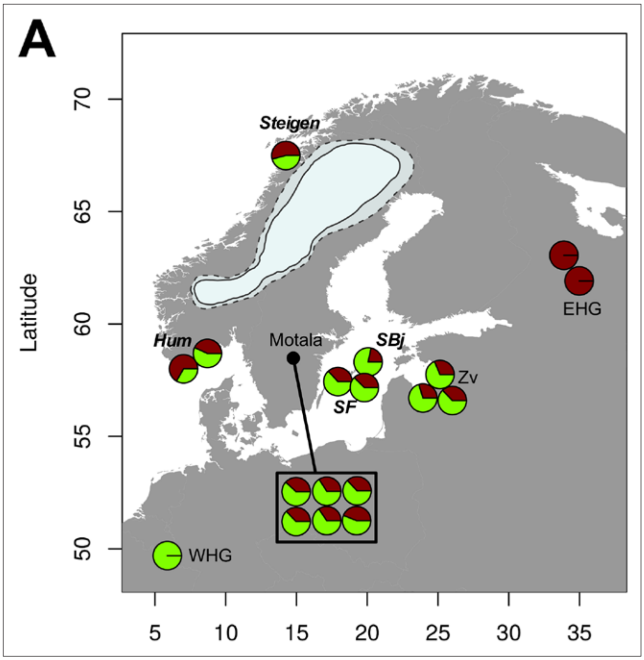

Figure 2*: Mesolithic samples and their genetic affinities. (A) Map of the Mesolithic European samples used in the genetic study. The pie charts show the model-based estimates of genetic ancestry for each SHG individual. The map also displays the ice sheet covering Scandinavia 10,000 cal BP (most credible [solid line] and maximum extend [dashed line] following Hughes et al. 2016). The sequenced individuals are shown with bold and italic site names. (B) Magnified section of genetic similarity among ancient and modern day individuals using PCA, featuring only the Mesolithic European samples. Symbols representing the sequenced individuals have a black contour line. (C) Allele sharing between the SHGs, Latvian Mesolithic hunter-gatherers (Zv), and EHGs versus WHGs. Data shown in this figure can be found in Günther et al. 2018: S1 data. EHG, eastern hunter-gatherer; SHG, Scandinavian hunter-gatherer; WHG, western hunter-gatherer; Zv, Latvian Mesolithic hunter-gatherer from Zvejnieki. Re-printed with permission from © 2018 Günther et al.*

Admittedly the sample is small, but getting a so-called representative sample of human remains from the Middle Mesolithic of Scandinavia is unlikely to ever occur. The above mentioned success in extracting human DNA from chewed mastics is, however, a promising future line of investigation, as mastics when recognized at Mesolithic sites, does preserve better than bone. The presence of the particular admixture found at Hummervikholmen to be repeated 3000 years later in Steigen, is an indication of continued influx of EHG into Middle Scandinavia over a long time. The stable isotope signatures in the Steigen individual is a strong indication of the specialized maritime adaption persisting at least as one of several into the Late Mesolithic.

If we combine climatic modelling, material culture analysis, radiocarbon dates, isotope analysis and genetic results it becomes clear that post-glacial colonization of Scandinavia is complex. The DNA results collaborate the chaîne opératoire analysis of blade technology and give us an indication that migration is an important aspect of the spread of technological innovations during the Middle Mesolithic.

The above analysis leads to a hypothesis on migrations scenarios during the early post-glacial (Günther *et al.* 2018, fig. 2). The scenarios are based on a combination of studies of lithic technology with the output from the genetic analysis.

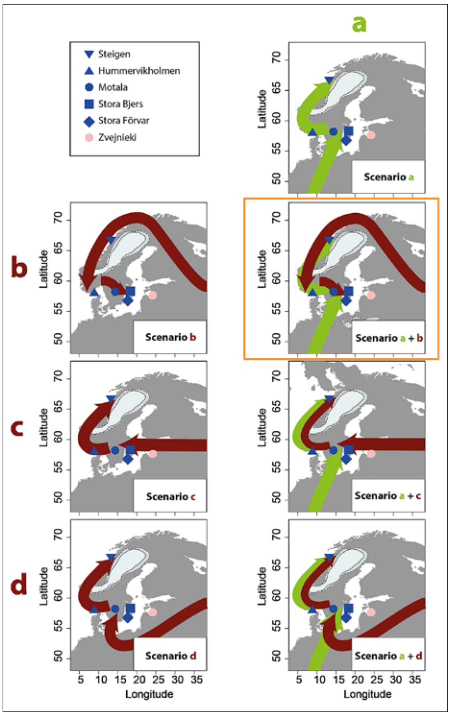

Figure 3: *Migration scenarios into postglacial Scandinavia. Maps showing potential migration routes into Scandinavia. Scenario (a) shows a migration related to the Ahrensburgian tradition from the south. Scenarios (b), (c), and (d) show different possible routes into Scandinavia for the EHG ancestry. The scenarios are discussed in the text and the scenario most consistent with genetic data and lithic technological introduction is a combination of routes (a) and (b). EHG, eastern hunter-gatherer. Re-printed with permission from © 2018 Günther et al.*

As there has been documented no Eastern hunter gatherers ancestry (EHG) in central and western Europe, it is assumed that the Ahrensburgians would have been of Western hunter gatherer ancestry (WHG). Scenario a) illustrates the entry of this population from northern Germany and through Denmark during the early Holocene. The entry of the EHG into Scandinavia has three possible scenarios b, c and/or d. Combining lithic technological studies with outcomes of the DNA studies warrants that the EHG migration took place after the WHG migration, as the earliest eastern-associated pressure blade finds postdate the southwestern-associated direct percussion finds in Scandinavia. Two migrations with admixture at different time-periods would generate a genetic gradient with the highest contribution of a source close to its geographic region of entry. The article thus states that the observed genetic pattern is consistent with a migration of the EHGs from the northeast moving southwards along the ice-free Norwegian Atlantic coast where the two groups started mixing (scenarios a and b). This would cause more EHG ancestry in western SHGs which is closer to the point of entry than the analyzed individuals from Gotland. The individuals sequenced here postdate these migrations, but a genetic eastwest gradient would be maintained over time in Scandinavia and only additional large-scale migrations from different sources would alter this pattern. This observation is important as the geographic pattern still holds with the results of analysis from Huseby Klev, thus indicating an influx of admixed people moving between todays Norway and central and western Sweden, as originally suggested by Sørensen *et al.* 2013. The inhabitants of Huseby Klev may, however, also be the result of a second migration wave entering directly into western Sweden from the East. The technologies of western Sweden and southern Norway are interchangeable during this period, which signals a high degree of mobility and networks among people. The chronologically much younger Steigen individual, may represent local continuity or most likely continued influx into northwestern Scandinavia from the east (Günther *et al.* 2018).

Discussion and conclusion

Considering the suggested scenarios of migration from the DNA studies one can question if it is in line with the structure of band organized Mesolithic societies to generate population movements on a very large scale. Alternatively, such movements would rather be at question of gradually taking new and recently opened territories into possession and admixture taking place as a result of cultural contact, while technology and adaptation strategies would have developed through transmission of knowledge. The cold event 10,300 cal. BP seems to have halted further expansion of Post-Swiderian groups following the northwestern colonization route until around 10,150 cal. BP, at this time the central Fennoscandian ice sheet is very reduced. After this setback, the colonization continues and perhaps along several routes of entry (Damlien *et al.* 2018). From the technological evidence this leads to a substitution of the old technology in southern Norway, while this scenario is not entirely clear in other parts of the country, for example recent studies in Central Norway rather indicate contemporaneous use of both direct percussion and CCPBC on the same sites (Holen 2018). This narrative of culture mix will most likely always be vague and transmission of knowledge between groups may well have taken different shapes depending on the amount and character of contact. The question is to which degree these forager societies were resilient to the very dynamic nature grid conditions. We are lacking a detailed understanding of the contemporary push and pull factors for the suggested exodus. While the pull factors may be related to the rich marine environments and utilizing newly opened inland resources, the push factors are ambiguous.

The DNA results supplement the narrative that can be told based on the lithic studies by demonstrating a clear admixture of the two groups, rather than a substitution of populations. It is also reasonable to assume that the specialized coastal adaptation, demonstrated in the Hummervikholmen individuals is part of a pioneer cognition that was shared as part of the communication between groups and individuals in the process of cultural exchange. In southern Norway there is, however, an apparent transformation in lithic tradition and thus in the hunting and fishing gear, illustrating knowledge transfer pertaining to lithic and bone technology. The introduction of rituals as expressed in the use of procession artifacts and ritual deposition of the dead could have been part of a Post-Swiderian cultural package, as these material culture elements are predated on Russian sites. These phenomena, however, take a variation of shapes in the transfer process. In combination with a gradually stronger belonging to particular landscapes as demonstrated in settlement structures and quarrying, ritualization also points towards a beginning social stratification of society. Providing the shoreline dating of the pronounced rock art tradition in northern Norway is correct, and there are no good reasons why they should not be, the tradition predates and survives the cultural transformation and the likely meetings between groups of independent cultural origin.

Analyzed together the records demonstrate a fascinating merge of cultural cognition that comes into being during the first 500–1000 years of the middle Mesolithic in Scandinavia. Further studies will help deepening the understanding of regional dissimilarities, networks and social processes during this period. While the record of Middle Mesolithic human individuals is fragmented, particularly the chaine operatoire studies of lithic material – the most abundant source of knowledge from these sites – has enabled a remarkably detailed understanding of demographic expansion in association with this until recently unacknowledged early Holocene migration. The records interpreted together quite clearly demonstrates that one can neither directly translate genetic populations into cultural groups, nor take technological changes to indicate entire population replacement.

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Almut Schülke

Placing – fragmenting – circulating: Mesolithic burial and mortuary practices in Norway in a Northern European perspective

Abstract

This contribution investigates burial and mortuary practice in the Mesolithic period (9300–3900 BC) in what today is defined as Norway. This issue has received little attention, as poor preservation conditions for bone material in the forest zone of the North has led to a low number of finds. Recent excavations of single burials at e.g. Brunstad and Sømmevågen trigger off a reassessment of the topic. The twelve sites with human bones, which could be identified, dating to the Middle and Late Mesolithic, were studied and compared. Even though statistically not significant, they exhibit some common traits: Human remains are mainly found in the places of the living: on coastal settlement sites, including caves/rockshelters and open-air sites. This broad spectrum of sites indicates human engagement with different natural and cultural elements when dealing with the dead: hollows, water, earth and cultural debris. Both graves with apparently intact human bodies and single (loose) human bones can be identified. Together with sites found in wetlands with seemingly selected types of bones, these bear witness to a broad range of mortuary practices, including inhumation, the fragmenting of corpses and the circulation of selected bones. This is in line with practices observed in other parts of Northern Europe; a special closeness to finds from Western Sweden is observed. As in other areas it is most likely that only a small number of people were actually buried, while most of them received other treatment in death, not easily visible archaeologically. The identification of these various phenomena will hopefully make it possible to identify other find contexts in future, and will be important when discussing social and ritual aspects of Mesolithic hunter-gatherer societies, not least regarding studies on genetics and mobility.

Introduction

In the areas which today constitute Norway the Mesolithic period is attested by a rich body of archaeological material with thousands of predominantly coast-based settlement sites. In contrast, direct evidence of Mesolithic people through human remains is almost absent in the record, hampering studies of physical biographies, death, the handling of dead people by the living community, mortuary practices and burial structures. This shortage of mortuary evidence, also observed in the neighbouring areas of Northern Sweden and Finland (Mökkönen 2013, Ahola 2017), has been explained in terms of poor preservation conditions for osseous material in the acid soils of the coniferous zone (Glørstad 2010, p. 240–243). Death as a topic has therefore hardly been touched upon in the Norwegian Mesolithic debate (Lødøen 2015, p. 86). The few finds of mortuary evidence from Norway are, at first sight, ambiguous in material expression, spanning across long time periods and large areas (earlier overviews in Indrelid 1996, p. 53–57, Sellevold and Skar 1999, Solberg 2006). By contrast the moraine and limestone soils of South Scandinavia, the Central European plain and of the Baltic area have preserved human bones from the Mesolithic period. Between the 1960s and 1980s key finds from these regions such as the grave fields from Vedbæk on Zealand (Brinch Petersen 2015), Skateholm I and II in Scania (Larsson 1988), or Zvejnieki in Latvia (Zagorskis 2004, Larsson and Zagorska 2006), shaped the understanding of Mesolithic mortuary practices, implying that inhumation was the most common mode of burying the dead from the 9th to the end of the 5th millennium cal. BC. Recent research has substantiated that Mesolithic mortuary practices were much more varied than formerly assumed (Bugajska 2014, Stutz 2014, Grünberg 2016). New finds and reviews of older finds that were previously written off as atypical, show that the dead and dead bodies were treated in manifold ways, including manipulation of the buried body (e.g. Stutz 2003, Gray Jones 2011, Gumiński and Bugajska 2016), cremation (Bugajska 2014, Tab. 3, p. 65–66, Eriksen and Andersen 2016, Niekus *et al.* 2016, Sjögren and Ahlström 2016) and the laying out/elevation of the dead, with re-burying or re-use of bones after the disintegration of the body (Gray Jones 2011, Petersen 2016, Sørensen 2016). Some recent finds of Mesolithic graves in Norway, such as Brunstad and Sømmevågen, have triggered new interest in these topics. Furthermore, new studies of west Norwegian Mesolithic rock art suggest that the low number of Mesolithic burials might be connected to the existence of mortuary rituals which could involve defleshing of corpses, which might be depicted on some rock carving sites (Lødøen 2015).

This article deals with Mesolithic mortuary and burial practices in Norway (c. 9300–3900 cal. BC), represented through twelve sites which have yielded human remains that can be dated to the Mesolithic period. Even though the number of finds is low and covers thousands of years, some trends in the material can be identified, revealing variation in the treatment of the dead, their bodies, the way these bodies or body parts were deposited, and the diversity of contexts and places of deposition, also regarding natural and cultural elements. This will be discussed in the light of Mesolithic mortuary practices in adjacent regions of Northern Europe.

Mortuary remains as evidence of intertwined actions, (ritual) practices and events with different temporal dimensions

A more nuanced general understanding of the treatment of the dead in archaeology in recent years (e.g. Fahlander and Oestigaard 2008) has opened up for understanding mortuary remains and burial finds as more than representing a specific burial custom within a specific cultural frame. Rituals and treatment of the dead which involve practices before and after the body/body parts came into the earth have been included in the discussion (Stutz 2003). One way for archaeologists to explore and understand these dynamic processes are reviews of ethnographic data. They show a variety of modes of practically dealing with the dead and their bodily remains, often in several steps and with complex temporalities (Meyer-Orlac 1982, p. 139, Nieuwhof 2015, Fig. 7.2). As Figure 1 illustrates, dead bodies can be left behind or be exposed right after death (e.g. elevated in a tree), they can be (either as intact bodies or body parts) buried shortly after death, either unburned or cremated. They can also be stored, preserved or skeletonized and manipulated/fragmented and only deposited in the ground later. Single body parts can be kept in circulation for a long time before they, for some reason, come into the ground. Exposed or retained body parts can be eaten by carnivores.

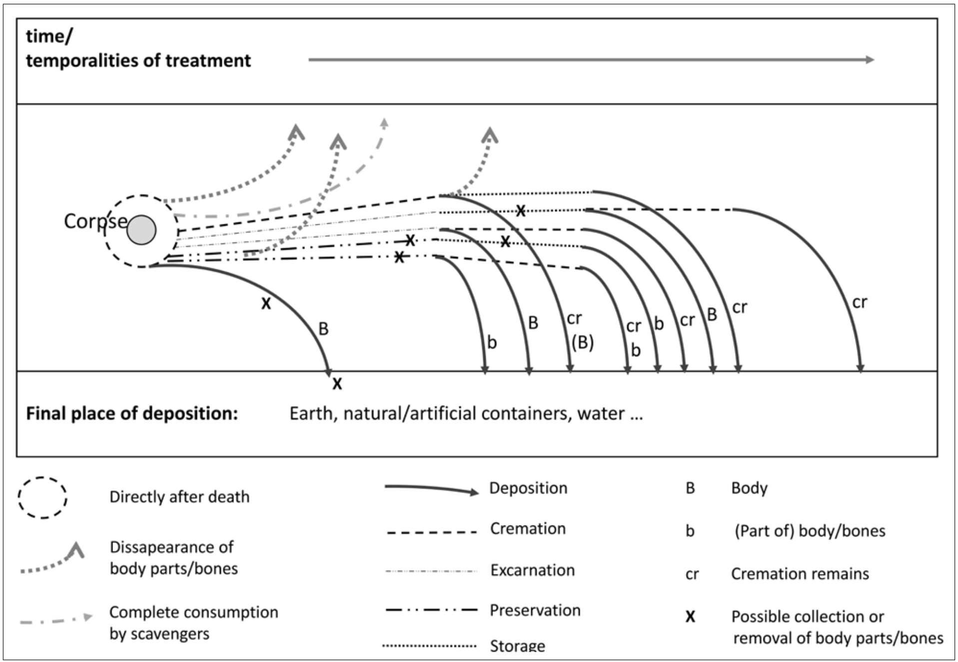

Figure 1: *Sketch of diverse ways of dealing with dead bodies and possible combinations of practices (not exhaustive) (after Meyer-Orlac 1982; 139 and Nieuwhof 2015, Fig. 7.2), slightly revised by the author.*

The theoretical perspective applied here sees the archaeological site not only as a place of deposition, in this case of the Mesolithic human remains, but also as a focal point from which various intertwined processes and actions can be studied (Schülke 2016). These are related to intentions and practices behind the depositions of these bodies/body parts, with different temporal dimensions, and can trace mortuary practice beyond the mere find-spot – temporally and spatially. However, the form and place of deposition also have an effect on the surroundings and thus are more "concrete" than many of the more ephemeral practices that lead to their formation. The deposition of the body/body parts is one stage in a temporally enmeshed sequence of practices and events within a certain social context. These include the times before the human remains were deposited (e.g. biography in the sense of physical and mobility history of the once living individual, dying and mortuary ritual performed by the survivors including the steps in the treatment of the dead body), during the act of deposition, and even after the remains were placed (e.g. revisiting a grave or monument, later manipulation of the burial etc.). Thus, archaeological mortuary contexts can be considered as parts of a series of (ritual) practices or operational chains – each with different temporalities, but also as places which, from the time of their making, affected their surroundings. Such dynamics have been addressed for specific aspects of Mesolithic burial finds. These include the construction of a grave (Larsson 2016a), the treatment, manipulation, adornment and positioning of the body/bodies of the deceased (e.g. Stutz 2003, Gray Jones 2011), the character, positioning and the lack of grave-goods (e.g. Kjällquist 2001, Larsson 2016a) and the way of filling and possible marking of the grave (e.g. Brinch Petersen 2015, p. 101–105). It also encompasses anthropogenic post-burial events, for example newer graves which cut into older ones (Stutz *et al.* 2013). Studies of more complex, multistep mortuary practices attest to intentional manipulations of burials, where specific bones/body parts are taken out of the grave context and later deposited together with bones of other humans and animals in pits close by (Bugajska and Gumiński 2016). Further, the topic of loose human bones in settlements and *møddinger* has been discussed in the light of ethnographic studies, which report that ancestors' bones were used in living life (e.g. Brinch Petersen 2016).

The more considered the interpretation of the evidence regarding the involvement of temporally different steps of activity, the more difficult it is to establish a clear terminology. This is e.g. reflected in discussions of the term "grave" (Larsson 2016b), or on how to denominate multistep burials (e.g. Struwe 2016, footnote 5). Furthermore, drawing the line between burials and the mistreatment of/violence against humans and their bodies is a challenge from the archaeologist's perspective (e.g. Gummesson *et al.* 2018).

In the following I will use these terms:

- deposition: intentional or unintentional deposition of material/human remains
- burial: intentional depositions of human remains within mortuary practice
- grave: a burial which is dug down into either a cultural layer, into earth, or into a stone pile
- mortuary practice: practice in the widest sense connected to the death of a person (before, during and after burial)
- burial practice: practice connected to the burial of a person/persons.

Mesolithic human remains, burials and mortuary practices from Norway

This study focuses on the twelve sites from Norway[1] which have yielded human bones dated to the Mesolithic period (9300–3900 BC) (Figure 2: sites 1–12). In Figure 4 and Figure 5 the sites which have yielded both remains of intact bodies and of single (loose) human bones are split up into (a) and (b).

The data were mainly compiled from the literature, in some cases excavation reports were consulted.[2] A number of factors bias the data. These include the heterogeneous quality of the publications. Several of the finds were made in connection with older excavations of settlement sites and were regarded as side products which were not documented in any detail. Another factor is preservation conditions, which can obfuscate the mere presence of human bone material, including the character of the originally deposited human bodies/body parts. Furthermore, encompassing archaeo-osteological or thanatological analyses must remain subject of future research. They can provide insights into health during lifetime, into the pre-, peri- and post-mortem treatment of the body. This might include lethal injuries, manipulations of the dead body such as the removal of body or skeletal parts, or a closer study of taphonomic factors of the deposition situation, such as physical and biochemical processes which can alter the composition and spatial order of deposited human remains.

__Figure 2__: Map of the Norwegian sites with human bones dated to the Mesolithic period. Mesolithic period. For more information on the sites see Figure 4 and Figure 5. Illustration: A. Schülke, based on geographic information by Statens Kartverk.

A variety of site locations along the coast

All of the sites with Mesolithic human bones were located at the coast at their time of use (Fig. 2): three in southeast Norway (nos. 1, 6, 7),[3] two in north Norway (nos. 10, 12) and seven in west Norway (nos. 2, 3, 4, 5, 8, 9, 11).

The Mesolithic topographic locations vary, however, in terms of local topography and accessibility (Figure 2 and Figure 3). Five of the finds (41.7%) stem from rock shelters (nos. 3, 8, 9) and caves (nos. 5, 12). These are situated along the west Norwegian coast (nos. 3, 5, 8, 9) and in Nordland (no. 12). Two, Grønehelleren (no. 8) and Steigen (no. 12), are spectacularly located on islands in the outer archipelago. Viste cave is placed on a rather sheltered islands in an archipelago (no. 5), Sævarhelleren (no. 9) alongside a fjord (nos. 3, 9), and Skipshelleren (no. 9) in a fjord.

	Total	Outer archipelago	Inner archipelago	Along fjords/ coastal mainland
Rockshelters/caves	5	2	1	2
Open-air settlements	5		4	1
Wetlands/sea	2		2	

Figure 3: *Site types and topographic context of the sites with Mesolithic human bone material. Diagram: A. Schülke.*

Five (41.7%) stem from open coastal settlements. Søndre Steghaugen (no. 4), Brunstad (no. 6), Torpum 9b (no. 7) and Sømmevågen (no. 11) are placed on rather sheltered islands in archipelagos and Gropbakkeengen in north Norway (no. 10) near the coast on the mainland. Two of the finds (16.6%) were made in modern wetlands: while Bleivik (no. 2) was a seabed in the Mesolithic, Hummervikholmen (no. 1), which today is an underwater site, most likely represents a transgressed coastal site in the inner archipelago of the southern Norwegian (Skagerrak) coast.

Direct and indirect dating of the human bone material

Chronologically the contexts with human bones from the twelve sites stretch from c. 7900–4000 cal. BC (Fig. 5). Two of them date to the Middle Mesolithic (8200–6350 cal. BC), nine to the Late Mesolithic (6350–3900 cal. BC), while one could be both (no. 3). Eight contexts are ^{14}C-dated directly on bone or tooth material (nos. 1, 2, 5a, 8a, 10, 11b, 12). For most of these a δ^{13}C-value is also reported, which allows a correction of the datings for the marine reservoir effect. The others are indirectly dated, either through ^{14}C-dating of charcoal from their direct context (no. 6, most likely also no. 4, see below) or through stratigraphic affiliation.

Human bones from wetlands/wet contexts

The human bones from Hummervikholmen (no. 1), which were found under water in the 1990s and again in 2013, most likely stem from a coastal site located on a little island in the Inner Archipelago of the Skagerrak coast, which was later transgressed. The human bones were found in an area of approximately 8×10 metres, together with some boulders, four wooden sticks and some bones of marine animals (Eggen and Nymoen 2014, Nymoen 2014, p. 57). The first bones were found in the mid-1990s under water after the site had been damaged

No.	Site, County*	Mesolithic location	Site context	Subsurface	Number of individuals (from intact bodies and single bones)	Intact bodies	Single bones	Find context	Body position	Grave-goods	Source
Middle Mesolithic											
1	Hummervikholmen, Vest-Agder	island, archipelago, sea	?	sea-floor/ sand	3–5	–	x	?	?	–	Sellevold/Skar 1999; Eggen/Nymoen 2014; Nymoen 2014; Skar et al. 2016; Günther et al. 2018 S1 Tab. S1.3.
2	Bleivik, Rogaland	sea	seafloor	sea	1	–	–	?	–	–	Lie 1985; Indrelid 1996, 53 footnote 28.
Middle/Late Mesolithic											
3	Sævarhelleren, Hordaland	along fjord	rock-shelter	cultural layer	1+	–	x	cultural layer	–	–	Bergsvik/Storvik 2012, 29 (no. 10).
Late Mesolithic											
4	Søndre Steghaugen, Møre og Romsdal	island	coastal settlement	sand	1	?	–	grave/ deposit?	?	–	Åstveit 2008; Sellevold 2008.
5a	Viste cave, Rogaland	island	cave	cultural layer	1	x	–	grave?	possibly flexed	–	Brøgger 1908; Fürst 1909; Gjessing 1920; Hufthammer/ Meiklejohn 1986; Bergsvik/Storvik 2012, 31 (no. 22); Schulting et al. 2016.
5b	Viste cave, Rogaland	island	cave	cultural layer	1+	–	x	?	–	–	Fürst 1909 Fig. 3–5; Bergsvik/Storvik 2012, 31 (no. 22).
6	Brunstad, Vestfold	island, archipelago	coastal settlement	sand	1	x	–	in grave	half-sitting, flexed legs	–	Reitan et al. 2018; Schülke et al. 2019; Reitan et al. 2019.

No.	Site, County*	Mesolithic location	Site context	Subsurface	Number of individuals (from intact bodies and single bones)	Intact bodies	Single bones	Find context	Body position	Grave-goods	Source
7	Torpum 9b, Østfold	island	coastal settlement	cultural layer	1+	–	x	?	–		Tørhaug 2003.
8a	Grønehelleren, Sogn og Fjordane	offshore island	rock-shelter	cultural layer	3	x?	–	in one or more grave pits	skeleton II: flexed, skeleton III and IV: unsure	–	Jansen 1972; Indrelid 1996, 53 footnote 27; Bergsvik/Storvik 2012, 27 (no. 6).
8b	Grønehelleren, Sogn og Fjordane	offshore island	rock-shelter	cultural layer	1+	–	x	?	–	–	Jansen 1972.
9	Skipshelleren, Hordaland	along fjord	rock-shelter	cultural layer	1+	–	x	?	–	–	Bergsvik/Storvik 2012, 27 (no. 8).
10	Gropbakkeengen, Finnmark	mainland, coast-based	coastal settlement	gravel	1	x	–	grave in a stone heap	hocker-position	x	Simonsen 1961, 182–183; Helskog 1980.
11a	Sømmevågen, Rogaland	island, archipelago	coastal settlement	sand	1+?	?	–	in grave	–	x	Denham 2016.
11b	Sømmevågen, Rogaland	island, archipelago	coastal settlement	sand	1+	–	x	in rubbish heap	–	x	Denham 2016; Meling et al. 2020; Meling et al. in press.
12	Steigen, Nordland	offshore island	cave	cave floor	1	–	x	deposited	–	–	Günther et al. 2018, Supplement S1.

** county before the county reform from 2020*

***Figure 4**: Find contexts with human bones dated to the Mesolithic from Norway, in chronological order. For the dating of the finds see Figure 5. – denotes "non-existent", ? denotes "uncertain", + indicates that more individuals than the given number might be represented.*

by dredging. After the sieving of the re-deposited sediments the remains of at least three, but maybe up to five adult individuals were verified – amongst them fragments of at least three skulls and of (partly fragmented) long bones (Sellevold and Skar 1999, Skar *et al.* 2016). Nine bone samples were ^{14}C-dated to a rough timespan between 8227 and 6828 cal. BC (Skar *et al.* 2016, Table 14.1); taking the marine reservoir effect into account they most likely were some hundred year's younger (Günther *et al.* 2018, Supplementary information p. 7). Skar *et al.* (2016) argue that even if there were *no clear signs of grave pits* (ibid. p. 230) during excavation, the excellent preservation of the bones together with stratigraphic observations indicate that the finds represented a grave site, which had been flooded by the Tapes transgression c. 6950 cal. BC (8000 BP), and afterwards sealed by an oyster bank. In 2013 more bones were found at the same spot in connection with an underwater archaeological excavation before further dredging (Eggen and Nymoen 2014, Nymoen 2014). Eight bones of at least two individuals were with certainty human, including cranial fragments and teeth as well as fragments of an upper and of a lower leg bone. Additionally, bones of fish, seabirds and seal were found, as well as four wooden sticks, which showed no signs of human treatment. Two of the human bones were dated to the Middle Mesolithic around 7500 cal. BC, 8393±55 BP (Ua-47891) and to 8446±51 BP (Ua-47892), while the two dated wooden sticks are several hundred years older (Eggen and Nymoen 2014, fig. 22). In the light of the 2013 excavations, the theory of Hummervikholmen representing a grave-site was rejected, and it was discussed whether the find might represent the remains of a ritual deposit (Eggen and Nymoen 2014). Nymoen (2014) argues that the stratigraphy of the seabed most likely indicates a repositioning of the human bones from dry ground close to the beach into the sea – caused by a natural event such as a flood wave or tsunami, and that the wooden sticks most likely represent naturally deposited wood. It is important to stress that the datings of the human bones from Hummervikholmen stretch across some hundred years (see Fig. 5).

From the coast-near wetland at Bleivik (no. 2), which was a seabed in the Mesolithic, skeletal parts of a person around the age of 60 were found through trenching (Lie 1985). The following bones were dug up: a cranium, some teeth, some ribs, two vertebrae, two thighbones and an upper arm bone (Lie 1985, Indrelid 1996, p. 53); according to Sellevold and Skar (1999) the remains of a woman. One bone was ^{14}C-dated to around 6900 BC, 7950±110 BP (T-2882) (Indrelid 1996, 53 footnote 28, Sellevold and Skar 1999, p. 8). It has been suggested that the individual might have drowned (Bang-Andersen 1983), or that the (dead) body might have been plunged into the sea (Lie 1985).

Burials of human bodies from caves and rock shelters

The records of finds of human remains from cultural layers in caves and rock shelters vary (Bergsvik and Storvik 2012). Common for all of these sites are the good preservation conditions for bone material due to the large amounts of shells in these layers.

Excavations in the Viste cave (no. 5) in 1907 yielded the skeletal remains of a juvenile individual, placed close to the rock wall in the rear of the cave (Brøgger 1908). The find, with one of the first known Stone Age humans from Scandinavia, was a sensation at its time. The context of the human remains was not documented on site. Later, it was reconstructed that they most likely were covered by a human-made shell layer (Brøgger 1908, Gjessing 1920, 76–77). The positioning of the body was described as possibly *half-sitting*, as the remains of the skull were recorded as having been higher up in the sediments than the leg bones (Brøgger

1908, p. 26–29). An osteological analysis by the renowned Swedish anthropologist C. M. Fürst (1909), who also took down oral accounts on the find situation, stated that the body was deposited in unscathed condition, with the head leaning against the rock wall, perhaps in a hocker position. Fürst did not, however, fully rule out that the corpse was just placed on the ground and then covered by the shell layer over time.[4] The Viste skeleton was recently dated on bone to 6255–6025 cal. BC, corrected for the reservoir effect, 7537±39 BP (OxA-30405) (Schulting *et al.* 2016).

In the rock shelter Grønehelleren (no. 8) several burials were excavated in 1964 and 1966. These are described in Jansen (1972), although detailed plans, drawings or photos of the situation are missing. Skeleton I (*skjelett I*) was very well preserved and placed in a hocker position on its right side, in a pit parallel to the wall of the rock shelter (Jansen 1972, p. 58–59). It is dated to the Middle Neolithic (Bergsvik and Storvik 2012, 27 (no. 5), Indrelid 1996, 53 footnote 27), and thus not relevant here. Two teeth and a collarbone were found near to skeleton I (Jansen 1972, p. 61); their date is unclear. Not far from skeleton I the remains of at least three other individuals (Skeletons II–IV; *skjelett II–IV*) were found in a 'pit' (*nedgravning*) (Jansen 1972, p. 16–18). The unclear stratigraphic situation suggests either that the persons were buried at the same time because 'they are touching each other' (*da de berører hverandre*) or in several grave-pits (Jansen 1972, p. 18). Skeleton II, which was almost completely preserved and analysed as a woman in her forties, was placed on the left side, the legs flexed. Skeleton III, analysed as a man around 40 years of age, placed right beside skeleton II, was only partly preserved. Skeleton IV, of which only parts were preserved, was found under skeleton III. Skeleton II was dated to 5343–4686 cal. BC, 6080±140 BP (T-5847) (Bergsvik and Storvik 2012, p. 27 (no. 5), Indrelid 1996, 53 footnote 27), to the Late Mesolithic period. There is however some uncertainty about this dating.[5] The case of the partly fragmentary Grønehelleren skeletons II–IV exhibits the classic dilemma of the interplay of preservation conditions and the question whether the bodies of the dead were intact when buried or whether they might have been manipulated before they came into the earth or after burial. Either way, at least the three individuals found in Grønehelleren, which might be of Mesolithic age (skeletons II, III and IV), seem to have been buried in one or more pits. The circumstances of the deposition of the Viste individual are more unclear: the body might have been buried in a pit – not identified – in the shell layers, it might have been left behind unburied in the cave, or the person might have even died in the cave without being buried – in these cases later covered by shells.

Graves on open-air settlements

Several open-air settlements have yielded human remains which were deposited in graves. On a coastal settlement dated to 6000–4700 cal. BC at Søndre Steghaugen (no. 4) 18 fragments of unburned human bones, including the fragments of a skull, fragments of a mandible and fragments of ribs of a child 2–4 years of age, were found in an agglomeration of hardpan of yellow-red sand and gravel delimited as structure S 44 with a size of 0.6 m × 1.4 m (Sellevold 2008, Åstveit 2008). Due to its Mesolithic context, the find was first supposed to be a Mesolithic grave with ochre. The bones (part of the jaw) were ^{14}C-dated to between 1975 and 1880 cal. BC and were therefore interpreted as a Late Neolithic burial, being much later than the settlement (Åstveit 2008). A piece of charcoal which was placed directly into a bone fragment was however ^{14}C-dated to 6230–6175 cal. BC, 7405±45 BP (TUa-4949).

No.	Site	14C-dating Lab.no.	BP	Cal BP	Cal BC	Standard deviation	δ13C	Approximate date BC	Dated on	Source
Middle Mesolithic										
1	Hummervikholmen	TRa-952	8850±65	9732-9368*		2σ	-13.4		occipital bone, human	Sellevold/Skar 1999; Skar et al 2016; Günther et al. 2018 S1 Tab. S1.3.
		TUa-2107	8700±70	9524-9191*		2σ	-12.6		femur, human	Ibid.
		TRa-954	8690±50	9471-9225*		2σ	-13.0		cranial fragment, human (Hum 1)	Ibid.
		TRa-953	8680±85	9534-9125*		2σ	-13.2		tibia, human	Ibid.
		TRa-951	8665±100	9555-9065*		2σ	-13.0		frontal bone, human	Ibid.
		TUa-2106	8635±75	9462-9102*		2σ	-13.3		occipital bone, human	Ibid.
		TUa-1257	8600±95	9461-9011*		2σ	-13.4		cranial fragment (Hum 1) , human	Ibid.
		TUa-2108	8455±75	9275-8895*		2σ	-12.9		tibia, human	Ibid.
		Ua-47892	8446±51		7589-7371	2σ	-14.5		cranium X90, human	Eggen/Nymoen 2014.
		Ua-47891	8394±55		7573-7342	2σ	-14.3		leg bone X84, human	Eggen/Nymoen 2014.
		TUa-2105	8095±55	8789-8441*			-13.6		frontal bone, human	Sellevold/Skar 1999; Skar et al 2016; Günther et al. 2018 S1 Tab. S1.3.
2	Bleivik	T-2882	7950±110						Upper arm bone, human	Lie 1985; Indrelid 1996, 53 footnote 28.
Middle/Late Mesolithic										
3	Sævarhelleren	-	-		-			7000-5800	stratigraphy	Bergsvik/Storvik 2012, 29 (no. 10).

No.	Site	14C-dating Lab.no.	BP	Cal BP	Cal BC	Standard deviation	δ13C	Approximate date BC	Dated on	Source
Late Mesolithic										
4	Søndre Steghaugen	Tua-4949	7405±45		6230-6175				charcoal from filling	Åstveit 2008.
5a	Viste cave	OxA-30405	7537±39		6255-6025*	2σ	-14.7		long bone, human	Schulting et al. 2016.
5b	Viste cave	-	-		-			6800-5020	Stratigraphy	Fürst 1909 Fig. 3-5; Bergsvik/Storvik 2012, 31 (no. 22).
6	Brunstad	LuS-11115	7060±45		6018-5845	2σ			charcoal from grave-filling (A2400)	Schülke et al 2019; Reitan et al. 2019.
		UBA-28737	6943±44		5971-5731	2σ			charcoal from grave-filling (A2400)	Ibid.
		Beta-383181	7030±30		5989-5846	2σ			charcoal from grave-filling (A2400)	Ibid.
		UBA-28740	7067±37		6019-5881	2σ			from hearth A3185 cutting the grave-pit	Ibid.
7	Torpum 9b							5500-5300		Tørhaug 2003.
8a	Grønehelleren	T-5847	6080±140		5343-4686				bone (skeleton II) , human	Jansen 1972; Indrelid 1996, 53 footnote 27; Bergsvik/Storvik 2012, 27 (no. 6).
8b	Grønehelleren	-	-		-				Stratigraphy	Jansen 1972
9	Skipshelleren	-	-		-			5200-4900	stratigrafi	Bergsvik/Storvik 2012, 27 (no. 8)
10	Gropbakkeengen	T-2159	6210±110		-				marine shell	Simonsen 1961, 182-183; Helskog 1980.
11a	Sømmevågen	-	-					4000	typology	Denham 2016
11b	Sømmevågen	Beta-381097	5440±30		4460-4355	2σ	-15.9		arm bone	Denham 2016; Meling et al. 2020; Meling et al. in print.
12	Steigen	Beta-349961	5450±30	5950-5764*		2σ	-13.0		mandible, human	Günther et al. 2018, Supplement S1

** Corrected for the marine reservoir effect.*

***Figure 5**: Dating of the find contexts with human bones*

Considering the fact that bone material from Mesolithic graves can generally be difficult to date by radiocarbon (e.g. Kjällquist 2001, Reitan *et al.* 2019) the find at Søndre Steghaugen might represent a Mesolithic burial and is therefore included here. The spatial placement of the bones is not described closely in the publication, but the bone agglomerations as shown in Åstveit 2008 (Fig. 3.998 and Fig. 3.301), with a distance of c. one metre between them, is rather long considering the body proportions of a child aged 2–4 years. This could indicate two deposits of bones/burials, or a later disturbance of the burial.

At Brunstad in Vestfold, human bone material was found in a grave (A2400) which was placed on a coastal Late Mesolithic settlement (no. 6). The archaeo-osteological analysis of the poorly preserved bone material, combined with the 3D-GIS reconstruction of the spatial placement of the bone elements, revealed that an adult individual was placed in an oval, east-west oriented grave-pit 1.5 m×1.1 m in size, the floor of which was partly lined with stones. Cranial fragments, including parts of the mandibula, rib bones, elements from the upper and lower extremities (arm, legs) and the right and the left side of the skeleton were represented (Schülke *et al.* 2019, Fig. 7 and Supplementary material 2). With the head to the east, the body was placed on the back in a half-sitting position, the head slightly bending forward. The legs to the west were extremely flexed, the knees laid to the left (Schülke *et al.* 2019) (Figure 6). No grave-goods were identified. The grave-pit was filled with different layers of filling material (Reitan *et al.* 2019, see below).

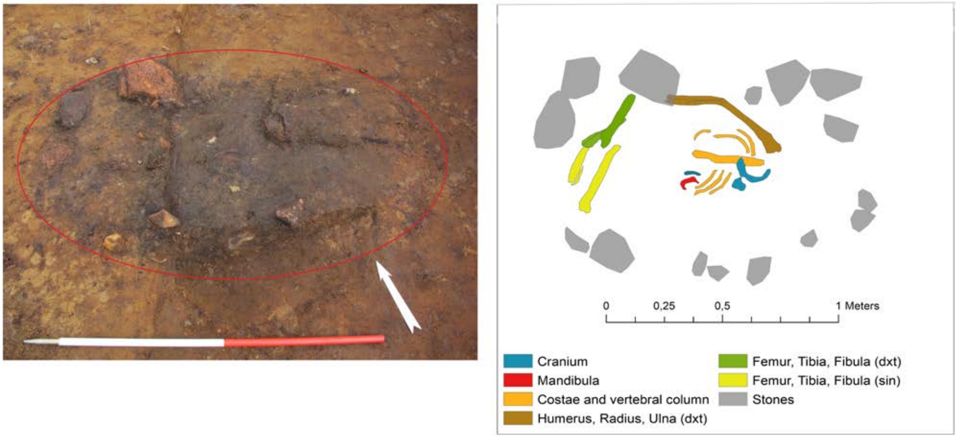

***Figure 6**: The grave (A2400) at Brunstad. Photo of the grave-pit in planum (to the left) before excavation of the bone material (here marked with a red circle), and map of the situation of the preserved bone material in the grave (to the right), after Schülke et al. (2019), indicating the burial of an adult individual in flexed/half-sitting position. Photo: G. Reitan, MCH, UiO; map: K. Eriksen, MCH, UiO.*

The grave with bone material too poorly preserved for ^{14}C-dating is radiocarbon dated to around 5900 cal. BC on charcoal from the grave-filling: 7060±45 BP (LuS-11115), 7030±30 BP (Beta-383181), 6943±44 BP (UBA-28737)) and from the hearth A3185 which cut the southern part of the grave, 7067±37 BP (UBA-28740) (Fig. 4, Reitan *et al.* 2019, Schülke *et al.* 2019).

On the Late Mesolithic coastal settlement site of Sømmevågen (no. 11) an east-west oriented oblong pit with the size of 1×2 m, delimited by stones, was found (Denham 2016). In its western part fragments of human teeth and in its centre fragments of a human hip were recovered. They were identified as the remains of a 20- to 30-year-old individual. Denham (2016) argues that the positioning of the bones might indicate a stretched-out body position. However, the bone material is too fragmentary to assess the placement of the body. At the centre of the pit three stone axes and a stone chisel, typologically dated to the Late Mesolithic/ Early Neolithic transition were found. These date the grave to the years around 4000 BC. Around the grave, several fragments of animal bones were deposited, including the jawbone of a bear at the northeast and the hip of a seal at the northwest corner of the grave.

At the fringe of the Stone Age settlement of Gropbakkeengen in Finnmark (no. 10), three stone piles (*røyser)* were excavated (Simonsen 1961, p. 177–183). Only one of them, *røse C*, contained the remains of a body, the trace of the skeleton represented as a black lardy substance. Only one knee joint was preserved as bone material. The burial was placed in the stone pile, in a stone-free space (*et stenfrit gravrum*) which was irregular, almost three-sided, and framed with stones (Simonsen 1961, p. 182–183, for this and the following). The body, encompassed in a layer of sand, was deposited on a charcoal layer, which was placed on top of a compact mass of shells which had been spread on the natural gravel floor. The head was placed to the northeast, on its left side, the legs strongly flexed in a distinct hocker position. Two items of grave-goods were identified, an arrow made of hornfels and a piece of carved whalebone. The grave is radiocarbon dated to 6210±110 BP (T-2159) (Helskog 1980, p. 49).[6]

Single (loose) human bones from caves/rock shelters and open-air sites

Single human bones, also referred to as loose human bones, are found, in small quantities, at seven sites: in two caves (nos. 5b, 12), in three rock shelters (nos. 3, 8b, 9) and on two open-air settlements (nos. 7, 11b). Three of these sites have additionally yielded the remains of possible burials (nos. 5a, 8a, 11a).

Two finger bones and a metatarsal bone of an adult individual/adult individuals were found in the Mesolithic layers at Viste cave (no. 5b) (Fürst 1909, Figs. 3–5). From Grønehelleren some disarticulated bones are recorded, although it is unclear whether these are of Mesolithic date (no. 8b) (Bergsvik and Storvik 2012, p. 27). Furthermore the fragment of a human skull and a finger joint were found in Mesolithic layers at Sævarhelleren (Bergsvik and Storvik 2012, p. 29) (no. 3). Isolated human bones, all from the extremities such as foot, hand and finger, were found at different spots in Mesolithic layers at Skipshelleren (no. 9) (Bergsvik and Storvik 2012, p. 27).

At Steigen, on the exposed island of Måløya, in Nordland (no. 12), a well-preserved human mandible was found in 2013. About a hundred metres inside a cave it was deposited on a gravel floor close to a large boulder. The subsequent investigation of the surrounding floor did not yield any further finds; however, for safety reasons the boulder was not removed. Teeth from the jaw were dated to 5955–5763 cal. BP, 5450±30 BP (Beta-349961) corrected for the marine reservoir effect (Günther *et al.* 2018, Supplement S1; see also Fig. 4), that is, in the late part of the Mesolithic.

Given the excellent preservation conditions for bone material in the caves, these finds might actually attest that only a small number of such bones came into the ground here, probably representing other practices than inhumation.[7]

Loose human bones are likewise recorded from the open-air settlement of Sømmevågen (no. 11b). About 30 metres from the grave described above, several skeletal fragments of a human arm were found together with numerous animal bones in a Late Mesolithic trash heap. One bone fragment was ^{14}C-dated to around 4400 cal. BC, 5440±30 BP (Beta-381097) (Meling *et al.* 2020; Meling *et al.* in press). The situation is interpreted as representing some kind of ritual, perhaps including the removal of bones from a grave; but it is all but certain that the arm bones are contemporaneous with the documented grave (Denham 2016).

On the Late Mesolithic settlement at Torpum 9b, Østfold (no. 7), three fragments of burnt human bone were found in a settlement layer (A2) just above a pit (A4) and a hearth (A2c); charcoal and hazelnut shells from the cultural layer and the structures are ^{14}C-dated to around 6500–6375 BP (5500–5300 cal. BC) (Tørhaug 2003). These were formerly discussed as possible remains of *skeleton burials* (*skjelettbegravelser*) in a *mødding* (Glørstad 2004, p. 62–63; Glørstad 2010, p. 240–243). In the light of the above, these bones might represent human bones which were circulated amongst the living, and which were intentionally or unintentionally exposed to fire. But they could also be the remains of a destroyed (?) cremation grave.

Conclusion – Trends in the material

The study of the twelve Mesolithic sites with the remains of a minimum 19 individuals, including at least one child, one juvenile and several adults of both sexes, span a period of 4000 years. The qualitative and comparative study of these contexts exhibits the following trends:

– All of the sites are located at the coast. They encompass caves/rock shelters, open-air sites, a former wetland and a possibly transgressed site.

– A variety of types of deposition and treatment of the dead is observed, including burials on open-air sites, burials or depositions in rock shelters/caves, the deposition of dead (?) bodies or body parts in saltwater, and single (loose) human bones deposited on activity areas – either in the open-air or in rock shelters/caves.

– The one deposition in a wetland is dated to the Middle Mesolithic period, while graves are first documented from the Late Mesolithic period.

– In four cases the burial of intact bodies seems likely. Three of these (nos. 6, 8a [skeleton II], 10), possibly four (no. 5a), were arranged in a flexed body position.

– Grave-goods are only recorded for the youngest burials (nos. 10, 11a).

– Single burials seem to prevail (nos. 4, 6, 11a and probably 5a), but places with several burials exist (no. 8a; no. 10).

– A marking of the burial above ground is observed in two cases (no. 6: a hearth; no. 10: a stone pile).

– The deposition of different types of bones can be observed in different contexts. Beside the remains of supposedly integrated bodies, the finds of single human bones in well-preserved contexts support varieties of the treatment of the dead.

These trends testify to diverse ways of dealing with and handling the dead, their bodies and remains, which indicate a range of possible mortuary practices.

Discussion: Aspects of Mesolithic mortuary practices from Norway in a Northern European perspective

In the second part of this paper, several aspects and temporalities of mortuary practice observed in the Norwegian material will be discussed against the backdrop of the theoretical background introduced above and in the light of evidence from Northern Europe. Generally, the Norwegian finds with Mesolithic human bones exhibit material expressions which also are known from other parts of Scandinavia and the Baltic region (see e.g. Bugajska 2014).

Hollows, earth, settlement debris and water: Depositing the dead as practical engagement with different elements

Mesolithic people activated suitable surroundings when placing the dead. In many areas of Europe existing natural bedrock hollows (caves and rock shelters) were purposefully used for the deposition of human remains, such as in Western, Central and Southern Europe, while a large number of inhumations from open-air sites are known, especially from the Central and Northern European plains, where light and deep (moraine or limestone) soils prevail, including Denmark and Southern Sweden (Grünberg 2000 Abb. 7). Burials in human-made shell middens occur in the areas where these are common – mainly along the Atlantic façade (Grünberg 2000 Abb. 7).

The depositional context of the dead, their bodies or body parts shows engagement with different natural or cultural elements, which is also observed in other areas (Conneller 2007, Bugajska 2014, Tõrv 2016). The Norwegian finds of human remains from the Mesolithic exhibit a variety of locations: caves/rock shelters which in most of the cases also were used for settlement, open-air sites and saltwater (Figure 7).

	Cave/rockshelter	Open-air site	Saltwater
Settlement/ cultural layers	nos. 3, 4, 5a, 5b, 8a, 8b, 9	nos. 6, 7, 10, 11a, 11b	
No settlement remains	no. 12	no. 1	no. 2

***Figure 7**: The relation of finds of human bones to natural and cultural elements. Loose human bones are marked in red, unequivocal graves in blue.*

The rocky and often steep coastal façades of the west/northwest Norwegian coast, including mainland, fjords and islands, provided natural hollows or overhangs, which offered not only shelter or hiding possibilities for the living, but also natural spaces for depositing the dead. Except for the Steigen find, the human remains from caves/rock shelters are found in connection with artificial cultural layers including shells and settlement debris (Figure 7). These provided good conditions for digging grave-pits. Graves in shell middens have parallels in Western Europe, especially along the Atlantic façade, where this form of burial seems to be an important ritual phenomenon, e.g. in the Sado valley in Portugal (Peyroteo-Stjerna 2016), or on the French islands of Téviec (Péquart *et al.* 1937, p. 25–70) and Hoëdic (Péquart and Péquart 1954).

However, places with deeper sandy soils were also used to dig pits to bury a dead body, such as Brunstad and Sømmevågen. To find places with the right conditions was most likely more difficult than it might seem at first sight. Still today, and especially along the coast, most areas are characterized by rather thin layers of soil (10–30 cm) on bedrock. This would have been even more pronounced in the Mesolithic period, when, in the course of the complicated land-upheaval processes, the drying out of seabeds first started to advance with former seabeds turning into dry land at paces which showed great regional variation (e.g. Schülke 2020). Thus, digging of a pit deep enough for the inhumation of an intact adult body would only have been practicable at specific places, such as e.g. provided at the open settlement sites with graves. Even in later times, burials in rock clefts, which provided natural hollows, are common (e.g. Glørstad and Wenn 2013), and the covering of burials with stone piles (*røyser*) is a common practice, as e.g. also observed at Gropbakkeengen. Even the placement of today's churchyards/grave-fields, often in depressions close to wetlands, where sediments are deep enough to dig a grave, reflect this (Fig. 8). They often consist of marine deposits of blue clay formed in the last few millennia. Due to their conserving effects and their tendency to collapse easily, these sediments face today's gravediggers with a number of practical challenges (Krüger and Solbu 2019).

The finds of human bones from a former silted-up seabed at Bleivik most likely represent a specific mortuary practice (see below), while it cannot be fully ruled out that it represented an accident such as drowning. Depositions of human bones in wetlands are known from other parts of Northern Europe in the Mesolithic period (Grøn and Skaarup 1993, Sjögren and Ahlström 2016). Bugajska (2014, p. 69) observes that human bones/bodies deposited in water/wetlands from Scandinavia might – together with cremations – belong to the earliest Mesolithic burial types.

The material qualities and idiosyncrasies of these places, with hollows, earth, (salt)water, and settlement debris, involved different practical aspects which in some way or other must have been part of the mortuary practices involved. The question is of course whether these places were chosen because their meaning was important, or simply because they were practical to deal with. Most likely these also had different symbolic, cosmological or social meanings (Conneller 2007, Bergsvik and Storvik 2012, Schulting 2016). Elements that the corpse/body parts would be placed in would be on the one hand either solid (earth, settlement debris) or fluid (water), on the other hand fully enclosing (earth/cultural debris) or openly enclosing (cave, rock shelter).

Engaging with these would require different practices for depositing a body/body parts. Amongst these are (a) throwing/drowning into the water, (b) digging a hole, (c) depositing in a dug-out hollow or in a cave/rock shelter, (d) filling up a hole with specific materials, as e.g. in the case of Brunstad (see below). These practices would include bodily experiences and tools. The act of digging, probably with digging tools, would imply an intrusion into the ground, a practice which is not regularly conducted in Southeast Norwegian Mesolithic contexts (but see Achard-Corompt *et al.* 2017). Another question is whether the burial happened at the place where the person had died, which is often observed in hunter-gatherer communities (Littleton 2007, Struve 2016). But it is also conceivable that in some cases a dead was transported to a convenient place for burial; this could e.g. be the case for the dead that were buried on sites which were repeatedly used as such (see below). This might have been the case at Brunstad with its most suitable conditions for burying a body: If the buried person did not die on the rather small island, the corpse would have had to be transported to the island by boat (Schülke *et al.* 2019). This opens up for thinking about burial rituals, e.g. with regard to how regulated such a boat crossing would be, considering the people participating, the use of specific (?) vessel/boat or other items related to the burial, and so on.

***Figure 8**: The spatial placement of modern graveyards in Southeast Norway – typically in the area of former marine deposits – is related to their qualities as places with soil deep enough to dig a grave. Example: Klemetsrud, Oslo. Photo: A Schülke.*

Placing the dead: The living and the dead intertwined

Most of the finds with Mesolithic human remains from Norway stem from sites which have primarily yielded settlement material, all placed along the coast at their time. The places where the dead or parts of their bodies were deposed reflect mobility networks and areas of communication and movement of the living communities, be it along the coastal mainland, fjords, on islands, or even offshore. Most of these coastal areas are however also those which today are most densely inhabited and thus developed, archaeologically surveyed and excavated in recent years Therefore, a certain bias of the coastal affiliation of the sites with human remains needs to be considered, together with the placement of the graves on settlements, as these represent the find-rich spots where archaeologists dig. The coast might have had ambivalent meanings, featuring as the edge of the (living) world and as the centre of life, and its potential cosmological role has been stressed (Larsson 2003, Bergsvik 2009, Sørensen 2016).

The graves, which all date to the Late Mesolithic, are either placed in cultural layers in caves or on open-air settlements (Fig. 4 and 7). Graves on or directly beside settlements are common in Scandinavia and the Baltic area, such as at Vedbæk, Tågerup, Skateholm, Strandvägen or Zvejnieki (Kjällquist 2001, Larsson 2003, Larsson and Zagorska 2006, Brinch Petersen 2015, Gummesson and Molin 2016,), but there are also exceptions (e.g. Terberger *et al.* 2015), also for some west Swedish sites (Sjögren and Ahlström 2016). The large Mesolithic burial sites of Northern Europe such as Zvejnieki, Vedbæk or Strandvägen were assembled throughout hundreds of years as revealed by radiocarbon dating (Zagorska 2006, Brinch Petersen 2015, p. 110–125, Gummesson and Molin 2016). These places surely had functions as important anchor points for the living communities, and the repeated return to bury people at these sites, even after long time-spans, indicates that they were actively remembered for generations (Larsson *et al.* 2017, Ahola 2018). That the memories of burial sites might have been passed on might also have been the case for sites with just a few repeated burials (Kjällquist 2001, Terberger *et al.* 2015, Sjögren and Ahlström 2016), even though coincidental repeated placing at certain favourable spots cannot be ruled out (Littleton 2007).

The Norwegian situation with mainly single burials and a few places with the sequential burial of several individuals is similar to the Western Swedish evidence (Sjögren and Ahlström 2016). However, places with just one burial also allow us to think about the relations of the living communities to these. The grave at Brunstad (no. 6, Figure 9) provides valuable insights into the intentions behind and the accomplishment of mortuary practices on an existing settlement. It was erected around 5900 cal. BC at the fringe of a shore-based Late Mesolithic island settlement spread out on two plateaus (lok. 24 and lok. 25), which by that time had already been frequented for some centuries. The placement of the grave-pit (A2400) was meticulously chosen, geometrically arranged in a sheltered position right between two south-north oriented rocky outcrops, where the soil was deep enough to dig a pit deep that could house a flexed and half-sitting body (see above and Schülke *et al.* 2019). Different materials were used to fill the pit, which might have been important to ideally create a connection between the grave and the surroundings (Reitan *et al.* 2019): the corpse was covered with sand, a loose stone packing was placed on top, and finally the hollows and the top of the pit were filled up with settlement debris. Afterwards a hearth/cooking pit (A3185) was cut into the top of the grave on its southern side. The temporal closeness of the radiocarbon dates from the grave filling and from the hearth (all on charcoal; see Fig. 5) suggests that the hearth was dug not long after the grave had been filled (Schülke *et al.* 2019). This prompts the assumption that the hearth might be connected to practices/ritual related to the burial, performed relatively shortly after, either by people who knew of/remembered/were attached to the grave or by those who recognized it as a grave. Hearths close to or on Mesolithic graves are recognized in other areas (Schülke *et al.* 2019 with further literature). The radiocarbon dates of other hearths and structures at Brunstad show that the settlement area was reoccupied several times after the grave was erected – up to around 5600 cal. BC (Reitan *et al.* 2019; Schülke *et al.* 2019) (Figure 9).

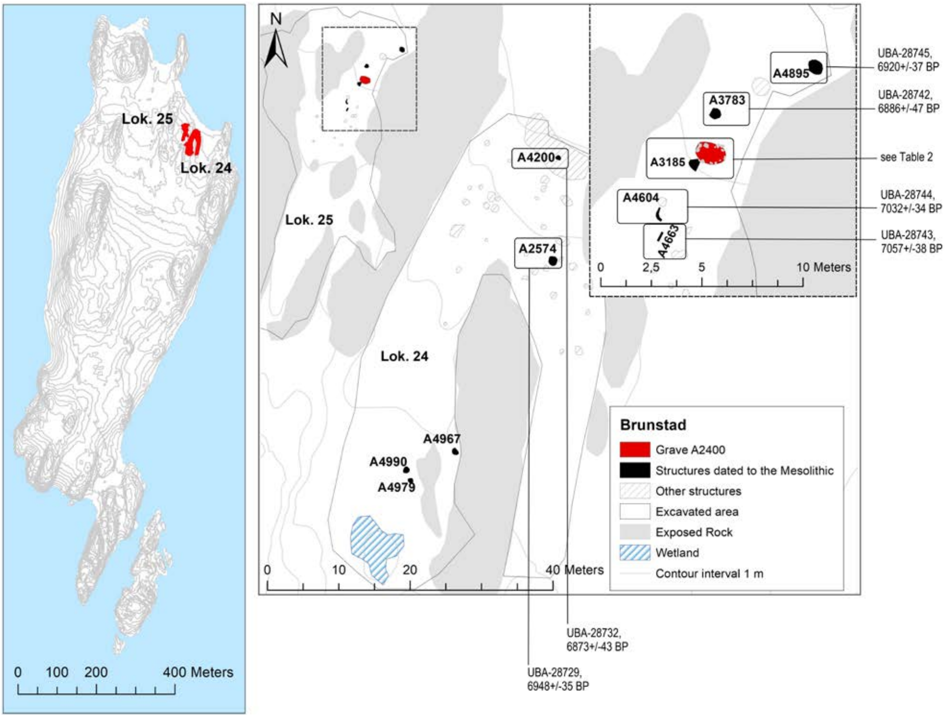

***Figure 9**: The spatial placement of the grave A2400 at Brunstad. The use of lok. 24 and 25 before and around the time of the creation of the grave, and later re-visits are documented by 14C-dated structures. Contemporaneous and later visits are marked in the figure (according to Schülke et al. 2019; Reitan et al. 2019). Most of the structures that are marked as "other structures" most likely also date to the Mesolithic. Illustration: A. Schülke, based on maps by K. Eriksen, MCH, UiO.*

The question is whether these later structures represent targeted revisits to the site which included an act of memorizing the grave, or whether the reoccupations were coincidental – maybe not even visited by the same group (see Schülke *et al.* 2019). Ethnographic sources attest that hunter-gatherers leave places after someone has died/is buried there (Knutsson 1995, p. 66, Littleton 2007). It might therefore be that the site was abandoned directly after the burial and related rituals at the grave, and only revisited after some years/generations.

Burying and getting buried: Body position of the dead, adornment and other features

Considering the low number of finds one can proceed from the assumption that burials of integrated bodies were practised only in specific cases in the Mesolithic period; most people would have been buried/treated in death otherwise, probably in ways that are not archaeologically visible (Nilsson Stutz 2014, Lødøen 2015, Gramsch 2016, Tõrv 2016). However, in which cases which custom would have been practised – e.g. in certain circumstances of death, for persons with certain qualities, at certain places – is difficult to determine as so far there is no substantial comparable material of individuals that were not buried.

All the inhumations of more or less intact bodies from Norway show a flexed body position, with either possible hocker positions (nos. 5a, 8a, 10), and a case of a half-sitting position with extremely flexed legs (no. 6). Graves with bodies in flexed/sitting positions occur across all of Europe (Grünberg 2008). They are especially typical along the Swedish coast, where they mostly occur as single burials. The earliest stem from the Middle Mesolithic, with graves such as Österöd, Skibevall (both in Bohuslän), Vannborga (Åland), Barum/Bäckaskog (Skåne) and Kambs (Gotland), while Stora Bjers/Stenkyrka 30 (Gotland) and Uleberg (in Bohuslän, with two individuals in flexed position) are dated to the Late Mesolithic, respectively to between c. 6000 BC and 5700 BC (Sjögren and Ahlström 2016, Alexandersson *et al.* 2018). This indicates that the flexed body position was, from the Middle Mesolithic onwards, a rather common position for inhumations in the region stretching from the west of Sweden and further north into Norway.

Though burials in flexed/sitting positions occur, with or without grave-goods, across Europe in the Mesolithic, some researchers have argued that they could represent graves of special people – 'ritual specialists' according to their grave adornments (Zvelebil 2008, Alexandersson *et al.* 2018). There are also ethnographic examples that shamans, chieftains, warriors or saints are buried in sitting position (Grünberg 2008). Bodies that are buried in flexed/sitting/half-sitting positions occur however in larger numbers in the graves in shell middens along the Atlantic façade (Péquart *et al.* 1937, Péquart and Péquart 1954, Peyroteo-Stjerna 2017). To study possible ideas behind these flexed burials must be a future comparative research task.

While grave-goods are common in many Mesolithic graves, and known from places such as Zvejnieki in Latvia (Zagorskis 2004) and Vedbæk on Zealand (Brinch Petersen 2016), there are also many examples of burials which, like most of the Norwegian ones, have not yielded grave-goods, or where grave-goods (e.g. of organic material) are not preserved, especially from Swedish sites such as Skateholm, Tågerup and Strandvägen (for an overview see Bugajska 2014, Tab. 6, and p. 66–67, Gummesson and Molin 2016). However, fillings of burial pits with settlement debris could have been part of an important grave-ritual (Kjällquist 2001, Reitan *et al.* 2019).

The covering or embedding of the dead in ochre was important in many parts of Europe (e.g. Zagorska 2016, Brinch Petersen 2015). In Finland, where – as in Norway – acid soils have not preserved bone material, the red colour of ochre is used to identify Stone Age graves (Mökkönen 2013, Ahola 2015). At the same time, ochre is also absent from many grave-finds in Scandinavia (Bugajska 2014 tab. 9 and p. 66). In South Norway, however, ochre is found on quite a number of settlement sites (Bang-Andersen 1982). Patches of ochre were observed in Skipshelleren, were there also are found a few single human bones (Indrelid 1996, p. 56–57, Bergsvik and Storvik 2012, no. 8), in Grønehelleren (Bang-Andersen 1982, 61, Indrelid 1996, p. 57), and probably also at Søndre Steghaugen (Åstveit 2008).

Mesolithic cremation graves are known from Northern Europe, in some cases even with grave-goods in the form of flint artefacts (e.g. Eriksen and Andersen 2016, Niekus et al. 2016, Bugajska 2014, p. 65–64). Such finds are not known from Norway; only Torpum 9b (no. 7) might represent remains of a cremation. As bone material usually is badly preserved in the region, surviving elements of possible cremations, such as charcoal or lithic artefacts, would usually be interpreted as remains of settlements.

Disarticulation of human bodies and deposition and circulation of specific bones

Single finds of human bones from caves/rock shelters and from open-air sites in Norway bear witness to other types of treatment of the dead than burying them in the ground or in cultural layers. Such isolated or loose human bones occur on many Mesolithic settlement sites in other regions and have recently received enhanced attention in the discussion of Mesolithic mortuary practices, beyond earlier ideas of cannibalism, with renewed interest in the multi-phased treatment of corpses including the disarticulation of human bodies, either through targeted decomposition (e.g. through elevation), or through targeted defleshing/fragmentation of the bodies (e.g. Conneller 2007, Gray Jones 2011, Brinch Petersen 2016). Ethnographic examples show that human bones are used amongst the living, e.g. as talismans, mediating the ancestor's special abilities to the living (Brinch Petersen 2016). Trond Lødøen (2015) has put forward the idea that specific steps of such possible multi-phased treatment of corpses might be depicted in western Norwegian rock art. Encompassing manipulation and multi-phased treatment of corpses is documented, for example, for hunter-gatherer burials at Dudka, northeast Poland, where graves were manipulated by taking out bones which later were reburied in other pits (Bugajska and Gumiński 2016).

The phenomenon of loose human bones is also observed in southern Scandinavia (e.g. Brinch Petersen 2016, Sørensen 2016). In western Sweden such single bones occur at the Middle Mesolithic sites Huseby Klev (Kashuba *et al.* 2019), Sandarna and Stora Förvar (Günther *et al.* 2018 supplement S1), and the Late Mesolithic sites Rottjärnslid (Sjögren and Ahlström 2016) and Dammen (Schaller 2007).

Fragmentation of human bodies, which indicates a circulation of human bones among the living, could be identified at several Norwegian sites. Smaller extremity bones (e.g. finger and hand bones) stem from preserved cultural layers or activity areas on settlement sites, both open-air and in rock shelters/caves (Viste, Sævarhelleren and Skipshelleren). Caves and rock shelters provided good preservation conditions for bone material, and thus the finds of smaller human extremity bones might represent a deposition of precisely these types of bones amongst the living – after circulation. But even the Middle Mesolithic wetland sites (Bleivik and Hummervikholmen) could indicate such practices. Both have yielded long bones and/or whole or partial crania. Taphonomic problems need to be considered for these sites, including circumstances of discovery or excavation methods or bioturbation. Smaller extremity bones could have been more easily washed out or re-located underwater and thus could be more difficult to find or even unfindable in the excavated material, even it was meticulously sieved as at Hummervikholmen.

One interesting aspect which might strengthen this idea is the presence or absence of mandibles amongst the bones at Bleivik and Hummervikholmen. Mandibles are documented for most of the grave-contexts (nos. 4, 5a, 6, 8a), even though the evidence is fragmentary. Amongst the three skulls/cranial fragments found in the 1990s at Hummervikholmen no mandibles were present (see Sellevold and Skar 1999, Fig. 2), and the bones dug up in 2013 likewise did not include remains of mandibles (Eggen and Nymoen 2014, Fig. 21). Nor does the Bleivik find contain remains of a mandible. At Steigen, on the contrary, a single human mandible was found. The Steigen find, although much later than the two other contexts, shows that (some of) the bones of the dead could be recirculated amongst the living – even though the time of deposition in the cave is not dated; this could in principle have been much later. This find might help us to better understand the Hummervikholmen and Bleivik contexts. They could represent assemblages of bone material, which already had undergone a treatment which led to defleshing, such as decomposition through elevation, before they were deposited in the water (Bleivik) or before they were taken by the sea (Hummervikholmen). The find at Hummervikholmen could therefore represent a transgressed storage place for selected human bones/manipulated bodies, and as such be an important source for mortuary ritual. This could match with the ^{14}C-dates which are not completely "contemporary" (Figure 5, see also Skar *et al.* 2016, Table 14.1, Günter *et al.* 2018, S1, p. 16). It could indicate that specific human bones of individuals who had died at different times were placed in a type of storage/bone house/shrine, while the bones that were not deposited there might have been re-used by the living (and maybe came into the ground at some other place). This storage place could then have been transgressed, and embedded in the sea-floor. An encompassing archaeo-osteological analysis of the bone material is necessary to further investigate these issues, for example related to cause of death, life histories, possible marks of parting bodies, scalping etc.

The special treatment of skulls in Mesolithic death ritual is a widespread phenomenon, and the removal of the cranium and mandible after the decay of flesh, muscles and ligaments is documented across Europe – in some cases with marks left by scalping (Conneller 2007, Gray Jones 2011, Schulting 2015, with overview). At the wetland site of Kanaljorden, Motala, east-central Sweden, c. 8000–7500 cal. BP, a carefully planned complex deposition of crania of at least ten human individuals, dislodged from the body and without mandibles was found together with animal bones; the crania were placed on wooden sticks stuck into a stone pavement in a little wetland (Gummesson *et al.* 2018). The archaeo-osteological analysis revealed that this mortuary ritual was conducted for a specific group of people who had received trauma to the head before death (Gummesson *et al.* 2019). What happened to the rest of the bodies and the mandibles of the Kanaljorden individuals is not known. Schulting (2015, p. 27) mentions examples from the Mesolithic sites of Lepenski Vir, Serbia, where the mandible of a woman was placed around a large stone-set hearth in building no. 40, according to Schulting *together with a series of vertically set stone slabs mimicking the mandible's triangular shape* (after Srejović 1972, p. 199, Fig. 64). As mandibles of the ancestors they might have had important symbolic significance with special powers and might have been used in rituals. The mandibles of animals also play a role in Mesolithic depositional practices. They occur in graves, amongst others on South Scandinavian sites such as Bøgebakken and Gøngehusevej in Vedbæk, Zealand, and Tågerup and Skateholm I and II in Scania, and as ritual depositions on the coastal site of Syltholm, Lolland (Sørensen 2020, with further literature). In this context it is interesting to note that one of the animal bones placed at the corners of the Late Mesolithic grave at Sømmevågen was the mandible of a bear (Denham 2016). Conneller (2007) suggests that the difference between humans and animals might not have been this distinct in hunter-gatherer communities.

A difference between death cult and ancestor cult and their different social significance for the community of the living has been pointed out (Pfälzner 2001). Ethnographic observations from West Africa show that bones of individuals with special skills were often used in ancestor cults (Pfälzner 2001). While death cult regulates the passage of a living individual into this person's existence in the realm of the dead, ancestor cults are performed as integral and recurrent parts of living communities (Pfälzner 2001). Even though both can be materially intertwined, e.g. when graves are turned into places of ancestor cult, this division can be good to think with in our context. Loose human bones, from caves/cave settlements or open-air settlements, could therefore be regarded as remnants of an ancestor cult. Several possibilities as to why they ended up at the respective find spots are conceivable: they might simply have been lost, they might have been part of a – now decayed – shrine or altar (see e.g. Pfälzner 2001), or they might have been, as single objects that were ascribed special power, intentionally deposited at a location with a special significance. The latter is likely for Steigen (no. 12), where the mandible was placed deep in a large cave on an offshore island in the outer Archipelago of Nordland.

Conclusion and perspectives

This study of twelve contexts with human bones dated to the Mesolithic period from Norway shows that there was a broad span of practices for how the dead and their material remains were handled. The find material indicates inhumation of more or less complete bodies, but also hints at other practices such as the deposition of selected human bones and the circulation of single bones including larger (e.g. mandible) and smaller bones (extremities). This attests to multi-phased treatments of corpses, which could include elevation and decomposition. In chronological terms the few finds attest that practices which included the deposition and circulation of selected bones started in the Middle Mesolithic, while graves first occur in the Late Mesolithic period. As regards mortuary practices in Northern Europe in general, however, this picture is likely to change with any future find.

The situation with the existence of one or a few burials at one place, of wetland depositions and of loose human bones, is thus not very different from what is known from other parts of Northern Scandinavia, especially from Western Sweden.

The traits of burial and mortuary practice identified in this study will hopefully enable recognition of future finds. Together with the significant growth of knowledge about the Mesolithic period in Norway in recent years, these will help to discuss mortuary practices, rituals and ancestor cult in relation to potential social developments – in spatial and temporal terms. This can also pave the way for a revision of the structures/contexts without human bones, which are interpreted as settlement finds or deposits, which could indicate mortuary practices. A revision of bone finds from Mesolithic settlement sites will most likely also reveal other contexts with loose human bones.

Identifying future finds will lie at the intersection of understanding the actually practised mortuary ritual in the past, of hitherto identified archaeological criteria for Mesolithic mortuary ritual in the present, and of matters of decay and preservation. Favourable conditions such as natural shell banks, as known for western Sweden, or the cultural layers containing shells in the western Norwegian caves, have led to the preservation of human bones on precisely these sites, and might bias the picture. Also, wetland finds of bones are most likely to be better visible than other possible depositions of bones in acid soils, which now are decayed.

The conclusion that very likely only few people actually were buried, while most of them were treated in different ways in death, is most relevant for the ongoing discussion of demographic topics. This relates to the reconstruction of population sizes, but also to the question of migration and cultural contact, which is discussed in DNA studies regarding genetic origin (e.g. Günther *et al.* 2019) or isotope analysis, regarding mobility patterns (e.g. Kjällquist and Price 2019). We have to be aware of the DNA of who we analyse, and who/which people might not be represented in such material today. The analysis of loose human bones might help in these matters, but here too it is important to be aware that the human bone material that is preserved today might be a cultural selection; and that much of it could be missing due to e.g. carnivore activity, practices of bone-crushing or deposition at places where it would be difficult, due to poor preservation conditions, to identify finds of Mesolithic human bones.

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Endnotes

1 The finds of human remains from a wetland at Bønes-Kyrkjetangen south of Bergen, found in 2015, are about to be published and are therefore not further discussed in this article.

2 See references in Figure 4.

3 Numbers here and in the following according to Figure 4.

4 The reconstruction at AmS today (see e.g. Schulting et al. 2016 fig. 1) is thus an attempt to illustrate the situation.

5 The bone material that was sampled had been treated chemically for conservation – e-mail of 2 June 2020 from Knut Andreas Bergsvik to the author.

6 A dating which would be classified as Neolithic in Northern Norway.

7 However, not all of the dugout masses at these sites were sieved (Bergsvik/Storvik 2012 Table 3.1).

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Krister Scheie Eilertsen

The Tananger-hut – A contribution to the diversity of settlement structures in the Early Neolithic in Southwestern Norway

Complex composite structural remains are rarely encountered on sites from the earlier parts of the younger Stone Age (4000–2300 BC) in southwestern Norway. This hut, an Early Neolithic structure unearthed at Tananger on the coast of southwestern Norway is presented in this article. Its architectural elements and associated lithic and macrofossil assemblages suggests that the structure is a hut functioning as a short-term living space. While there are strong indications that this activity dates to the Early Neolithic the results of carbon dating are contradicting. However, there are also problems with this interpretation. Contradicting ^{14}C results challenge the huts age, making it crucial to analyse surrounding archaeological finds and the dwellings constructive elements to give a complete interpretation. I will highlight some of the questions this feature rises concerning function and social significance primarily within the stated period.

This example will therefore highlight and expand our knowledge of Early Neolithic dwellings. Analysis of lithic artefacts and archaeobotanical material from the site provide insight into settlement patterns and the economy in this period. Sheltered from wind by turf walls dug down into the sand this structure gives the impression of representing a short-term living space used primarily for hunting and gathering activities in the Early Neolithic. The Tananger-hut has several similarities regarding shape, size and lithic assemblage with Early Neolithic structures from settlements, in southern Sweden, Denmark as well as other areas of northern Europe where agriculture was the primary means of subsistence.

Introduction

During the summer of 2015, an area approximately 13,500 m² was investigated in connection with the Tanangervegen road development project in Tananger, Sola municipality, Rogaland County (Fig. 1).

The project discovered several house structures and activity areas in close proximity to one another reflecting activity in this area from the Late Mesolithic to the Roman Iron age. Amongst the most substantial discoveries were a Late Mesolithic cultural layer, several longhouses dating to the Bronze Age, and occupational features going into the Roman period.

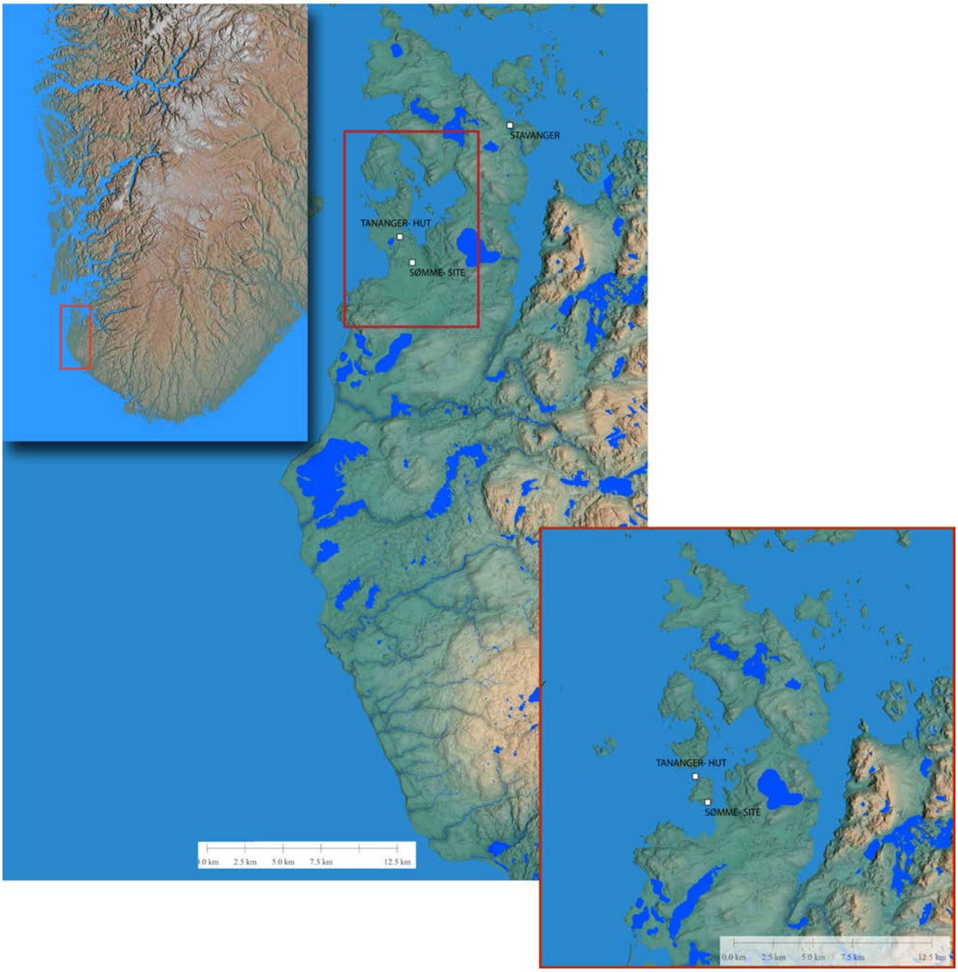

***Figure 1**: Map over Jæren and Tananger peninsula, Tananger area shown at the bottom right (shoreline at 7 m.a.s.l). Map: Theo Gil, AM/UiS.*

This article presents the results from the excavation as well as discussing problems with interpreting and dating the hut. The excavation aimed at ascertaining the character of this dwelling in order to explore how the remains of a hut of this type might materialize in the archaeological record in this area.

At Tananger, the conditions for the preservation of archaeological remains are exceptionally good compared to more exposed sites along the Norwegian coast due to the Aeolian sand-cover that cover some sites along the coast (Prøsch-Danielsen and Selsing 2009). The recently excavated Sømme site is a good example of this where vast amounts of organic material such as bone- and wood- artefacts were retrieved (Denham 2016, Meling 2016). Some of the country's earliest ^{14}C dates on cereal and the biggest collection known of Late Neolithic two-isled houses in Norway are recorded in the Tananger area (Eilertsen *et al.* 2018, Fyllingen and Armstrong 2012, Soltvedt in prep.).

During the last decades a number of settlement sites dating to both the Late Mesolithic and Early Neolithic have been unearthed along the west coast of Norway (Bjerck *et al.* 2008, Åstveit 2009, Eilertsen 2016, Meling 2016, Eilertsen *et al.* 2018, Dugstad *et al.* 2018,). Most are open sites comprised of large amounts of lithic scatters, but with few indications of more complex dwelling features.

In this article, I will be using the term *hut* as defined by Fretheim (2017) when describing this structure. Fretheim uses the term *house* when discussing dwellings that are more permanent. Dwellings that are not considered as permanent and have a lower degree of time-investment include tents and huts. Tents are portable dwellings while huts are more stationary but provisional dwellings (Fretheim, 2017). Although Fretheim uses the term in a Mesolithic context, many economic and social complexions continue into the Early Neolithic (4000–3300 BC (Bergsvik 2001b, Midtbø *et al.* 2011), the definition is therefore applicable to this period as well.

The hut

After the plough-soil was removed, a dark brown-grey, rectangular area measuring approximately 5 x 5.5 m became visible (Fig. 2). This feature somewhat resembled a tree-throw, and its cultural origin was initially questioned. However, the presence of flint artefacts within the top layers of the feature's deposit led us to examine it further. These were all surface finds from the feature. The plough-soil was not sieved for artefacts.

***Figure 2**: The hut after topsoil removal. Photo: Krister Scheie Eilertsen, AM/UiS.*

During the Mesolithic and most of the Neolithic period, the Tananger area consisted of a series of islands. For the duration of the site's occupational phase it was situated on a headland protruding from the northwestern end of a large island. Placed at the western end of a beach it would have been a shore-bound locality, whereas today it is approximately 7.5 m.a.s.l. (Fig. 1).

The structure seemed to have been partially cut into the former beach. Its subterranean character provides functional evidence for interpreting the feature and has been a crucial factor leading to its preservation. It also answers the question as to why we seldom, or never, uncover structures of this character. Tananger and the adjacent area is in varying degree dominated by Aeolian sand caused by wind moving fine sediments from the surrounding shores and beaches (Prøsch-Danielsen and Selsing 2009).

The feature was found to consist of several structural elements, such as remnants from walls, posts and stakes, which comprise a complex structure interpreted as a hut. The outer walls consisted of turf, much of which was still visible and possible to distinguish and sample during the excavation (Fig. 3). Situated on gently sloping ground, the structure's back wall was cut 70 cm into the sand and the front wall 20 cm. This enabled the builders of the hut to establish an approximately levelled floor with an extent of approximately 17.5 m². Although there is no explicit evidence for an entrance, it is presumed that it would have been located at the north end of the hut facing the contemporary shoreline (Eilertsen *et al.* 2018).

Situated on this weathered outpost on an island facing the North Sea, the winds can at times be devastating. We can assume that the top parts of the feature have been influenced or removed by modern day farming, but the lower parts showed high degree of preservation. Not only would creating a pit dwelling with a sunken floor provide the occupants with protection from wind and the mentioned Aeolian sand, it may also have contributed to preserving the lower parts of the feature itself from being ploughed away by modern farming.

Figure 3*: Mid-excavation overview of the hut with some of the structural elements highlighted. Mosaic: Krister Scheie Eilertsen, AM/UiS.*

Structural components: hearths, walls and postholes

Although no stones were discovered, two circular features were initially interpreted as the remains of fireplaces. They were approximately 50 cm in diameter consisting mainly of sand, ash and small pieces of charcoal. However, ^{14}C dating of these features returned dates of

925 ± 40 BP (UBA-31930) and 941 ± 25 BP (UBA-33234) (Fig. 7), demonstrating that they are probably a result of activity at the site during the Viking age. No additional hearths were identified during the investigation.

Twelve circular features were discovered in the centre of the hut and along some of the wall sections. In spite of their shallow depth, these are interpreted as the remains of post-/stake-holes that would have supported the roof of the hut. The character of these features could reflect seasonal usage of the hut where replacement or maintenance of posts would have been necessary (Fig. 3 and 5).

The most prominent feature of the hut is brown, compact deposits of turf interpreted as the remains of walls. An outer turf wall surrounds the entire depression demarcating the limits of the hut. In the southern portion of the hut, a circular ring of turf is interpreted as a division of activity areas or representing different phases of building.

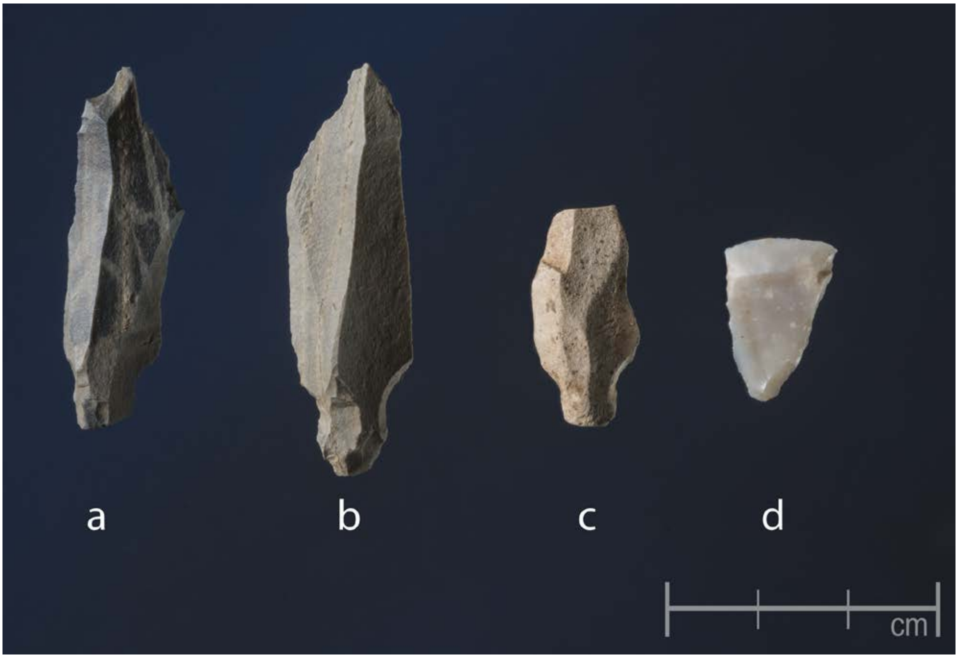

***Figure 4**: Projectile points retrieved from the hut. A and B) A1- type tanged points made from rhyolite, C) A1- type tanged point made from flint, D) Transverse arrowhead made from flint. Photo: Terje Tveit, AM/UiS.*

The lithic material

A total of 1032 artefacts were retrieved in association with the hut. The artefact assemblage is dominated by waste material from stone tool production. Of the 1012 lithic finds 933 (c. 90%) were made of flint. Other raw materials represented are rock crystal, greenstone, rhyolite, pumice and granite. The finds, including A1-type projectile points and cylindrical cores of rhyolite, can be typologically related to the Early Neolithic in southwestern Norway (Olsen, 1992, Bergsvik 1999, Skjelstad 2003).

Rhyolite is a dark volcanic rock with distinctive quartz veins that has many of the same qualities as flint. The rhyolite component of the assemblage provides evidence for long-distance acquisition as its source is located at Siggjo, Bømlo in southern Hordaland County, approximately 95 km north of Tananger, Sola (Alsaker 1987, Bergsvik 1999, Nyland 2016a). The exploitation of this rock is one of the changes marking the start of the Neolithic in this region and is virtually absent from contexts dating to the Mesolithic and the Late Neolithic. This raw material is rarely found on archaeological sites in the eastern parts of Norway. The distribution of rhyolite is thought to reflect a social/cultural complex in western Norway in the Early Neolithic (Solheim 2007, Nyland 2016b). The technological change from micro blade technology and conical cores to cylindrical cores also mark the transition to the Early Neolithic. Greenstone has its provenance in the southern Hordaland region as well. The biggest known quarry is at the small island of Hespriholmen and has a wide distribution throughout western and southern Norway (Alsaker 1987, Nyland 2016a). Finding a significant proportion of what we would call exotic artefacts at a site does not automatically imply that locally derived task groups were involved in their direct acquisition (Bergsvik 2002). Raw material could also have been retrieved through exchange relations between several groups.

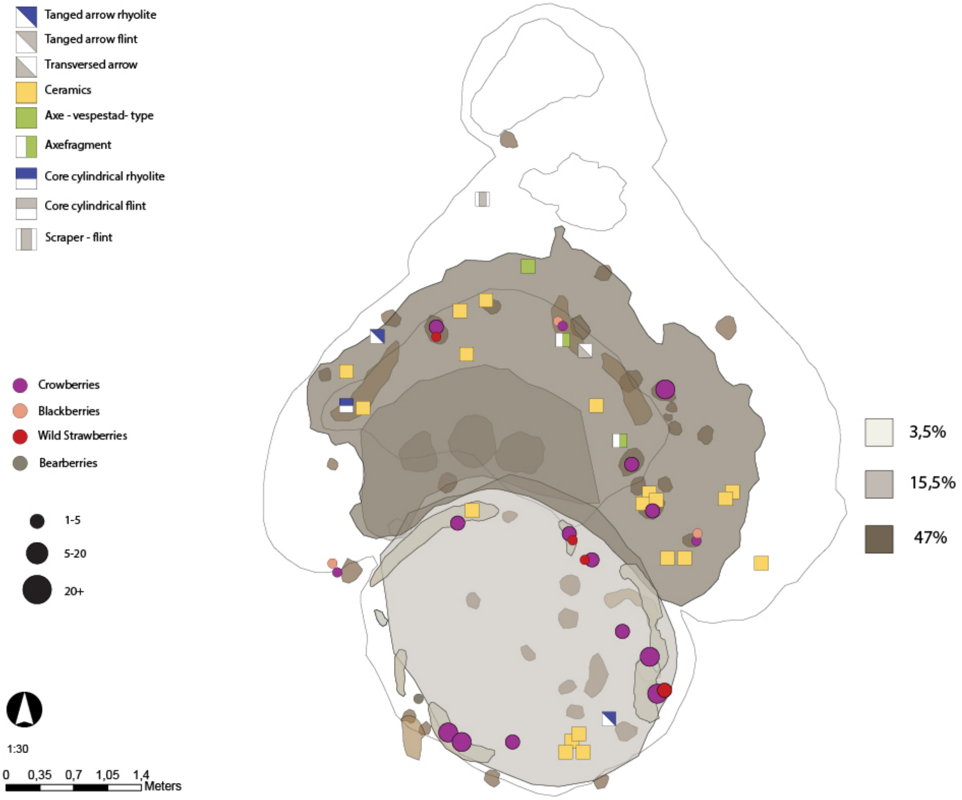

__Figure 5:__ Schematic overview of the hut showing measured contexts, find distribution and distribution of fossilized berry remains. Distribution of lithic artefacts in % is shown on the right. Illustration: Krister Scheie Eilertsen, AM/UiS.

The amount of finds retrieved from the Tananger-hut, a little more than 1000, is a low volume compared to the high number of finds frequently encountered on settlement sites from the Early Neolithic period in western Norway (Olsen 1992, Bergsvik 1999, Bjerck *et al*. 2008, Midtbø *et al*. 2011,). Sømme, the closest known contemporary site, produced c. 100,000 finds, showing a markedly different use to the Tananger site (Meling 2016).

The material found in relation to the hut contains many of the objects that could be expected in an inventory belonging to an Early Neolithic hunting station. That 89.5% of the lithic assemblage can be classified as waste material supports an interpretation of the site as short-term with few visits and limited tool production. A tool percentage of 10.5% could indicate that some of the tools recovered at the site were prefabricated prior to being brought to the hut.

Ceramics

The most unexpected find of the excavation was 20 fragments of ceramics. Nearly all were recovered close to, or in direct connection with remnants of walls or postholes. Weighing 15.9 g in total the sherds were fragmented and in poor condition, the largest measuring only two cm in length. The small size of the fragments along with the overall lack of decoration made typological determination impossible. To attempt to date the ceramic assemblage, a destructive method such as "bulk shard organics" was necessary. A single shard from the site was dated, the result however gave an unexpected date of 3580 ± 30 BP (Beta-462435) (Eilertsen *et al*. 2018) assigning it to the Late Neolithic period, approximately 1200 years later than the presumed age of the hut.

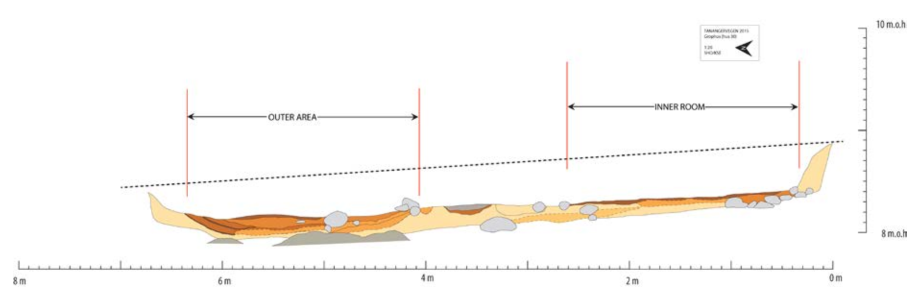

***Figure 6**: Stratigraphic profile through the hut displaying layers and their relation between the two activity areas. The section is cut diagonally through the hut. Illustration: Krister Scheie Eilertsen, AM/UiS.*

Multiple rooms?

The structural components of the hut allow for at least two possible interpretations of settlement activity at the site (Fig. 3 and 5). One possibility is that the hut consisted of two rooms separated by a turf wall. A second interpretation is that the overall size of the hut was smaller, and that it had an adjoining activity area. This area would have been supported by a wall running along the outer limits of the feature, lowered in the same way as the actual hut. This hypothesis is supported by the distribution of finds, as there is a clear differentiation between the inner and outer rooms (Fig. 5). A lower density of finds in the inner room suggests that this area has been cleared of debris. Lithic and botanical finds in this area were mostly found in close association with the remains of walls. In contrast, finds from the adjacent activity area were found scattered throughout the entire floor surface. The different characteristics of the two areas are further evident in a soil profile running across the length of the feature. In the profile, a layer of sand separates two distinct deposits that correspond to the two areas described above (Fig. 6). Although interpreted as a single phased site, the hut could have been subjected to several visits. If so, the visits would have taken place within a restricted space of time, possibly specific seasons in consecutive years. This can be inferred from looking at the collective find-assemblage of the lithic material, which is single-phased and clearly placed in the Early Neolithic period. If this had been a site used during multiple chronological phases, we would expect to have recovered artefacts related to different prehistoric periods. A site used for several phases would also most likely display a more elaborate combination of layers and deposits.

The botanical remains

Macro- and micro fossil samples were collected from the various structural elements of the hut. Paleo-botanical analysis of the samples enabled us to compare the composition of different deposits and allowed for the retrieval of organic material for dating purposes. The most significant result from the analysis of the macrofossil assemblage was the identification of seeds from a variety of wild berries including wild strawberries (*Fragaria vesca*), crowberries (*Empetrum nigrum*), bearberries (*Arctostaphylos uva-ursi*) and blackberries (*Rubus fruticosus*). No other traces of these plants were observed in the macrofossils, suggesting that the berries were brought to the site. The different types of berries acquired from features in this hut are all resources that could have had its provenance within a relatively short distance to the site. It is important to note that material analysed in macro- and pollen-samples are primarily collected from features that consists of organic materials. Organic material, in this case turf, have a high degree of decomposition and the chance of mixing with overlying, external components or sediments is high, and therefore something to be aware of when interpreting the data.

All the berries identified on the site are edible species of fruit bearing plants. In addition, crowberries in particular are known to have medicinal qualities (Mabberley 2008) that could have been exploited in the Early Neolithic. Fossilized remains from turf and heather were also recorded in the macro-morphological material. Anomalies in the paleo botanical record including cereal grains (*hordeum vulgaris*) are evidence of contamination from later activity and may be associated with the decomposition of the hut's structural elements and its exposure to contaminants from surrounding activity. Comparison of botanical remains across the site showed an inter-feature differentiation in content from wall sections, floor layers and posts, supporting the interpretation of these as distinct construction elements.

Pollen samples taken from the basal deposit within the depression, a layer into which some of the hut's structural elements were cut, do not show definitive evidence of contamination. The layer did however contain a high amount of *Ericaceae* (heath) together with the species *Calluna vulgaris* (heather, ling). They both appear in the paleo botanical record as early as the Early Neolithic. Species within the family are not always easy to distinguish, and the family name *Ericaceae* (heath) is commonly used when referring to this plant (Eilertsen *et al.* 2018).

Problems with dating or dating the problem?

Six samples from deposits associated with the hut's structural elements were sent for radiocarbon dating early in the post-excavation process. However, none of the dates obtained corresponded with the chronology of the site as suggested by the artefact assemblage. Ranging from the Late Neolithic until the latter part of the Viking age, the ^{14}C dates demonstrated that shifting Aeolian sands have likely exposed and re-covered the site several times leaving it exposed to contamination. In an effort to affirm the Early Neolithic date for settlement activity suggested by the archaeological finds, two additional samples were sent for dating (Eilertsen *et al.* 2018). These results again show activity in the Late Neolithic and Late Iron Age rather than confirming assumptions of the Early Neolithic interpretation (Fig. 7).

Context	Material	Sample	Uncalibrated	Calibrated (2σ)	Lab. Ref.
Wall	Cereal	2015/02-130	3470±30 BP	1884–1695 BC	Beta-413532
Wall	Charcoal	2015/02-225	3066±37 BP	1416–1226 BC	UBA-33236
Layer/Wall	Cereal	2015/02-212	3522±41 BP	1959–1701 BC	UBA-30934
Layer/Wall	Charcoal	2015/02-212	2591±37 BP	831–557 BC	UBA-33235
Deposit/Layer	Charcoal	2015/02-124	925±40 BP	1024–1203 AD	UBA-31930
Deposit/Layer	Charcoal	2015/02-133	941±25 BP	1029–1155 AD	UBA-33234
Deposit/Layer	Cereal	2015/02-144	3579±34 BP	2030–1781 BC	UBA-30932
Ceramics/Deposit	Ceramics	2015/02-453	3580±30 BP	2028–1828 BC	Beta-462435
Crowberry/Wall	Crowberry	2015/02-219	1270±30 BP	663–859 AD	Beta-462436

Figure 7: *^{14}C results. Illustration: Krister Scheie Eilertsen, AM/UiS.*

To explain the non-conforming dates, the larger Tananger site complex must be considered. The area that was stripped of topsoil close to the hut contained features and structures from several prehistoric periods. Sediments and organic material from these contexts may have been translocated by taphonomic processes and intermixed with deposits within the structure as the turf walls slowly decomposed. Such contamination is often evident on archaeological sites and especially contexts dominated by sandy soils. The Donk site at Herk-de-Stad in Belgium is a good example of this phenomenon (Van Strydonck *et al.* 1995). At Donk a number of ^{14}C dates did not match with the archaeological contexts due to distortion of the stratigraphy by erosion and Aeolian sand. Hence, both the Donk and the Tananger site show that archaeological contexts within organic features are extremely exposed for contamination and contextual and stratigraphic distortion. Debatable radiocarbon dates has also been a topic within the Swedish Mesolithic sites that show traces of settlement. Disturbed contexts, external contaminants and disturbances from activity both modern and prehistoric shed doubt on some of the ^{14}C analysis (Johansson 1993, Cronberg 2001).

Decomposition of a structure's organic components can have a major impact on associated deposits depending on environmental conditions and soil chemistry. In the case of a turf wall, its layers decompose over time and younger material can descend into underlying deposits. Modern disturbance and shifting sands might also explain the anomalies encountered in the radiocarbon record.

'Task group'-dwelling?

Huts and pit-house dwellings are common throughout northern Norway and the wider Fennoscandia region. They are heterogeneous in form and are dated to both the Mesolithic and Neolithic periods (Olsen, 1994, Mökkönen, 2011). Given the scarcity of Early Neolithic dwelling structures in southwestern Norway, the single phased dwelling from Tananger is an extraordinary find. The closest parallels to the Tananger-hut are found in the Scania area of southern Sweden where a number of single phased sunken-floored Early Neolithic structures have been investigated at Östra Odarslöv, Saxtorp 23 and Dagstorp 19 (Andersson 2004, Andersson *et al.* 2016). These features are also similar in size, ranging from 4–7 meters in diameter and display comparable find assemblages. The remnants of turf walls found at Tananger however, are to the author's knowledge without parallel in Scandinavia.

The reason why there are few comparable dwellings from the Early Neolithic in southwestern Norway is that prehistoric sites often contain a mixture of artefacts and features from several different periods. In Rogaland there seems to be significant continuity in the choice of settlement location as Late Mesolithic sites are frequently found superimposed under Early Neolithic sites (Meling 2016, Sørskog *et al.* 2017, Dugstad *et al.* 2018, Eilertsen *et al.* 2018). There is much debate concerning the degree to which settlement patterns and economy changed during the transition from the Late Mesolithic to the Early Neolithic (Bergsvik 2001b, Bjerck *et al.* 2008, Solheim and Persson 2018). This debate will continue as long as we keep unearthing new settlement types in different landscapes.

Due to the relatively low artefact density and thin deposits, the Tananger-hut can be classified as a short-term camp, visited a few times. It is important to note that artefact density in itself is not an absolute proxy for activity. The tool assemblage could have consisted of a considerable number of artefacts made of perishable organic material such as bone or wood and could not be considered when estimating the total amount of finds. Knut Andreas Bergsvik (2006) argues that larger sites with thick deposits and high artefact density combined with high variation in raw materials classifies as long-term camps. Moreover, he also argues that these long-term camps are more closely related to sedentism than short-term camps in the Mesolithic and Neolithic periods (Bergsvik 2006). Assuming that organic material will build up in the flooring sections of a dwelling like this hut over time, the layers will increase (Grøn 1995). Keeping this in mind the thin layers uncovered in the Tananger-hut could represent a relatively low number of isolated visits to the site.

Whether it is viewed as a base camp or a specialized hunting station, individuals lived and performed their daily activities of working, eating and sleeping at the camp (Nærøy 2000). In Mesolithic hunter-gatherer societies, we know of a variety of dwelling types and sites that could indicate various forms of mobility. The change from mobile tents to more elaborately constructed dwellings most likely reflects a change in the economic strategy in the Late Mesolithic. This would most likely represent reoccurring visits from task-groups, which are more prominent during these periods (Åstveit 2009). Comparing the hut from Tananger with other prehistoric periods in southern Norway, we find the closest parallels in the Mesolithic periods, when looking at the constructive elements (Bjerck *et al.* 2008, Damlien and Solheim 2013). This view is also shared by Ole Grøn (Grøn 2003) and he states that the "Late Mesolithic" pattern continues in the Finnish and Swedish pit dwellings of the Baltic Late Mesolithic and Neolithic hunting-gathering cultures. It could also be argued that these structures may have something in common with some of the lenticular layers, investigated in the southern parts of Sweden and Denmark. These are often dated to both Mesolithic and Neolithic periods.

In addition, two layers could represent re-occurring visits to the same site within a short timespan (Grøn 2003). Bergsvik (2002) argues that this type of demographic trait not only explains sites with accumulated thick deposits, but also answers some of the questions regarding the smaller short-term living spaces. Bergsvik defines a 'task-group' as an activity group ranging in numbers from 2–3 persons up to 15 families, depending on the tasks. The tasks vary from collecting berries to engaging in war, trade or hunting (Bergsvik 1995). When trying to identify what the Tananger-hut represents in a 'task-group mobility' model it stands out as a seasonal hunter-gatherer station with local fruits being one of the resources acquired. Leif Inge Åstveit (2009) states that a common assumption is that the marine ecosystem, regardless of time period, provides a broad spectre of resources stimulating the possibility of a year-round occupation and minimizing the risks of periodic collapse. This is supported by the traces of economic exploitation recovered from the dwelling. The results from the natural sciences and analysis of macro and pollen from the feature imply a combined economic resource base. No remnants of hearths was detected inside, which could indicate that the dwelling was used during a season stretching over the warmer months of summer, or that hearths was established on a material that did not leave any traces for us to detect during excavation. In sum, and despite the obvious challenges presented by the lack of consistent radiocarbon dating, the Tanangervegen-hut is interpreted as representing a short-term living space that should most likely be associated with a task-group mobility model.

Final remarks

In southwestern Norway, several sites with Early Neolithic dates, both radiocarbon and typological, have been excavated. This material gives us good insight into the technology and artefact types that people surrounded themselves with and fits well with what we know from southern Norway as a whole (Bergsvik 1999, Solheim 2007, Midtbø *et al.* 2011). When it comes to dwellings, we are missing a complete overview of the various types that were used in southwestern Norway. What we have is a number of isolated features such as fireplaces, single postholes, pits and stake-holes, providing fragmented evidence of habitation structures (Kuijt 2000, Bergsvik 2006, 2010, Artursson *et al.* 2016, Grøn 2017). The evidence from Tananger is a significant addition to our record of Early Neolithic dwellings, it is however important to underline that more data is required before it is possible to draw definite conclusions.

The Late Mesolithic-Neolithic transition is frequently discussed in terms of settlement patterns, with much emphasis on sedentism gradually increasing during the Neolithic period in western Norway (Olsen 1992, Olsen and Fasteland 1992, Bergsvik 1995, 2001a, Nyland 2016b, 2017). Although we see clear evidence supporting the economic transition that took place in the Neolithic, we still do not fully understand the evolution of domestic dwellings during this period. In other parts of Scandinavia, and the British Isles, there is evidence of two-isled houses dating back to the Early Neolithic (Darvill and Thomas 1996, Iversen 2015, Whittle *et al.* 2017). Early evidence for two-aisled houses is missing in our region and this phenomenon could have several possible explanations. Ole Grøn (2003) suggests that the changes in the northern European Neolithic reflect an impact of Neolithic ideology long before a recognizable Neolithic economy is introduced, and that the existence of a pre-

Neolithic phase should be considered in this region (Grøn 2003). The absence of two-isled houses in southwestern Norway may be a manifestation of this theory. Poor preservation conditions and lack of awareness concerning these early structures may also be responsible for the lack of evidence.

The Tananger-hut provides a reference to be used in future investigations of prehistoric sites in Rogaland. It represents a previously undocumented type of dwelling in this region, and its discovery is a significant contribution to our understanding of the economy and society of the Early Neolithic period.

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Dag Erik Færø Olsen

Stone Age rockshelters in the high mountains

Stone Age rockshelters in the high mountains

In 2016, the University of Bergen conducted an archaeological field school at Hallingskeid in the high-mountains in Ulvik County, western Norway. One of the sites investigated was a boulder-shelter with a cultural layer that showed periodical activity from the Late Mesolithic, the Neolithic, and the Bronze Age. At the time, this was the first boulder-shelter to be investigated in these mountain areas since the 1970s and provided valuable insight into the chronological depth of the activity at these permanent shelters. This raised the question whether this site was an anomaly or if these types of settlement structures were equally 'important' also before the transition to farming? Permanent shelters have received less focus as research subject the last 40 yerars, especially in the high mountains. A larger study of the Hardangervidda and Nordfjella mountain areas show a considerable use of these habitation structures at least from the Late Mesolithic and on. This paper aims to look at rockshelters and boulder-shelters in a longer perspective with a focus on their use before and after the Middle-Late Neolithic (MN-LN) transition to farming c. 2350 BC to discuss their importance among hunter-fisher-gatherer communities in South Norway.

Introduction

In this paper, rockshelters as settlement sites in the high mountains will be reviewed addressing two topics – the hypothesis stating that these sites were primarily used from the Late Neolithic by farmers (Indrelid 1994, p. 229, 269) and the site type as part of an overall settlement pattern in the mountain areas, using results from a recent reclassification of the archaeological material with ^{14}C dates (Olsen 2020). In order to differentiate between geologically different types, the shelters will be either referred to as boulder-shelter or rockshelter. The former is made up by one or several larger glacier transported boulders, creating shelters from wind and rain. The latter is naturally occurring cliff overhangs forming a roof over a living space. They vary in size and form and are often situated away from contemporary open-air settlement sites.

The study area Hardangervidda and Nordfjella is situated in the middle of South Norway and effectively separate eastern from western Norway (Fig. 1). The two adjacent mountain areas comprise a rich and diverse archaeological material with activity form the Early Mesolithic and throughout the Middle Ages. In prehistory, this activity was mainly seasonal with the purpose of hunting reindeer, a tradition that is still practised today. The hunters came from groups with different social and cultural background from both eastern and western Norway and social interaction could have been motive as well. In a study (Olsen 2020) 81 sites was analysed, consisting of 61 excavated and 20 surveyed sites, with a general dispersal in the study area. Of these, seven sites are defined as boulder-shelters and four as rockshelters (Fig. 1) covering a long time span based on archaeological material and ^{14}C dates. The 81 sites are representative for activity from at least the last part of the Late Mesolithic and throughout the Bronze Age (c. 4500–500 BC) and are well suited for discussing settlement and subsistence in a long-term perspective.

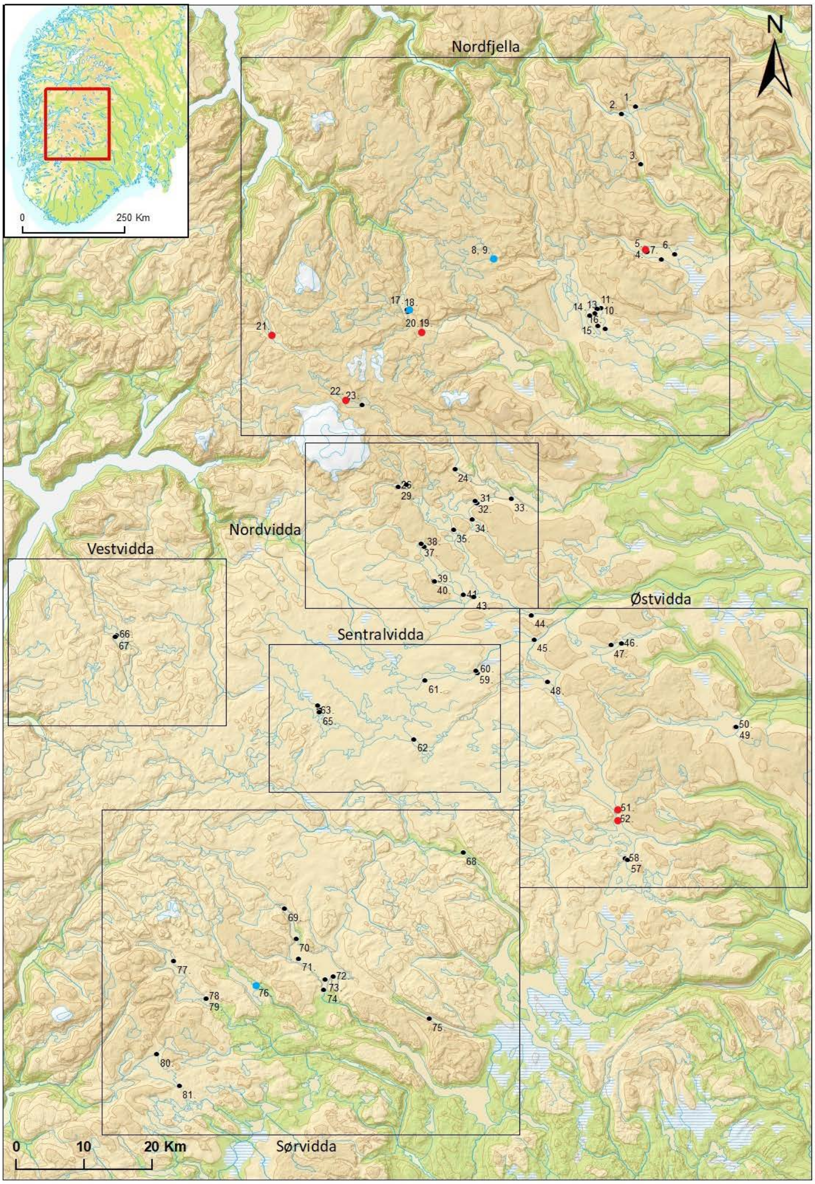

Figure 1*: The study area divided into sub-regions and with the analysed sites. Rock shelters and boulder-shelters marked with blue and red respectively.*

Caves and rockshelters (no. *hule and heller)* have a long history of research in South Norway dating back to the 1800s (e.g. Bendixen 1870, Brøgger 1907, Bøe 1934, Gjessing 1920). These sites were mostly situated at the coast and were initially interpreted as short term, seasonal hunting stations (Bergsvik and Storvik 2012, p. 24). This interpretation is still relevant today as a general description for the type of activity that took place in rockshelters and caves (Bjerck 2007) and might be particularly true for the sites in the high mountains. Several rockshelters have been excavated in the recent years along coastal South Norway (e.g. Bergsvik 2016) but few in the mountain areas (an important exeption is Skrivarhellaren in the Årdal mountains in western Norway e.g. Prescott 1995, Prescott and Melheim 2017). Several have however been investigated in the Hardangervidda and Nordfjella area between the late 1950s and throughout 1970s as part of the development of hydroelectricity (Indrelid 1994, Martens and Hagen 1961).

Even though little research has been done on these type of settlements in the mountain areas in recent years, some studies has been conducted in western Norway. The most important was 'det Vestnorske Hellerprosjektet' (the western Norwegian rockshelter project) which focused on rockshelters in Herand, a small hamlet in Jondal municipality in Hordaland County. These had not been excavated earlier and several rockshelters provided information on human occupation and activity from around 7000 BC and well into the Iron Age (e.g. Bergsvik and Hufthammer 2009, Bergsvik and Storvik 2012). As part of this project, a master thesis by Storvik (2011) investigated 84 caves and rockshelters in Rogaland County in southwestern Norway which included nine rockshelters from the mountain areas but no boulder-shelters. An estimation was made of varying intensity in use of the 84 sites and relevant results for this discussion is a possible increase from the Mesolithic to the Neolithic, followed by a slight decrease in the late Neolithic/Early Bronze Age (Storvik 2011, p. 31, see also Bergsvik and Storvik 2012). This indicates that the degree of activity was at least at similar levels before and after 2350 BC, possibly higher in the older phases. Of the nine mountain sites, four had activity from the Mesolithic and the Neolithic, one with activity both before and after 2350 BC. Three sites had a general Stone Age dating and one with activity after 1500 AD. There are no comparable studies of caves and rockshelters in eastern Norway and it is difficult to determine if the trends in activity seen in Rogaland can be transferred to eastern parts of Norway. The above review still provides a basis for analysing the results from Hardangervidda and Nordfjella in order to discuss changing patterns of activity.

I will mention one other study of a well-known rockshelter, Bukkhammeren, situated in the mountain areas of Østerdalen at the border between middle and south Norway (Gustafson 1990). The activity in the shelter was ^{14}C dated to the Mesolithic, the Neolithic and the Iron Age, including Late Neolithic and Early Bronze Age. The sparse lithic material supports the dates in general, but no bifacial material was found to support activity in the period after 2350 BC. A rich bone material suggests that hunting for beaver was the primary activity, which took place sporadically over a period of 6000 years, in addition to hunting big game, birds and fishing. The activity, except hunting for beaver, follows the same pattern as on other mountain sites further south, providing a basis for comparison with Hardangervidda and Nordfjella.

In the following, the 11 sites from Hardangervidda and Nordfjella will be presented in detail to establish separate activity phases based on archaeological material and ^{14}C dates (cf. Olsen 2020). The aim is to explore the level of activity before 2350 BC and if there was a shift in use after the transition to farming. Was there significant activity before this at these types of settlement sites or have they mostly been used in relation to outfield activity (e.g. transhumance or as early shielings)? How does the activity at boulder-shelters and rockshelters compare to the general activity in the mountain areas in the long-term perspective?

The sites

Of the 11 sites, eight was situated in the sub-region Nordfjella (Fig. 1), two in the eastern parts of Hardangervidda and one to the south. The distribution pattern can likely be attributed to a geography with higher peaks and deeper valleys in the north, including more large boulders and glacial deposits in general. The presentation starts with the northern sites moving towards the southern areas. One of the sites was excavated recently (Berg and Olsen 2017) while the remaining ten were examined from the late 1960s and during the 1970s.

In 2016, as part of a field school for master students in archaeology at the University of Bergen, a boulder-shelter (NG II) was excavated at Hallingskeid, Ulvik municipality. The site had a cultural layer with archaeological finds indicating periodical activity from the Late Mesolithic, the Neolithic and the Bronze Age. This was the first boulder-shelter to be investigated in these mountain areas since the 1970s and provided valuable insight into the chronological depth of the activity at many of these sites.

Nedre Grøndalsvatn II (NG II) (Fig. 1, no. 21) was situated c. 988 m.a.s.l. and approximately 100 m east of the lake inlet and c. 10 m above in sloping terrain. The shelter was made from a boulder with an adjacent cleared surface of 15 m^2 (Fig. 2).

Figure 2: The site Nedre Grøndalsvatn II. Left: the site during excavation, facing north. Right: plan over the excavated area with cooking pits and surrounding boulders and rock outcrops. Photo and map by author.

One side of the boulder was slanting providing a roof-like structure with c. 1 meters depth from the dripline, protecting from the elements towards the north. A cultural layer covered most of the site with varying thickness from 5–40 cm of which c. 70% was excavated. At the edge of the cleared surface opposite the boulder, three cooking pits and/or sunken fireplaces was discovered, one of which ^{14}C dated to the Early Iron Age. The cultural layer consisted of two separate phases, the topmost ^{14}C dated to 835–755 BC (UBA-33865, 2600±34 BP) (Late Bronze Age) and the lower half to 5840–5670 BC (UBA-33866, 6865±39 BP) i.e. the Late Mesolithic. The long time span between the radiocarbon dates could be complemented with the activity reflected by the archaeological material. Of a total of 988 lithic finds, of which 50% flint, 27% quartz and 23% quartzite, most was debris from tool production, but also included arrowheads. Microblades of flint substantiate the oldest radiocarbon date, but transverse and single edged arrowheads indicate activity between c. 4500–3500 BC (Late Mesolithic–Early Neolithic).

Blades from cylindrical cores of flint indicate activity in the Middle Neolithic (c. 3500–2350 BC) as does a fragment of a rhombic arrowhead of slate. Bifacial arrowheads with a straight base were used in the Late Bronze Age (cf. Mjærum 2012), which is consistent with the ^{14}C date of the upper part of the cultural layer.

This site had multiple phases of activity with the oldest in the first half of the Late Mesolithic. The next phase was in the transition between the Late Mesolithic and the Early Neolithic followed by activity in the Middle Neolithic. Then there is a hiatus in the Late Neolithic/ Early Bronze Age with activity again in the Late Bronze Age and Early Iron Age. There were tool production at the site from all activity phases and it is not possible to establish, or discard, increased activity after the transition to farming after 2350 BC.

Øljuvatn heller III and V was situated in the northern part of the Nordfjella sub-region (Fig. 1, no. 8–9) at the far eastern side of the lake Øljuvatn. The two adjacent rockshelters were separated by variation in the cliff overhang and might have been used at the same time. Øljuvatn heller III was ten meters long facing southwest with a circular base. The dripline was seven meters at its highest and the habitable space had a maximum depth of four meters. A total of 30 m2 was excavated (>70%) revealing a cultural layer with three separate phases. The stratigraphy had been disturbed after the original activity, as a concentration of fire-cracked rocks with charcoal in the bottom layer was ^{14}C-dated to the Early Iron Age while another similar structure was radiocarbon dated to 5990–5670 BC (T-3621, 6940±90 BP) e.g. the Late Mesolithic. Lithic material (819) was found throughout the cultural layer with flint as the dominating raw material (c. 67%), with quartzite (18%), quartz (13%) and slate (2%) also represented. Flint was also the primary material used for scrapers and transverse arrowheads. All categories of arrowheads were found in the bottom and presumably oldest stratigraphic layer, which confirms a secondary disturbance of the site. The types include, in addition to transverse arrowheads, single edged, tanged A-points (flakes), rhomboid slate points and bifacial arrowheads. The largest single category is the bifacial type with 63 finds including prefabs and fragments. The majority are later types such as leaf shaped with straight or convex base and the triangular type. Only one of the bifacial arrowheads is of flint and represents an early type from the Late Neolithic, leaf shaped with a concave base (also known as 'heart shaped'). The archaeological material show similar levels of activity from the Late Mesolithic and throughout the Bronze Age including tool production at the site. Considering just the bifacial arrowheads it is possible that the main activity was from the Early Bronze Age and forwards, but interestingly with marginal activity in the Late Neolithic.

The adjacent ***Øljuvatn heller V*** was nine meters long and with a maximum depth of 4.5 m. The height varied from 1–2.5 m in central areas to 15 m at its highest. An area of 13 m^2 (35%) was excavated revealing a cultural layer with several stratigraphic phases. In the bottom layer charcoal from a section was ^{14}C dated to 5920–5485 BC (T-3620, 6790±130 BP), e.g. the first half of the Late Mesolithic, overlapping with the oldest radiocarbon date from ***heller III***. Of 536 lithics the majority was flint (69%) followed by quartzite (25%), quartz (4%) and slate (2%). Microblades were found scattered throughout the site and could represent activity contemporary with the ^{14}C date. The diagnostic archaeological material consisted of transverse and single edged arrowheads, tanged A-point (flake), rhomboid slate points and bifacial arrowheads. Flint was the primary raw material among the four first types while the bifacial ones were mainly of quartzite. At this site the early types of bifacial arrowhead with concave base was in majority and one could be determined as a triangular type. One of the slate points is a so-called *phyeensilta* that also had an incised furrow lengthwise, a trait specific for the last part of the Middle Neolithic (T.B. Olsen 2009).

This site shows activity from the beginning of the Late Mesolithic and throughout the Neolithic and Bronze Age, and the rockshelters at Øljuvatn was used consistently both before and after the transition to a farm based society.

Skyrvenut V (Fig. 1, no. 5) was situated 200–250 m from the lake Gyrinosvatn, in the eastern part of Nordfjella, and approximately ten meters higher in sloping terrain. The site consisted of a large slanting boulder that gave shelter towards both east and west and the entire estimated activity area was excavated (21 m^2) (Martens and Hagen 1961, p. 31). A cultural layer was detected with a varying thickness of 2–10 cm and the majority of lithic material was found in the western part. A structure interpreted as a fireplace or a cooking pit was identified just outside the dripline, and in the north stretching four meters to the south was a wall made of stones that could possibly have been a windbreak. Charcoal from the main activity area in the west was ^{14}C dated to 5850–5065 BC (T-257, 6550±200 BP) e.g. the first half of the Late Mesolithic. The lithic material (300) was dominated by quartzite (67%) followed by flint (23%) and quartz (10%). A few arrowheads were found at this site, the oldest types being transverse and single edged points of flint, but Neolithic finds also included tanged A-point (blade) of flint and an atypical A-point of quartzite (microblade). In addition two bifacial points of quartzite was found, one leaf shaped with a straight base and the other triangular indicating activity in the Late Bronze Age/Pre Roman Iron Age. Blades and microblades suggest tool production at the site in late Early Neolithic and/or the Middle Neolithic and cores of green quartzite should probably be related to production of bifacial arrowheads. The site had several activity phases, the earliest in the beginning of the Late Mesolithic, then in the Late Mesolithic/Early Neolithic followed by activity in the Middle Neolithic. The last phases were in the Late Bronze Age and Pre Roman Iron Age.

Vestredalsheller I (Fig. 1, no. 18) was situated in the western parts of Nordfjella the lake Vestredal. Beneath an overhanging cliff, two small rooms each approximately 4 m^2 was excavated. The majority of the lithic material was found in the northernmost room at 60–80 cm depth, in a cultural layer with several phases. Charcoal from layer VI at c. 60 cm was ^{14}C dated to 2495–2035 BC (T-696, 3840±90 BP), e.g. the transition between the Middle Neolithic B and the Late Neolithic. The archaeological finds (729) was predominately of quartzite (93%) and the remaining flint (7%). The only arrowheads found was bifacial of the triangular type (the Late Bronze Age and Pre Roman Iron Age) found in layer IV and the majority of the quartzite at the site should be related to tool production in this phase. Flint debitage and a blade could represent activity in the Middle Neolithic and match the radiocarbon date, but the main activity phase at the site was likely in the Late Bronze Age or later.

Further east lay two boulder-shelters, ***Geiteryggheller I and II*** (Fig. 1, no. 19–20) c. 30 m apart in an area with large ice transported boulders. Geiteryggheller I was situated furthest east and consisted of large boulders to the north and west creating a living space with a 25 m^2 flat floor partly covered with stone tiles. Approximately 25% was excavated and a cultural layer with a possible cooking pit was identified, but with no radiocarbon dates. Of 475 lithic finds, c. 98 % was quartzite (the rest flint) and related to the production of bifacial arrowheads. Several types were identified with varying chronological significance, with the oldest from the Late Neolithic/Early Bronze Age. Leaf shaped with straight or convex base and triangular arrowheads from the Late Bronze Age and Pre Roman Iron Age shows activity throughout the later parts of the stone using periods, and with few indicators from earlier periods.

The ***Geiteryggheller II*** site was also made up by large boulders around a flat surface of c. 30 m^2. The entire site was excavated and charcoal from a cultural layer was radiocarbon dated to the Early Iron Age. The lithic material (5912) was predominately of quartzite (98%) and is similarly to Geiteryggheller I from the production of bifacial arrowheads. The earliest indicator of activity is a transverse arrowhead from Late Mesolithic/Early Neolithic and fragments of rhomboid slate points from Early Neolithic/Middle Neolithic. The majority of the archaeological material is from Late Bronze Age/Pre Roman Iron Age (triangular and leaf shaped with straight/convex base), but there was also points from Late Neolithic/Early Bronze Age. The two rockshelters at Geiteryggheller were both predominately used from the Late Neolithic and through the Pre Roman Iron Age, after the transition to a farm based society.

The last site from the Nordfjella region is ***Sandå I*** (Fig. 1, no. 22) at the northern end of the Lake Finsevatnet, just north of the Hardangerjøkulen glacier. Sandå I was a small site of 3 m^2 adjacent to a low rock outcrop and a boulder. The site was fully excavated with 98 lithic finds of which 70% quartz, 24% flint and the rest slate. Diagnostic material includes transverse arrowheads, tanged A-points of blades and fragments of rhombic slate arrowheads and points to activity from the last part of the Late Mesolithic and in the Early and Middle Neolithic. Interestingly there were no indications of bifacial tool production or any activity after the Middle Neolithic.

Two boulder-shelters have been analysed from Mår in the southwestern part of the Østvidda sub-region. ***1106 Mår*** (Fig. 1, no. 53) was a site with two large boulders shielding a 20 m^2 flat surface. A cultural layer has been ^{14}C dated to the Middle Age. A trench was dug from the site thorough a waste deposit towards the adjacent rockshelter 1058 Mår. Charcoal from the bottom layer was radiocarbon dated to 1565–815 BC (T-1450, 2980±170 BP), e.g. Early to Late Bronze Age. The site showed signs of secondary disturbances and various types of arrowheads were found without stratigraphical order. Of 1481 lithic finds, 65 % was of flint and the rest quartzite. The main parts of the finds are linked to bifacial technology with arrowheads from the last part of the Early Bronze Age and throughout the Pre Roman Iron Age (leaf shaped with straight/convex base and triangular). There was also a conical core and blades/microblades from activity in the Middle Mesolithic and/or the early parts of the Late Mesolithic, but the main activity phases were likely after 2350 BC.

The site ***1058 Mår*** (Fig. 1, no. 51) had an estimated activity area of 12 m^2 delimited by two large boulders in the west and to the south. The entire surface was excavated (19 m^2) revealing a cultural layer which had been disturbed and multiple concentrations of charcoal and pits were identified, some interpreted as possible fireplaces. A ^{14}C analysis of charcoal from a fireplace gave the date 835–190 BC (T-1452, 2420±140 BP), Late Bronze Age/Pre Roman Iron Age. The bottom of the cultural layer was radiocarbon dated to 2485–1980 BC (T-1445, 3810±90

BP), Middle Neolithic B/Late Neolithic. Burned fragments of bone from the cultural layer and the fireplaces have been identified as mainly reindeer with some evidence of fowl and fish. Of 2775 lithics, 83% was quartzite and the remaining of flint. Diagnostic material includes 25 arrowheads: a transverse and a tanged A-point (blade) and 23 bifacial. The latter consist of four different types: leaf shaped with concave (Late Neolithic/Early Bronze Age), straight and convex (Late Bronze Age) and triangular (Pre Roman Iron Age). Blades and microblades found throughout the stratigraphy should be linked to activity in the late Mesolithic and/or Neolithic. The majority of the bifacial arrowheads were made of quartzite and the main activity phases at the site were likely from the Late Neolithic/Early Bronze Age and on.

Only one rockshelter is known in the sub-region Sørvidda and the site was situated 150 m from and 10 m above the lake Bordalsvatnet.

Bordalshelleren (Fig. 1, no. 76) was formed by an overhanging cliff with a dripline as high as 6–8 m. Approximately 70% of the site was excavated (18 m^2) revealing a cultural layer without any structures. Lithic material was found scattered in all stratigraphical layers indicating later disturbances. Charcoal was radiocarbon dated to 380 BC–73 AD (T-217, 2100±100 BP), Pre Roman Iron Age/Early Iron Age. The archaeological material consisted of 643 lithics of which 86% quartzite, 12% flint and 2% quartz. Diagnostic material was seven bifacial arrowheads of quartzite; six leaf shaped with convex base and a triangular type. The arrowheads were used between the Late Bronze Age and the first half of Pre Roman Iron Age (c. 800–200 BC). Some blades and microblades of quartz and quartzite indicate activity possibly from the Mesolithic, but the main activity phase of this site was from the Late Bronze Age and on.

The presentation of these eleven boulder- and rockshelters clearly shows variation in terms of long-term or short-term occupation and the degree of activity before and after 2350 BC. These types of settlement sites will be discussed further in light of recent research and as part of the general settlement pattern of the mountain areas.

The shelters – long-term use?

Long-term activity at Hardangervidda and Nordfjella

Rockshelters and boulder-shelters are relatively rare compared to open-air sites, which could be placed almost anywhere. In order to use the shelters one would have to accept the placing in the terrain and landscape. Varying preferences is a factor that could have influenced the use of rockshelters and should be included when considering changing trends in activity over time.

Data from the investigated sites at Hardangervidda and Nordfjella provides a basis for discussing the use of these types of permanent settlement structures. Looking at the radiocarbon dates from the sites (Figure 3) it seems that the main activity as recorded by ^{14}C dates was from the Middle Neolithic B/Late Neolithic transition and on. Before this, there is a hiatus with no activity from the end of the Late Mesolithic and in the Early Neolithic/Middle Neolithic. The majority of the activity according to ^{14}C dates was after c. 1000 BC (Late Bronze Age/Pre Roman Iron Age) and an interesting question is how the archaeological material relates to this trend.

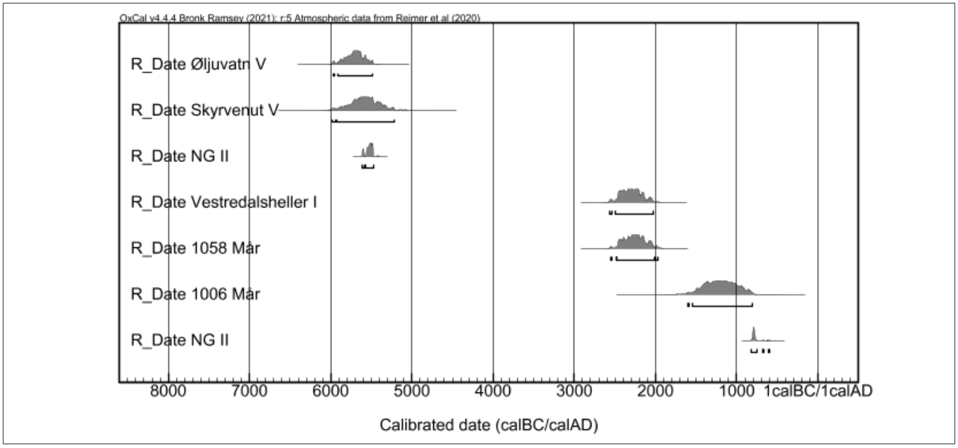

***Figure 3**: Multiple plot of the radiocarbon dates from periods using lithic technology (>ca. 200 BC).*

The lithic material from the sites can mostly be used for a low-level chronology to show the activity over time. It will however indicate certain trends, and together with the radiocarbon dates, it gives us an insight into the relative importance of these types of sites. The arrowheads, raw material and technological traits can be used as markers to establish activity within chronological phases. Here all finds are equal and do not factor the degree of activity in terms of intensity as might be reflected in the number of finds. It is however clear from the review of the sites that the activity is evenly distributed before and after 2350 BC and that for most situations the lithics represents more than one isolated visit. The chronological activity phases reflects the general use of rockshelters, and can be compared with other indications of mountain activity. The phases vary in duration between 1000–1300 years due to the long continuity of the various arrowhead technologies.

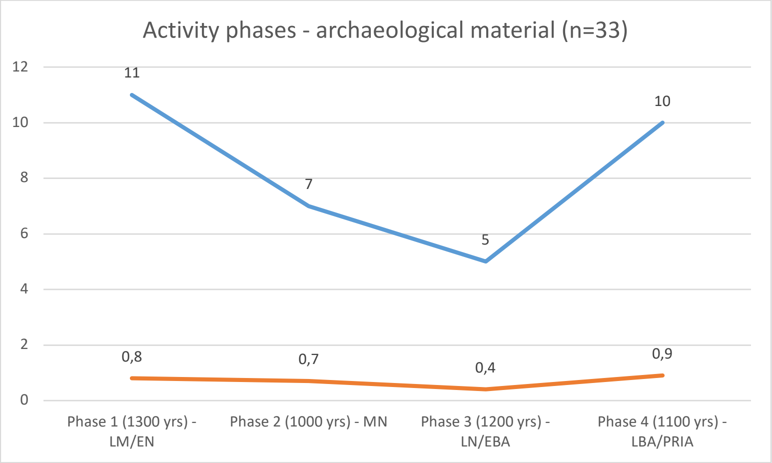

***Figure 4**: Diagram of activity phases based on chronological dating of lithic artefacts and technological traits. The top line shows number of individual activity phases at the rock shelters within each chronological phase. The bottom line shows the number of activity phases pr. 100 years.*

In Figure 4, 33 different activity phases from the eleven rockshelters are distributed within four main chronological phases. The timeline starts at c. 4500 BC (the Late Mesolithic phase 4) and ends c. 200 BC based on the presence of lithic material. The diagram shows some variation in activity with similar levels at the beginning and the end with a gradual decrease towards the transition to the LN/EBA. The dataset is limited and does not say if the change is gradual or stretched over long periods. When comparing this analysis with the multiple plot of ^{14}C dates, it is clear that they complement each other providing a fuller picture of the use of these settlement structures. The radiocarbon dates (mentioned in the text) show a lacuna in the Late Mesolithic – Middle Neolithic and with the main activity after c. 1000 BC at the transition to the Late Bronze Age. The activity phases also show a rise in activity in the Late Bronze Age and Pre Roman Iron Age and substantiate the ^{14}C trends. The lacuna is however not real when including the archaeological material. The trend is rather the opposite with relative high activity at least from the Late Mesolithic, providing a better understanding of the activity in general.

The activity at the sites at Hardangervidda and Nordfjella fits with the above-mentioned studies of rockshelters elsewhere, suggesting that the sites have been in use and seen as 'attractive' throughout the Neolithic and in the Early Bronze Age and that hunting and fishing was the primary focus. In the following, the shelters will be discussed in light of the general settlement pattern at Hardangervidda and Nordfjella to see if this particular settlement type differed from open-air sites.

Rockshelters and boulder-shelters as part of the general settlement pattern

The use of rockshelters must also be discussed in light of the general activity and settlement pattern in the mountain areas. The majority of the sites were open-air used seasonally for hunting reindeer. This also applies for the activity in the Late Neolithic and the Early Bronze Age, although the degree of transhumance and the use of mountain areas as pasture is an uncertain factor (Indrelid and Moe 1982, Kvamme *et al.* 1992, Indrelid 1994, p. 233–234, Eide *et al*. 2006). Figure 1 shows the general dispersal of sites and the activity has shown similar variation to the use of rockshelters. Looking at the ^{14}C dates from the analysed sites at Hardangervidda and Nordfjella a few trends can be discerned.

The first is an increase in radiocarbon dates in the Early Neolithic that started already in the last part of the Late Mesolithic. This was followed by a drop towards the beginning of the Middle Neolithic. Then there was a new increase with a peak in the last part of the Middle Neolithic (B) before a new low in numbers in the first part of the Late Neolithic. In the last part of the Late Neolithic, there was another rise with a new drop in the Early Bronze Age.

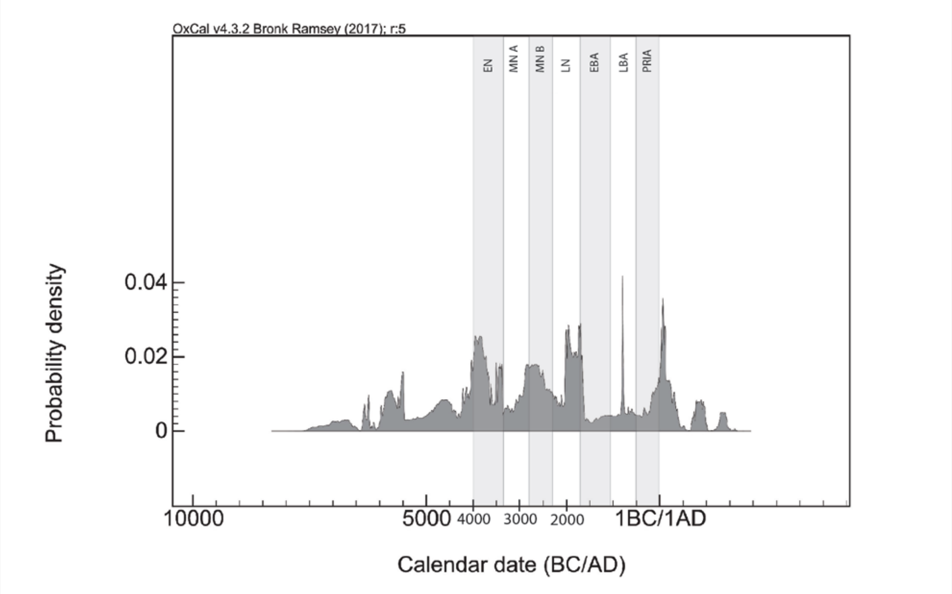

***Figure 5**: Summed probability curve for radiocarbon dates from sites in the study area (n=70).*

Placing the combined indications of rockshelter activity within this context it is clear that they overlap and show similar trends. The general activity shows a variation with highs and lows in the Neolithic and the Bronze Age, and is further corroborated by the activity as reflected by the archaeological material (Olsen 2020, p. 348–349). A prominent trait in the long-term demographic trajectory for the study area was the decline in activity during the first half of the Late Neolithic indicated by both the ^{14}C dates and the archaeological material (e.g. Olsen 2020, p. 358ff). This can also be seen at the rockshelters where few sites contain the earliest types of bifacial arrowheads but show an increase in the Bronze Age material. In addition, a high level of activity in the Late Mesolithic and the Early Neolithic is also comparable and the analysis clearly suggests that the activity at the rockshelters does not differ from the general historical trajectory for the mountain areas. Ten of the rockshelters have been interpreted as mountain base camps and one (Sandå 1) as a specialized activity area. This applies for all the different activity phases indicating that this type of shelter have been considered interesting for long periods. This also transcends the division between hunter-gatherer and agricultural based societies, at least throughout the Bronze Age. This should not come as a surprise as naturally occurring permanent shelters are scarce and it seems that the location of the sites, often farther away from bodies of water than open-air sites, did not influence or restrict the use. There is also no clear difference in the use of the two types of shelters as people seem to have used what was available to in the area they were active.

A challenge when compiling various data from the sites is how to weight different indicators of activity. Several sites have ^{14}C dates from the first half of the Late Mesolithic, a period without arrowhead technology as a defining chronological marker. As a contrast, many of the sites have bifacial technology present giving an impression of more activity from the Late Neolithic and on. Most sites have Mesolithic blades, microblades and debitage but this is often undercommunicated, as the material is hard to use chronologically without a technological study. In their review of Mesolithic rockshelters and caves from coastal and inland areas in western Norway, Bergsvik and Storvik (2012) show that many of these dwellings were used throughout the Middle and Late Mesolithic (c. 8000–4000 BC) with varying intensity and occupation length. In this study the relatively small caves and rockshelters was interpreted as less important to the groups compared to the much larger open-air sites in the region (Bergsvik and Storvik 2012, p. 33). This might in part be because in the Late Mesolithic people became more sedentary occupying the same space over longer periods, demanding larger areas than available in the rockshelters and caves. This is not relevant when analysing the sites in the mountain areas since the occupation was short term with smaller groups of hunters. The rockshelters was part of the overall settlement system with base camps and specialized activity areas, mainly relating to the first type even if the stay was only for a few days or a week. There is also a point to be made regarding the mountain sites where the potential numbers of rockshelters probably were fewer than in lower lying regions, and that the permanent dwellings was of general interest.

The use of the high mountain areas was also influenced by general demographic trends in South Norway where highs and lows can be seen in the proxy data for population variation (Nielsen *et al.* 2019). Climatic variation during the Holocene also had an impact on the activity and one notable trend was a temperature decline after 3200 BC leading to a lower forest line and a glacial expansion (e.g. Bakke *et al.* 2005, Bakke *et al.* 2008, Gjerde *et al.* 2016, Olsen 2020, p. 76ff). An effect was that the study area became mostly deforested leading to larger pastures for reindeers and bigger herds. This in turn led to an increase in activity by groups both from eastern and western Norway with higher level of contact and cultural exchange. In contrast, there was a population decline between 2500–2100 BC (Nielsen *et al.*, 2019) leading to a change in settlement patterns and possibly less activity in the mountains. This might also be connected to less focus on these areas during a time of large-scale societal changes in the first half of the Late Neolithic (Olsen 2020, p. 416ff, Solheim 2021). This changed during the Early Bronze Age when mountain resources gained an increasing importance (Prescott and Melheim 2017).

Conclusion

The analysis of the rockshelters from Hardangervidda and Nordfjella show that there is little basis for arguing increased importance in early agricultural based societies. The material from the sites clearly demonstrates that permanent shelters has always been used and most frequently in a base camp capacity. The use also corresponds with the general settlement pattern and follows the general variation in activity at the Hardangervidda and Nordfjella mountain range. It seems that decent habitation sites have been attractive for both hunter-gatherer groups and agriculturalists, regardless of the sites location in the landscape.

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Gaute Reitan

A Revised Chronology of the Mesolithic in Southeast Norway

Abstract

A chronological outline of the Mesolithic in southeast Norway was published by Egil Mikkelsen in 1975, dividing the Mesolithic period into four succeeding phases. Since then, this chronology has remained the main framework for arranging Mesolithic settlement finds, although with slight later adjustments. However, when Mikkelsen published his study, very few settlement sites had been excavated. This has now changed, as a large number of sites have been investigated in recent years. The data from these sites have dramatically raised the potential for studies into the chronological development in the region. However, the newly unearthed assemblages are in some cases difficult to fit into the established chronology. In this paper, the empirical foundation of the established Mesolithic chronology is reassessed, and it is concluded that the chronological scheme is due for a revision. Based on a high number of recently excavated sites and associated radiocarbon dates, a revised chronology of the Mesolithic in southeast Norway is suggested. It is claimed that six Mesolithic phases can be distinguished – three main phases (Early, Middle and Late Mesolithic), with each of them, in turn, divided into two sub-phases.

Introduction

In 1975, Egil Mikkelsen published a study on changes in the ecological adaptation during the Mesolithic of southeast Norway (Mikkelsen 1975a). A chronological framework has been recognised as the most important contribution made by this study – a framework that divides the Mesolithic into four subsequent phases. Mikkelsen's chronology was the first chronology outlined for southeast Norway, and it was developed on local shoreline-displacement curves, local finds and typological patterns expressed in the native archaeological record. Although subjected to adjustments after later excavations, Mikkelsen's four-phased division (Fig. 2) persists as the main reference for the Mesolithic in southeast Norway. Initially in this paper, I will present Mikkelsen's chronology and discuss the revisions that were suggested and widely accepted around the turn of the millennium. Until recently, however, certain transitional sequences have only been partly explored. This situation has now drastically altered, as a rich data material from a multitude of excavations during the last decades sheds new light on the long-term chronological and technological trajectory in the region. This newly excavated material has turned out to be difficult, at least in part, to fit into the four-phased scheme first suggested by Mikkelsen more than 40 years ago. It is consequently argued in this paper that the established Mesolithic chronology is due for a revision. Based on technological shifts and what I consider as chronologically dependent trends in the recently recorded assemblages, along with new local shoreline displacement curves and a large number of radiocarbon dating results (cf. Solheim and Persson 2018), it is possible to distinguish six different phases in the Mesolithic (Fig. 2 and 17). This new chronological outline also provides new dating frames for classic tool-types, such as the Nøstvet adze, the chubby adze and the handle-core. The revised chronological outline relies heavily on data obtained within two large-scale excavation projects – one carried out in the counties of Vestfold and Telemark in 2010–2012 (Melvold and Persson 2014, Reitan and Persson 2014), the other in the county of Aust-Agder in 2014–2016 (Reitan and Sundström 2018). Additionally, my analysis encompasses a comprehensive body of data from other excavations, both published and previously unpublished, across southeast Norway (Fig. 1). Artefacts typical for the period like axes/adzes, cores, blades/microblades and projectile points are, along with flint reduction strategies, all central in my reassessment – find categories that have traditionally been pivotal in the chronological discourse on the Mesolithic (Fig. 3–6). Although the present study is based mainly on excavated material from the Oslo Fjord area, the conclusions are arguably relevant to the bordering areas of western Sweden at least south to the Gothenburg area (for the chronology of the Mesolithic in the coastal areas of western Sweden, see e.g. Jonsäter 1984, Nordqvist 2000a, Johansson *et al.* 2013, Lindman 2013a, p. 9, 2013b), and likely also Denmark in terms of contact networks (e.g. Nielsen *et al.* 2019, p. 88).

In part, this study overlaps with a previously published paper in norwegian (Reitan 2016). However, the results in the present paper are based on a considerably larger amount of site-data. Additionally, this study includes a discussion of the Early Mesolithic, unlike the previously published paper.

The study area and the level of archaeological activity

A mountain range divides southern Norway, i.e. south of Trøndelag in central Norway, into an easterly and a westerly half. The easterly of the two, in total c. 95,000 km^2, is archaeologically administered by the Museum of Cultural History, University of Oslo (Fig. 1). A major part of this area constitutes a large drainage basin with big river systems running from the mountains through several long valleys cutting through the landscape towards the coastline around the Oslo Fjord. The areas along the coast are largely characterized by hilly terrains with a steep drop to the fjords and the present-day shoreline.

So far (winter 2019/2020), approximately 460 sites from different parts of the Stone Age have been investigated within this area since the turn of the millennium (Reitan 2018a). Archaeologically, the coastal areas surrounding the Oslo Fjord are the most intensely investigated (cf. Glørstad 2006, 2010). Overall, the recorded data from these examined sites constitute an information potential which is exceptional in a European perspective.

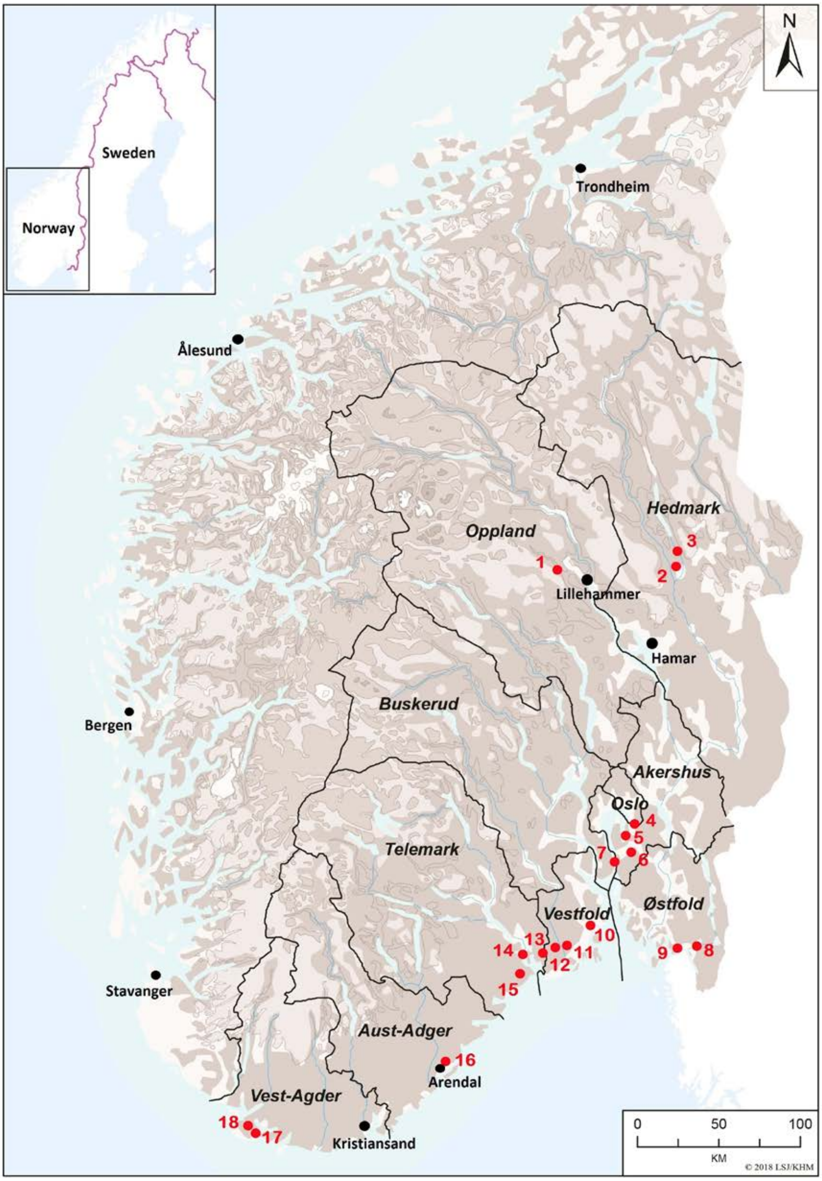

***Figure 1**: Important multi-site Stone Age excavations carried out in southeast Norway over the last decades: 1) Dokkfløy, 11 sites (Boaz 1998), 2) Rødsmoen, 14 sites (Boaz 1997), 3) Gråfjell/Rena elv, 25 sites (Stene 2010), 4) Follobanen/Elgsrud, 5 sites (Eymundsson and Mjærum 2015; Eymundsson et al. 2018), 5) Vinterbro, 3 sites (Jaksland 2001), 6) E6/Dobbeltspor, 12 sites (Berg 1995, 1997), 7) Oslofjordforbindelsen, 10 sites (Ballin 1998), 8) Halden, 5 sites (Lindblom 1990), 9) Svinesund, 15 sites (Glørstad 2004), 10) Brunstad, 3 sites (Reitan et al. 2019, Schülke et al. 2019), 11) E18 Bommestad–Sky, 11 sites (Solheim and Damlien 2013), 12) E18 Brunlanes, 10 sites (Jaksland 2012a, 2012b, Jaksland and Persson 2014), 13) Vestfoldbanen, 29 sites (Melvold and Persson 2014, Reitan and Persson 2014, Reitan 2016), 14) Skutvikåsen, 3 sites (Ekstrand 2013), 15) E18 Rugtvedt–Dørdal, 30 sites (Solheim 2017), 16) E18 Tvedestrand–Arendal, 34 sites (Reitan and Sundström 2018), 17) Farsund, 28 sites (Ballin and Jensen 1995), 18) Lundevågen, 8 sites (Berg-Hansen 2010; Reitan 2010). Map produced by L.S. Johannessen/G. Reitan (after Reitan 2018a).*

The importance of shoreline displacement curves

Due to the continuous postglacial land uplift, shore-bound settlement sites from the Mesolithic period are situated on dry land around the Oslo Fjord and south to the Arendal-Grimstad area, Aust-Agder. The archaeological investigations carried out in the region leave a distinct impression of a Mesolithic population that has relied heavily on marine resources, a trait already pointed out by Brøgger over a hundred years ago (A.W. Brøgger 1906, cf. W.C. Brøgger 1905, but see e.g. Mjærum 2018). The connection between the settlement and the contemporary sea is reflected in both the ecofact material and in stable isotopes in human bones when preserved, as well as in the distribution of the settlement sites – the sites have often been located on terraces on slopes and with easy access to the contemporary shore (e.g. Mikkelsen 1975b, Breivik 2014, Jaksland 2014, Persson 2014a, Skar *et al.* 2016, Boethius and Ahlström 2018, Breivik *et al.* 2018, Darmark *et al.* 2018a, cf. Åkerlund and Nordqvist 1997). Consequently, a detailed knowledge of the sea level displacement provides critical input for an understanding of the diachronic settlement patterns and of landscape use in a spesific coastal area. Mappings of the sea level changes, carried out by geologists, have therefore been undertaken as integrated parts of several large-scale archaeological excavation projects in recent years (Sørensen *et al.* 2014a, 2014b, Romundset 2018, Romundset *et al.* 2018). The postglacial sea level changes rely on a number of factors, and substantial differences in the course of shoreline displacement within short distances have been documented. This important aspect has recently been convincingly demonstrated by Anders Romundset (2018) in connection with the excavations carried out by the *E18 Tvedestrand–Arendal project* (Reitan and Sundström 2018). The rapid land uplift, most notable in the first part of the Holocene, combined with a hilly landscape, makes well-dated shoreline displacement curves highly reliable and precise tools for dating sites located on ancient raised shorelines, not least when organic material suited for radiocarbon dating is lacking – a problem commonly encountered in Early and Middle Mesolithic contexts (cf. Jaksland 2014, p. 43–44, Damlien 2016a, p. 24–26, Solheim and Persson 2018, Viken and Reitan 2018). It must be stressed, however, that shoreline dating of a site relies on the premise that the given site has in fact been shore-bound (Mikkelsen 1975a, p. 20, cf. Åkerlund and Nordqvist 1997, Berg-Hansen 2009).

The establishment of a Mesolithic chronology for southeast Norway, and later revisions

For decades the Mesolithic of southeast Norway was divided into two phases (or 'cultures') – the Early Mesolithic *Fosna phase* and the Late Mesolithic *Nøstvet phase* (e.g. Nummedal 1929, Gjessing 1945, cf. Mikkelsen 1975a, p. 19–20). Up until Mikkelsen's study was published, it was even discussed whether the foraging 'Nøstvet people' possibly lived side by side with an Early Neolithic farming population (Ingstad 1970). Instead, Mikkelsen (1975a) suggested a division of the Mesolithic into four phases with the *'Fosna culture'* (phase 1) and *'Late Boreal/ Early Atlantic settlement sites'* (phase 2) as the two earliest, constituting the Early and Middle Mesolithic, respectively. The Late Mesolithic was divided into two sub-phases – the *'Nøstvet culture'* (phase 3), and a transition phase between the Nøstvet phase and the Early Neolithic – the *'late flint-point-using groups'* (phase 4) (Fig. 2). Mikkelsen (1975a, p. 24–26) based his chronological outline mainly on shoreline displacement curves combined with the presence or absence of certain tool types that he considered characteristic of the different phases, such as flint cores, axes/adzes and projectile points.

By the early 1970s, relatively few coastal settlement sites that could shed light on the chronological trajectory in southeast Norway had been properly investigated, and very few radiocarbon dating results had been obtained. Moreover, the material recorded from the Kjeøy site itself, the basis for Mikkelsen's fourth and last Mesolithic phase, had not even been archaeologically excavated, only superficially collected. It can therefore be claimed that Mikkelsen's suggested chronology was both bold and hampered by uncertainties. Nevertheless, Mikkelsen's four-phased Mesolithic chronology remains the current scheme according to which eastern Norwegian settlement material is sorted, albeit slightly adjusted after later studies and excavation projects (Lindblom 1984, Ballin 1995, 1999a, 1999b, 2000, 2004, Berg 1995, 1997, Jaksland 2001, Glørstad 1998a, 2002, 2004, 2011). In his synthesising of the results of a large-scale excavation project at Svinesund in Halden, Østfold County in 2001–2003, Glørstad (2004) suggests a more nuanced version of Mikkelsen's scheme (Fig. 2).

Below, I will briefly introduce the basis for the current Mesolithic chronology of southeast Norway. This introduction will also constitute the foundation for my subsequent reassessment.

As previously pointed out, geographically southern Norway consists of two halves – western Norway and eastern (or southeastern) Norway (Norw. '*Vestlandet*' and '*Østlandet*', respectively). The two halves are treated as materially separate regions throughout the Mesolithic, and with deviating chronological schemes (for the chronology of western Norway, see e.g. Bruen Olsen and Alsaker 1984, Bruen Olsen 1992, Nærøy 1993, 1999, Bjerck 1986, 2008a, 2008b, Bjerck *et al.* 2008). For southeast Norway, there is a tradition for basing chronological transitions on trends and breaks in the archaeological record through time. In comparison, recent studies of the long-term trajectory of western Norway have suggested a division of the Mesolithic into eleven *chronozones* (EM1–3, MM1–3, LM1–5), each of them lasting 500 calendar years (Bjerck 2008a, 2008b, Bjerck *et al.* 2008). The chronozones are intended to provide a neutral time reference system that may clarify the presentation of variations in the archaeological record across different regions. If applied in a rigid manner, however, my view is that chronozones may blur potentially important shifts in the archaeological record within the different chronozones.

Phase	Mikkelsen 1975a	Berg 1995, 1997	Ballin 1998, 1999a, 2004	Jaksland 2001	Glørstad 2002, 2004	Reitan, present paper
Early Mesolithic	Phase 1, 'Fosna culture' 9300–7400 BC (9800–8300 BP)	Phase 1/Fosna 9300–7400 BC (9800–8300 BP)	EMA 9500–8800 BC (10,000–9500 BP)	EM 9500–8250 BC (10,000–9000 BP)	Fosna phase 9500–8250 BC (10,000–9000 BP)	EM1 9300–8600 BC (9800–9350 BP)
			EMB 8800–8250 BC (9500–9000 BP)			EM2 8600–8300 BC (9350–9100 BP)
			MMA/Tørkop phase 8250–7500 BC (9000–8400 BP)	MM 8250–6350 BC (9000–7500 BP)	Tørkop phase 8250–6350 BC (9000–7500 BP)	MM1 8300–7000 BC (9100–8000 BP)
Middle Mesolithic	Phase 2, 'Late Boreal/ Early Atl. settlement sites' 7400–6300 BC (8300–7400 BP)	Phase 2/MM 7400–6600 BC (8300–7800 BP)	MMB/ Lundevågen phase 7500–6350 BC (8400–7500 BP)			
						MM2 7000–5600 BC (8000–6700 BP)
		Phase 3/Nøstvet 6600–4400 BC (7800–5600 BP)				
Late Mesolithic	Phase 3, 'Nøstvet culture' 6300–5300 BC (7400–6300 BP)		Nøstvet phase 6350–4400 BC (7500–5600 BP)	Nøstvet phase 6350–4650 BC (7500–5800 BP)	Nøstvet phase, early 6350–6000 BC (7500–7100 BP)	
					Nøstvet phase, middle 6000–5700 BC/ (7100–6800 BP)	
					Nøstvet phase, late 5700–4650 BC (6800–5800 BP)	LM1 5600–4500 BC (6700–5650 BP)
	Phase 4, 'Late flint-point-using groups' 5300–3800 BC (6300–5000 BP)					
				Transverse arrowhead phase 4650–3800 BC (5800–5000 BP)	Kjeøy phase, early 4650–4300 BC (5800–5500 BP)	
		Phase 4 4400–3800 BC (5600–5000 BP)	Gjølstad phase 4400–4000 BC (5600–5200 BP)			LM2 4500–3900 BC (5650–5100 BP)
					Kjeøy phase, late 4300–3800 BC (5500–5000 BP)	

***Figure 2**: Main studies discussing chronological questions in Mesolithic southeast Norway, with the terms used by the various scholars. Abbreviations: 'EM' = Early Mesolithic, 'MM' = Middle Mesolithic, 'LM' = Late Mesolithic (cf. Figs 3–6).*

The Early Mesolithic (phase 1), c. 9500–8250 cal. BC (c. 10,000–9000 BP)

According to Mikkelsen (1975a, p. 23–26) a typical Early Mesolithic inventory is characterized by a varied projectile point material (microliths, single-edged points, tanged points), microburins, flake axes and blades primarily struck from one- or two-sided cores with one platform (Fig. 8).

Until recently, a low number of excavated Early Mesolithic sites have provided a poor basis for a discussion of the development of such material in southeast Norway. Nevertheless, some technological traits have been identified, and the microburin technique, as well as the projectile points and the axe material, have been central in the discussion. Certain trends in the material within the Early Mesolithic have been suggested as chronologically dependent, not least in the wake of the *E18 Brunlanes project* investigations in 2006–2007 (Jaksland 2012a, 2012b, Jaksland and Persson 2014, see also Bang-Andersen 1990, Ballin 2004).

Important later contributions to the chronology of the Early Mesolithic are highlighted in Figure 3.

The Early Mesolithic		
Project, location (literature)	Chronological closures	Key sites, dating methods
Various sites in southwest and southeast Norway (Bang-Andersen 1990, Ballin 1999a, 2004, Fuglestvedt 1999, 2007, Waraas 2001)	Based on fluctuations in the arrowhead/microlith ratio, the Early Mesolithic can be divided into two sub-phases. The older, EMA, is characterized by Zonhoven points, tanged points with the proximal end possibly removed by bilateral microburin technique, and single-edged points with the tip in the proximal end. Blades are produced from unilateral cores. The replacement of these types by simple lanceolates produced by unilateral microburin technique, and the presence of flake axes and core adzes are characteristic of the younger sub-phase, EMB. Conical cores may occur toward the end of EMB. The dating of the transition between the two sub-phases is uncertain, but the time around 8800 BC is suggested by Bang-Andersen (1990). On coastal sites, flint is the dominant raw material throughout the EM.	The Myrvatn sites The Fløyrlivatn sites The Høgnipen sites The Galta sites Stunner Typology/technology/ shoreline/C14
Various sites along the coast of Norway (Bjerck 2008a, 2008b)	Bjerck suggests a division of the Early Mesolithic (c. 9500–8000 BC) into three *chronozones*, EM1–EM3, each lasting 500 calendar years. However, Bjerck's subdivision is not based on specific material or technological changes.	
The E18 Brunlanes project, Larvik municipality, Vestfold County (Jaksland 2012a, 2012b, 2014, Jaksland and Fossum 2014)	A subdivision of the EM into three sub-phases is suggested by Jaksland (2014), and at first sight, this subdivision is quite similar to that of Bjerck (2008). The main objective of Jaksland's division, though, is to call attention to the implications of two significant plateaus in the calibration curve within the EM. Nevertheless, certain chronologically dependent trends are pointed out in the axe and projectile material (Jaksland & Fossum 2014): through the 'Pauler sequence', ranging from c. 9000 to c. 8600 cal. BC, there is a decrease in single-edged and tanged points. Correspondingly, Høgnipen points and simple lanceolates gradually become more common. Locally available rock (metarhyolite) is also introduced as raw material for flake- and core axes during the EM. The morphology of the flake axes/-chisels seems to change over time, becoming gradually narrower and core-axe-like.	Pauler 1–7 Bakke Typology/technology/ shoreline

***Figure 3**: Important contributions into the chronology of the Early Mesolithic period.*

The Middle Mesolithic (phase 2), c. 8250–6350 cal. BC (c. 9000–7500 BP)

As typical artefacts of the Middle Mesolithic, Mikkelsen (1975a, p. 26) mentions, among other things, microliths such as the single barbed point (or barbed lancet, Norw. *hullingspiss*, see Fig. 10C) and the scalene triangle, along with blades, microblades, handle cores and conical cores. Cores with associated blades/microblades as well as microliths and stone adzes have since been central in discussions concerning the chronological development in the Middle Mesolithic.

More recent excavation results and publications that shed light on this phase are briefly summarised in Figure 4.

The Middle Mesolithic		
Project, location (literature)	Chronological closures	Key sites, dating methods
The Farsund project, Farsund municipality, Vest-Agder County Various sites along the coast of southern Norway (Ballin & Jensen 1995, Ballin 1995, 1999a, 1999b, Mikkelsen et al. 1999, Ballin 2004)	The Middle Mesolithic is divided into two halves. The first is the MMA/'the Tørkop phase' (c. 8250–7500 BC) with a microlith material dominated by barbed points (barbed lancets) produced by microburin technique. Core adzes also occur. The second is the MMB/'the Lundevågen phase' (c. 7500–6350 BC), in which the microlith material is dominated by scalene triangles produced without using the microburin technique, and barbed points and core adzes are no longer in use. The average blade width and platform flaking angle differ between the two halves of the MM. The discontinued use of scalene triangles marks the end of the MM.	Lundevågen R17 Lundevågen R21/22 Tørkop Typology/technology/C14
The Vinterbro project, Ås municipality, Akershus County (Jaksland 2001)	Scalene triangles manufactured without the use of microburin technique also occur in the early MM, whereas barbed points are only recorded from contexts dated to the first part of the MM. Jaksland (2001) therefore rejects Ballin's (1999a) division of the MM into two sub-phases based on average blade width and flaking angle. The use of bipolar cores increases throughout the MM, and rock adzes and mace heads are introduced c. 7500 BC.	Vinterbro 12 Vinterbro 9 Vinterbro 3 (Rørmyr II) Typology/technology/shoreline
The E18 Bommestad–Sky project, Larvik municipality, Vestfold County (Damlien and Solheim 2013, Solheim 2013, Damlien 2016)	Serial production of blades and microblades from conical or semi-conical cores is the prevalent technological concept throughout the phase. Other platform cores as well as bipolar cores also occur. Scalene triangles are in use throughout the phase, but barbed points no later than c. 7500 BC. Microliths are often recorded along with microblades with informal secondary working along the edges, but which cannot be classified as typical microliths. The production of pecked stone adzes with round/oval cross-section ('chubby adzes') and core adzes of metarhyolite (a flint-like rock type) is documented from c. 7800 BC. Mace heads/hatchets with shaft-hole occur after c. 7500 BC.	Hovland 1 Hovland 2 Hovland 3 Hovland 4 Hovland 5 Nordby 2 Torstvet Typology/technology/shoreline/C14

Figure 4: *Important contributions into the chronology of the Middle Mesolithic period.*

The Late Mesolithic Nøstvet phase (phase 3), c. 6350–4650 cal. BC (c. 7500–5800 BP)

The Nøstvet adze is recognized as the key artefact typical of this phase (Mikkelsen 1975a, p. 26; cf. Jaksland 2005, Glørstad 2010, 2011) – a coarse stone core adze manufactured by flake reduction along the sides of a blank with a flat ventral side. The production process provides a characteristic three-sided cross-section, commonly also with a pointed neck and normally the grinding of Nøstvet adzes is limited to the convex edge. Other typical finds are grinding slabs and knives of sandstone with polished edges, small flint tools like flake borers, flake scrapers with convex retouch, and irregular cores, handle cores and microblades (Fig. 12). As for the transition between the Middle Mesolithic and the Late Mesolithic Nøstvet phase (phases 2 and -3 respectively), Mikkelsen specifically underlined the cessation in the production of microliths and the increased production of microblades from handle cores. In addition, he pointed out that the adze material of the Nøstvet phase differs from that of the preceding and the subsequent phases, and that borers were more common in the Nøstvet phase.

The Nøstvet adze and the microblade production have been central issues in research into the Late Mesolithic Nøstvet phase – see Figure 5.

The Late Mesolithic Nøstvet phase		
Project, location (literature)	Chronological closures	Key sites, dating methods
The Dobbeltspor/E6 project, Vestby, Ås and Frogn municipalities, Akershus County (Berg 1995, 1997)	The Nøstvet adze is introduced c. 6600 BC, and it is suggested that the MM–LM transition be backdated to this point. The Nøstvet adze is in use throughout the Nøstvet phase, whereas the use of chubby adzes ceases c. 5800 BC. In addition to a comprehensive adze material, sandstone knives and thick flint borers are characteristic of the Nøstvet phase. A division of the Nøstvet phase into three sub-phases, based on the blade/microblade material, is cautiously suggested: narrow microblades dominate in the middle sub-phase, wider blades are more common in the earliest and the latest sub-phases.	Rød nedre R72 Trosterud lok. 1 Kvestad lok. 2 Kvestad lok. 3 Typology/shoreline/C14
Oslofjordforbindelsen, Hurum and Frogn municipalities, Buskerud and Akershus Counties respectively (Ballin 1998)	The introduction of the handle core marks the beginning of the Nøstvet phase, dated c. 6300–6000 BC.	Kongsdelene R71-2 Kongsdelene R62 Storsand R53 Typology/technology/shoreline/C14

Continues

The Late Mesolithic Nøstvet phase		
Project, location (literature)	Chronological closures	Key sites, dating methods
The Svinesund project, Halden municipality, Østfold County (Glørstad 2002, 2004)	The discontinued use of of microliths marks the MM–LM transition. Based on fluctuations in certain artefact types, the Nøstvet phase is divided into three sub-phases. In the early sub-phase (c. 6350–6000 BC) the adze material is dominated by chubby adzes with round cross-sections. The typical Nøstvet adze with its characteristic three-sided cross-section is still not introduced, neither are thick flint borers. The blade assemblages consist of a large number of blades *versus* microblades. Grinding slabs of sandstone and handle cores of flint are so far uncommon. The middle sub-phase of the Nøstvet (c. 6000–5700 BC) is characterized in particular by chubby adzes with a plane ventral side and a heavily curved dorsal side, forming a semi-circular cross-section. In the last sub-phase (also termed 'classic Nøstvet', 5700–4650 BC) the chubby adzes are completely replaced by the Nøstvet adzes. Adzes and adze-related debris is now more common than in the earlier sub-phases, but seems to decrease toward the end of the period. Microblades, handle cores/keel-shaped cores and coarse borers with a triangular cross-section are more common types than in the preceding sub-phases of the Nøstvet phase.	Torpum 1 Torpum 2 Torpum 9a Torpum 9b R16 Rørbekk 1 Berget 1 Typology/technology/shoreline/C14

Figure 5*: Important contributions into the chronology of the Late Mesolithic Nøstvet phase.*

The Late Mesolithic Kjeøy phase (phase 4), c. 4650–3800 cal. BC (c. 5800–5000 BP)

The transitional Kjeøy phase, between the Nøstvet phase and the Neolithic, constitutes an important component in Mikkelsen's scheme. The separation of the Kjeøy phase was based on a rich, surface-collected, but not archaeologically unearthed, settlement site in Halden, Østfold County. The collected assemblage from the Kjeøy site differed from that of the preceding Nøstvet phase sites of the same region. The most important elements from the Kjeøy site are projectile points of flint – transverse-tipped arrowheads, tanged type A points and single-edged points. The Kjeøy site material also encompasses a relatively large portion of blade tools. Only one fragmented and atypical adze was found on the Kjeøy site. This led Mikkelsen (1975a, p. 30–31) to conclude that the stone adze material of the Kjeøy phase is scarce, and that adzes do not characterize this phase in the same manner as they do the Nøstvet phase.

The introduction of the arrowheads as well as the ratio of blades (> 8 mm wide) to microblades (< 8 mm wide, cf. Helskog *et al.* 1976, p. 14) are central elements in the research into the final Mesolithic Kjeøy phase – see Figure 6.

To sum up, the Nøstvet phase is so far the most intensively studied of the different Mesolithic phases (Jaksland 2005, p. 32). Even so, the establishment of the duration of the Nøstvet phase must be considered uncertain. Although it is unclear which material changes provide a valid basis for dating, the transition between the Middle and Late Mesolithic (Mikkelsen's phases

2 and -3) is commonly dated to c. 6350 cal. BC (see Fig. 2). The typical traits of the two Late Mesolithic sub-phases, i.e. the Nøstvet phase and the Kjeøy phase (phases 3 and -4), are fairly well mapped (see Figs. 5 and 6). However, the date of the transition between the two has not been established to a satisfactory degree, in my opinion. The same applies to the Late Mesolithic–Early Neolithic transition. In light of new excavation results, I will discuss these vaguely dated and unconvincingly defined transitions below.

The Late Mesolithic Kjeøy phase		
Project, location (literature)	Chronological closures	Key sites, dating methods
The Dobbeltspor/E6 project, Vestby, Ås and Frogn municipalities, Akershus County (Berg 1995)	The transition between the Nøstvet phase and the Kjeøy phase is marked by the introduction of arrowheads of flint. This coincides with a technological shift encompassing an abrupt decrease in microblade production. A notable number of knives and scrapers are made of blades. The transition between the two Late Mesolithic sub-phases is dated to c. 4400 BC, but cannot be established with certainty – a dating of the transition to 4800 BC is possible.	Gjølstad R33 Typology/technology/shoreline/C14
Various sites in Østfold and Akershus counties (Glørstad 1998a) *The Svinesund project*, Halden municipality, Østfold County (Glørstad 2002, 2004)	This final Mesolithic stage is divided into an early and a late sub-phase. The earlier is characterized by transverse-tipped arrowheads as the only projectile type. Additionally there are several similarities with settlement site material from the latest part of the Nøstvet phase – one of these similarities is that there are more microblades than blades as well as conical/semi-conical and microblade cores and handle cores. The few occurring adzes are atypical and are easily distinguished from the adzes of the Nøstvet phase. In the later sub-phase of the Kjeøy phase, i.e. from c. 4300 BC, transverse-tipped, single-edged and tanged type A arrowheads all occur. All the key artefacts typical of the Nøstvet phase are gone, and blades are more common than microblades. Pieces of polished flint and pottery may occur already at this final stage of the Late Mesolithic. The Kjeøy phase is dated to 4650–3800 BC, but a dating of its onset to c. 4500 cannot be excluded.	Halden lok. 5 Gjølstad R33 Ystehede Rørbekk 1 Torpum 10 Torpum 13 Berget 2 Vestgård 8 Typology/technology/shoreline/C14

***Figure 6**: Important contributions into the chronology of the Late Mesolithic Kjeøy phase.*

Chronological results from recent, large-scale excavation projects

In this section, I will present technological traits and artefacts typical for their period from the 26 sites that I have examined closely in this study. As previously mentioned, the closures of the present paper are to a large degree based on data from the *Vestfoldbane project* and the *E18 Tvedestrand–Arendal project*. Within these two, 63 Stone Age sites were investigated (Melvold and Persson 2014, Reitan and Persson 2014, Reitan and Sundström 2018). Additionally, results from e.g. the *E18 Bommestad–Sky* and the *E18 Rugtvedt–Dørdal projects* are taken into consideration (see Solheim and Damlien 2013, Solheim 2017a – cf. Fig. 1). All the excavation projects were carried out ahead of large-scale infrastructural construction works, comprising more than one hundred different sites and virtually all of them shore-bound. As the sites in question were investigated applying the same methods, and the assemblages were consistently classified (Melvold *et al.* 2014, Koxvold and Fossum 2017, Solheim 2017b, Sundström *et al.* 2018), they are well suited for comparative studies. Moreover, the sites are in general well dated, either by means of radiocarbon dating obtained from organic matter from reliable contexts, or based on their height above the present sea level and local shoreline displacement curves (Sørensen *et al.* 2014a, Romundset 2018) (Figs. 7, 9, 11, 13 and 15). The investigated sites cover the entire Mesolithic period and beyond, and the collected data are therefore well suited for enquiries into chronological developments in the long-term. Based on dating results, technological and typological similarities, and the presence of artefacts characteristic for their period, the sites are grouped into different time intervals (three to eleven sites per interval) – periods that deviate from the established chronological scheme (cf. Fig. 2).

The period c. 9500–8300 cal. BC (c. 10,000–9100 BP)

Several sites excavated within the E18 Tvedestrand–Arendal project in Aust-Agder County shed light on this interval (e.g. Darmark 2018a, 2018b, Darmark and Viken 2018, Darmark *et al.* 2018b, Stokke *et al.* 2018, Viken 2018a, 2018b), along with the Vestfoldbane project sites Solum 1 (Fossum 2014a) and Nedre Hobekk 2 (Eigeland 2014) (Fig. 7). The assemblages from most of the sites are flint dominated, and overall the flint is of high quality (Eigeland 2018). Even so, half of the sites listed in Figure 7 yielded considerable quantities of other raw materials – primarily quartz and rock crystal for small tools, along with *metarhyolite* (also termed *ignimbrite*, a dense, volcanic rock, see Fig. 8E) for axes, bearing witness to flexible raw material strategies. The flint technology of the Early Mesolithic was primarily aimed at the production of blades (Fig. 8D), with blades constituting as much as nearly one-third of all collected flints from Kvastad A9 (Darmark 2018c). The blades were mainly produced by direct percussion from one-sided single-platform cores with steep platform angles, but two-sided, dual-platform cores also occur (Fig. 8C; see e.g. Skar and Coulson 1986, Damlien 2016a, Eigeland 2018, cf. Berg-Hansen 2017 for discussion).

Apart from Sagene B4, which is dominated by scrapers (Darmark 2018b), the small-tool inventory from the sites is clearly dominated by projectile points. With microliths included, they constitute an average of 1 % of all flints from the studied sites in this time span (Fig. 7, cf. Jaksland and Fossum 2014, p. 50). Overall, the arrowheads exhibit considerable morphological variation (Fig. 8B, cf. Waraas 2001, p. 103, Jaksland and Fossum 2014, p. 54), but with the Høgnipen points as a highly standardized exception (Darmark and Viken 2018). The examined sites demonstrate a distinct decrease in the ratios of tanged and single-edged points around the middle of the period. Correspondingly, Høgnipen points and lanceolates increase in numbers, reflecting a shift in the projectile point technology. Numerically, microburins constitute a rather marginal category of finds. Still, microburins are identified in eight of the eleven discussed assemblages, albeit with an apparent decrease – making up an average of 0.9 % of the flints from sites older than c. 8600 BC, and only 0.2 % on average on sites younger than c. 8600 BC. Axes (or axe production waste) are represented on all but three sites (Sagene B4, Sagene B6 and Kvastad A9, see Darmark 2018b, 2018c). Flake axes and flake chisels seem to be the only axe type on the earlier sites (Fig. 8A), whereas core axes dominate on certain of the younger sites. One axe of metarhyolite, with parallel sides and extensive thinning on the ventral side, was recovered at Sagene B1, c. 8800 BC (Viken 2018a, Fig. 2.2.3.7), but this raw material is more common at a later stage – in fact metarhyolite is the dominating axe raw material from the younger Early Mesolithic sites in this study.

Only one Early Mesolithic radiocarbon dating result was obtained from the sites in question (Kvastad A1, see Eskeland 2013, p. 361–362, Stokke *et al.* 2018). The lack of radiocarbon dates is a problem frequently encountered on sites from this phase (Viken and Reitan 2018, cf. Damlien and Solheim 2018, Solheim and Persson 2018).

Key sites and important tendencies in the Early Mesolithic material are summarized in Figure 7.

Site name	**Flint ratio**	**Ratio, blades and microblades**	**Technological characteristics, artefacts typical of the period**	**Radiocarbon dates (2 σ)**
Sagene B2 (c. 9000 BC)	94.8 %	Blades 8.6 % Microbl. 8.5 %	The flint technology seems to have been focused on the production of blades, mainly from one-sided single-platform cores. Bipolar cores and irregular cores also occur. Although microblades constitute up to 14 % of the flint assemblages, microblades are considered unintended by-products. The tool production seems to rely heavily on flint in the early part of the phase. Some inventories, however, witness that local raw materials were exploited to a considerable degree as early as shortly after 9000 BC, and the sites demonstrate notable individual variation in terms of raw material procurement within the same geographical area. Projectile points are a key artefact group. Tanged and single-edged points dominate the arrowhead material from the older sites, whereas Høgnipen points and lanceolates and diverse microliths are more common on younger sites. Correspondingly, the ratio of microburins decreases through the period. Flint flake axes seem to be in use throughout the Early Mesolithic. Core axes are introduced c. 8600, at the latest, and tend to dominate the axe material after that. Metarhyolithe is applied as an alternative raw material for axes shortly after 9000 BC, but is more common in the last centuries of the EM.	Kvastad A1: 8470–8280 BC/9150 ± 40 BP (Beta-366066, Pinus)
Sagene B4 (c. 9000 BC)	97.9 %	Blades 13.0 % Microbl. 5.9 %		
Sagene B6 (c. 8900 BC)	76.4 %	Blades 10.5 % Microbl. 9.3 %		
Sagene B1 (c. 8800 BC)	42.4 % (?)	Blades 15.9 % Microbl. 4.6 %		
Nedre Hobekk 2 (c. 8600 BC)	58.2 %	Blades 2.1 % Microbl. 0.7 %		
Solum 1 (c. 8600 BC)	94.5 %	Blades 9.5 % Microbl. 0.0 %		
Kvastad A9 (c. 8500 BC)	88.3 %	Blades 29.4 % Microbl. 14.5 %		
Kvastad A4 East (c. 8500 BC)	57.1 %	Blades 7.8 % Microbl. 2.1 %		
Kvastad A1 N/S (c. 8400 BC)	95.4 %	Blades 5.1 % Microbl. 3.8 %		
Kvastad A5-6 N/S (c. 8300 BC)	33.9 % (?)	Blades 24.8 % Microbl. 6.4 %		

***Figure 7**: Sites recently excavated within the E18 Tvedestrand–Arendal and Vestfoldbane projects, with traits outlined as characteristic of the Early Mesolithic, c. 9500 (9300)–8300 BC. All radiocarbon dates presented in this paper are obtained using OxCal v4.3 (Bronk Ramsey 2009) and IntCal13 atmospheric curve (Reimer et al. 2013).*

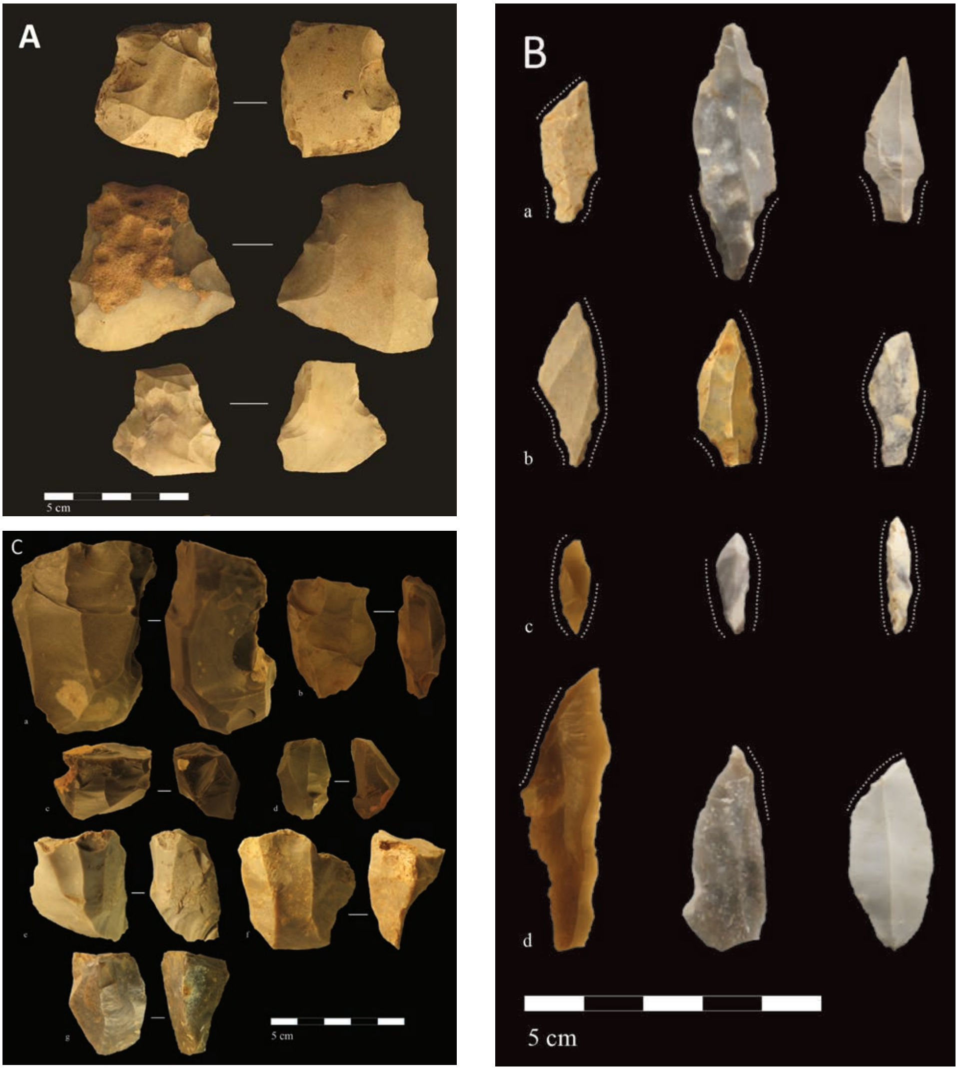

Figure 8: *Artefacts characteristic of the period c. 9300–8300 BC (cf. Fig. 7): A) Flake axes of flint from Sagene B1 after Viken 2018a, B) Examples of complete tanged points (a), single-edged points (b), Høgnipen points (c) and lanceolate microliths (d) found within the E18 Tvedestrand–Arendal project after Darmark and Viken 2018, C) Flint cores from Sagene 4 (a–d) and Sagene B6 (e–g) after Darmark 2018b, (Fig. 8 contiues on next page)*

Figure 8*: D) Selection of flint blades from Sagene B1 after Viken 2018a, E) Core axe of metarhyolite from Solum 1 after Fossum 2014a.*

The period c. 8300–7000 cal. BC (c. 9100–8000 BP)

The Vestfoldbane project sites Sundsaasen 1 (Eggen 2014a), Gunnarsrød 7 (Fossum 2014b) and Prestemoen 1 (Persson 2014), along with the E18 Tvedestrand–Arendal site Hesthag C4 (Viken 2018c), date to this period (Fig. 9, for more sites, see e.g. Solheim and Damlien 2013, Solheim 2017a). The assemblages are clearly flint-dominated, and the recorded materials point to a specialised production of both blades and microblades based on conical or semi-conical cores by indirect technique as the prevalent technological concept on the sites (cf. Damlien 2016a, Eigeland 2018). Even so, the core material is commonly dominated by bipolar cores. It is, however, questionable whether all these bipolar cores should actually be considered as cores, or whether some of them may have been used as wedges, planers or other similar tools (for discussion, see Koxvold 2013, p. 122, 130, Solheim 2013, p. 269, Fossum 2014b, p. 186, Persson 2014, p. 207–209, Eigeland 2015, p. 160–161, Damlien and Solheim 2018, p. 348).

Among the fragmented blades, the medial fragments are the most numerous. This may indicate that blades were broken systematically and deliberately, probably in order to produce square or rectangular pieces to be used as knives – 'rulers'. From each of the four sites in Figure 9, two to five typical scalene triangular microliths are recorded (Fig. 10B). No other types of microliths were uncovered, but a number of retouched microblades probably relate to microliths and the use of composite arrows. The microliths seem to have been produced by removal of the percussion bulb by retouching, and no traces of *microburin technique* were identified in any of the four assemblages.

Apart from the flint inventory, all four sites yielded a small number of fragments of grinding slabs. The grinding slabs are to be associated with (mainly) bifacially produced point- or round-butted, pecked adzes or chisels with ground, convex or sometimes hollow edges (Fig. 10D) and rounded/oval cross-sections (Norw. *trinnøkser*, literally meaning 'chubby adzes', and hereafter referred to with this name, cf. for example Bjerck 2008a), and various types of ground shaft-hole hatchets or mace heads made of locally available rock. The shaft-hole hatchet from Hesthag C4 (Fig. 10A) indicates that such tools were introduced around 8000 BC or even slightly earlier (Viken 2018c, see also Fossum 2017 on Hegna Vest 1). It is reasonable to assume that the introduction of these new axe types is linked to the technological shift in the flint industry around 8300BC (cf. Eymundsson *et al.* 2018).

Relevant sites, radiocarbon dates and characteristics of the archaeological record of the period c. 8300–7000 BC are listed in Figure 9.

Site name	Flint ratio	Ratio, blades and microblades	Technological characteristics, artefacts typical of the period	Radiocarbon dates (2 σ)
Hesthag C4 (c. 8000 BC)	96.1 %	Blades 9.2 % Microbl. 5.1 %	The combined production of both blades and microblades from conical cores by indirect pressure is the prevalent technological concept. This marks a distinct break with the previous time period. Still, the core material is dominated by bipolar cores. Knives, scrapers and drill-bits are primarily made of blades/microblades. A small number of microliths (scalene triangles) is recorded from all the four sites, but without traces of microburin technique. Chubby stone adzes and shafthole hatchets with ground, convex edges and associated grinding slabs are introduced around 8000 BC at the latest – seemingly with a slight increase through the period. Thoroughly ground, hollow-edged stone adzes and chisels are in use, too, predominantly in the earlier stage of this period. Core axes of flint and metarhyolite are still in use.	Hesthag C4: 8170–7730 BC/8800 ± 40 BP (Beta-448123, Pinus) Prestemoen 1: 7795–7590 BC/8671 ± 45 BP (Ua-45176, Corylus, nutshell), 7740–7575 BC/8620 ± 45 BP (Ua-45177, burnt bone, indet.), 7720–7545 BC/8593 ± 46 BP (Ua-45178, Corylus, nutshell)
Sundsaasen 1 (c. 7800 BC)	97.5 %	Blades 0.7 % Microbl. 1.6 %		
Prestemoen 1 (c. 7600 BC)	93.6 %	Blades 2.1 % Microbl. 4.3 %		
Gunnarsrød 7 (c. 7500 BC)	99.1 %	Blades 3.5 % Microbl. 2.2 %		

***Figure 9**: Recently excavated sites with inventory characteristic of the period c. 8300–7000 BC.*

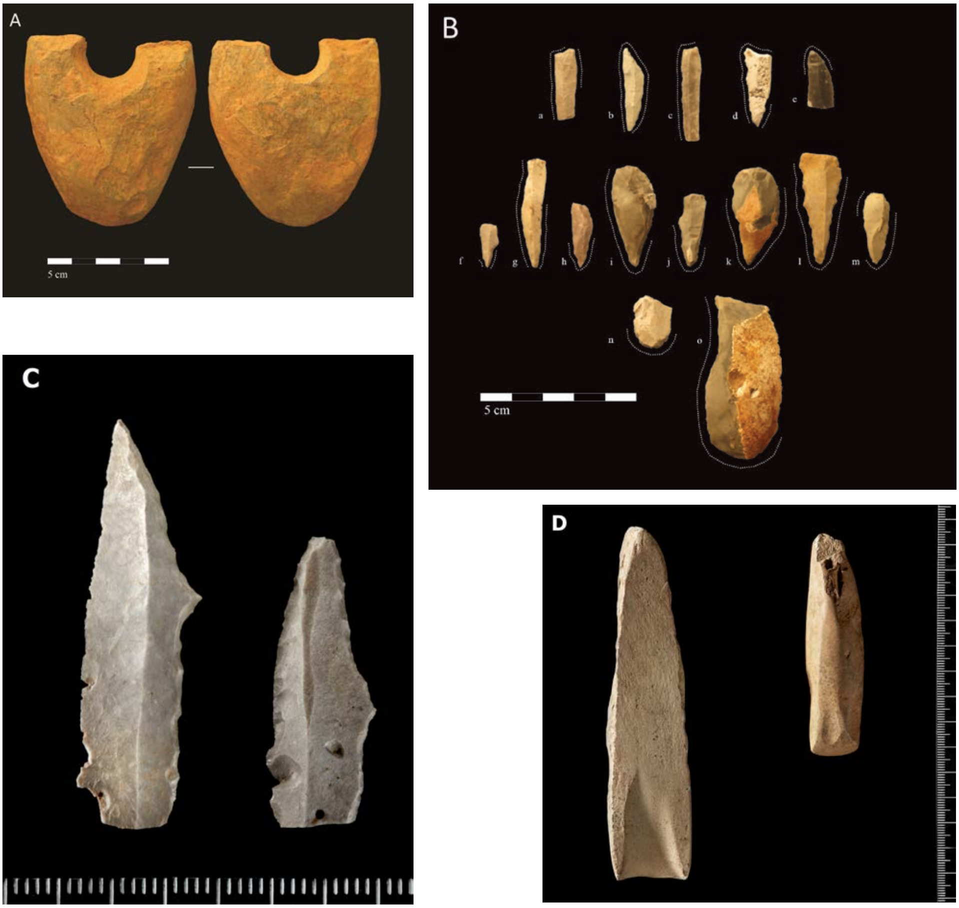

***Figure 10**: Artefacts characteristic of the period c. 8300–7000 BC (cf. Fig. 9): A) Fragmented shaft-hole hatchet from Hesthag C4, B) Scalene triangles (a–e), borers (f–m) and scrapers (n–o) from Hesthag C4, C) Barbed points from Hovland 3 after Solheim and Færø Olsen 2013, D) Hollow-edged stone adze (left) and reworked chisel, originally hollow-edged (right), from Hegna Vest 1 after Fossum 2017.*

The period c. 7000–5600 cal. BC (c. 8000–6700 BP)

For this previously little explored interval the comprehensive assemblage from the well-dated site Langangen V. 1 (Melvold and Eigeland 2014) is central, but Gunnarsrød 6 (Carrasco *et al.* 2014), Gunnarsrød 4 (Reitan 2014a) and Gunnarsrød 2 (Reitan and Fossum 2014) also shed light on this period (Fig. 11).

Overall, the investigated sites demonstrate a distinct decrease in the flint ratio compared to sites from the preceding period (Fig. 9), along with a corresponding increase in the amount of adze-related rock material (cf. Reitan 2016, Table 9). The flint industry is still oriented towards the production of both blades and microblades from the same conical or semi-conical cores (Fig. 12C), but the share of microblades increases after 7000 BC. However, the core material is dominated by bipolar cores to a larger degree than earlier, for example at Gunnarsrød 6 (cf. Jaksland 2001, p. 35). No typical handle cores are recorded from these sites, but a small number of microblade cores from both Brunstad (see below) and Gunnarsrød 6 exhibit traits similar to narrow-faced cores from the Baltic region (see Carrasco *et al.* 2014, Fig. 13.7 d–f, cf. Hertell and Tallavaara 2011). The assemblages do not include any microliths – not even from the rich Langangen V.1, which demonstrates repeated occupations between c. 7000 and 6500 BC (see Fig. 11). The use of what can be designated as 'informal microliths' (microblades with retouch along one or either side), on the other hand, continues throughout the period in question (cf. Jaksland 2001, Hernek 2005, p. 247–248).

Knives of sandstone are a significant novelty of this interval (Fig. 12D). Another and even more striking feature of this phase is the number of chubby adzes and the associated waste material (Fig. 12A). No adzes from this interval can be classified as Nøstvet adzes (Fig. 14A). The measurements and the morphological traits of the chubby adzes vary somewhat, but the differences do not appear to rely on chronology. The adzes are normally point-butted, and the cross-sections normally rounded or oval, but some specimens exhibit a D-shaped cross-section with a plane ventral surface, the latter type likely manufactured from loose blocks or nodules from moraines. In addition, a few thin chisels with pointed oval cross-sections are recorded from several of the sites listed in Figure 11, but not from sites from other periods (Fig. 12B).

The data from the recent investigations of three adjacent sites at Brunstad south of Tønsberg, Vestfold County, including a stone-lined primary grave dated to c. 5900 BC, are presented elsewhere (Reitan and Schülke 2018, Reitan *et al.* 2019, Schülke *et al.* 2019) and are hence not included in Figure 11. Even so, the Brunstad sites deserve brief mention here, as they shed important light on this period. A total of 15 radiocarbon dates from Brunstad covers the time-span between c. 6400 and 5600 BC (Reitan *et al.* 2019, Fig. 7). The dates witness to repeated occupations in what was then a shallow bay on a small island. The dating results cover the first two parts of the Nøstvet phase, according to the established chronology of the region (see Fig. 2, Glørstad 2004). Typical chubby adzes were recorded from all three sites, whereas no Nøstvet adzes were found, not even on the youngest of the three sites, which, according to the altitude, dates to c. 5800–5600 BC. Even though the three Brunstad sites cover a period of up to 800 years, the assemblages from them can be characterized as typologically and technologically homogeneous. The similarities between Brunstad and the Vestfoldbane project sites from 7000–5600 BC are apparent.

Sites and assemblages epitomizing the period c. 7000–5600 BC are presented in Figure 11.

Site name	Flint ratio	Ratio, blades and microblades	Technological characteristics, artefacts typical of the period	Radiocarbon dates (2 σ)
Langangen V. 1 (7000–6500 BC)	73.0 %	Blades 0.4 % Microbl. 3.7 %	The production of blades/ microblades from conical/ semi-conical cores is the dominating technological concept. Even so, the core material, here too, is dominated by bipolar cores, and to a larger extent than from sites older than 7000 BC. Typical handle cores are not recorded from any of the sites in this table. Assemblages from the later stage of this interval, however, include certain small microblade cores that can be designated as narrow-faced. The production of microblades increases significantly compared to the previous time period. Yet, small-tools like drill-bits, scrapers and knives are primarily made of blades. The assemblages from this interval do not encompass any microliths. The flint ratio is lower than in the previous period. This relies on the distinct increase in stone adze-related production waste and the occasionally high numbers of chubby adzes with round or oval cross-section. Additionally chisels with elliptical cross-section occur – a type not recorded from other parts of the Mesolithic. Knives of sandstone with ground edges are a novelty in this time period, whereas the characteristic Nøstvet adze with its three-sided cross-section is not yet introduced.	Langangen V. 1: 7130–6702 BC/8030 ± 55 BP (TRa-4117, *Pinus*), 7063-6711 BC/8005 ± 45 BP (TRa-4118, *Salix/Populus*), 7037–6692 BC/7945 ± 45 BP (TRa-4121, *Betula, Salix/Populus*), 7025–6606 BC/7875 ± 45 BP (TRa-4120, *Corylus*), 7023–6601 BC/ 7870 ± 45 BP (TRa-4114, *Betula, Sorbus*), 7003–6592 BC/ 7850 ± 45 BP (TRa-4119, *Betula, Corylus*), 6750–6501 BC/ 7800 ± 45 BP (TRa-4116, *Corylus*), 6692–6506 BC/ 7795 ± 40 BP (TRa-4122, burnt antler), 6685–6505 BC/ 7785 ± 40 BP (TRa-1994, burnt bone, *indet*.), 6820–6461 BC/ 7780 ± 70 BP (TRa-2243, *Pinus*), 6651–6484 BC/ 7760 ± 40 BP (TRa-1995, burnt bone, *indet*.), 6644–6485 BC/ 7745 ± 35 BP (TRa-4123, burnt antler), 6645–6476 BC/ 7740 ± 45 BP (TRa-4115, *Corylus*) Gunnarsrød 4: 6209-6006 BC/7210 ± 38 BP (UBA-19158, *Pinus*), 5963-5732 BC/6941 ± 36 BP (UBA-19159, *Betula*)
Gunnarsrød 2 (7000–6400 BC)	91.0 %	Blades 2.9 % Microbl. 5.8 %		
Gunnarsrød 6 (6300–6000 BC)	60.7 %	Blades 0.7 % Microbl. 4.8 %		
Gunnarsrød 4 (6200–5700 BC)	72.2 %	Blades 3.7 % Microbl. 10.5 %		

Figure 11: *Recently excavated sites with inventory characteristic of the period c. 7000–5600 BC (cf. Reitan et al. 2019 on the Brunstad sites, c. 6400–5600 BC). Note that the site Langangen V. 1 originally was published under the name Langangen Vestgård 1. The site name is here abbreviated to avoid confusion with other previously excavated and published Vestgård sites at Svinesund (see Glørstad 2004). This also applies to other and younger Langangen Vestgård sites mentioned in this paper.*

***Figure 12**: Artefacts characteristic of the period c. 7000–5600 BC (cf. Fig. 11): A) Chubby adzes of diabase from Gunnarsrød 6 after Carrasco et al. 2014, B) Stone chisel with elliptic cross-section from Gunnarsrød 2 after Reitan and Fossum 2014, C) Conical microblade core of flint from Gunnarsrød 4 after Reitan 2014a, D) Sandstone knives from Brunstad lok. 25 after Reitan et al. 2019.*

The period c. 5600–4500 cal. BC (c. 6700–5650 BP)

The sites Vallermyrene 4 (Eigeland and Fossum 2014) and Krøgenes D2 (Mansrud *et al.* 2018) are representative of this period, arguably also Vallermyrene 1A (Reitan 2014b). The comprehensive inventory retrieved at Vallermyrene 4 encompasses all the typical artefacts of the sub-phase occasionally referred to as 'classic Nøstvet' (Fig. 14) – thick flake borers, handle cores, sandstone knives, as well as numerous flint microblades and stone Nøstvet adzes and associated grinding slabs (e.g. Glørstad 2004, Jaksland 2005). The assemblages reflect an extensive production of microblades mainly based on handle cores (Fig. 14B), as demonstrated by Vallermyrene 4 and Krøgenes D2 (Fig. 13, see however Eigeland 2018, p. 520–521 and Mansrud *et al.* 2018 for discussion of possible regional differences in the core material). The production of wider blades, on the other hand, has not been a part of the reduction strategy

(Eigeland 2015, p. 376). Additionally, small flint tools were made from flakes, not blades, throughout this period.

The number of rock finds in the assemblages is striking, constituting as much as 71 % of the total c. 50,000 finds unearthed at Vallermyrene 4 (Fig. 13). The varied raw material composition is a characteristic trait of this interval, and large numbers of rock adzes are recorded from the sites (Jaksland 2005, Glørstad 2010, see e.g. Nordqvist 2000b and Johansson 2006 on Margreteberg and Bjällvarpet, respectively, for parallel, adze-rich sites from the same phase in southwest Sweden). The chubby stone adze is now abruptly replaced by the Nøstvet adze (Fig. 14A). Based on analyses of the production waste material, Eigeland and Fossum (2014) have concluded that approximately 200 Nøstvet adzes were produced at Vallermyrene 4, although the number of adzes actually retrieved on the site is significantly lower (cf. Mansrud *et al.* 2018 on calculations for Krøgenes D2). The material from Vallermyrene 1A suggests that the adze production decreases towards the end of the period. An almost complete Nøstvet adze was recorded from Vallermyrene 1A (Reitan 2014b, Fig. 4.6), whereas no adze and very little rock production waste were collected from the slightly younger Vallermyrene 1B.

Diagnostic artefacts, technological trends and key sites representative of the period c. 5600–4500 BC are found in Figure 13.

Site name	**Flint ratio**	**Ratio, blades and microblades**	**Technological characteristics, artefacts typical of the period**	**Radiocarbon dates (2 σ)**
Vallermyrene 4 (5500–4800 BC)	28.7 %	Blades 0.3 % Microbl. 8.5 %	The technological concept is clearly oriented toward the serial production of microblades, and not wider blades, from handle cores. There are however tendencies to an increased production of blades towards the end of the time period. In addition to handle cores other platform cores and irregular cores occur, as well as certain bipolar cores. The ratio of secondarily worked flint is low. Among the small-tools of flint scrapers and drill-bits with a distinct three-sided cross-section are numerous. These are normally made of flakes, not blades. Knives of sandstone are still a central category. A comprehensive rock material debris and high numbers of Nøstvet adzes characterize the period. The rich finds of locally available rock indicate a specialized adze production and to a far larger degree than before 5600 BC. The selection of raw materials for the Nøstvet adzes seems more varied than on earlier sites in the same area. The chubby adzes are no longer in use, and the pecking of the adzes ceases. The amount of adze-related rock waste seems to decrease at the final stage of the period.	Vallermyrene 4: 5541–5340 BC/6381 ± 37 BP (Ua-45170, burnt bone, mammal) 5470–5307 BC/6489 ± 50 BP (Ua-45169, burnt bone, mammal), 5296–5040 BC/6197 ± 40 BP (Ua-45172, *Pinus*), 5203–4842 BC/6067 ± 41 BP (Ua-45171, *Pinus*) Krøgenes D2: 5375–5080 BC/6297 ± 44 BP (Ua-50980, *Pinus*), 5317 – 5081 BC/6260 ± 30 BP (Beta-448128, *Alnus*), 5213–4956 BC/6132 ± 45 BP (Ua-50982, *Pinus*) Vallermyrene 1A: 4712–4537 BC/5770 ± 35 BP (Ua-45182, *Pinus*), 4691–4501 BC/5748 ± 35 BP (Ua-45181, *Pinus*)
Krøgenes D2 (5300–5000 BC)	47.2 %	Blades 2.1 % Microbl. 13.8 %		
Vallermyrene 1A (4700–4500 BC)	85.6 %	Blades 2.7 % Microbl. 3.3 %		

Figure 13: *Recently excavated sites with inventory characteristic of the period c. 5600–4500 BC.*

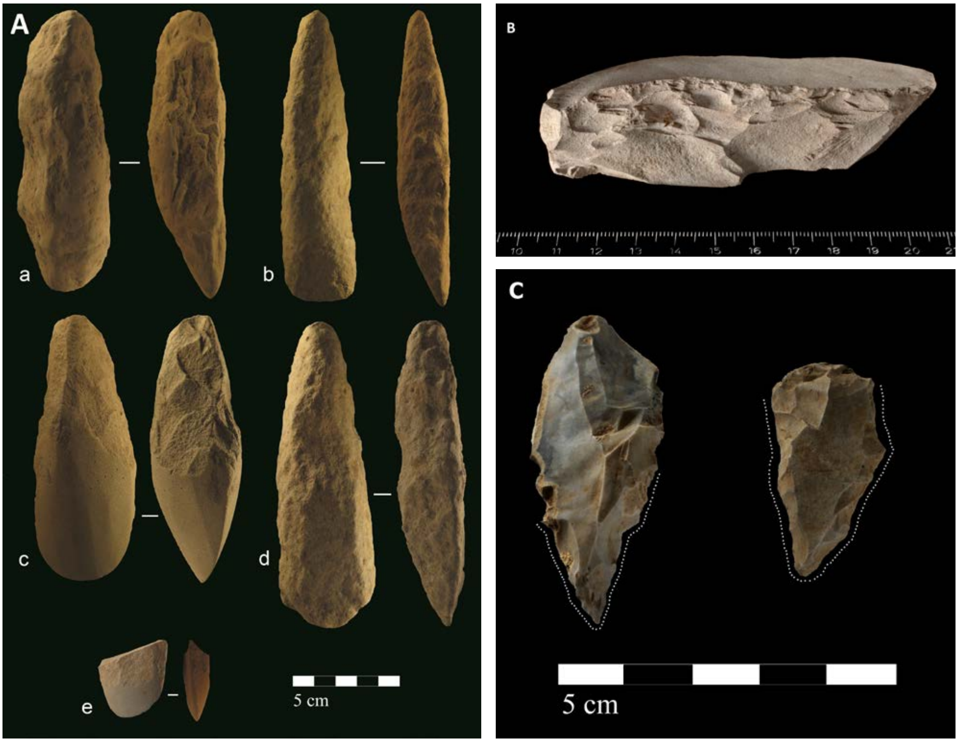

***Figure 14**: Artefacts characteristic of the period c. 5600–4500 BC (cf. Fig. 13): A) Nøstvet type adzes of eroded hornfels (a, b, d) and igneous rock, probably diabase or basalt (c, e), from Krøgenes D2 after Mansrud et al. 2018, B) Flint handle core preform from Vallermyrene 4 after Eigeland and Fossum 2014, C) Flint borers with three-sided cross-sections from Vallermyrene 4, photo: G. Reitan / Museum of Cultural History.*

The period c. 4500–3900 cal. BC (c. 5650–5100 BP)

Evidence for the chronological development in the final stage of the Late Mesolithic is provided by the sites Vallermyrene 1B (Reitan 2014b) and Langangen V. 3 (Eggen 2014b), along with the northern part of Langangen V. 5 (the latter is not included in Fig. 15 due to its multi-phased inventory, see Reitan 2014c). The collected material from the first two of these sites points towards a consistent handle-core-based production of microblades. Even so, the production of wider blades was an element in the technological strategy, as suggested by the Vallermyrene 1B material (Fig. 15), where the systematic selection of wide and thick blades is traceable among the scrapers (Fig. 16C).

Arrowheads are a prominent tool category in these last centuries of the Mesolithic, and transverse-tipped, single-edged and tanged varieties occur. The transverse arrowheads dominate the projectile point material, usually made of flakes (Fig. 16B); the other two main types are generally made of narrow blades or blade-like flakes.

The body of adze-related material from this period is scarce compared to the preceding period (see Reitan 2016, Table 9). One stone adze is recorded from Langangen V. 3, but the specimen is heavily eroded and difficult to classify. Within a small area on the elevated, northern part of Langangen V. 5, and isolated from other both earlier and younger concentrations of finds, microblades, blades and a transverse arrowhead, inter alia, were collected, along with two extensively ground stone adzes with oval cross-sections (Fig. 16A). The adzes were located next to each other and adjacent to two hearths, both radiocarbon dated to c. 4400 BC (Fig. 15, Reitan 2014c). The two adzes share several characteristics both in terms of morphological traits and in terms of raw material, but they do not exhibit any typical Nøstvet adze traits. Nor do they display any features normally associated with Neolithic varieties, such as four-sided cross sections or distinct side faces.

Important traits of the archaeological record from the period c. 4500–3900 BC are summarized in Figure 15.

Site name	**Flint ratio**	**Ratio, blades and microblades**	**Technological characteristics, artefacts typical of the period**	**Radiocarbon dates (2 σ)**
Vallermyrene 1B (4300–4100 BC)	97.7 %	Blades 3,0 % Microbl. 3.3 %	The technological strategy is focused on the production of microblades, primarily based on handle cores. However, the numbers of other types of platform cores increase, whereas the bipolar cores become fewer than in the preceding period, a development probably linked to an increased blade production. Blades now seem to be preferred for small tools like knives and scrapers, and borers made of flakes are no longer in use. However, arrowheads constitute the critical novelty of this interval. Transverse arrowheads dominate, but single-edged points and tanged points of type A also occur. As a rule the transverse-tipped arrowheads are made of flakes, the two other arrowhead types of small blades or blade-like flakes. The flint ratio increases substantially, whereas stone adzes become notably fewer. The relatively few recorded adzes differ clearly from the Nøstvet adzes both in raw material and morphology in addition to being more extensively ground. The use of sandstone knives ceases.	Vallermyrene 1B: 4331–4063 BC/5373 ± 34 BP (Ua-45180, *Betula*) Langangen V. 3: 4876–4726 BC/5910 ± 10 BP (TRa-2248, *Pinus*), 4348–4057 BC/5400 ± 55 BP (TRa-2246, *Pinus*), 4323–4003 BC/5325 ± 40 BP (TRa-2247, *Pinus*), 4323–4003 BC/5325 ± 40 BP (TRa-2250, *Betula*), 4322–4005 f.Kr/5325 ± 45 BP (TRa-2249, *Betula*) Langangen V. 5 North: 4575–4465 BC/5695 ± 50 BP (TRa-2255, *Pinus*), 4520–4405 BC/5645 ± 45 BP (TRa-2254, *Betula*, *Salix/ Populus*)
Langangen V.3 (4300–4000 BC)	99.7 %	Blades 0.4 % Microbl. 2.6 %		

***Figure 15**: Recently excavated sites with inventory characteristic of the period c. 4500–3900 BC.*

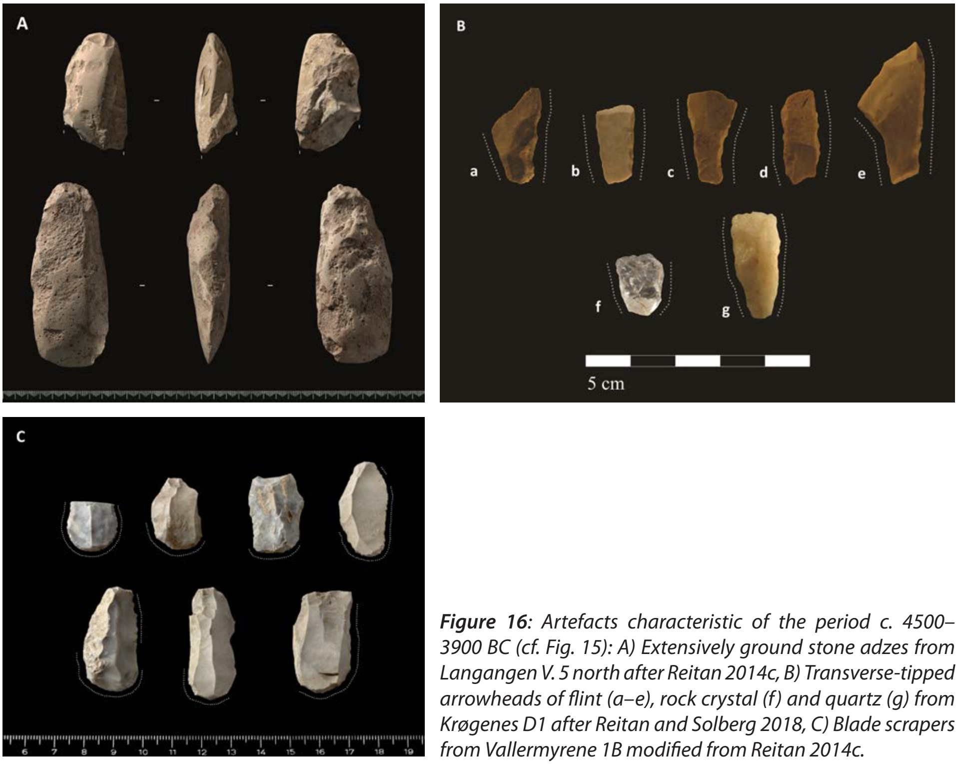

Figure 16*: Artefacts characteristic of the period c. 4500–3900 BC (cf. Fig. 15): A) Extensively ground stone adzes from Langangen V. 5 north after Reitan 2014c, B) Transverse-tipped arrowheads of flint (a–e), rock crystal (f) and quartz (g) from Krøgenes D1 after Reitan and Solberg 2018, C) Blade scrapers from Vallermyrene 1B modified from Reitan 2014c.*

C. 3900 cal. BC (c. 5100 BP) – the onset of the Neolithic

It is beyond the scope of this paper to go into detail about the Neolithic period. Nevertheless, it is appropriate to mention some important aspects of the two Early Neolithic Vestfoldbane project sites Langangen V. 5 and Langangen V. 6, as they provide valuable insights into the initial part of the Early Neolithic period and consequently the end of the Late Mesolithic. The assemblages from the two Langangen sites together comprise approximately 21,000 finds, and the age of each site is determined by a series of radiocarbon dating results to c. 3950–3700 BC (Reitan 2014c, 2014d).

The production of blades has been the predominant goal of the flint reduction on both sites. Handle cores are no longer in use, and the strategic production of microblades has ceased. Furthermore, the two sites demonstrate a striking increase in the share of flints with secondary working in the Early Neolithic – 3.9 % at Langangen V. 5 and 4.7 % at Langangen V. 6 (cf. 4.2 % of in all c. 46,000 finds at the contemporary site Vestgård 6 at Svinesund, see Jaksland and Tørhaug 2004). In comparison, the average ratios of flints with secondary working from the Late Mesolithic sites in Figures 13 and 15 are 1.0 % and 1.7 %, respectively. The arrowheads from the Early Neolithic are of the same main types as those in the final Mesolithic stage, but they increase significantly in numbers. Moreover, the arrowheads are more often produced on the base of wider and more regular blades. Bipolar cores constitute a half of all cores (for the fabrication of transverse arrowheads?), but the increased production of blades can be associated with different platform cores.

Considering the uncertainties regarding the extent and the character of farming in the Early Neolithic (for discussions, see e.g. Østmo 1988, 1998, Mikkelsen 1989, Prescott 1996, Glørstad 1998a, 2002, 2004, Reitan *et al.* 2018), I see novelties in the archaeological record, i.e. polished flint and stone axes/adzes with four-sided cross-sections and pottery, as the prime Early Neolithic markers. Complete polished flint axes are not recorded from any of the two Langangen sites. However, small pieces of polished flint were retrieved from both of them, demonstrating that flint axes were in use and secondarily used as flint resources for small tools. Ground stone axes and adzes with distinct four-sided cross-sections were also unearthed at both sites. These axes and adzes clearly differ from Late Mesolithic types. Besides, more than a thousand potsherds from at least six different vessels of the funnel beaker type were collected at Langangen V. 6 (Reitan 2014d). Assemblages with similar characteristics were recovered from a number of sites examined within the Svinesund project – sites dated to the same period as the two Langangen sites (Glørstad 2003, Jaksland and Tørhaug 2004, Johansen 2004).

Correcting the map – newly identified chronological patterns in a wider perspective

The Early Mesolithic – fluctuations in the projectile point and axe material

Until recently, the low number of excavated Early Mesolithic sites has hampered attempts to address chronological questions on local terms (Fig. 2). Consequently, previous Norwegian studies of the Early Mesolithic have to a large degree focused on cultural affinities with southern Scandinavian and continental finds (e.g. Waraas 2001, Fuglestvedt 1999, 2007, Bjerck 2008a, cf. Damlien 2016a, p. 39–42, Berg-Hansen 2017, p. 21–40). This situation has now changed, mainly as a result of the investigations within the E18-related projects in Brunlanes, Vestfold County, and in Tvedestrand–Arendal, Aust-Agder County, with their 8 and 14 excavated Early Mesolithic sites respectively (see Jaksland and Persson 2014, Reitan 2018b). In addition to the sheer number of sites and the time-span they cover, the value of the excavated data is amplified by precise and well-dated, local shoreline displacement curves, especially in the Tvedestrand–Arendal area (Romundset 2018, cf. Sørensen *et al.* 2014a, 2014b). Admittedly, not every single site encompasses quantitative qualities suitable for comparative analyses. There are also considerable individual variations between contemporary sites, potentially owing to differing site functions (Viken 2018d, cf. Eigeland 2018). So far, no investigated site in the region can be convincingly dated any earlier than the Preboreal oscillation, c. 9300–9200 BC (Glørstad 2013, p. 58, Berg-Hansen 2017, p. 30–36 with references, Damlien and Solheim 2018, p. 339, cf. Björck *et al.* 1997 and Mangerud and Svendsen in this volume).

Certain fluctuations in the Early Mesolithic material recorded from the E18 Brunlanes project were identified by Jaksland and Fossum (2014) as being chronologically dependent (Fig. 3). The investigated Brunlanes sites cover a period of approximately 400 calendar years, ranging from c. 9200–8900 to 8800–8500 BC – the Pauler sequence (Jaksland 2014, p. 39–40). Two quantitative trends are particularly prominent in this material. Firstly, while single-edged points dominate the projectile point material in the early part of the Pauler-sequence, over time the share of single-edged points decreases distinctly. Secondly, and concurrently with the decrease in single-edged points, the proportion of lanceolate microliths increases. It has been suggested that the latter trend is linked to an increased use of microburin technique (Jaksland and

Fossum 2014, p. 57). The number of Høgnipen points increase during the Pauler-sequence, too, but less markedly than the lanceolates. Further observations can be made based on the Brunlanes material. First, that the flake axe is the only axe type in use throughout the first half of the ninth millennium BC; second, that the sides of the axes become increasingly parallel and that flake chisels are more common on the younger sites (Jaksland and Fossum 2014, p. 57–58). The changes identified in the Brunlanes projectile point material are consistent with trends previously observed for the time-span c. 8900–8200 in southern and southwestern Norway (e.g. Bang-Andersen 1990, Ballin 1999a, 2004, Fuglestvedt 2007).

Moving on to the E18 Tvedestrand–Arendal material, the blade and core material seems to confirm that the production technique remains the same throughout the Early Mesolithic (Eigeland 2018, cf. Damlien 2016a, p. 389). But the same 'microlithisation development' is evident in the projectile point material, most likely expressing a higher dependency on composite projectile point designs, including Høgnipen points as tips and microliths as (unilateral?) elements in slotted bone points or wooden shafts (Darmark and Viken 2018). However, as underlined by Jaksland and Fossum (2014, p. 56), tanged points/single-edged points and lanceolate microliths are not mutually exclusive – both types occur throughout the Early Mesolithic (cf. Darmark and Viken 2018, Table 3.8.2). It therefore seems reasonable to conclude that this shift can be designated as a gradual one. To judge from the E18 Tvedestrand–Arendal site material, the time frame during which these changes appear can be narrowed down to c. 8800–8600 BC.

The axe material from the E18 Tvedestrand–Arendal sites also seems to reflect certain chronologically dependent changes, namely a gradual increase in flake chisels and core axes, although flake axes/chisels occur throughout the Early Mesolithic. Core axes, on the other hand, are only recorded from sites younger than c. 8700–8600 BC. Overall, the available material also reflects an increased use of local non-flint raw materials in the same period.

At present, it may be disputable whether these trends in the recently excavated material – outlined above – really justify a division of the Early Mesolithic into two sub-phases. If they do, it is reasonable to suggest a dating of the transition to c. 8700–8600 BC. It is anticipated that investigations of further sites from this period may contribute to a clarification of this.

As for the end of the Early Mesolithic and the introduction of the conical core pressure blade technology, Damlien (2016a, p. 387–392, cf. M. Sørensen *et al.* 2013) has suggested a backdating of the Early Mesolithic/Middle Mesolithic transition in the Oslo Fjord area to c. 8400 BC. Sites from the period between c. 8500 and 8000 BC excavated within the E18 Tvedestrand–Arendal project (Fig. 9, see Darmark *et al.* 2018b, Stokke *et al.* 2018, Stokke and Reitan 2018, Viken 2018b) may however suggest that Damlien's proposed dating of the transition is somewhat too early, at least regarding the southern parts of the region. Besides, relatively few sites from the Early/Middle Mesolithic transitional phase have been investigated and dated precisely. Altogether, the presently available data suggest that c. 8300 is a reasonable dating of the Early/Middle Mesolithic transition.

The Middle Mesolithic – microliths as chronological markers?

Microliths only constitute a marginal share of the assemblages from the Middle Mesolithic sites included in the present study (Fig. 9). This applies also to other investigated sites from the same period in the region (Mansrud 2013, p. 76; Solheim 2013, p. 269–272, Fig.

17.6). Even so, microliths have been a key tool category in discussions of chronology in the Middle Mesolithic, as shown in Figure 9 (e.g. Ballin and Jensen 1995, Ballin 1995, 1999a, 2000, Jaksland 2001, Mansrud 2013, Solheim 2013). It has previously been suggested that microliths were an integrated part of the lithic industry up until the transition to the Late Mesolithic Nøstvet phase, c. 6350 BC according to the established chronology. This was based on the presence of microliths in assemblages from sites investigated at Lista in Farsund, Vest-Agder County, in southernmost Norway (Figs. 1 and 4): numerous scalene triangles as well as conical blade- and microblade cores were retrieved from two sites, *R17* and *R21/22*. A burnt hazelnut shell collected from the layer of finds on R17 was radiocarbon dated to 6820–6450 BC (7770 ± 75 BP, Ua-3556) (Ballin and Jensen 1995, p. 61–62). This led Ballin (1999a) to assume a direct link between this single dating result and the microliths from both R17 and R21/22. Instead, I would claim that the dating of the microliths from both sites is far from certain, not least owing to the fact that the relative sea level history of the Farsund area shows a very modest land uplift in comparison to areas further north (see Romundset *et al.* 2015). As a consequence of the small changes and slowstands in the sea level, terraces suitable for marine oriented occupation have repeatedly, or over long periods, been situated adjacent to the shoreline. As a result, the archaeological finds on such sites are a mix from different parts of the Stone Age, representing an interpretational problem, surely relevant also to R17 and R21/22 (e.g. Ballin and Jensen 1995, Reitan and Berg-Hansen 2009, Reitan 2010).

With reservations about potential differences between contemporary sites in the Lista and the Oslo Fjord areas, Ballin's (1999a) closures concerning the microlith production are not consistent with tendencies identified in recently excavated assemblages from the counties of Vestfold and Telemark. For instance, the site Langangen V. 1 (Fig. 11, see Melvold and Eigeland 2014) fits temporally very well into Ballin's suggested Middle Mesolithic B/ 'the Lundevågen phase' (c. 7500–6350 BC, see Fig. 4). Based on comprehensive finds from Langangen V. 1, encompassing a wide range of tools, the assemblage is likely typical of the time frame c. 7000–6500 BC. From a technological point of view, Melvold and Eigeland (2014) have characterized the Langangen V. 1 flint core and blade inventory as distinctly Middle Mesolithic. Yet, no microliths are recorded from the site. This means that one of the artefacts designated as characteristic of the period is lacking. Moreover, knives made of thin sandstone plates with ground edges are among the finds – a tool type commonly acknowledged as characteristic of the Late Mesolithic Nøstvet phase (Figs. 11 and 13, see Jaksland 2005). However, Langangen V. 1 lacks other typical Nøstvet phase finds, such as handle cores and Nøstvet adzes (Fig. 14). As a result, the Langangen V. 1 material can represent a transitional phase between the Middle Mesolithic/phase 2 and the Late Mesolithic Nøstvet phase/phase 3 (cf. Fredsjö 1953, p. 89–97, Kindgren and Åhrberg 1999, Nordqvist 1999, 2000a on what has been labelled *the Enerklev phase* in western Sweden).

In the collected material from the four 8300–7000 BC sites analysed in this study (Fig. 9), scalene triangles produced without microburin technique clearly dominate the microlith material. The sites Gunnarsrød 7 in Porsgrunn municipality and Skutvikåsen 3 in Skien municipality, both in Telemark County, are the youngest sites I know of with distinct microliths present, both shoreline dated to c. 7300–7100 BC (see Fossum 2014c and Ekstrand 2013, respectively). The youngest site that I presently know of where a microburin (one single) has been identified is Lågerødåsen in Sandefjord municipality, Vestfold, dated on the base of a new shoreline displacement curve suggested by Persson (2008) to c. 7400–7000 BC (Eymundsson

2014). Overall, the find material analysed in the present study at hand towards a termination of the use of *typical* microliths approximately 7000 BC (cf. Helskog *et al.* 1976, p. 28, for discussions on ‘informal microliths’, see e.g. Bjerck 2008a, Mansrud 2013, p. 77–78, with references). This conclusion is in keeping with a previously outlined tendency for the same time frame in the Oslo Fjord area (see Mansrud 2013).

The adzes of the Middle Mesolithic and the Late Mesolithic Nøstvet phase

The assemblages from the sites listed in Figure 9 share many important traits – traits also identified in other assemblages from the same time frame across southeast Norway (e.g. Jaksland 2001, Solheim and Damlien 2013). Together these draw an ever-clearer picture, which is largely in line with the one outlined by Jaksland (2001) for the Oslo Fjord area (see Fig. 4): the combined production of blades and microblades from the same conical or semi-conical cores persists throughout the whole period, whereas the use of barbed points and the microburin technique terminates approximately 7500 BC. Chubby adzes, shaft-hole hatchets/mace heads and associated sandstone grinding slabs are introduced at an earlier stage than previously assumed – already around 8000 BC at the latest, as shown by Hesthag C4 (Viken 2018c, cf. Jaksland 2001, p. 67, Solheim 2013, p. 274). This development is likely closely linked with other technological changes around 8300 BC (see Damlien 2016a, Eymundsson *et al.* 2018). The amount of stone adze-related material, albeit scarce, is consistent throughout this period of just over one thousand years.

In the centuries after 7000 BC, the chubby adze is clearly the dominant adze type, but the amount of adze-related material now constitutes a far bigger share of the collected assemblages (Reitan 2016, Table 9). Sites in Vestfold and Telemark, especially, demonstrate that adze production was largely based on a dark brown to blackish diabase, bearing witness to a well-established adze tradition including strategic raw material procurement in the area. This tradition thus transcends the established transition between the Middle Mesolithic and the Late Mesolithic Nøstvet phase (cf. Glørstad 2004). A reassessment of the collected stone adze material from the site Trosterud 1 in Vestby municipality, Akershus County, strongly challenges Berg’s (1997) asserted introduction of the Nøstvet adze c. 6600 BC (Fig. 5, see Reitan 2016, note 5 for recalibrated dating results from Trosterud 1). Of the 22 complete or partly fragmented adzes from Trosterud 1, Berg classified 16 as Nøstvet adzes. In my re-evaluation of this material, only chubby adzes and production debris from such were identified – none of them could be classified as Nøstvet adzes. The finds from the Vestfoldbane project along with the Brunstad assemblages demonstrate that the chubby adzes are not replaced by the Nøstvet adze until c. 5600 BC. This shift in the adze technology can be characterized as abrupt, and it takes place simultaneously on both sides of the Oslo Fjord (e.g. Glørstad 2004). In other words, Nøstvet adzes occur only within a period of just over one thousand years in the latest part of the Nøstvet phase as it is delimited in the established chronology – that is, in the period commonly referred to as ‘classic Nøstvet’.

What defines the Late Mesolithic Nøstvet phase?

Ever since Mikkelsen’s (1975a) study it has been widely agreed that the beginning of the Nøstvet phase can be dated to c. 6350 BC (Fig. 2). As shown in Figure 5, however, different scholars disagree on what they consider as the major markers of the onset of the phase. Certain scholars have focused on the discontinued use of microliths at the transition between the Middle Mesolithic and the Late Mesolithic Nøstvet phase (Ballin 1995, Glørstad 2004), while others have pointed to the introduction of the Nøstvet adze (Berg 1997) or the sandstone knife (Jaksland 2005) as the main markers. The introduction of the handle core has also been highlighted by some (Mikkelsen 1975a, Lindblom 1984, Ballin 1998, Jaksland 2001).

As demonstrated, excavations carried out in recent years indicate that the Nøstvet adze was not introduced until approximately 5600 BC – that is, some 700–800 years after the beginning of the Nøstvet phase according to the established fixation of the transition, whereas typical microliths are discontinued equally far ahead of the established transition, c. 7000 BC. In fact, there is not one single, well-defined tool type that is unique for the Nøstvet phase, which does not also occur in other parts of the Mesolithic (Jaksland 2005, p. 39).

Glørstad (2004) points out a certain continuation from the Middle Mesolithic and into the earliest part of the Nøstvet phase, in, inter alia, the material of blades and chubby adzes. At the same time, he stresses that there are considerable variations over time within the defined Nøstvet phase, too. In this connection, it is worthwhile to take a closer look at the site Torpum 1 in Halden municipality, Østfold County, excavated within the Svinesund project (Johansen 2003, Glørstad 2004). Based on the height above the present sea level and typological traits, including a few handle cores, and drawing on similarities with e.g. Trosterud 1 and Vinterbro 3 (see Berg 1997, Jaksland 2001), the site was originally dated to the initial part of the Nøstvet phase, c. 6300 BC. However, Eigeland's (2015) recent technological analysis of the Torpum 1 material identified that a combined production of blades and microblades based on conical/semi-conical cores, and not handle cores, has been at the centre of the flint reduction strategy. Eigeland concludes that the technology identified in the Torpum 1 material is distinctly Middle Mesolithic, not Late Mesolithic. The Torpum 1 finds share far more similarities with e.g. the Middle Mesolithic Langangen V. 1 than with the Late Mesolithic Vallermyrene 4 from the classic Nøstvet phase. Compared to settlement site material from the latest third of the Nøstvet phase, the Torpum 1 finds may contribute to a clearer picture of Glørstad's (2004) revision of the Nøstvet phase. On the other hand, the Torpum 1 finds cannot be used to demonstrate any technological break around 6300–6000 BC.

In my opinion, there is nothing in the archaeological record, either in the Vestfoldbane project material or in previously excavated settlement site material, to justify maintaining a phase transition around 6350 BC. Instead, the assemblages collected from sites like Langangen V. 1, Gunnarsrød 6, Gunnarsrød 4, Trosterud 1, Torpum 1 and the Brunstad sites reflect continuity in terms of both artefacts typical of their period and technology between c. 7000 BC and c. 5600 BC. A marked break appears around 5600 BC. At this point, the strong chubby adze tradition is replaced by an even stronger Nøstvet adze tradition. At the same time, the production of microblades from handle cores becomes central in the technological strategy, whereas the production of wider blades ceases. Thick flake borers are another typical artefact that is introduced at this point. These changes are potentially some of the most manifest and abrupt ones of the entire Mesolithic. Vallermyrene 4 in Porsgrunn, Telemark, dated to c. 5500–4800 BC (Eigeland and Fossum 2014), illustrates these shifts in adze- and flint production strategies especially well (cf. Nordqvist 1999, 2000a on synchronous, similar changes in bordering areas of western Sweden).

The chronological delimitation of the Late Mesolithic Kjeøy phase

There are similarities in the core material as well as in the blade/microblade material from the late Nøstvet phase and the early Kjeøy phase, according to Glørstad (1998a, 2004). Even so, Eigeland (2015, p. 379) has identified clear-cut qualitative technological differences between them. These changes encompass a distinct decrease in bipolar cores, increased blade production and new strategies within stone adze production. Based on these changes, Eigeland suggests that the material recorded from the last centuries of the Mesolithic may be traces of a new population possibly migrating from southern Sweden. A discussion of a possible migration is beyond the scope of the present paper. However, it is worth pointing out that the sites analysed in connection with my study also reflect considerable changes at the end of the Mesolithic, with Vallermyrene 4, Krøgenes D2 and Vallermyrene 1A on one side of the break, and Langangen V. 3 and Vallermyrene 1B (in addition to the northern part of Langangen V. 5) on the other (see Figs. 13 and 15).

As noted at the beginning of this paper, I would claim that the chronological delimitation of the Kjeøy phase is not satisfactory. Glørstad's (1998a) dating of the transition between the Nøstvet phase and the Kjeøy phase relies heavily on the shoreline dating of the site Halden 5, the youngest of five Mesolithic sites investigated in 1989 in Halden municipality, Østfold County (Lindblom 1990). Finds from the excavation included 34 transverse-tipped arrowheads (but no other arrowhead types), in addition to eight stone adzes – all classified as atypical (Juhl 1990). The majority of the finds are assumed to date to the Kjeøy phase. However, the radiocarbon dating results span from c. 5150 BC to c. 4350 BC, indicative of multiple occupations over several centuries (see Reitan 2016, Note 6 for 2 σ recalibrated dating results from Halden 5). The arrowheads were mostly recovered from the lower end of the site, around 40 m.a.s.l., where the hearths providing the youngest radiocarbon dates were located. Local topographical features and the relative sea level changes in the area (cf. Sørensen 1999) indicate that the lower part of Halden 5 was occupied from 4500 BC at the earliest. These factors reveal that Halden 5 cannot firmly contribute to establishing the beginning of the Kjeøy phase at 4650 BC. This is in line with the conclusion drawn by Dekov Hafting (2007) in her re-analysis of the Halden 5 material (cf. Jaksland 2003, Glørstad 2004, p. 28 on the Svinesund site Rørbekk 1). In my opinion, there is no evidence for dating the Nøstvet phase/Kjeøy phase transition any earlier than c. 4500 BC.

Along with the introduction of flint projectile points, the Vestfoldbane project sites demonstrate another marked change in the adze material at this transition: the adzes are fewer, are produced in a different manner, and they exhibit traces of more extensive grinding in comparison with adzes from the preceding Nøstvet phase (see Fig. 16A).

The end of the Late Mesolithic and the beginning of the Early Neolithic is commonly dated to 3800 BC (Fig. 2). Instead, I would suggest a backdating of the transition to the Neolithic to 3900 BC, and that this should not be based on a poorly mapped shift to a farming mode of production, but rather on the introduction of ceramic vessels and polished axes of stone and flint with a four-sided cross-section. Such finds were unearthed at Langangen V. 5 and Langangen V. 6 (Reitan 2014c, 2014d). The presence of pottery and polished flints in contexts predating 3800 BC, traditionally acknowledged as Late Mesolithic time, has previously caused an interpretational problem (Glørstad 2004, p. 34–35). The two Langangen sites at the Langangen Fjord in Telemark, mentioned above, can be characterized as typical, marine oriented foraging sites. The recorded assemblages from the two are clearly comparable with, for example, two sites excavated within the Svinesund project in Østfold – Vestgård 3 (Johansen 2004) and Vestgård 6 (Jaksland and Tørhaug 2004, cf. Glørstad 2004). In addition, all these sites have provided radiocarbon dates where the calibrated results point to an earlier date than 3800 BC. Several other sites in southeastern Norway with typical Early Neolithic elements have provided equivalently early dating results (e.g. Sjurseike 1991, Glørstad 1998b, Solheim 2012, p. 127–129, Bjørkli and Mjærum 2016).

Concluding remarks – a revised chronology of the Mesolithic in Southeast Norway

The analysis outlined in the present paper is based on trends and breaks identified in the archaeological record from a large number of recently excavated sites and associated radiocarbon dating results. My assessment does not support the established chronological division of the Mesolithic in southeast Norway. Especially, there is reason to question the asserted duration of the Nøstvet phase between c. 6350 and 4650 BC. I have demonstrated that there are much closer similarities between sites dated to 6800 BC and 5800 BC (e.g. Langangen V. 1 and Brunstad) than there are between sites dated to 5800 BC and 5300 BC (e.g. Brunstad and Vallermyrene 4). In my view, the designation 'the Nøstvet phase' should be reserved for the time frame when the Nøstvet adze was in use (Fig. 18), i.e. the just over one-thousand-year-long period often referred to as the 'classic Nøstvet'.

If the division of the Early Mesolithic into two sub-phases is valid, the Mesolithic period can be divided into six instead of four different sub-phases. To avoid confusion with previously applied terms on various phases in southeast Norway, I suggest a division of the Mesolithic as shown in Figure 17. The outlined chronological development has several similarities with trends identified in the archaeological record from bordering areas of western Sweden. Moreover, the backdating of the Mesolithic/Neolithic transition to 3900 BC is in line with the dating of the transition in both southern Sweden and Denmark.

Phase name	Cal. BC	^{14}C -years BP	Major chronological markers
Early Mesolithic 1 'The single-edged point phase'	9300–8600 BC	9800–9350 BP	Single-edged points, tanged points, Høgnipen points, blades, narrow blades, flake axes, one-sided single-platform cores, microburins, blade small-tools
Early Mesolithic 2 'The Høgnipen point phase'	8600–8300 BC	9300–9100 BP	Høgnipen points, lanceolate microliths, core axes, flake chisels, microburins, blade tools, blades, narrow blades, one-sided single-platform cores
Middle Mesolithic 1 'The microlith phase'	8300–7000 BC	9100–8000 BP	Various microliths (mainly scalene triangles), core axes, hatchets/mace heads with shaft-hole, chubby adzes, blade tools, rulers, conical cores, bipolar cores
Middle Mesolithic 2 'The chubby adze phase'	7000–5600 BC	8000–6700 BP	Pecked chubby stone adzes, flat stone chisels, sandstone knives, sandstone grinding slabs, blade small tools, blades, microblades, conical/semi-conical cores, bipolar cores
Late Mesolithic 1 'The Nøstvet adze phase'	5600–4500 BC	6700–5650 BP	Nøstvet stone adzes, sandstone grinding slabs, sandstone knives, flint flake borers with triangular cross-section, microblades, handle cores
Late Mesolithic 2 'The transverse arrowhead phase'	4500–3900 BC	5650–5100 BP	Transverse points, tanged points, single-edged points, blade small tools, blades, microblades, blade-like flakes, various platform cores

***Figure 17**: Suggested new chronological outline for the Mesolithic of Southeast Norway.*

Differences in time and space, such as shifts in raw material procurement strategies, new tool types and new tool production techniques, may reflect actual cultural historical breaks. Minor adjustments of a century or two back or forth can seem insignificant in terms of the time frames that we are dealing with in Stone Age research. In transitional phases, however, such adjustments might contribute to an increased knowledge of key social processes like the transmission of knowledge and techniques, or even migrations. The settling of new groups into the region may be the backdrop of several of the discussed transitions, e.g. the one around 5600 BC (see also e.g. M. Sørensen et al. 2013, Eigeland 2015, p. 379, Damlien 2016a, 2016b, Damlien and Solheim 2018, Kashuba *et al.* 2019).

It is anticipated that coming investigations will shed more light on Mesolithic chronology in southeast Norway, and hence test the validity of the outline suggested in this paper.

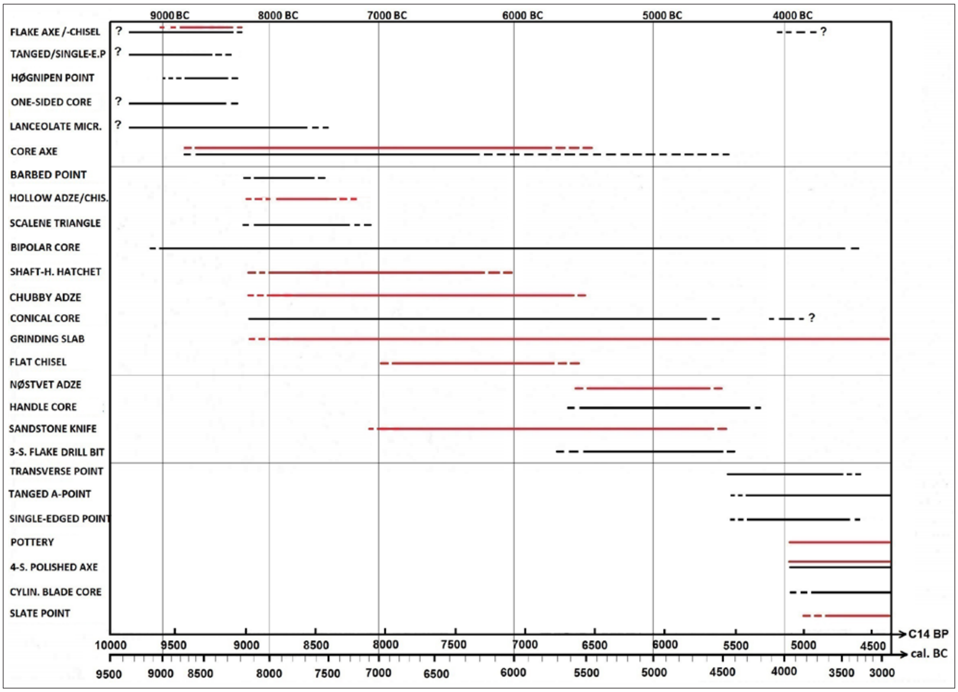

***Figure 18**: Timeline showing the period of use of selected diagnostic Mesolithic and Early Neolithic artefacts. The graph is based on a large number of both published and previously unpublished excavation results. Black lines are flint, red lines are other lithic raw materials or ceramic ware. The uneven spacing of the 500-year periods on the axis of calibrated age owes to different plateaus in the calibration curve. Illustration: G. Reitan/Museum of Cultural History.*

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Sessions and Papers at the Conference

Session 1–5	Theme I–VII	Papers/Posters
From study to strategy – raw material and technology / *Fra studie til strategi – råstoff og teknologi*	-	6 papers
Migration and population/ demography / *Migrasjon og befolkning*	Technological traditions / *Teknologiske tradisjoner*	6 papers
	Natural scientific approaches / *Naturvitenskapelige innfallsvinkler*	5 papers
Settlement pattern – new interpretations and approaches / *Bosetningsmønster – nye tolkninger og tilnærminger*	Settlement studies / *Boplasstudier*	10 papers
	Possibilities and challenges within the cultural heritage management / *Forvaltningsmessige muligheter og utfordringer*	5 papers
Communication, ritual and networks / *Kommunikasjon, ritual og nettverk*	Ritual practice / *Rituell praksis*	4 papers
	Symbolic communication / *Symbolsk kommunikasjon*	5 papers
	Social and economic networks / *Sosiale og økonomiske nettverk*	4 papers
Poster session	-	8 posters

Session 1. From study to strategy – raw material and technology.
«Fra massemateriale til teknologisk tradisjon», by *Inger Marie Berg-Hansen & Hege Damlien*
«Hvor kommer all denne flinten fra egentlig? En råstoffdiskusjon med utgangspunkt i en mellommesolittisk lokalitet fra Sarpsborg i Østfold og et flintdepot fra Larvik i Vestfold», by *Lucia U. Koxvold*
«Flintliknande råstoff» – på sporet av littisk teknologi og strategi i vestnorsk seinmesolitikum», by *Tina J. Granados*
«Rogalendingenes bruk av grønnstein fra Hespriholmen i senmesolitikum «revisited"», by *Astrid J. Nyland, Kidane Fanta Gebremarian & Ruben With*
«Fyrsetting i steinalderen! Eksperimentell produksjon av chert i det mesolittiske bruddet ved Melsvik i Finnmark», by *Per Storemyr & Anja R. Niemi*
«Teknologi, morfologi eller begge deler? Utfordringer og resultater fra E18 prosjektet Rugtvedt-Dørdal med fokus på katalogisering, littiske analyser og råstoffinndeling», by *Lucia U. Koxvold & Guro Fossum*

Session 2. Migration and population. Theme I: Technological traditions
«Utviklingen i håndverkstradisjoner i sørnorsk tidlig og mellommesolitikum - et interregionalt perspektiv», by *Hege Damlien*
«Flekkeproduksjon i Skandinavia omkring slutten av istida - kontinuitet og variasjon i håndverkstradisjoner», by *Inger Marie Berg-Hansen*
«Littisk teknologi i nordvestlige Fennoskandia ca. 8500–7500 f.Kr. Et overblikk over Nord-Norge og en case studie fra Nord-Troms», by *Anja R. Niemi*
«En teknologisk studie av littisk flekketeknologi fra den mellommesolittiske lokaliteten Hovland 3 i Larvik, Vestfold», by *Eirik H. Røe*
«Hugge, skrape, skjære, slå. Slitesporanalyser av tidligmesolittiske skiveøkser fra Sørøst-Norge», by *Steinar Solheim, Guro Fossum & Helena Knutsson*
«Tidligmesolittiske besøk i Aust-Agder – steinteknologi, råstoffbruk og landhevingsforløp», by *Lars Sundström & Gaute Reitan*

Session 3. Settlement pattern – new interpretations and approaches. Theme III: Settlement studies
«Barklag med hasselnøtter - en utradisjonell lokalitet fra mellommesolitikum?», by *Sigrid A. Dugstad*
«En delvis nedsenket tidligneolittisk hytte på Tananger, Sola kommune», by *Krister S. Eilertsen*
«Hellere på fjellet i eldre og yngre steinalder. Nye resultater og perspektiver», by *Dag Erik Færø Olsen*
«Teknologiens romlige kontekst på en mellom-neolittisk boplass på Vestlandet», by *Arne Johan Nærøy*
«Gone fishing – den tidligmesolittiske bosetningen på Vestlandet», by *Leif Inge* Åstveit
«Bergartshakker i Nordland - En kilde til forståelse av enkeltindivider og sosialt mangfold i mesolitikum?», by *Jan-Ivar Trones*
«The Weakest Link? Tidligmesolittiske fjordlokaliteter i Møre og Romsdal», by *Martin Callanan, Heidi M. Breivik, Svein V. Nielsen & Raymond Sauvage*
«Hva 16 funnkonsentrasjoner kan fortelle om tidligmesolittisk landskapsbruk og bosetningsmønster», by *Synnøve Viken & Linnea S. Johannessen*
«Befolkningsstørrelse og -tetthet ved Sørøysund, Vest-Finnmark, i steinalderen med utgangspunkt i tuftelokalitetene», by *Kennet Vollan*
«Når begynner historien om jordbruket og jordbrukerne på Vestlandet?», by *Asle Bruen Olsen*

Session 2. *Continued*. Theme II: Natural scientific approaches
«Genetics of the Scandinavian Mesolithic», by *Per Persson*
«Genetikk og steinteknologi - brikker til forståelse av migrasjon og livsformer i mellom mesolitikum», *Birgitte Skar*
«Isen smelter tilbake og ønsker folk velkommen til Norge», by *Jan Mangerud & John Inge Svendsen*
«Steinalderarkeologi er også steinaldergeologi - om havnivåendringer og betydningen for bosetningshistorien på Vestlandet», by *John Inge Svendsen & Leif Inge* Åstveit
«Om tilpasning, robusthet og kuldehendelsen 8200 år siden», by *Guro Fossum*

Session 3. *Continued*. Theme IV: Possibilities and challenges within the cultural heritage management
«Eldre og yngre i eldre steinalder. Et forslag til ny kronologi for mesolitikum i Øst-Norge», by *Gaute Reitan*
«54 plasser på 6 dager: Neural-Network basert prediktiv modellering av pionertidslokaliteter i Varanger», by *Hans Peter Blankholm*
«Skogens steinalder», by *Jostein Gundersen*
«Mesolittiske boliger - fortidige trender og nåtidige registrerings- og tolkningspraksiser», by *Silje Fretheim*
«Et grovmasket GIS-studie av synsfelt i Østlandets eldre steinalder», by *Isak Roalkvam*

Session 4. Communication, ritual and networks. Theme V: Ritual practice
«To mesolittiske skjeletter på Vestlandet - nye undersøkelser og resultater», by *Anne Karin Hufthammer, David Simpson & Knut Andreas Bergsvik*
«Hvor ble de døde av? Spor av mesolittiske begravelsesritualer i Norge i et Skandinavisk perspektiv», by *Almut Schülke*
«Rituelle kontekster på boplasser fra overgangen mellom eldre og yngre steinalder - et eksempel fra Rogaland», by *Trond Meling*
«Skjeformede skrapere som utrykk for rituelle handlinger?», by *Sigrid M. S. Hervig*

Session 4. *Continued*. Theme VI: Symbolic communication
«Geografisk kunnskap og landskap i helleristingar frå Steinalderen i det nordlege Fennoskandia», by *Jan Magne Gjerde*
«Fra Altafjord til Åskollen, fra kronologi til samfunn og fra dyreberg til dødens kodeks», by *Trond Lødøen*
«Verdsetting av dyr i steinalderen», by *Marianne Skandfer*
«Marin bærbar kunst i eldre steinalder på Vestlandet», by *Knut Andreas Bergsvik, David Simpson & Hanne* Årskog
«Å presse maling ut av stein – digital fotohandsaming og bergmalingar», by *Trond Linge*

Session 4. *Continued*. Theme VII: Social and economic networks
«Identitetslandskap og langdistansekontakt i senmesolitikum», by *Ingrid Fuglestvedt*
«Ting og mennesker i endring. Rav og skifer, nettverk og materielle konfigurasjoner ved overgangen til det fjerde årtusen», by *Morten Ramstad*
«Steinalderboplassen Håkonshella. Landskapsrom, bygd miljø og materiell kultur», by *Tor Arne Waraas, Morten Ramstad & Camilla Zinsli*
«Neolittiske langflekker i Norge», by *Svein V. Nielsen*

Poster session
“Bergkunst på løsblokker i Vest-Finnmark og Nord-Troms”, by *Mari S. Arntzen*
“Klokkebegerspissene fra Halsvik, fremmede impulser og lokal tradisjon”, by *Morten Ramstad & Camilla Zinsli*
“E18 Rugtvedt-Dørdal”, by *Steinar Solheim & Lucia Koxvold*
“Mohalsen-I, Vega. En arkeologisk og geologisk analyse av råstoffvariasjon og landskapsbruk i tidligmesolitikum”, by *Skule Spjelkavik*
“Strandvollbosetning på langs og på tvers”, by *Christine Tøssebro & Hanne* Årskog
“Senmesolittiske dyrefigurer i kleber fra Tjeldstø, Øygarden”, by *Hanne* Årskog *& David Simpson*
“Rekonstruksjon av det forhistoriske landskapet ved Longva, Haram”, by *Hanne* Årskog *& Trond Lødøen*
“Presentasjon av ph.d.-prosjektet: “Interaction in early prehistory: exploring the social dimensions of axe production and raw material procurement in the Early- and Middle Mesolithic of Northern Europe (9000–7500 BC)”” by *Carine S. R. Eymundsson*

In this volume, 10 papers from the Stone Age Conference in Bergen 2017 are presented. They range thematically from the earliest pioneer phase in the Mesolithic to the Neolithic and Bronze Age in the high mountains. The papers discuss new research and methodological developments showing a diverse and dynamic Stone Age research community in Norway.

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