UBAS
University of Bergen Archaeological Series

The Stone Age Conference in Bergen 2017

Dag Erik Færø Olsen (ed.)

UNIVERSITAS BERGENSIS
UNIVERSITY OF BERGEN

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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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Bergen University fund (UiB), University Museum of Bergen (UiB), Museum of Cultural History (UiO), Museum of archaeology, University of Stavanger (UiS), The Arctic University of Norway (UiT), NTNU University Museum, Department of Archaeology, History, Cultural Studies and Religion (UiB), and the Directorate for Cultural Heritage (Riksantikvaren). Without this support it would not have been possible to organize the conference. The Museum of Cultural History also contributed generously towards the production of the book.

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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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.

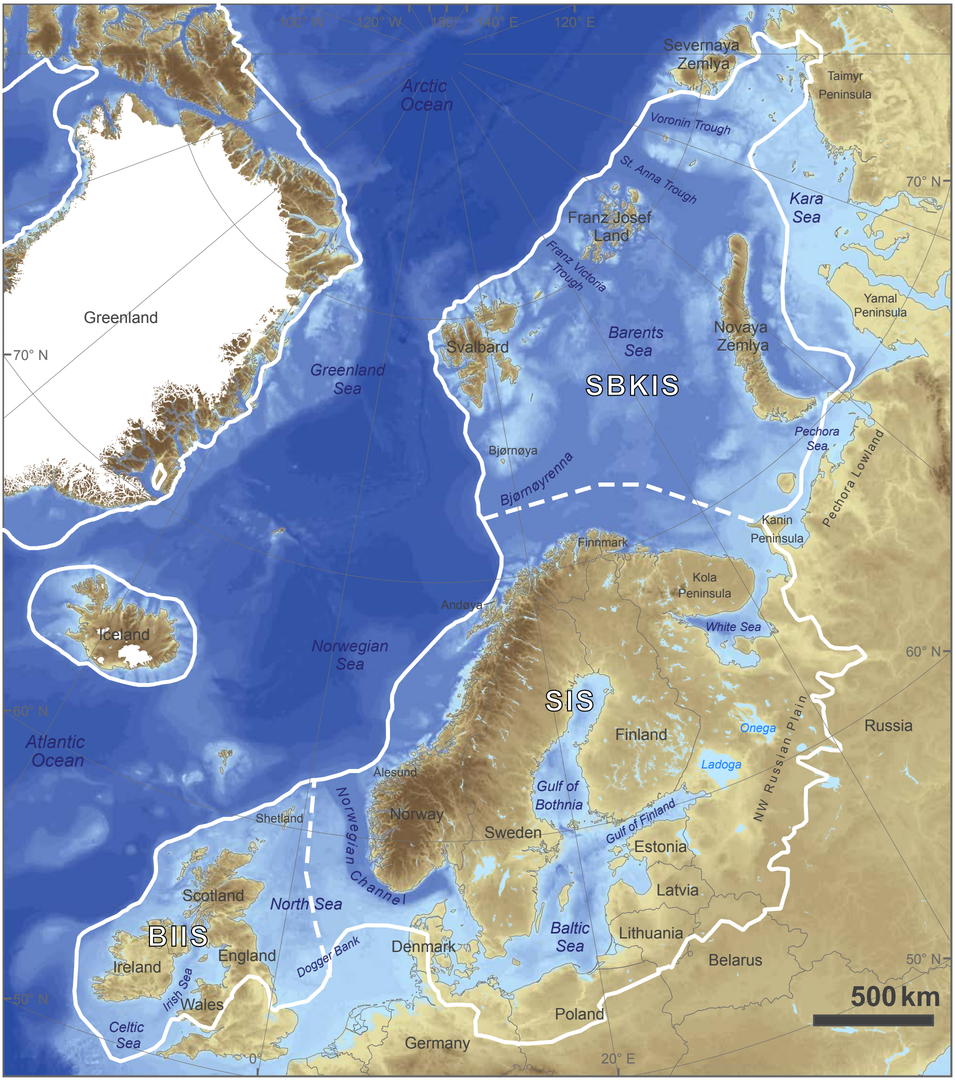

***Figure 1**: The maximum extent of the Eurasian Ice Sheet during the Last Glacial Maximum (LGM). The boundary is not synchronous around the ice sheet; it is about 26,000 years old in the west and some 17,000 years in the east. BIIS – the British-Irish Ice Sheet; SIS – the Scandinavian Ice Sheet; SBKIS – 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.

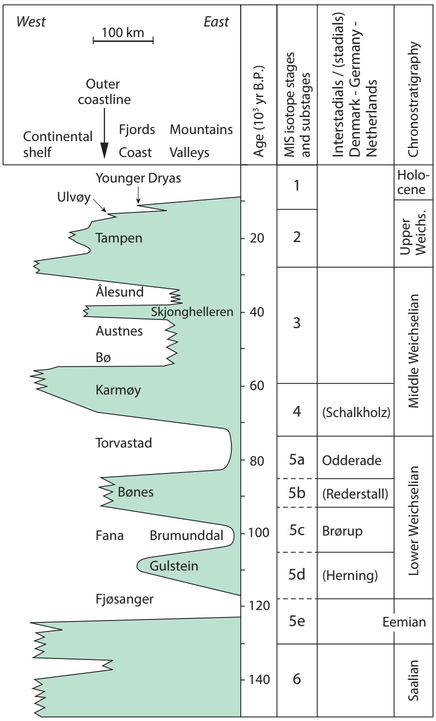

***Figure 2**: The fluctuations of the western flank of the Scandinavian Ice Sheet through the entire last Ice Age, the Weichselian. The green curve shows schematically the position of the ice margin, i.e. how the glacier expanded from the mountains through the valleys and fjords to the continental shelf 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).

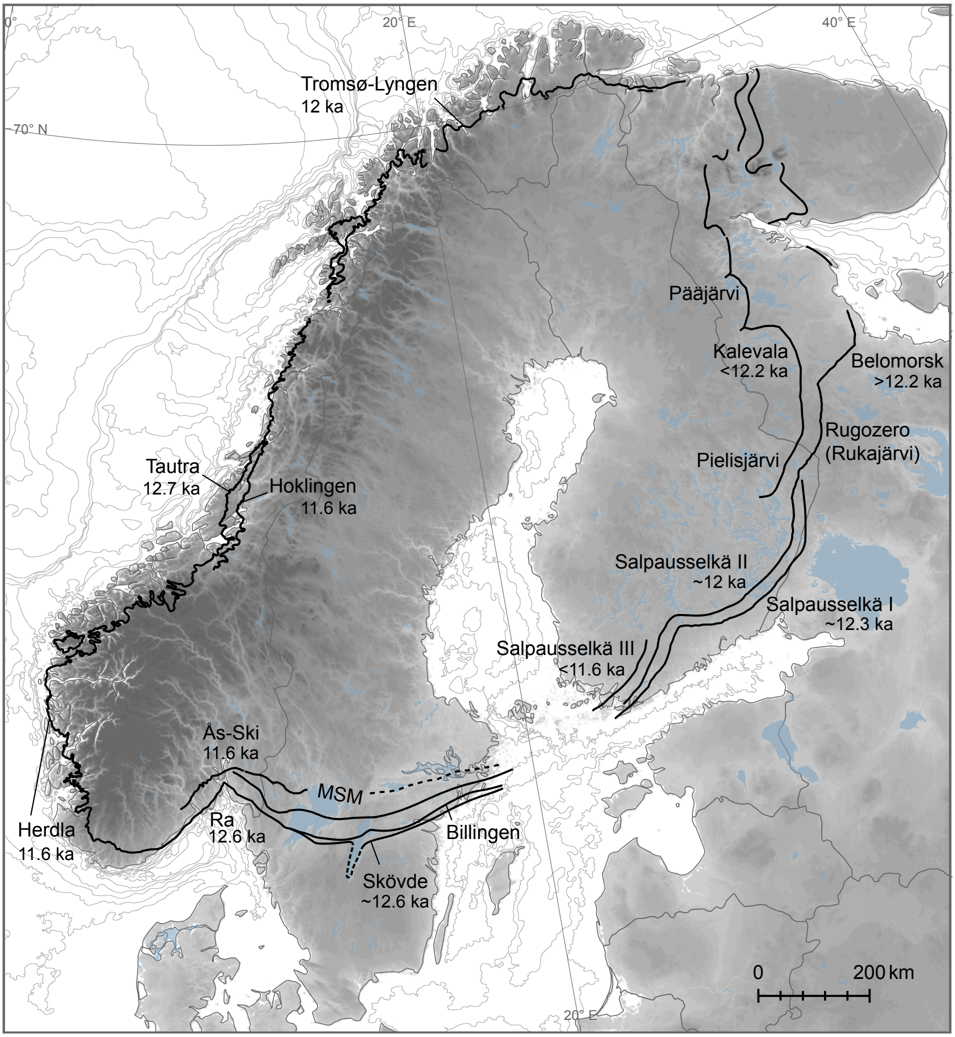

***Figure 3**: The Younger Dryas (YD, 12,700-11,600 cal ka BP) moraines around the Scandinavian Ice Sheet. Selected ages of named moraines are given in thousand years (ka). Note that some moraines were formed during early YD whereas others at the very end of YD. Modified from Mangerud et al. (2016).*

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).*

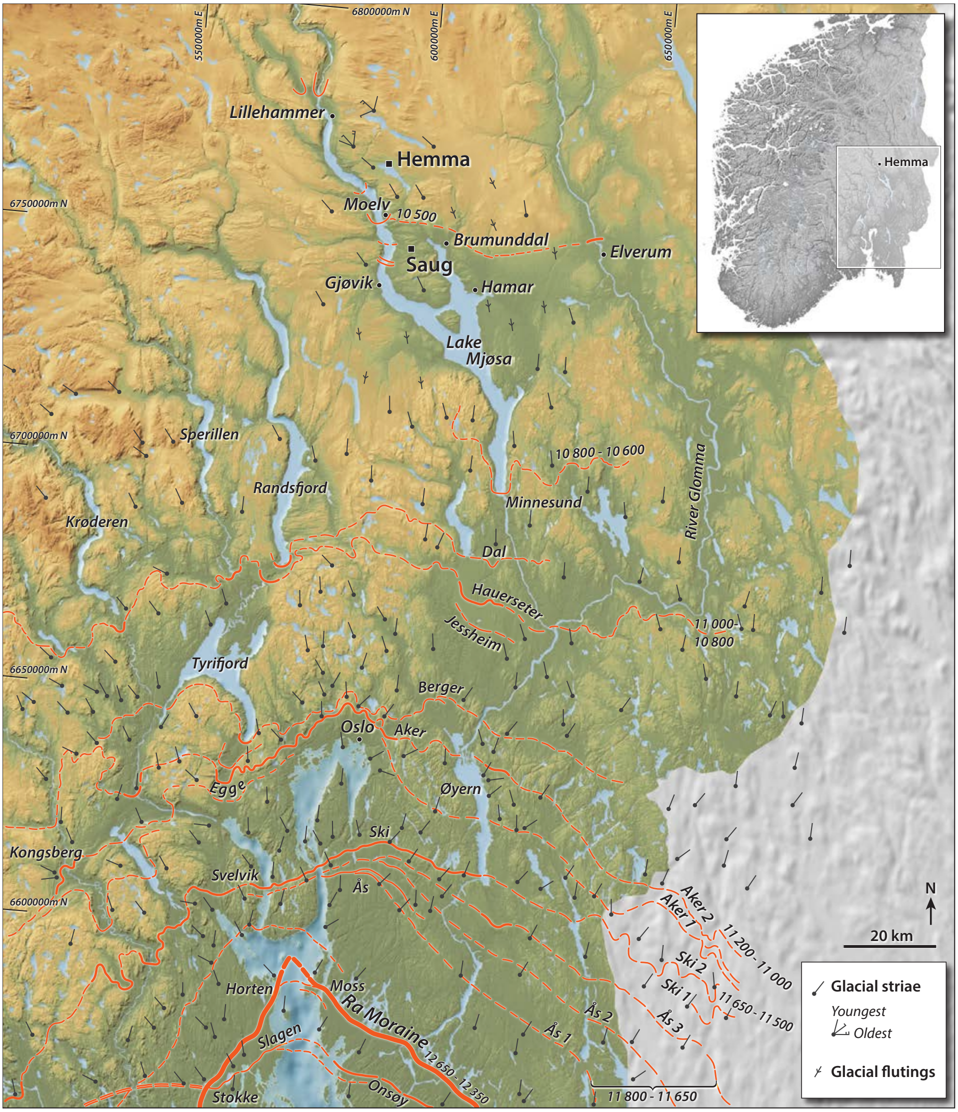

***Figure 4**: The deglaciation of eastern Norway. Red lines show named ice-margin positions and assumed ages for the moraines. Modified from Mangerud et al. (2018).*

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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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