

Preserving Rural Settlement Sites in Norway? Investigations of Archaeological Deposits in a Changing Climate

Vibeke Vandrup Martens



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On the cover: Opening the trench at Voldstad farm mound, August 2013. Photo Vibeke Vandrup Martens (NIKU).

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**Preserving Rural Settlement Sites in Norway?
Investigations of Archaeological Deposits in a Changing Climate**

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1 Outline and scope of this thesis

1.1 Aims and scopes of the study

Since the adoption of the Malta Convention (Council of Europe 1992), the strategy of cultural heritage management in many countries has changed from *ex situ* to *in situ* preservation of archaeological remains. The question is whether this change in strategy increases the protection or the risk of losing the undocumented heritage it was meant to protect? The strategy puts a large responsibility on present and future generations, as the concept of *in situ* preservation implies that the heritage sites remain unchanged ‘forever’. To ensure that *in situ* preservation may be considered a possibility, knowledge about the present state of preservation as well as the physical and chemical conditions for future preservation capacity is necessary. This accumulated knowledge is called environmental monitoring. The alternatives to *in situ* preservation are to simply let sites deteriorate and eventually disappear, or to preserve through detailed archaeological investigation and documentation, also called *ex situ* preservation or preservation by record. The possibilities, limitations and consequences of *in situ* site preservation are main topics of this work.

Archaeology is a human science of complementary discourses (Bintliff & Pearce 2011:5). Archaeological remains - visible or invisible - are physical or tangible parts of our cultural heritage containing traces of our past practices and interactions with our natural and social environment leading to the formation of the societies and civilizations we know today. These remains are often unique and irreplaceable. The value of these remains as raw material for archaeological research depends on several factors among which the state of preservation is of the utmost importance. The better the preservation, the more detailed information may be extracted. Another important factor is that methods for extracting knowledge are improving over time. This has motivated the wish to preserve as much as possible for future generations to investigate with hitherto unknown methods and questions. However, such a strategy implies that it is possible to preserve archaeological remains *in situ* without significant loss of information potential. The consequences of this assumption are the focus of this study.

How fast do archaeological deposits, artefacts and soil features degrade? And which measures may we take in order to promote a sustainable *in situ* preservation? Maintaining equilibrium between artefacts, ecofacts and their surroundings ensures long-term preservation *in situ*. Even small changes in the conditions of deposition, as caused by the global environmental development or local structural changes, may accelerate deterioration (Kars & Kars 2002, Peacock 2002). Obvious threats are anthropogenic causes for degradation; development projects, infrastructure maintenance, farming, forestry and other industries. A number of other issues which can be summed up as changes in environment are equally threatening; climate change causing higher temperatures, increased precipitation, more concentrated precipitation events, changes from snow to rain, raised sea levels causing erosion of coastal sites, etc., and reducing the number of archaeological excavations in favour of *in situ* preservation may consequently lead to an irrevocable loss of information.

In which ways may archaeological considerations be included into the overall societal planning and thus reduce the impact on archaeological remains? To enable *in situ* preservation, one needs to know exactly which remains and monuments there are, in which state of preservation at present, and what the conditions are for continued *in situ* preservation. One needs to establish which possible threats to the sites exist today and how these might develop in future. If sites are threatened by these changes, we should be prepared with strategies for how to manage this. These can range from strategies to

mitigate the effects or as tools to decide when *in situ* preservation is no longer an option and the only way to save a site is by excavation and documentation, i.e. *ex situ*. The *in situ* preservation strategy poses great demands on the cultural heritage management.

Specific aims of the present study are:

- To which extent is archaeological contextual readability retained in rural archaeological deposits at different stages of degradation?
- Which are the possible effects of the rates of degradation on their contextual readability?
- Is it possible to define threshold levels in the archaeological deposits?
- When archaeological observations are coupled with environmental parameters, can one define which parameters most affect the present conservation state and conditions for future *in situ* preservation of archaeological deposits in the unsaturated zone?
- What may be the effects of climate change on these parameters?
- How can studies of artefact preservation and microscopic and macroscopic subfossils contribute to evaluations of state of preservation?
- Can degradation processes be curbed or mitigated? If so, which mitigation strategies may be required for the investigated sites?
- How may this contribute to a decision support system for cultural heritage management?

1.2 Legal frameworks and conventions

The importance of the preservation of cultural heritage is stressed by several conventions. The Convention Concerning the Protection of World Cultural and Natural Heritage was adopted by the General Conference of UNESCO in 1972. The European Landscape Convention (2000, ratified 2004), also advocates cultural heritage. The Malta or Valletta Convention¹, which was approved in 1992, and designated to protect the archaeological heritage as a source of the European collective memory and as an instrument for historical and scientific study, has been ratified by most European countries. Article 1 of this treaty defines archaeological heritage as all remains and objects and any other traces of mankind from past epochs² (Appendix I).

The aims and intentions of many cultural heritage management agencies have since then been to preserve most archaeological remains, sites and monuments *in situ* if at all possible, even if many countries have their own time limits of what may be considered archaeological heritage, something which the Malta Convention does not have. The Framework Convention on the Value of Cultural Heritage for Society (the Faro Convention, Council of Europe 2005³) acts as a supplementary tool to ensure preservation and understanding of the societal value of cultural heritage, as described in its aims and definitions (Appendix II)⁴.

In Norway the Cultural Heritage Act⁵ with some specified exceptions stipulates a general border between protected and non-protected heritage remains at the year AD1537. The text of the act describes both definitions used and statutory limits (Appendix III)⁶. The Norwegian act speaks of ‘automatic protection’ to the effect that any heritage remains that fall within the definitions of the act are equally protected. Whereas it may not be difficult to explain to a general audience that a grave mound or a stave church is an archaeological monument, it may be more difficult to communicate the intrinsic scientific value and importance of hidden archaeological soil features or deposits as information sources.

¹ <http://www.coe.int/nb/web/conventions/full-list/-/conventions/rms/090000168007bd25>

² See appendix I for full text of Article 1 of the Malta Convention.

³ <http://www.coe.int/en/web/conventions/full-list/-/conventions/rms/0900001680083746>

⁴ See Appendix II for full text of Articles 1 and 2 of the Faro Convention.

⁵ <https://www.regjeringen.no/en/dokumenter/cultural-heritage-act/id173106/>

⁶ See Appendix III for full text of the Norwegian Cultural Heritage Act §§ 1-4.

The Norwegian Directorate for Cultural Heritage, the overarching national cultural heritage management, has proposed that it will undertake its statutory duty of preserving the national heritage primarily by seeking to preserve archaeological sites *in situ*.

This is in accordance with the former Norwegian Ministry of Environment's stated aim to preserve the underground archives and at the same time establish conditions for continued use of the pertinent areas (White paper 16 (2004-2005) (MD 2005)). It also adheres to the guidelines in the national standard from 2009 (Norwegian Standard NS 9451, 2009).

Today most questions concerning disturbance of archaeological remains are handled by the local cultural heritage management, first and foremost through heritage departments at the 19 County Administrations, by registration, dissemination and possible management actions. The five Norwegian archaeological university museums are advisers for the authorities, but have no legal right to decide on management actions. The 19 counties are distributed unevenly to the five museums; Østfold, Akershus, Oslo, Hedmark, Oppland, Buskerud, Vestfold, Telemark, Aust-Agder and Vest-Agder report to the Museum of Cultural History at the University of Oslo; Rogaland reports to the Archaeological Museum at the University of Stavanger; Hordaland, Sogn og Fjordane and Sunnmøre (the southern part of Møre og Romsdal) report to Bergen University Museum; Møre og Romsdal (except Sunnmøre), Sør-Trøndelag and Nord-Trøndelag report to the NTNU University Museum in Trondheim; Nordland, Troms and Finnmark report to Tromsø University Museum. The administration is made difficult because of lacking knowledge related to the state of preservation and future preservation conditions for the sites.

Adhering to the Malta Convention causes problems that have not yet been solved for the majority of archaeological sites, concerning implementing measures for the long-term physical protection for the conservation and maintenance of the archaeological heritage, preferably *in situ* (cf. Smits 2006, Willems 2008, Johnsen 2009, Willems 2014). The treaty has changed the way many archaeologists work, shifting the focus from investigation and documentation to attempt solving these preservation problems (Nilsson 2011, Bazelmans 2012:10, Duineveld *et al.* 2013, Dries 2014). A basic assumption is that the potential for conservation of cultural heritage for the future depends on the state of preservation at present. The term 'preservation' has so far not been truly defined. Does it mean that the archaeological deposits shall remain unchanged for ever or can one accept that degradation processes continue at an unknown rate (Membrey 2008)? Debating which archaeological remains or types of remains to preserve and from which periods, is a question of cultural heritage politics. To adhere completely to the Malta Convention and preserve '*all remains and objects and any other traces of mankind from past epochs*' would require unlimited funds and is not a realistic option in any society. Hopefully this thesis may contribute to enabling informed decision processes in cultural heritage management on how and what to preserve under which circumstances.

1.3 Factors affecting preservation and study methods

Archaeological deposits of various ages present in the urban and rural landscapes are important sources to our history and are specific geo-ecosystems affected by environmental processes, besides being part of our cultural heritage. *In situ* preservation is therefore not just a simple act of protection against development projects. Ongoing processes brought on by man or manmade climatic or hydrological changes may already be at work and affect preservation conditions. Some of these factors will be studied in depth in the following chapters.

One way to study changes in preservation is to compare modern with earlier observations made at the same site. However, comparison is limited by the observations originally made at the sites in question and the original investigators usually did not have *in situ* preservation as a focus. Examples of this type of research including demonstrations of major threats to heritage preservation are presented in the conference reports, 'Før landskabets erindring slukkes' (Before the landscape memory is extinguished⁷) (Nørgård Jørgensen & Pind 2001), and 'The Plow Zone as Context' (Martens & Ravn 2016).

⁷ My translation from Danish.

In these two volumes examples are shown of how modern agriculture destroys archaeological contexts and moves finds into the plough zone. If a site has only been ploughed over once, it may still be possible to reconstruct the original context (Johansen *et al.* 2003), but after multiple ploughings, marked degradation of each context and destruction and distributions of artefacts far from their original context often takes place (Henriksen 2001). Similarly, studies have been made on different artefact types in soil, e.g. archaeological bone, iron, bronzes, leather and other organic materials. These investigations include reburial of modern and archaeological materials and comparisons between sites excavated now and 100 years previously, which demonstrate the effects of modern agriculture tools and environmental processes (see e.g. Borg *et al.* 1994, Nord *et al.* 2002, Kars *et al.* 2004, Ullén *et al.* 2004, Nord *et al.* 2005, Peacock 2005, Peacock *et al.* 2008, Huisman 2009, Peacock & Turner-Walker 2009). If looking at the above stated examples of modern agriculture, re-excavated sites, pollution, climate change damage and modern societal development and infrastructure projects are taken as indicators, continued *in situ* preservation of archaeological remains in modern society does seem a risky strategy, unless mitigating actions at a wide scale are carried out.

Another method used in the present work is by monitoring *in situ* preserved monuments over time to study how the conditions are changing in response to the changing environment (see further in Chapter 2). Research on preservation conditions in the unsaturated zone, i.e. above the groundwater level, is a relatively new field of research. Research projects conducted at Bryggen in Bergen and at a number of sites in the UK, the Netherlands, and other European countries (Keevill *et al.* 2004, Christensson *et al.* 2008, Christensson & Dunlop 2015:83, Rytter & Schonhowd 2015) are examples of research on mainly saturated deposits below the ground water table and have shown that archaeological deposits are usually very well preserved under strongly anoxic conditions that are predominantly observed in waterlogged environments (Caple 1998). However, as many archaeological sites are situated above the water table, research and practical work including and focusing on what happens there were deemed essential for this project. Fluctuating air in soil is detrimental to good preservation of organic remains (French 2015:38).

1.4 Project framework and case studies

The focus of this thesis work is on three complex topics: 1) *in situ* preservation of unsaturated archaeological deposits, 2) rural medieval archaeology and 3) climate change and its effects on archaeological remains, all within the context of Norwegian Cultural Heritage management and research. The InSituFarms⁸ project of which this thesis work constitutes a major part and the InSituSIS⁹ project are the first Norwegian interdisciplinary research projects that investigate the state of preservation and the conditions for continued *in situ* preservation of archaeological deposits in the unsaturated zone. The study objects of *in situ* preservation were chosen outside the medieval towns but with known preserved deposits comparable to those of the towns, specifically farm mounds and Stone Age middens (see Figs. 1 and 2), their current state of preservation and the options for continued *in situ* preservation with the effects of predicted climate change combined with anthropogenic threats are discussed. These two monument types were chosen as sites because of their national importance as unique sources of archaeological and historical information, their high abundance (both site types consist of approximately 900 listed monuments), because they pose great challenges to the heritage management as many of the sites are still lived on (see Chapter 2) and because they are located in a

⁸ Archaeological Deposits in a Changing Climate. In Situ Preservation of Farm Mounds in Northern Norway (InSituFarms); <https://www.forskningsradet.no/prosjektbanken#!/project/208429/no>
http://www.niku.no/en/archaeology/environmental_monitoring/archaeological_deposits_in_a_changing_climate_in_situ_preservation_of_farm_mounds/In+Situ+Preservation+of+Farm+Mounds+in+Northern+Norway+%22InSituFarms%22.9UFRnWXh.ips

⁹ In Situ Site Preservation in the Unsaturated Zone (InSituSIS);
<https://www.forskningsradet.no/prosjektbanken#!/project/212900/no>
http://www.niku.no/en/research/research_projects/In+Situ+Site+Preservation+of+Archaeological+Remains+in+the+Unsaturated+Zone.9UFRjY3C.ips

part of Norway where climate change is predicted to cause significant increase in temperature and precipitation rates (see further in the following chapters).

A major point in both the overarching research project (InSituFarms) and the thesis work was to include the local and regional heritage management, exchange experiences and give input to future work on and management of the sites chosen for the present work. The Troms sites, Saurbekken and Voldstad, are farm mounds dated mainly to the medieval period (Holm-Olsen & Bertelsen 1973, Bertelsen 1984). Farm mounds or settlement mounds are rural settlements placed on top of each other for centuries, forming characteristic mounds (Chapters 2-4, 6 and 7). The northernmost site, Banjgohppi by the Varanger fiord in eastern Finnmark, is a midden belonging to a Neolithic house of the Gressbakken type (Simonsen 1961), dated to approximately 2200 BC.

Gressbakken houses might almost be considered type houses, as they have a very schematic outlay of entrances, fireplaces and middens. They are very common, particularly in Finnmark County, where a. 900 settlement sites are dated to this period (Myrvoll 1992; see Chapters 2 and 6).

Field work was carried out May 2012 (Saurbekken, geophysics), August 2013 (Voldstad and Banjgohppi, trenches) and October 2014 (Saurbekken, trench), and monitoring equipment was installed when the trenches were investigated. At Saurbekken the section exposed by infrastructure work was secured with clay as a mitigation act (see Chapter 2). The InSituFarms research project took its outset in a study of those three selected case sites. For this thesis, two comparative sites further south in the country (Avaldsnes and Åker) were included to demonstrate common threats and tendencies (Fig. 2).



Figure 1 The world seen from the Arctic. Please note the study area and its position north of the Arctic Circle (~67°); see also Fig 2. Map from Wikipedia 2015, https://en.wikipedia.org/wiki/Arctic_Circle#/media/File:Arctic_circle.svg. Redrawn by N.A. Hafsal, NIKU.

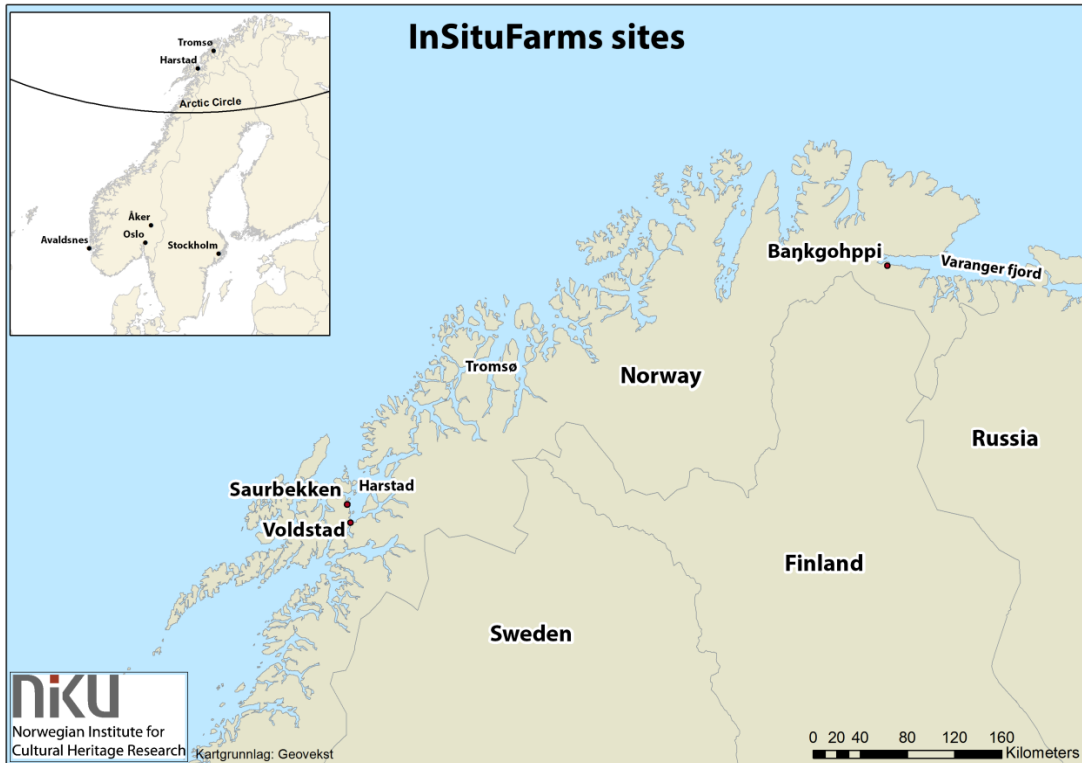


Figure 2 Map of InSituFarms sites, Voldstad, Saurbekken and Banjgohppi and comparative sites Åker and Avaldsnes. Map by Nils Aage Hafsal/NIKU 2016.

A major aim of the InSituFarms research project was to develop an interdisciplinary method to obtain a sustainable *in situ* management of cultural heritage by the identification of the environmental and societal parameters affecting the present conservation state and conditions for future preservation of archaeological remains. Another was to develop methods used for mapping archaeological deposits through the use of laser surface scanning and geophysical surveys. A third aim was to examine the possibilities, limitations and consequences of *in situ* site preservation by gathering information on their current state of conservation and preservation conditions.

Most of the sites chosen as case studies are exposed to deterioration through infrastructure activities. In addition, there are uncertainties about the effects on these cultural resources if climate changes lead to rise in temperature and precipitation. This is particularly sensitive in subarctic areas. If this change leads to major alterations of preservation conditions in the farm mounds, we are in danger of depleting or in worst case losing some of the main sources of Norwegian history.

The implications for cultural heritage management reach far wider than the few presented study sites, as the results presented in this thesis will give valid input for management of all rural archaeological sites with preserved deposits, independent of site type or dating. Information on which sites are most under threat and from which factors is an important decision base for all cases where exemption from the Cultural Heritage Act is sought, i.e. all cases that involve part or full disturbance of listed monuments.

1.5 Project partners and disciplines involved

In order to achieve the above stated goals, an interdisciplinary group was formed, covering several disciplines within humanities and science. From NIKU (Norwegian Institute for Cultural Heritage Research) the archaeologists project leader Dr. Knut Paasche, Dr. Elin Myrvoll and the author of this thesis. From NIBIO (Norwegian Institute of Bioeconomy Research (previously called Bioforsk))

microbiologist Dr. Ove Bergersen. From the Archaeological Museum, University of Stavanger palaeo-ecologist Dr. Paula Utigard Sandvik. From the Netherlands, ecologist Michel Vorenhout (MVH Consult) with a special research interest in soil chemistry and *in situ* preservation, and from Denmark, geographer Dr. Jørgen Hollesen (National Museum of Denmark) in the field *in situ* preservation of archaeological remains. Archaeologist Ragnhild Myrstad from the County Council of Troms and archaeologist Keth Lind from the Tromsø University Museum were part of the InSituFarms project from a cultural heritage management user perspective.

1.6 Outline of the thesis

The focus of this thesis is on three complex topics; *in situ* preservation of unsaturated archaeological deposits (discussed in Chapters 2, 4, 5, 6 and 7), rural medieval archaeology (discussed in Chapters 3, 4, 6 and 7) and effects of climate change on archaeological remains (discussed in Chapters 2, 4, 5, 6 and 7), all within the context of Norwegian Cultural Heritage management and research.

Chapter 2, *General introduction*, briefly discusses the background for evaluations of *in situ* preservation of archaeological sites, includes an introduction to rural medieval archaeology in Norway, the North Norwegian farm mounds as archaeological monuments, and discusses their role compared to that of the medieval towns. It also discusses heritage evaluation and climate change, with a brief overview of predicted climate change for the study area of Northern Norway. The chapter includes suggestions for threshold levels and some mitigating actions.

Chapter 3, *North Norwegian farm mounds - landscape conditions and assumed agrarian technologies required for their existence*, is a paper on farm mounds as an archaeological object. It puts the farm mounds into a research context and discusses the parameters that have affected their existence over time.

Chapter 4, *The Magnate farm of Åker. Past, present and future of a farm with central functions*, presents a south Norwegian farm mound as comparative material to those in northern Norway. This particular farm mound has played an important role as a central place in southern Norway for centuries, and it has been exposed to severe infringement and changes from modern infrastructure projects. Probes monitoring temperature and moisture were installed at the site in 2007, and the monitoring has continued since then, with a few breaks because of battery failure.

Chapter 5, *In situ site preservation in the unsaturated zone: case Avaldsnes*, gives a thorough description of the methods and equipment used in the monitoring projects, and an explanation of the methods and requirements advocated by the Norwegian Standard concerning deposit monitoring, and potential problems following that. This is another type of comparative site on the west coast of Norway with preserved rural archaeological deposits, in a climate that differs from the ones presented in chapters three and four, and gives some insight into how archaeological remains are preserved in a wet and wild climate.

Chapter 6, *Research and monitoring on conservation state and preservation conditions in unsaturated archaeological deposits of a medieval farm mound in Troms and a late Stone Age midden in Finnmark, Northern Norway*, contains the results from farm mounds and high north investigations, archaeological, geophysical, and geochemical and palaeobotanic analyses written with InSituFarms project partners. It also includes laboratory experiments on preservation of deposits in different temperature and moisture scenarios to give input to possible climate change effects, tying together the theories and heritage management aspects.

Chapter 7, *Synthesis; Implications for archaeological heritage management*, discusses the lessons learned from the thesis work and the InSituFarms research project. It is structured in accordance with the research questions posed in Chapter 1, on how climate changes may affect the studied objects (through decay studies and climate predictions), aspects of preservation, and ultimately the implications for archaeological heritage management of these sites and all rural archaeological sites with preserved deposits, independent of site type or dating. This chapter exemplifies definitions of threshold levels for different types of threats to continued preservation and suggests an improvement to the national heritage database including these considerations.

Chapter 8, *Conclusion and Further Perspectives*. This final chapter gathers the findings of the previous ones and points to future work.

1.7 Dissemination of results

Parts of this thesis have been published or are in print in the following journals and reports:

- Hollesen J, AB Møller, VV Martens & H Matthiesen (2016): Making better use of monitoring data. *Conservation and Management of Archaeological Sites* 18, 116-125.
- Martens VV, O Bergersen & C-E Amundsen 2012: Avaldsnes, Karmøy k., Rogaland. Arkeologisk kartlegging av bevaringstilstand og bevaringsforhold for arkeologiske kulturminner i forbindelse med Kongsgårdsprosjektet Avaldsnes. Delrapportering I. *NIKU Oppdragsrapport* 12/2012.
- Martens VV, 2013: The Magnate Farm of Åker. Past, present and future of a farm with central functions. In: J Klápště (ed.): Hierarchies in rural settlements. *Ruralia* 9, 329-339.
- Martens VV & O Bergersen 2013: Avaldsnes, Karmøy k., Rogaland. Arkeologisk kartlegging av bevaringstilstand og bevaringsforhold for arkeologiske kulturminner i forbindelse med Kongsgårdsprosjektet Avaldsnes. Delrapportering II. *NIKU Oppdragsrapport* 12/2013.
- Martens VV, 2014: Plan för säkring av kulturlager vid Enköping Torg. Kv. Fältskäraren, Enköping. *NIKU Oppdragsrapport* 46/2014.
- Martens VV & O Bergersen 2014: Avaldsnes, Karmøy k., Rogaland. Arkeologisk kartlegging av bevaringstilstand og bevaringsforhold for arkeologiske kulturminner i forbindelse med Kongsgårdsprosjektet Avaldsnes. Delrapportering III. *NIKU Oppdragsrapport* 5/2014.
- Martens VV, 2016 : North Norwegian Farm Mounds – economic resources and landscape conditions. In: J Klápště (ed.) *Agrarian Technology in the Medieval Landscape. Ruralia* 10, 173-184.
- Martens VV & O Bergersen 2015: *In situ* site preservation in the unsaturated zone: Avaldsnes. *Quaternary International* 368, 68-79.
- Martens VV & O Bergersen 2015a: Avaldsnes, Karmøy k., Rogaland. Kartlegging av bevaringstilstand og bevaringsforhold for arkeologiske kulturminner i forbindelse med Kongsgårdsprosjektet Avaldsnes. Delrapportering IV. *NIKU Oppdragsrapport* 3/2015.
- Martens VV, O Bergersen, M Vorenhout, PU Sandvik & J Hollesen (2016): Research and monitoring on conservation state and preservation conditions in unsaturated archaeological deposits of a medieval farm mound in Troms and a late Stone Age midden in Finnmark, Northern Norway. *Conservation and Management of Archaeological Sites* 18, 8-29.
- Martens VV, ER Myrvoll, O Bergersen, M Vorenhout, PU Sandvik & S Denham (in print): InSituFarms. Archaeological Deposits in a Changing Climate. Case Banjgohppi, Unjárgga gielda/Nesseby k., Finnmark. *NIKU rapport* 77 (in Norwegian).
- Martens VV, O Bergersen, M Vorenhout, PU Sandvik & J Hollesen (in prep.): InSituFarms. Archaeological Deposits in a Changing Climate. Case Voldstad, Harstad k., Troms. *NIKU rapport* (in Norwegian).
- Martens VV, O Bergersen & M Vorenhout (in prep.): InSituFarms. Archaeological Deposits in a Changing Climate. Case Saurbekken, Harstad k., Troms. *NIKU rapport* (in Norwegian).

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¹⁰ Preservation of Archaeological Remains In Situ – international conferences held a. every 5 years

2 General introduction

2.1 Cultural heritage and *in situ* preservation

The importance of the preservation of cultural heritage is stressed by several conventions. The Convention Concerning the Protection of World Cultural and Natural Heritage was adopted by the General Conference of UNESCO in 1972 (<http://whc.unesco.org>). The European Convention on the Protection of the Archaeological Heritage (Council of Europe 1992), also known as the Malta Convention or Valletta Treaty, was agreed in 1992 (implemented from 1995), and was in turn designed to protect the archaeological heritage as a source of the European collective memory and as an instrument for historical and scientific study. The Valletta Treaty calls for ‘the conservation and maintenance of the archaeological heritage, preferably *in situ*’. This means that archaeological sites must be actively maintained, or investigated, and not just left to natural deterioration or subject to anthropogenic destruction. From 2011, the Faro Convention (Council of Europe 2005) was implemented, designed to focus on protection and sustainable use of cultural heritage to further human development and quality of life. Whereas the Valletta Treaty has been implemented in many countries during the past two decades (e.g. Norway and Sweden from 1996, the UK from 2001, Denmark and the Netherlands from 2007), very few countries have implemented the Faro Convention (e.g. Norway from 2011¹¹).

It is an explicit aim for the Norwegian government and the cultural heritage management that preservation conditions for archaeological deposits and archaeological remains in the deposits should not be reduced by more than 0.5% a year (MD 2005), and to ensure long-term preservation of the archaeological remains (cf. MD 2010, 29-30). Archaeological deposits are regarded as a part of our cultural heritage and are in Norway protected by the Cultural Heritage Act of 1978 (Lov av 9. juni 1978 om kulturminner). However, the Heritage Act includes time limits as to what may be considered archaeological heritage, specifically that all archaeological remains prior to the Reformation of AD 1537 and standing buildings older than AD 1650 are automatically protected. For shipwrecks and for Sámi remains there is a floating 100 year limit, so that anything more than 100 years old is automatically protected. Until the updated heritage act was enforced, archaeological deposits had no or very little protection in Norway, but the large-scale and revolutionising excavations at Bryggen in Bergen from 1955 to 1968, demonstrated just how much archaeological and historical information could be gained by investigating the deposits (Herteig 1969, 1985, Christensson & Dunlop 2015). In this context, archaeological remains are regarded primarily as information sources, and their readability is stressed as an important factor, enabling the archaeologist to interpret past actions. When this readability is threatened by degradation, one should discuss whether continued *in situ* site preservation may be possible if mitigating actions are carried out, or if *ex situ* preservation or preservation by record, i.e. an archaeological investigation of the site, may be the best way to ensure survival of this information.

¹¹ To date, 17 member states have ratified the convention: Armenia, Austria, Bosnia and Herzegovina, Croatia, Georgia, Hungary, Latvia, Luxembourg, the Republic of Moldova, Montenegro, Norway, Portugal, Serbia, the Slovak Republic, Slovenia, Ukraine and ‘the former Yugoslav Republic of Macedonia’. In addition, five states have signed the convention: Albania, Belgium, Bulgaria, Italy and San Marino. The signing process is under way in a number of other member states of the Council of Europe.

Modern Norwegian cultural heritage management adheres at least partly to the Valletta Treaty (Council of Europe 1992), though within the set time frames of the Heritage Act, meaning that the intention is to preserve as many archaeological sites and as much of each individual site as possible *in situ*.

To achieve this, physical monitoring schemes are in place covering chosen municipalities spread over the country (Sollund & Holm-Olsen 2013), and on urban sites a series of monitoring wells, soil sample sites and installed monitoring probes contribute to monitoring geochemistry and water chemistry. The first of these projects was in 1996, in Schultz gate in the medieval town of Trondheim (Peacock 2002), followed 1999 by a project in the medieval town of Tønsberg (Eriksson 2006, Reed & Martens 2009). However, just like the development of urban archaeology, it was the work carried out at Bryggen in the medieval town of Bergen from 2000 that really carried momentum to deposit monitoring in Norway (Christensson 2004, Matthiesen *et al.* 2006, 2008, Christensson & Dunlop 2015, Rytter & Schonhowd 2015). After several years of intensive work at Bryggen, methods and equipment had been developed to such an extent, that the Directorate for Cultural Heritage started to include deposit monitoring as a premise for dispensation from the Cultural Heritage Act in development projects. As a result, deposit monitoring was also carried out on sites in the medieval town of Oslo from 2006 (Martens *et al.* 2012), and eventually again in Trondheim from 2008 (Petersén & Bergersen 2012, 2015). Very little work on deposit monitoring has been carried out in the medieval town of Stavanger (Amundsen 2012), and so far none at all in the remaining Norwegian medieval towns Hamar, Sarpsborg and Skien. This is partly a reflection of development pressure but also of equipment costs and a gradual development of the understanding of how deposit monitoring may contribute to knowledge and understanding of the cultural history of these sites.

The Norwegian monitoring projects have developed over time and as for the rest of Europe and the world, this has been a constant learning experience and evaluation of methods, technical equipment and interpretation of the results. In 1996, a first international conference was held on preserving archaeological remains *in situ* (with the acronym PARIS) – ‘born of frustration and optimism’ (Corfield *et al.* 1998, introduction). A second PARIS conference was held in 2001 (Nixon 2004), a third in 2006 (Kars & van Heeringen 2008), a fourth in 2011 (Gregory & Matthiesen 2012) and a fifth in 2015 (CMAS in print). These conferences and the published proceedings document both the frustration and the optimism as quoted above, and a constant development in methods, equipment and interpretations of monitoring data in attempts to answer the research and management questions about when archaeological sites may be safely left *in situ* and when they should preferably be excavated to preserve the information potential *ex situ*.

The peer-reviewed journal Conservation and Management of Archaeological Sites (CMAS) was launched in 1995¹², with a first published volume in 1996, as the only journal covering both theoretical and practical issues in heritage site management and conservation. This was a response to the obvious need for an interdisciplinary publication forum for these topics.

Guidelines and standards on how to deal with these topics have been and are in development. Already in the early 1980s, the Swedish Directorate for Cultural Heritage (Riksantikvarieämbetet) published books with recommendations for building on top of archaeological deposits (Bjerking 1981, 1984), and in 1994 they published a book on degradation of archaeological remains in soil (Borg *et al.* 1994). These publications have later been supplemented with papers on degradation of specific archaeological materials, e.g. iron (Nord *et al.* 2002), bronzes (Ullén *et al.* 2004) and bone (Nord *et al.* 2005), and different organic materials (e.g. Peacock 2005, Peacock *et al.* 2008, Peacock & Turner-Walker 2009).

Historic England¹³ (until March 2015 called English Heritage) have published a number of guidance documents, the most relevant for these topics being Piling and Archaeology (2007, updated 2015¹⁴), The use of science to enhance our understanding of the past (Williams 2009¹⁵), Waterlogged Wood

¹² <http://www.tandfonline.com/loi/ycma20>

¹³ <http://historicengland.org.uk/>

¹⁴ <https://www.historicengland.org.uk/images-books/publications/piling-and-archaeology/>

¹⁵ <http://historicengland.org.uk/images-books/publications/nhss-rep2-use-of-science-to-enhance-understanding-of-past/>

(2010¹⁶), Environmental Archaeology (2011¹⁷), Waterlogged Organic Artefacts (2012¹⁸), and not least a new guidance document on Preservation *in situ* being prepared in 2015¹⁹. A new book on the subject of *in situ* preservation has also been published in 2016 (Caple 2016).

In the Netherlands, studies have particularly been carried out on preservation of archaeological bone (e.g. Kars *et al.* 2004). An Archaeological Monitoring Standard was published in English in 2006 (Smit *et al.* 2006), updating an earlier Dutch version and making it accessible to a wider audience. To this was added the 2009 publication Degradation of Archaeological Remains (Huisman 2009), which is an excellent handbook compiling information on most archaeological material types and describing how to handle them on site and which factors were most likely to cause degradation. Each material has different qualities that define good or poor preservation, e.g. breakage strength for wood, size of sherds of glass or pottery, corrosion levels on metals, etc.

For Norwegian cultural heritage management, two important works have been produced as guidelines for archaeological evaluations of state of preservation and sampling and monitoring to evaluate preservation conditions, the so-called Monitoring Manual (RA & NIKU 2008) and a Norwegian Standard (NS 9451:2009) 'Cultural property. Requirements on environmental monitoring and investigation of cultural deposits'. Of the latter, an English version was produced in 2012 and made freely available by the Norwegian Directorate for Cultural Heritage (Riksantikvaren). These works are currently under evaluation, particularly after a web survey carried out by this author disclosed a rather limited knowledge of and even more limited use of the standard (de Beer *et al.* 2015:37-41) as well as a practical test of state of evaluation of deposits carried out by field archaeologists Spring 2015. The latter study was presented at the European Association of Archaeologists conference 2015 (Petersén & Taylor 2015) and demonstrated the need for training prior to enabling evaluations of state of preservation.

Simultaneously, discussions on the information potential of e.g. augered boreholes for monitoring wells in contrast to the information potential of proper archaeological excavations has also taken place (Johansen & Martens 2014, Christenson & Dunlop 2015:89). Excavation costs in Norway are now so great that to ensure sustainable urban development, building on piles has been allowed in many cases, with the stipulation that pile holes should be pre-augered under archaeological supervision. This should result in an archaeological evaluation of the state of preservation of the deposits at the time of investigation, and soil samples for geochemical analyses to evaluate preservation conditions for the remaining deposits should be taken (Christensson *et al.* 2008, Christensson & Dunlop 2015:83). From the massive information input of augered boreholes, which have virtually perforated the Norwegian medieval towns, new problems arose concerning the communication of the data and not least definitions of threshold values of observed changes in preservation and mitigation actions if or when critical levels were reached. The group of researchers, engineers and cultural heritage managers working at the Groundwater Project at Bryggen World Heritage Site, have come up with a series of possible solutions to at least some of these problems, communicated in a series of scientific papers in the publication 'Monitoring. Mitigation. Management' (Rytter & Schonhowd 2015).

The methods used in this thesis and on the sites included in both the InSituFarms and InSituSIS research projects are thoroughly described in the following chapters, particularly in Chapters 5 and 6. From an archaeological point of view, the main tool has been the on site assessment of state of preservation of archaeological remains as described in the Norwegian Standard (NS 9451:2009). Artefacts and ecofacts have been included as assessment factors. This is relevant even if little or nothing is preserved. On sites with many preserved archaeological artefacts, independent of material, an assessment of their conservation state will be immediately relevant for the excavation strategy and for an overall evaluation of state of preservation. Even a site with only few preserved artefacts will give that input, but it is not likely to have consequences for the excavation strategy.

¹⁶ <https://www.historicengland.org.uk/images-books/publications/waterlogged-wood/>

¹⁷ <https://www.historicengland.org.uk/images-books/publications/environmental-archaeology-2nd/>

¹⁸ <https://www.historicengland.org.uk/images-books/publications/waterlogged-organic-artefacts/>

¹⁹ <https://www.historicengland.org.uk/advice/technical-advice/archaeological-science/preservation-in-situ/>

On sites where artefacts of organic materials seem well-preserved, one would expect a similar state of preservation for microscopic and macroscopic microfossils. However, further analyses may give a more precise input on when and how degradation is or has been taking place (see Chapter 6).

2.2 Cultural heritage and climate change

The work cited above is all input to the understanding of the state of preservation and monitoring of preservation conditions, but as an outset it implies that no major changes should take place that may affect these conditions. However, climate change does have direct impact on human societies and on archaeological remains (Van de Noort 2011), and studies indicate that precisely such changes will take place within a not too far future (Selsing 1995, Alfsen *et al.* 2013, Nilsen *et al.* 2013, Hanssen-Bauer *et al.* 2015, IPCC²⁰ 2015, Simpson *et al.* 2015). How should cultural heritage management respond to the threats of climate change? In order to prepare adequate mitigation schemes, it is necessary first to know exactly what it is that one is trying to preserve, what state it is in now, and what the conditions for *in situ* preservation are. Obviously, these parameters will differ between sites and between different parts of a country that stretches over ca. 1790 km, with a coastal line of 25,148 km, differing in width from ca. 1.5 to a. 432 km (thus having both coastal and inland climate) and stretching over almost 13 latitudes from temperate to sub-arctic climate (ssb.no).

An updated report on climate change scenarios for Norway was published August/September 2015 (Hanssen-Bauer *et al.* 2015), based on the IPCC report of 2013/2015. With a scenario of continued increase in greenhouse gas emissions, the following median values for climate change in Norway towards year 2100 have been calculated:

- Average yearly temperature; increase of a. 4.5° C (span; 3.3-6.4°C),
- Average yearly precipitation; increase of a. 18% (span; 7-23%),
- Downpour episodes will be heavier and more frequent,
- Floods caused by rain will be more severe and occur more frequently,
- Snow melt floods will be fewer and less severe,
- In low-lying areas snow may almost disappear for many years, while high mountain areas may experience more snow,
- There will be fewer glaciers, and the remaining ones will have become much smaller,
- Sea levels will rise between 15 and 55 cm depending on location.

With reduced greenhouse gas emissions, climate change will be considerably less severe. For Norway, particularly the changes in precipitation (with subsequent problems of surface water and flooding) and sea level rise are deemed problematic (Nilsen *et al.* 2013, Hanssen-Bauer *et al.* 2015, Simpson *et al.* 2015). The main sites investigated in this research project are all situated north of the Arctic Circle (~67°N). For Northern Norway in particular, the temperature rise and the change in precipitation from snow to (heavier) rain will most likely cause the greatest problems, both for society in general and for continued preservation of cultural heritage sites because of increased risks of erosion. To raise awareness and interest of the population in general for preserving archaeological remains, it might be an idea to further look into carbon catchment at archaeological sites as a method (Durham *et al.* 2012).

Existing data should be gathered and used for risk assessment and to define threats and threshold levels. Microbial decay of organic archaeological materials is known to increase exponentially with increasing soil temperature (Matthiesen *et al.* 2014, Hollesen & Matthiesen 2015), but at the same time, very dry and very wet conditions may hinder microbial processes (Hollesen & Matthiesen 2015). Soil parameters like pH, organic matter and water content, oxygen content and redox potential form the boundaries in which archaeological materials can be preserved (Huisman *et al.* 2009).

For soil, it is believed that an increase in temperature of 10°C will increase microbial activity and degradation processes with two to three times in speed (Borg *et al.* 1994:49). The Q₁₀ relationship is a method to express the proportional change in the decay rate given a 10°C change in temperature (Hartley & Ineson 2008, Hamdi *et al.* 2013). For example, a Q₁₀ value of 3 states that the decay rate

²⁰ Intergovernmental Panel on Climate Change, <https://www.ipcc.ch/>

will triple if the temperature increases with 10°C. In Chapter 6, laboratory degradation studies on deposits from Banjgohppi (Neolithic) and Voldstad (medieval) are presented. For both Voldstad and Banjgohppi the mean annual temperature is expected to increase with approximately 3.0°C within the period 2017-2100 (relative to 1961-1990) and the mean annual precipitation sum is expected to increase by approximately 30% (Norwegian Meteorological Institute).

The precipitation is also expected to change to less snow and more (and heavier) rain. This may have a direct effect on the preservation conditions. The measurement of oxygen consumption showed that the decay rate could increase by 8.7-14.0% for Voldstad and 3.8-5.0% for Banjgohppi per 1°C increase in temperature (see Chapter 6).

According to the British Meteorology Services (MET office²¹, Morice *et al.* 2012), 2015 was the year we reached a global temperature rise of 1°C above the average temperature of the pre-industrial world (Fig. 3). That demonstrates the necessity of our investigations and accentuates the importance of preparing strategies to deal with climate change effects on cultural heritage sites. Focus for future research should therefore be on threshold levels and mitigating actions.

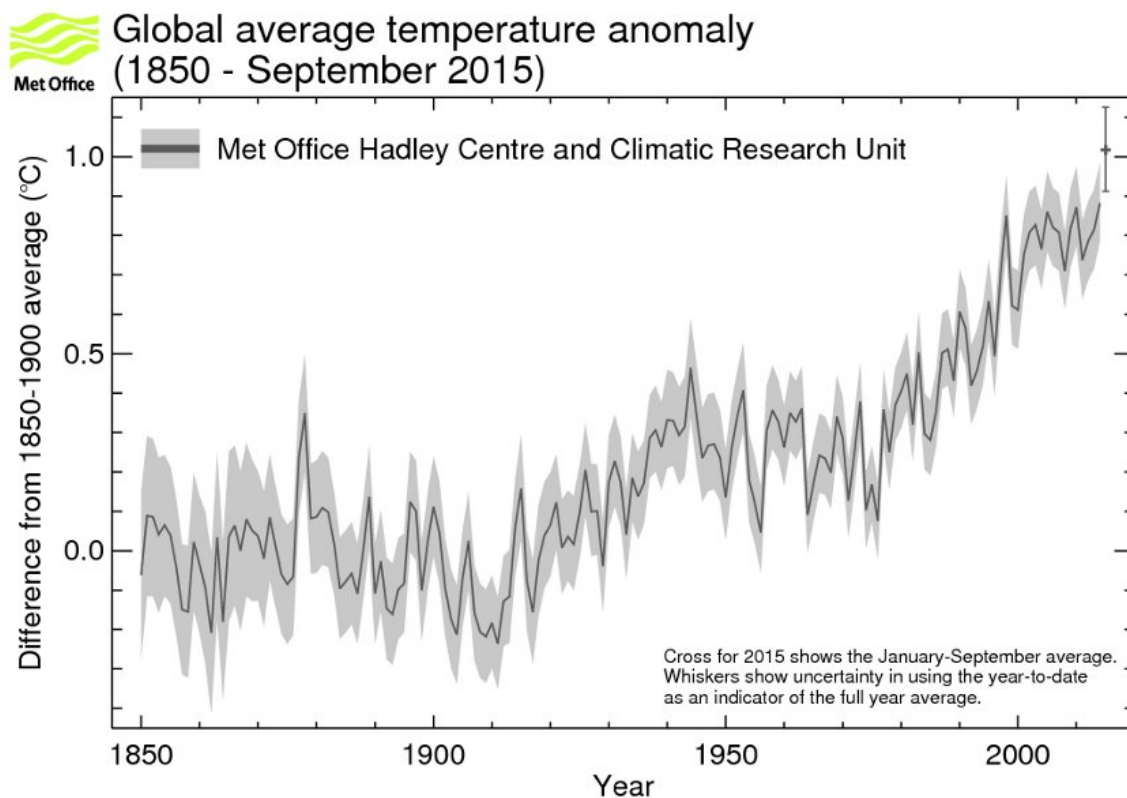


Figure 3 Graph from the MET Office of temperature averages from 1850 to 2015, the period 1850-1900 used as a reference period comparable to pre-industrial temperatures.

2.3 Rural medieval archaeology in Norway. Farm mounds as archaeological monuments

We know that only a minority of the medieval population of Norway lived in towns, probably less than 10% (Bagge & Mykland 1987:165, Martens 2009:7), and the volume of preserved remains of farm mounds approximately equals that of preserved urban deposits (see calculated size below in Tables 1 and 2). Still, there is a huge difference in the economic resources spent on urban archaeo-

²¹ MET Office, <http://www.metoffice.gov.uk/research/news/2015/global-average-temperature-2015>
<http://www.metoffice.gov.uk/hadobs/hadcrut4/>

logical investigations compared to the sums spent on rural medieval settlements or indeed farm mound investigations (see Table 3 and 4). This is not only because of higher pressure on urban development and infrastructure maintenance compared to pressure on development on farm mounds. It is also a matter of tradition of research, management and investigations.

In 2004, a seminar was organised at the Museum of Cultural History at the University of Oslo. The title of the seminar was ‘The lost middle ages? Central rural medieval settlements’ (Martens *et al.* 2009), and it exposed a crucial problem concerning heritage management responsibility distribution in Norway. The county council archaeologists and the five large museums share the jurisdiction and investigation responsibilities for all archaeological remains, except the medieval towns, churches, convents and castles which all are the responsibility and jurisdiction of NIKU (Martens 2009:14, Christensson & Dunlop 2015, Johannessen & Eriksson 2015). This division of jurisdiction leaves the major expertise on medieval remains at NIKU, while the whole rural medieval world is under the jurisdiction of institutions that in major parts of the country have had very little experience in dealing with such remains. The seminar exposed that more focus had been put on medieval outfield remains, the marginal settlements, than on the central rural medieval settlements.

Inventories of archaeological remains are dependent on personal interests and knowledge of the archaeologists doing the inventories. Registration and definition of farm mounds as archaeological monuments and including them in the national heritage monument database, Askeladden²², depended to a very large extent on the personal commitment of a series of archaeologists working at Tromsø University Museum and at Troms County Council who started research work on preserved deposits on farms already ca. 1960 and mapped the sites during the large registration campaigns in the 1960s and '70s, whereas the responsible archaeologists further south in the country did not prioritise searching for farm mounds during that period, and thus they were not listed as monuments in those areas (Bertelsen 2009). Discussions have also been going on at the other archaeological museums about the sheer number of sites which would then be listed, if farm mounds were to be registered as monuments in the other museum districts, and apparently that has been used as an argument to not list them (Ola Storsletten pers. comm.).

Investigations have shown, however, that the absence of the farm mounds as listed monuments in the southern part of the country as shown in Figure 4 is not a true picture, they are there but one needs to look for them. This is further discussed and exemplified in Chapters 3 and 4.

Table 1 Rough estimates of preserved deposits in the medieval towns of Norway.

Medieval town	Estimated amount of preserved deposits (m ³)
Bergen	~ 20,000,000
Oslo	~ 10,000,000
Trondheim	~ 6,000,000
Tønsberg	~ 3,000,000
Hamar	~ 300,000
Sarpsborg	~ 200,000
Skien	~ 200,000
Stavanger	~ 300,000
Total	~ 40,000,000

Table 2 Rough estimates of preserved deposits in the listed farm mounds.

Rough estimate of numbers and size	Rough estimate of preserved deposits (m ³)
300 large mounds, ~ 150x400x2m	~ 36,000,000
300 medium mounds, ~ 50x100x1.5m	~ 2,250,000
300 small mounds, ~ 30x30x1m	~ 270,000
Total	~ 40,000,000

²² <https://askeladden.ra.no>

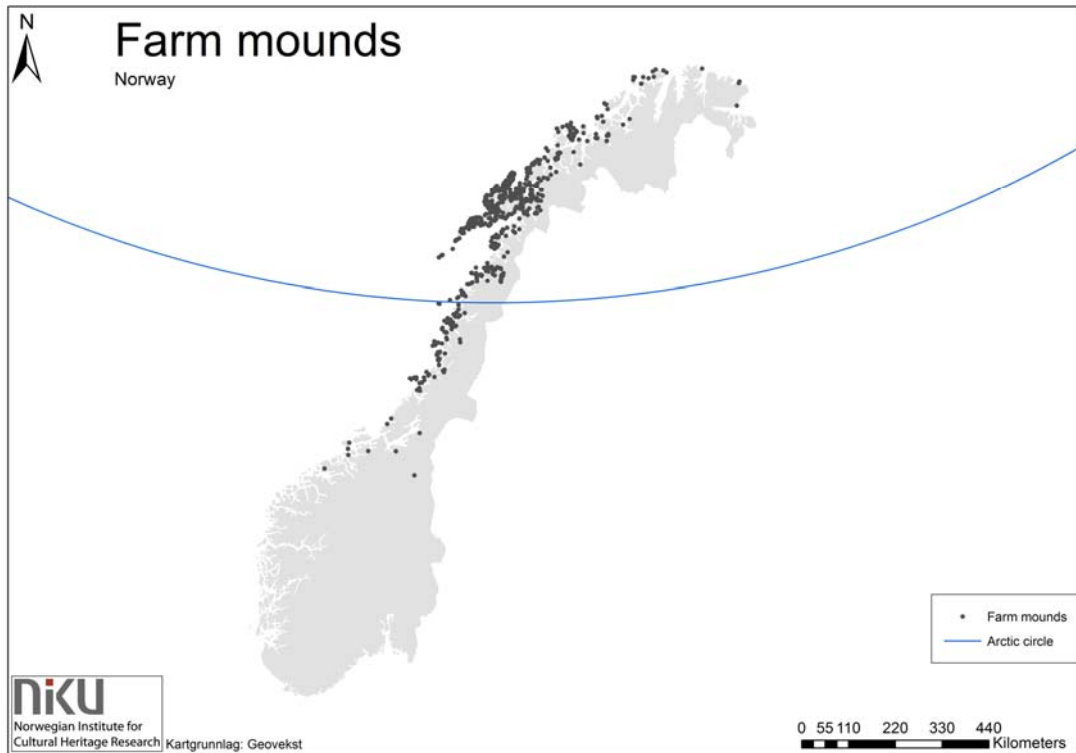


Figure 4 Map of all farm mounds in Norway listed in Askeladden heritage database November 2015. Blue line marks the Arctic Circle. Map by Nils Aage Hafsal/NIKU 2016.

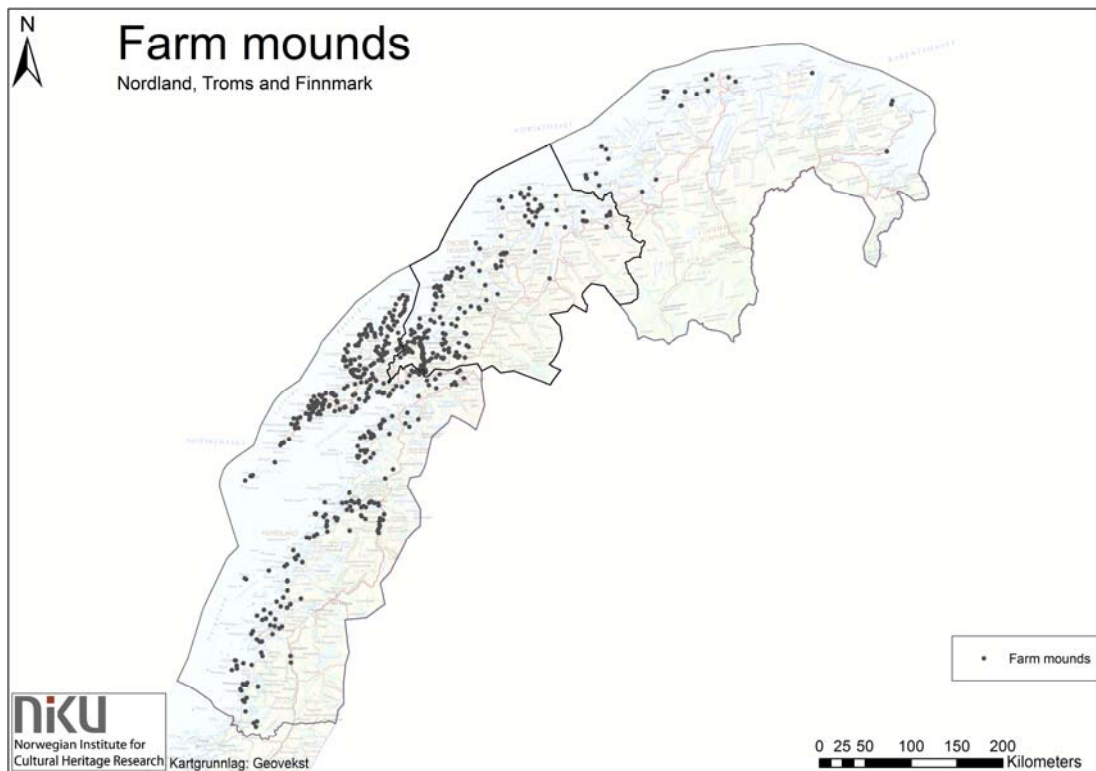


Figure 5 Map of all farm mounds in the three northernmost counties listed in Askeladden heritage database. Map by Nils Aage Hafsal/NIKU 2016.

The largest assemblages of preserved archaeological deposits in Norway outside the urban centres are the (mostly) medieval farm mounds or settlement mounds that are especially characteristic for Northern Norway (see Fig. 5 and definitions in Chapter 3). Since these were listed as monuments and protected by the Norwegian Heritage Act, not a single farm mound has been fully excavated. However, much research has been carried out from small research investigations and a few rescue excavations (Brox & Stamsø Munch 1965, Bertelsen 1973, Holm-Olsen & Bertelsen 1973, Bertelsen 1978, 1984, Griffin 1985, Bertelsen 1989, Urbańczyk 1992, Myrstad 2001, Bertelsen 2002, Lind 2002, Bertelsen 2007, Bergersen *et al.* 2009, 2011).

Since the majority of the farm mounds are also in a part of the country which is expected to be exposed to more severe climate change, this monument type was chosen as a logical outset for the research project presented here. In the same part of the country, another monument type with preserved archaeological deposits is present in approximately the same number of sites as the farm mounds; that is the Neolithic house type known as Gressbakken houses with middens containing large amounts of shells and bones (Simonsen 1961, Schanche 1989, Myrvoll 1992). This monument type was perceived to be under the same threats as the farm mounds, even though the sites differ considerably in composition, and thus Gressbakken middens were chosen as another research object within the framework of the project (see Chapters 3 and 6). For comparative sites were chosen the southern Norwegian farm mound Åker in Hedmark (Chapter 4) and the archaeological remains at Avaldsnes in Rogaland (Chapter 5). All investigated sites are shown on the map in Figure 2. There are only eight medieval towns within the borders of modern Norway). The approximate volume of preserved archaeological deposits within the medieval towns is 40,000,000 m³.

The numbers of estimated size and deposit depths are reached by combining information from RA & NIKU (2008) and Johannessen & Eriksson (2015). However, these numbers seem more accurate for the four larger towns (see Table 1, top of the list) and less detailed information exists about the four smaller medieval towns, so these are simply rough estimates.

Farm mounds or settlement mounds listed in Askeladden number 895 for the whole country, 861 for the three northernmost counties. The total number of farm mounds in Norway is not known, as most of the settlement mounds in southern Norway have not been listed as monuments. However, the total number probably equals at least a. 2000 (pers. comm. R. Bertelsen 2011). Using the information on farm mound size stated in the Askeladden database (which is only specified in some cases) and making a rough estimate for the rest, the approximate volume of archaeological deposits in farm mounds also equals about 40,000,000 m³, and that is not including all the non-listed sites. This means that the volume of preserved deposits in farm mounds roughly equals that of the medieval towns and would most likely exceed or even double it if heritage inventories in the rest of the country were as thorough on medieval remains as the northern museum district²³. However, the resources spent on investigating them differ widely.

Table 3 NIKU approximate budgets/costs for urban investigations during the period 2012-2015 in Norwegian kroner (NOK). Numbers gathered by Dalia Dargyte, NIKU, September 2015.

2012	2013	2014	2015	Total
11 096 431	18 950 289	33 419 935	24 526 705	87 993 360

Table 4 Tromsø museum approximate budgets/costs for farm mound investigations during the period 2012-2015 in Norwegian kroner (NOK). Numbers gathered by Keth Lind, Tromsø museum, September 2015.

2012	2013	2014	2015	Total
618 556	284 113	947 039	1 153 334	3 003 043

²³ Norway is separated into five university museum districts. Tromsø University Museum, NTNU University Museum in Trondheim, University Museum of Bergen, Archaeological Museum University of Stavanger and Museum of Cultural History University of Oslo, as described in Chapter 1.

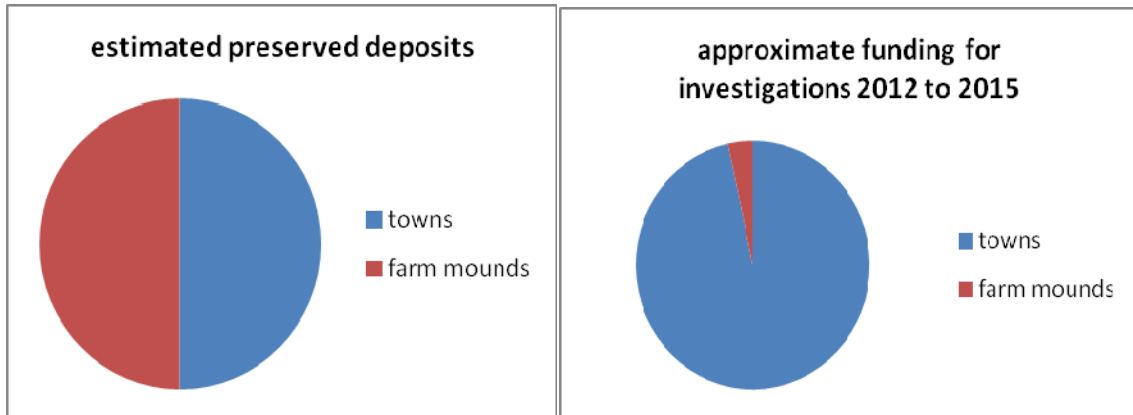


Figure 6 Pie chart of estimated amount of preserved deposits in towns and farm mounds, source: Tables 1 and 2. Compared to distribution of funding of archaeological investigations of towns and farm mounds (Table 3 and 4).

The tables above show approximate budgets and costs spent by NIKU on urban investigations within the past four years (the run time of this research project), and comparable numbers from Troms museum with costs for farm mound investigations in the same time period. This shows that the resources spent on farm mounds are only 3.4% of what is invested in urban investigations (Table 3 and 4; Fig. 6). Thus the places which housed only a minority of the population are used as the main sources to describe the whole. Even if a much greater development pressure in the towns may be deemed an at least partly valid reason, the consequence is that the archaeological interpretations of the heritage resources become extremely biased towards urban environments, and the rural landscape may indeed be termed ‘*The Lost Middle Ages*’ (Martens *et al.* 2009). The scarcity of the rural investigations makes interpretations of the few excavated sites more difficult.

If one looks at the available data on farm mounds in the Askeladden database, it is not only possible to get estimates of their size, but combined with information from Kartdata/Geovekst, it is possible to pick out the ones that have mapping data (see Table 5), and to sort the farm mounds into categories with or without buildings plus distance from town/village centre.

Table 5 Farm mounds in the three northernmost counties Finnmark, Troms and Nordland. This table distinguishes between mounds with or without mapping information. Of the mapped ones, there is a distinction between farm mounds with or without buildings and their proximity to a town/village (Norwegian ‘tettsted’²⁴).

	Selection 861 ²⁵	Selection 662 ²⁶	Selection 662 no building	Selection 662 with building	In town/ village	In town/ village with building	<10km from t	<10km from t with building	>10km from t	>10km from t with building
Finnmark	61	33	21	12			7	2	26	10
Troms	300	224	91	133	24	19	116	68	84	46
Nordland	500	405	209	196	33	30	227	109	145	54
Total	861	662	321	341	57	49	350	179	255	113

Most of the Finnmark mounds were placed on the outer coastline, and more than half of them are deserted as they have no buildings (Table 5, Fig. 9). Many of the Troms farm mounds are placed in the more protected areas of the inner fiords (Table 5, Fig. 10), and they are also the majority of the ones with buildings, meaning that they might still be lived on. In the Harstad area (in the left hand corner of the map) we find the greatest density of mounds. The farm mounds in Nordland are mainly situated at the outer coasts, though some have been deep within the fiord systems (Fig. 11).

²⁴ <http://www.ssb.no/natur-og-miljo/geodata> definition of tettsted

²⁵ total listed monuments

²⁶ mapped monuments



Figure 7 Røkenes farm mound, Troms. Photo VVM/NIKU 2011.



Figure 8 Grimsholmen farm mound, Troms. Photo Stephen Wickler/Tromsø University Museum 2014.

Table 6 Table of mapped farm mounds and the number of standing buildings on each. Source: byggbasen Kartdata/Geovekst 2015.

Present number of buildings	Number of farm mounds with this number of buildings ²⁷	Nordland county	Troms county	Finmark county
0	384	247	114	23
1	94	62	27	5
2	65	37	27	1
3	43	25	17	1
4	24	11	12	1
5	11	5	6	-
6	5	3	2	-
7	3	1	2	-
8	10	5	4	1
9	2	2	3	-
10	4	1	3	-
11	3	2	1	-
12	5	1	4	-
13	-	-	-	-
14	-	-	-	-
15	1	1	-	-
16	-	-	-	-
17	1	1	-	-
18	-	-	-	-
19	1	-	1	-
20	-	-	-	-
21	-	-	-	-
22	-	-	-	-
23	-	-	-	-
24	1	-	-	1
25	-	-	-	-
26	-	-	-	-
27	-	-	-	-
28	1	-	1	-
29	-	-	-	-
30	-	-	-	-
40	-	-	-	-
41	1	1	-	-
Sum	662	405	224	33

Additionally, it is possible to sort the farm mounds into number of buildings on each mound (Figs. 9-11; Table 6). The really interesting part is when one looks at farm mounds that are most likely still lived on, the presumption being that if there are two or more buildings on the mound, it is likely that it is still in active use, e.g. a main building and a garage. This is because there are numerous examples of farm mounds with one standing building that are used as museums (e.g. the farm mound Røkenes, Harstad municipality, Troms; see Fig. 7) or as holiday homes (e.g. Grimsholmen, Karlsøy municipality, Troms; see Fig. 8).

There are 184 farm mounds with more than one building – of these 96 in Nordland, 83 in Troms and only 5 in Finnmark.

Of the farm mounds with two buildings, 37 are in Nordland, 27 in Troms and one in Finnmark. With three buildings, the numbers decrease to 25, 17 and 1 (see Table 6). Farm mounds with 10 or more buildings are likely representing more than one farm unit, of these there are seven in Nordland, ten in Troms and one in Finnmark. The largest number of buildings on a farm mound is 24 in Finnmark, 28 in Troms and 41 in Nordland. These might more correctly be termed villages or village mounds, rather than farm mounds. For all three counties, a majority of the farm mounds have been deserted and have no buildings (this also includes the ones with no current mapping information). A large number have only one building and are thus likely not fully functioning modern homes.

²⁷ These numbers concern the number of farm mounds where information on buildings is available (mapped selection, see Table 55). Source: byggbasen Kartdata/geovekst.

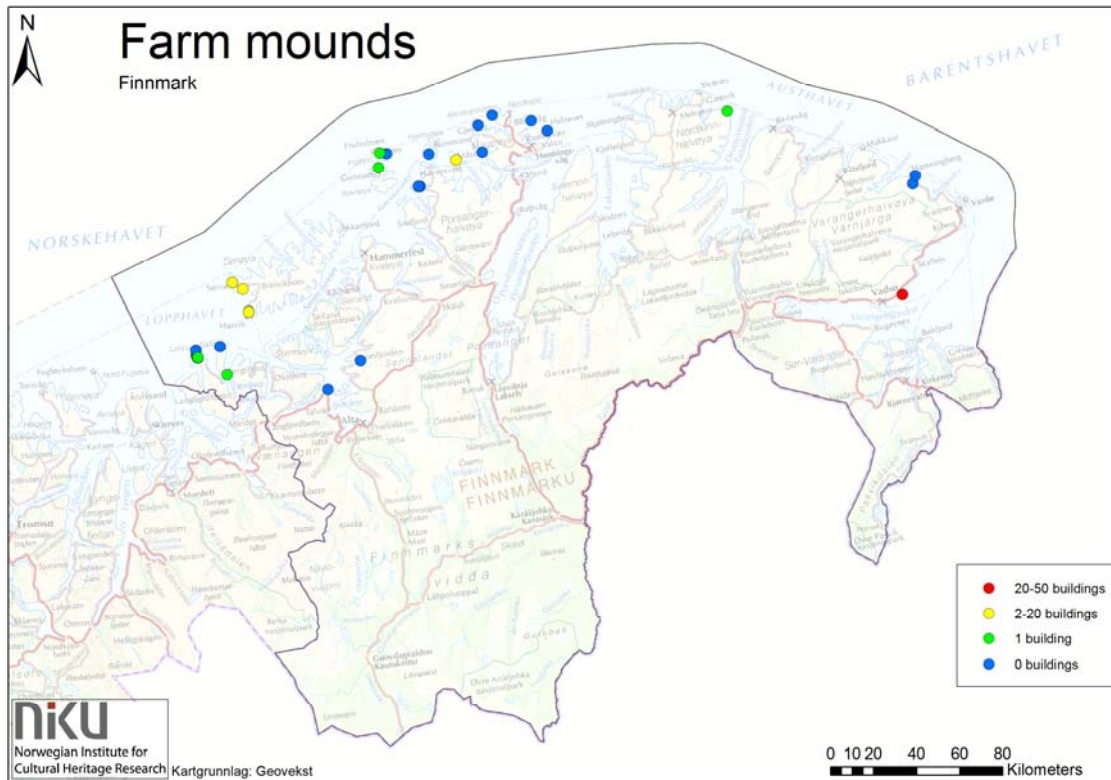


Figure 9 Map of known number of buildings on farm mounds in Finnmark. Map by Nils Aage Hafsal/NIKU 2016.

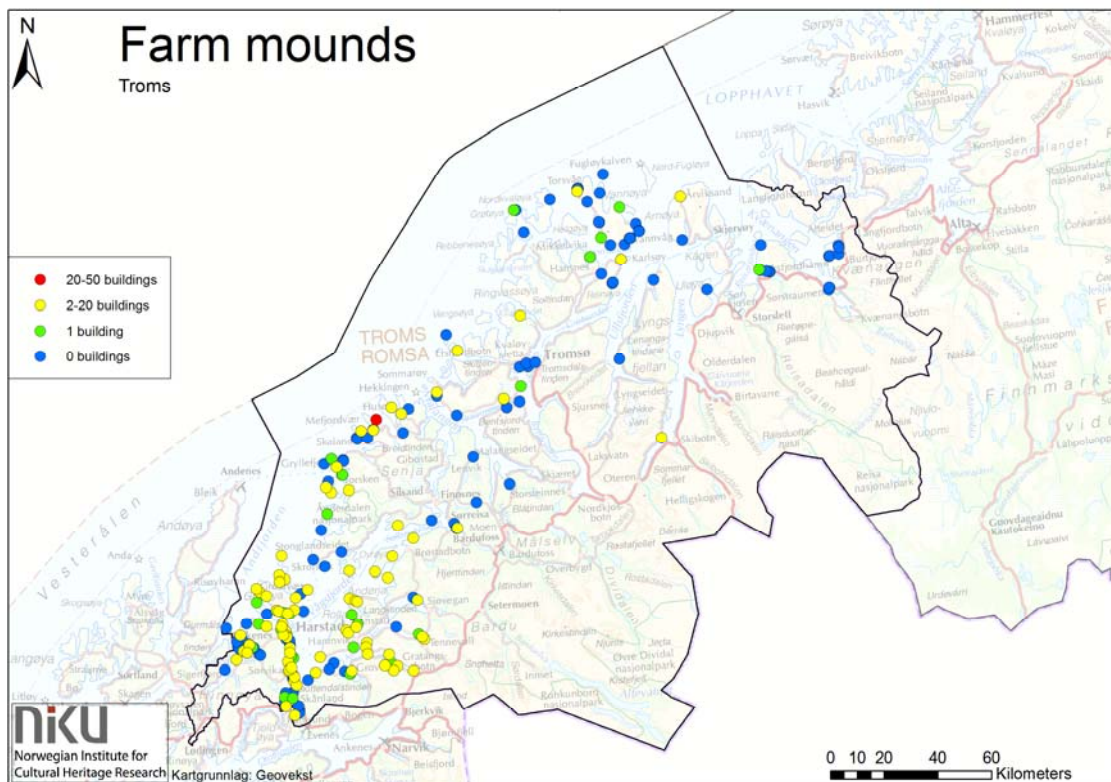


Figure 10 Map of known number of buildings on farm mounds in Troms. Map by Nils Aage Hafsal/NIKU 2016.

However, a respectable number of farm mounds are in active use today and still lived on, with all the preservation challenges that this issues. The distribution maps clearly demonstrate that the deserted farm mounds are mainly in the exposed outskirts of the community (more than 10 km from a town or village), with the exception of the Lofoten area in Nordland, where the mounds on the islands most exposed to the weather are also the ones closest to the best cod fishing grounds. Even today, the stock fish trade influences the settlement patterns, as it has done historically (see also Chapter 3). If one looks at the number of buildings on each mound, the pattern is even clearer, showing the large fishing villages, all placed close to the good fishing grounds.

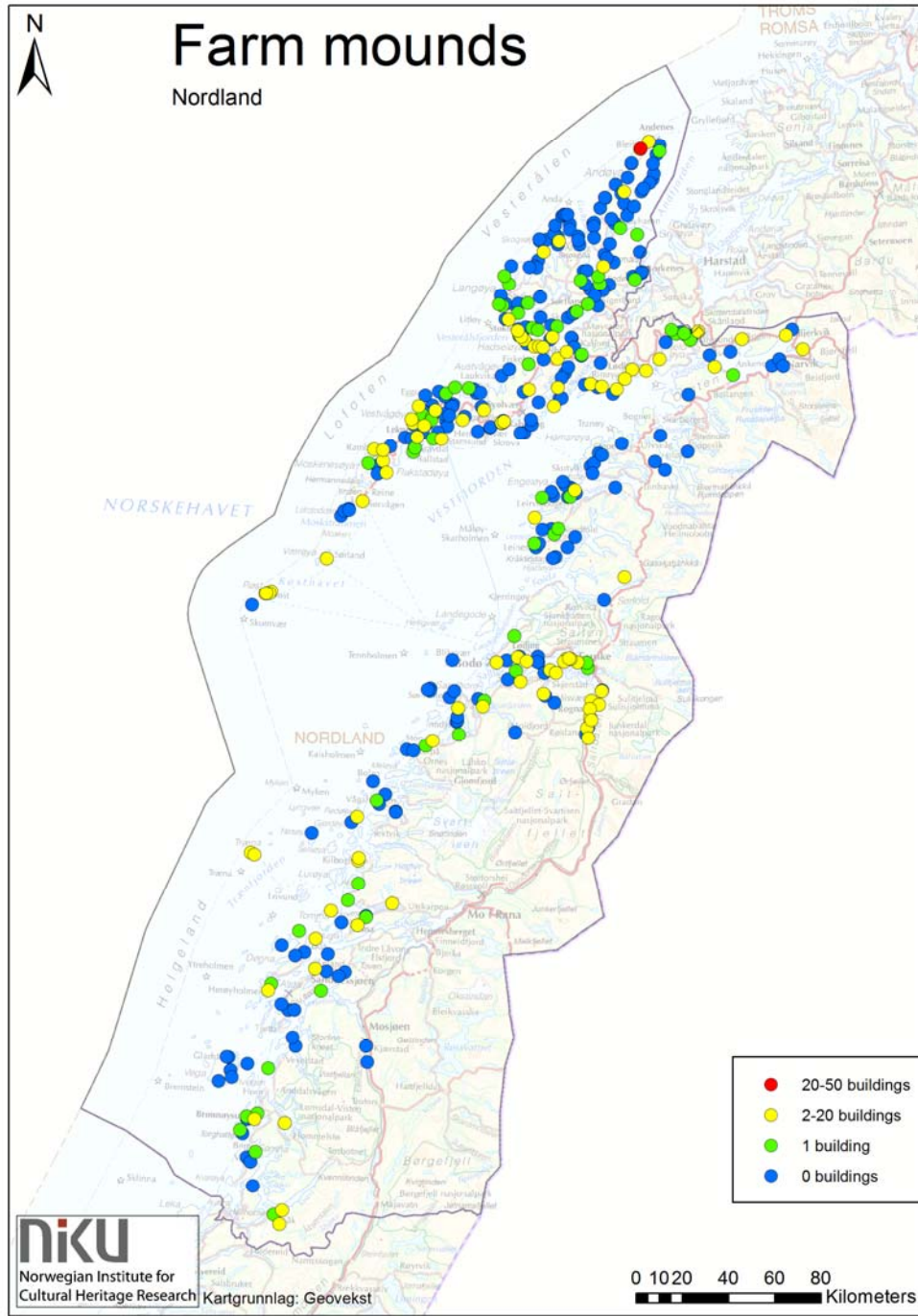


Figure 11 Map of known number of buildings on farm mounds in Nordland. Map by Nils Aage Hafsal/NIKU 2016.

When the sites for the InSituFarms project were chosen, the original plan was to primarily work on sites that were being disturbed from infrastructure maintenance projects or similar, as they are all listed and thus require permission from the Directorate to investigate. However, as it may take some time before this kind of project is actually carried out, we chose another selection procedure.

We wanted to investigate a typical farm mound that was still in active use as a farm (Voldstad, Askeladden ID 9382²⁸), and one in a modern town threatened by infrastructure development (Saurbekken, Askeladden ID 48774). Saurbekken was a particularly attractive case study because it had been partly excavated in 1972 (Holm-Olsen & Bertelsen 1973), thus allowing a comparison of deposit depth then and now. Any additionally investigated farm mounds during the project period would be included as additional case studies in the project. However, there have been exceptionally few investigations carried out these past four years. Because of the socioeconomic and climate pressure on archaeological sites in Finnmark, a Stone Age site was chosen for comparative investigation, (Ban̄kgohppi, Askeladden ID 7547). As has been stated above, this monument type is present in about the same number as the farm mounds, but in Finnmark alone, thus leaving it a much more exposed monument type in that landscape. From a heritage management perspective it was extremely relevant to get information on preservation and management of this monument type.

2.4 Threshold levels

It may feel scary or intimidating to define value or threshold levels of change. Scientists of all subjects are usually hesitant in doing this, fearing that setting a limit may have devastating consequences for anything that is deemed below level. For archaeology, that might mean that all sites deemed 'less valuable' or below certain preservation limits would then lose their automatic protection as listed monuments. However, as it may not be possible to preserve absolutely all monuments, it may be a useful experience to evaluate which sites are most under threat and which ones seem well protected. It might even be a good idea to have tools to help decide on 'the lesser evil', e.g. which sites to recommend for excavation rather than preservation in cases where development of an area may choose different routes. Actually very few attempts have been made to put any numbers on preservation threshold levels, but in a presentation at the European Association of Archaeologists meeting in Bournemouth, UK in 1999, Richard Hughes did set up a series of percentage changes in soil moisture level, 0-5% signalling safe conditions (green), 6-10% indicating potentially threatening conditions (amber) and 11% and higher (red) signalling immediately threatening change rates (Hughes 1999, Reed & Martens 2008:270), the red values calling for immediate mitigating actions.

If these levels of change in soil moisture can hold true, then similar threshold levels could be defined for preservation of whole sites, to be used as indicators of when to apply mitigating actions or decide when to preserve by record rather than *in situ* (see Chapter 7.4 and Table 16). In Norway, systems are actually in place with control registrations of archaeological sites, a monument's watch system checking on their physical state and possible changes that have occurred since the last inspection (Sollund & Holm-Olsen 2013). However, this control registration is only carried out in a limited number of municipalities spread out in the country, and it only includes the visible monuments. Working by a Norwegian national standard, NS 9450 (2003)²⁹, observation categories have been defined (unchanged/damaged/lost/not found), and a series of causes for loss or damage are described; agriculture, housing/leisure, infrastructure/industry, Forestry, sand/gravel extraction³⁰, vandalism, visitor amenities, and finally natural causes (including damage or loss caused by climate change). However, defining actual threshold levels as basis for actions has not been done, further than the 0.5% loss defined as a maximum by the government.

²⁸ Askeladden (<https://askeladden.ra.no/>) is the Norwegian national cultural heritage database.

²⁹ This standard was updated in 2012 to also include marine archaeology, and the 2003 version withdrawn.

³⁰ Sand/gravel extraction has been singled out as the most often represented industry threatening monument preservation.

I would suggest that perhaps the same numbers as for change in soil moisture levels might be applied here for new use or development of a site, i.e. 0-5% change signalling safe conditions (green), 6-10% indicating potentially threatening conditions (yellow/amber) and 11% and higher (red) signalling immediately threatening change rates. The physical state would be very important in evaluating e.g. erosion damage caused by raised sea levels.

I would also like to distinguish between the loss or damage caused by continued traditional use of a site and that caused by new use or development of a site, so that threshold levels should be higher for continued traditional use of a site, e.g. 0-10% change signalling safe conditions (green), 11-20% indicating potentially threatening conditions (yellow/amber) and 21% and higher (red) signalling immediately threatening change rates. Soil degradation rate threshold levels could be also defined like the percentage changes in soil moisture level, though perhaps modified a bit so that 0-10% change signals safe conditions (green), 11-20% change indicating potentially threatening conditions (yellow/amber) and 21% and higher changes (red) signalling immediately threatening change rates that call for heritage management reactions, either mitigation or excavation. For temperature, the suggested threshold levels could be an increase of 0.0-0.9°C signalling safe conditions (green), 1.0-1.9°C increase indicating potentially threatening conditions (yellow/amber) and 2°C and higher increase (red) signalling immediately threatening change rates.

If a particular site has more than one factor in the red field, this would be an indication that *in situ* preservation may no longer be an option unless mitigating actions are carried out; and if a majority of the factors are in the red danger field, this would mean that preservation *ex situ* is the only option apart from complete site loss.

2.5 Mitigating actions

One major question for this thesis was whether or not it would be possible to develop sustainable mitigation strategies to ensure further *in situ* preservation for the investigated site types. Development of mitigation strategies has so far been fairly limited, as it is easily forgotten in the steady stream of measurements of chemical and physical parameters. In urban settings, clay plugs have been used cutting across trenches to diminish water flow along the trench in sloping areas (RA & NIKU 2008).

In 2007, the author of this thesis attempted to not only install non-marine clay as plugs cutting across a modern trench, but also wrap a whole section with (at least until the time of investigation) well preserved archaeological deposits in clay to stabilise it and reduce dewatering through the new water pipe trench in Oslo (Martens 2010a). However, as this was carried out after the new pipe had been installed, it was necessary to do it manually and thus it was time consuming and heavy work.

In Enköping in Sweden, an excavation at the square in 2014 would expose sections with preserved deposits. To try and protect these from dewatering and preserve them for the future, a plan was made to push clay against the exposed sections with a digger under archaeological supervision (Fig. 12) (Martens 2014). This procedure was also carried out at the exposed section at Saurbekken in 2014 (Martens *et al.* 2015c), but as monitoring equipment was installed in part of it, that part of the section was clay covered partly by hand – the digger lifted the clay into the trench, and then it was pushed into place by hand (see Figs. 13-15). For the rest of the trench, the protective clay was pushed towards the section by the digger alone.

The type of clay cover of an exposed section with a digger is a relatively cheap and efficient way to at least minimize drying out and dewatering of exposed deposits in conjunction with a modern infrastructure trench.

Clay was chosen as opposed to bentonite pellets (clay mineral pellets) which have been used on some sites to seal off boreholes and are recommended in the Norwegian Standard (NS 9451:2009). Bentonite pellets require constant humidity to keep their sealing powers, if they dry out the mineral crumbles and turns to dust with no protective characteristics. Since humidity could not be guaranteed on these sites, clay was deemed a more appropriate and sustainable solution.

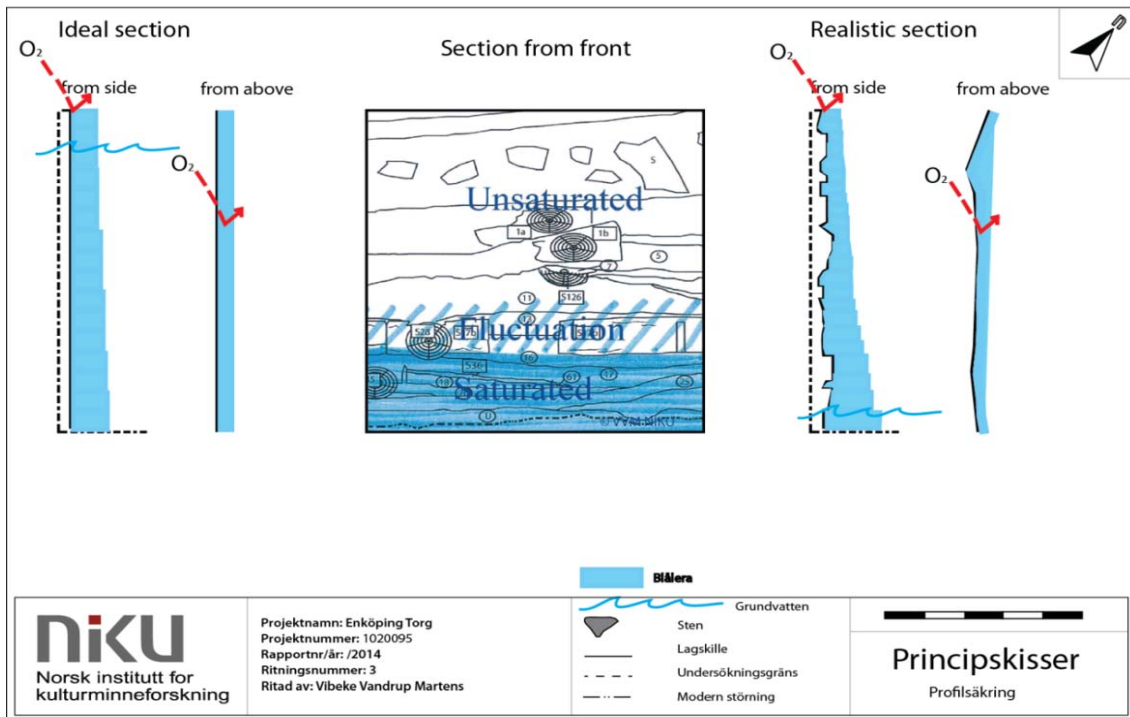


Figure 12 Securing a section with clay covering. Graphics VVM/NIKU.



Figure 13 Securing of section at Saurbekken with clay #1, lifted by the digger. Photo: MVH Consult.



Figure 14 Securing of section at Saurbekken with clay #2, pushed into place by the archaeologist. Photo: MVH Consult.



Figure 15 Securing of section at Saurbekken with clay #3. Photo: MVH Consult.

Covering a whole site with a layer of clay could be one way to protect from violent precipitation events. However, that kind of more drastic mitigation strategy is in conflict with the Cultural Heritage Act §3, which states that ‘No person shall, unless this is lawful pursuant to Section 8, initiate any measure which is liable to damage, destroy, dig up, move, change, cover, conceal or in any other way unduly disfigure any monument or site that is automatically protected by law or to create a risk of this happening.’ This is an issue which must be resolved if this procedure should be considered a valid option in the future.

Less drastic measures might be to preserve sites like the Stone Age middens or cemeteries from all periods by helping to keep their environment alkaline and thus preserve the bone and shell material. If heavy rainfall replaces snow, it might wash out material and alter the pH, changing it to an acidic environment (see also Chapter 6).

A sustainable mitigation strategy for that type of sites may be to simply spread chalk on top of them and let the rain wash it into the deposits, thus keeping the alkaline environment that protects the bone from degradation. However, before applying any form of chemicals to a site, one needs to consider the best preservation environment for all present find categories.

2.6 Heritage value theory – when do archaeological remains lose their value?

The whole idea of preserving archaeological remains *in situ* infers that they should have some information potential and that this potential should not be diminished. However, we do see that time robs us of at least some information from each site, depending on the original site information potential. So when should we chose between continued *in situ* preservation and excavation and documentation, also called preservation by record or *ex situ*? Figure 16 indicates the challenge for heritage managers; to keep the amount of degradation as low as possible to avoid excavation.

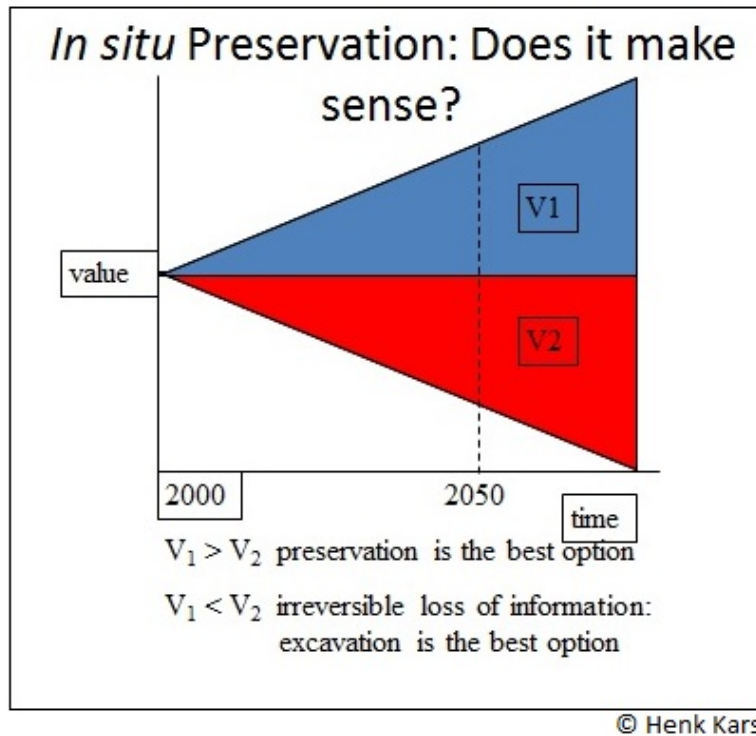


Figure 16 Schematic illustration of expected increase of intrinsic archaeological value of a site (due to improvement of techniques, change in paradigms, increasing insight, etc.). This is assumed to be larger than the expected physical loss of a site due to degradation. Time frames are not absolute, simply illustrative and hypothetical.

Archaeological remains are a finite resource, and excavation is a destructive process, preserving by record that which the excavators have managed to capture on drawings and photos, some of the artefacts and possibly ecofacts found, and an interpretation of the site formation. If a whole site is removed (mostly as rescue excavations because of development projects) there is no going back to check the excavation interpretations, because there is nothing to go back to. That is the reason why many advocate *in situ* preservation, in the hope that the next generation of archaeologists may have better tools, new insights and new research questions. This has already proved a success when re-excavating older sites with new techniques earlier, such as the complete mound build and dating of the passage grave Jordhøj (Kjærum 1969), revolutionising the interpretation of post holes at Trelleborg (Olsen 1968), evaluation of previous methods and source critique at Borremose (Martens 1991, 1994) or individual find sites (Rolfsen 2000), so it is reasonable to hope for even better methods and results in the future.

However, there is still the problem of natural or anthropogenic degradation of archaeological remains. We need to know that the archaeological remains at sites that are chosen as archaeological reserves for coming generations will actually still be there, and that they retain their readability.

To define the value of an archaeological site and to predict a future increase or decrease of value is something against which most Norwegian archaeologists instinctively struggle. Norway is by tradition a very egalitarian country, and this equality is also extended to the cultural heritage. However, even though archaeologists may state that all sites are equal in importance, all tend to relent when faced with practical questions. If one sees archaeological remains as information sources, then one cannot forcefully argue that a charcoal pit has the same value as a Viking Age ship burial or a burnt down Roman Period house, as there is so much more information in the latter as to render them simply incomparable. By refusing to distinguish between the value of different remains and prioritise, there is also a risk that changing governments may tire of the restrictive measures of the Cultural Heritage Act³¹, which forces developers to pay for rescue excavations, environmental monitoring and other mitigating factors; it might be changed and thus not equally protect all remains prior to the Reformation of AD 1537. The change from Catholic Christianity to Protestantism is the time limit for automatically protected archaeological remains in Norway, with the exception of standing buildings where the limit is AD 1650, and ship wrecks and Sámi remains which have a 100 year protection limit (§4 in the Cultural Heritage Act, see Chapter 1). It may turn out to be a benefit to society and enable archaeologists to concentrate on communicating cultural history, if more sites are actually fully excavated.

To enable us to assign value to different archaeological sites, perhaps we should look beyond traditional archaeological theoretical frameworks and look at what is in current use or development, e.g. for built urban cultural heritage such as the DIVE method (Reinar & Westerlind 2010), the D standing for Describe, I for Interpret, V for Valuate and E for Enable (see Table 7).

Table 7 The DIVE method. Redrawn from Reinar & Westerlind 2010.

Stage (work phases)	Objective	Relevant subtasks
<i>Prepare</i>	<i>Input</i>	<i>Organisation and work plan for the analysis</i>
S1 Describe	Historical character of the area of analysis	Establish a knowledge base, collate, describe and process information about the origins, development and character of the area
S2 Interpret	Historical meaning of the area	Explore the area's historical legibility, its significant and communicative contents, integrity, authenticity and overall condition
S3 Valuate	Value and potential of the area	Assess the value, development potential, vulnerability, tolerance and capacity for change of the cultural and historical resources
S4 Enable	Active intervention	Define the potential field of action for the cultural heritage, suggest strategies and principles, instruments and concrete measures for management and development
<i>Summarise</i>	<i>Output</i>	<i>Summary of the contents, results and recommendations of the analysis</i>

³¹ <https://www.regjeringen.no/en/dokumenter/cultural-heritage-act/id173106/>

A DIVE analysis can be used as a knowledge base for management at all levels of cultural heritage, environments and landscapes; physical and transport planning at both overview and detail levels; impact assessment of programs, plans and projects; community planning at the regional and local levels (Reinar & Westerlind 2010:6).

Using this method, knowledge value is based on its representativeness, context, authenticity and physical condition. Factors such as identity, symbolic value, architectural and artistic quality, etc. are assigned importance. Utility value can be assessed on the basis of economic, functional and ecological parameters. An area's historical character, significance, legibility, authenticity and integrity all contribute towards an overall cultural evaluation. Buildings and residential structures have historical value if they are considered to be significant expressions of their time or of evolutions through time, either as repositories of knowledge about the past, as sources for experiential discovery, or because they are important seen in a functional perspective (Reinar & Westerlind 2010).

The DIVE method has also been considered for archaeological landscape analyses (Jerpåsen 2013:56-57), but was in that case only deemed partly satisfactory. However, it may be a tool to consider in the future evaluations of preserving *in situ* or *ex situ*. Another good tool may be the Swedish Cultural historic valuation and selection, which is currently being developed. Value includes readability and the historic, artistic, economic, emotional, scientific, social and community values that can be assigned to a cultural heritage site (RAÄ 2015:38). This adheres even more to the Faro Convention (see Chapter 1) and incorporates intrinsic heritage values in modern society.

Faced with increased challenges of site deterioration caused not only by development or infrastructure projects but also by natural forces such as climate change, it will most likely be necessary to give value to and distinguish between sites. If they cannot all be protected *in situ*, one may choose to help preserve some sites where this may be accomplished by sustainable mitigation actions. That way one may preferably solve more than one problem at a time. A good example is urban sustainable water management systems that help keep deposits wet and keep sewers from overflowing (Boogaard 2015). Other sites may be chosen for research excavations to a larger scale than has hitherto been allowed on listed monuments, and yet others again may be left to simply deteriorate and lose information potential at whichever pace might be. These choices should preferably not be random but informed ones, and that requires an integrated cooperation between all cultural heritage management and research institutions – county councils, museums, research institutes and the Directorate for Cultural Heritage, looking at the whole set of threats. For many farm mounds, the use as holiday homes may prove more destructive in this and the coming decades, because people are now requiring all the comforts of home also while on holidays, including running water, electricity and sewage – all factors that require digging into the archaeological deposits. For sites near modern towns or villages, infrastructure maintenance is a constant threat that really cannot be avoided, when we want a functioning modern society. That means that one should look at each archaeological site and evaluate its intrinsic scientific and historic potential as well as all possible threats before assigning a value; that would for instance mean that a farm mound placed far outside populated areas and with no modern or functioning buildings on top and no likely disturbance from future development or infrastructure projects should be given a higher value than one situated in a modern town. This is not the same as stating that the latter does not have high information potential, it is simply stating that more factors threaten its continued *in situ* preservation, and these factors should be taken into account when heritage management authorities decide on how to proceed in development projects.

3 North Norwegian farm mounds - landscape conditions and assumed agrarian technologies required for their existence³²

Abstract

Farm mounds – built-up archaeological deposits from long term rural settlements at fixed sites – is a characteristic of the medieval rural settlement in Northern Norway, the Norse settlements on the North Atlantic Islands, the south west coast line of the North Sea and the Iron Age settlements in Northwest Jutland. The main elements of the farm mound deposits are house remains from houses built of wood and turf sods, and general household waste. A farm mound or settlement mound may support only a single farm, or several farms or holdings. In the present paper, the North Norwegian farm mounds are compared to the medieval rural settlements in Eastern Norway and to the Iron Age settlement mounds of North Jutland. It is argued that the formation of settlement mounds is a result of both social structures and economic strategies, the mounds representing an economical emphasis on husbandry in combination with fishing and other non-agricultural resources.

3.1 Introduction

The rural landscape in Arctic Northern Norway is characterized by a special type of settlements – the so-called farm mounds. These mounds are archaeological remains from centuries of settlements in the same location. A farm mound may represent a single farm or several farms or holdings clustered in a hamlet or a village. They represent diverging subsistence strategies, caused by different conditions in landscape or societal structures. Since the farm mounds were registered as archaeological monuments at an early stage, not a single farm mound has been completely excavated. In Norway they comprise the largest assemblages of medieval archaeological deposits outside the towns and thus represent a major source to cultural history of both Norse and Sámi rural settlements in Northern Norway.

Taking the outset in recent investigations of two farm mounds in Troms County, Voldstad and Saurbekken in combination with earlier research, this paper presents the North Norwegian farm mounds as an archaeological monument and discusses economic resources and landscape conditions as requirements for their existence. Why are the settlements fixated in the same spots, forming settlement mounds, instead of moving around in the landscape in order to maximise land use, as is found elsewhere in Southern Scandinavia and Europe?

3.2 State of research

During the national survey of archaeological monuments in Norway, farm mounds or settlement mounds were registered, particularly in the High North, in the three northernmost Norwegian counties of Finnmark, Troms and Nordland, which are all located in the Arctic zone. 869 such farm mounds are listed in the Norwegian national cultural heritage database Askeladden. The distribution of the farm mounds over the length of the country (Fig. 17) seems very clear, with the vast majority in the counties of Finnmark (56; Fig. 18), Troms (285; Fig. 19) and Nordland (494; Fig. 20).

³² This chapter has been adapted and slightly modified from Martens VV 2016): North Norwegian Farm Mounds – economic resources and landscape conditions. In: J Klápště (ed.): Agrarian Technology in the Medieval Landscape. *Ruralia* 10, 173-184.

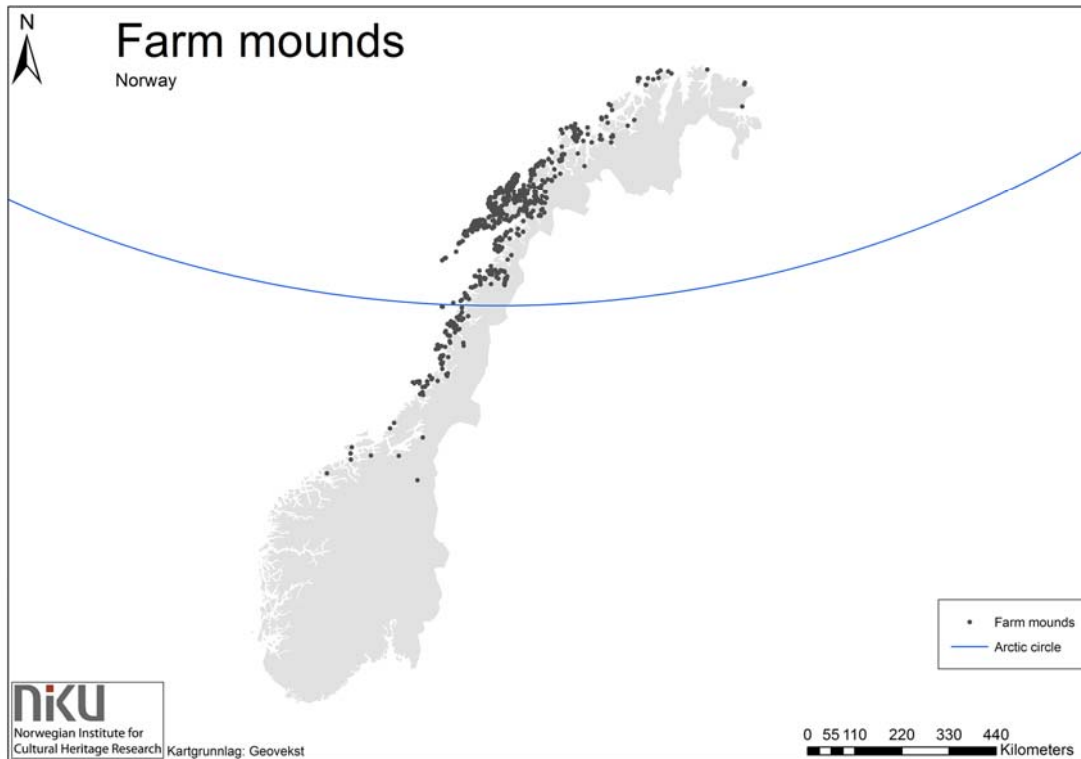


Figure 17 Map of all farm mounds in Norway listed in Askeladden heritage database November 2015. Blue line marks the Arctic Circle. Map by Nils Aage Hafsal/NIKU 2016.

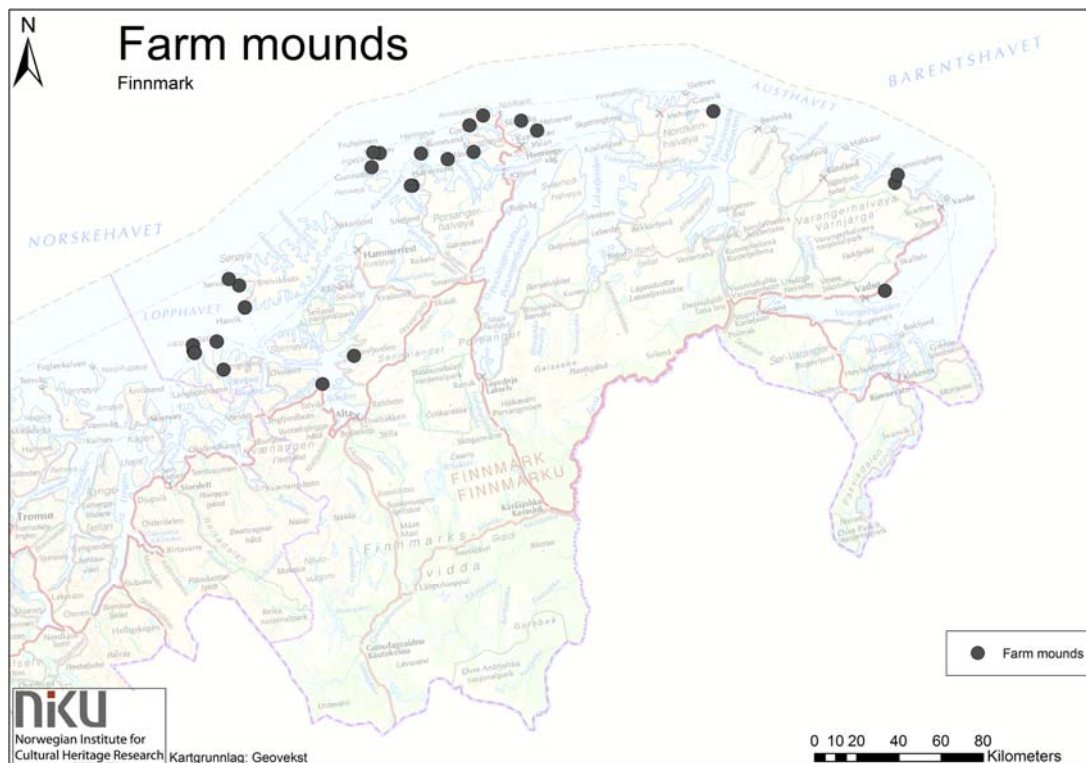


Figure 18 Map of farm mounds in Finnmark County listed in Askeladden heritage database November 2015. Map by Nils Aage Hafsal/NIKU 2016.

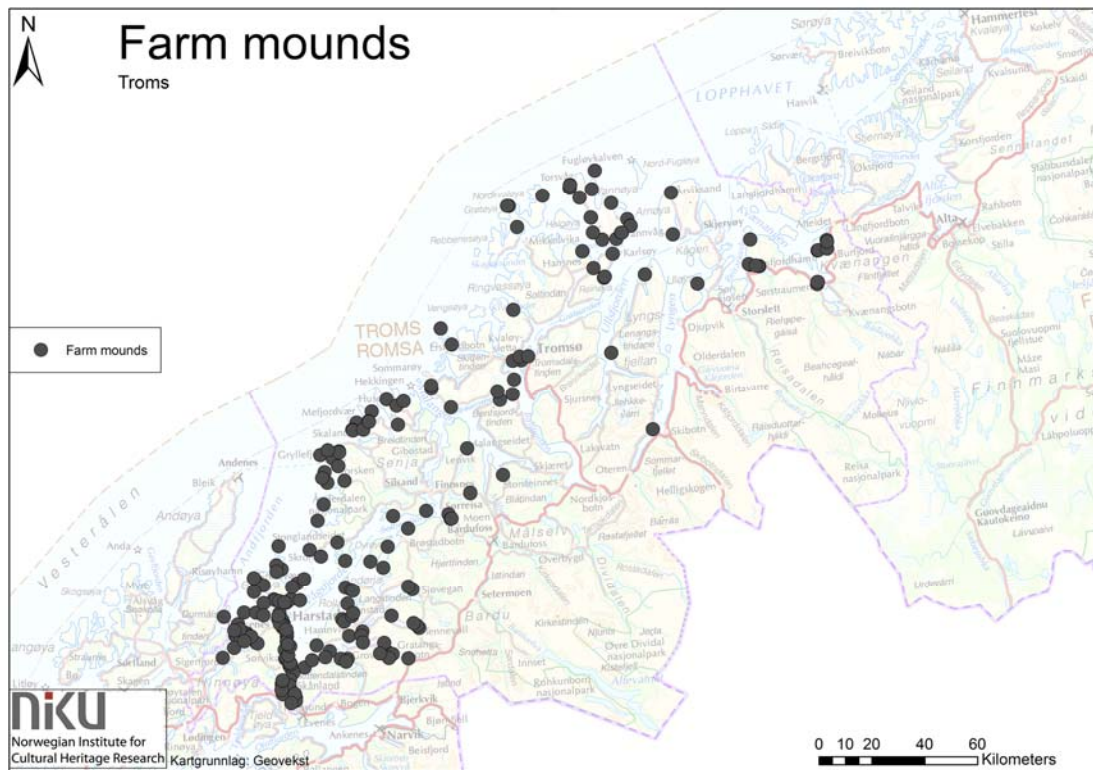


Figure 19 Map of farm mounds in Troms County listed in Askeladden heritage database November 2015. Map by Nils Aage Hafsa/NIKU 2016.

However, this is not necessarily a true or complete picture of the actual, physical presence of the monument type, but may be a reflection of different research traditions in different parts of the country.

In Eastern Norway it has been an established but untested truth that due to unbroken settlement continuity from Late Prehistory to present day at the central farmsteads nothing has been preserved for archaeological research. Surprisingly this assumption has not led to a wholesale monument listing of all modern farms, but rather left it to chance if or when farm mounds or any rural medieval remains have been found or investigated in those parts of the country (Martens 2009). In spite of this, minor excavations at a few sites have proved that even in this area settlement mounds with considerable preserved archaeological deposits may be found, and raised awareness may uncover more.

At Fusk in Østfold County, the deposits were 70 cm deep. They consisted of silty, humus-mixed sand with lenses of fine sand, charcoal and heat-affected stones. The few artefacts found in the trench were of stone; soapstone vessels, a spindle whorl, whetstone, loom weight and baking stone. All these could be dated from the shape of the soapstone vessels to the medieval period, and all are typical household waste finds consistent of a farm mound (Stene 2009).

Åker in Hedmark County has a distinct mound shape and preserved deposits of about 100cm in depth. Investigations at Åker have been carried out in many stages over decades, the latest as evaluations of state and extent of preserved archaeological remains in several different campaigns between 2005 and 2008. The deposits were coarse and dry, consisting mostly of humus-mixed silty sand mixed with heat-affected stones. In some areas of the mound, these stones form up to 30cm deep compact deposits, indicating possible brewery activities at the site. The artefacts found were consistent of a farm mound, typical household waste; animal bones, pottery, but even metal objects were well preserved in these dry deposits. The artefacts found in the central mound could be dated to late Viking Age/Early Medieval through to the 18th century but archaeological remains and particularly rich metal finds from earlier periods have been found elsewhere on the farm, indicating a high position in a social hierarchy (Martens 2013, see further in Chapter 4).

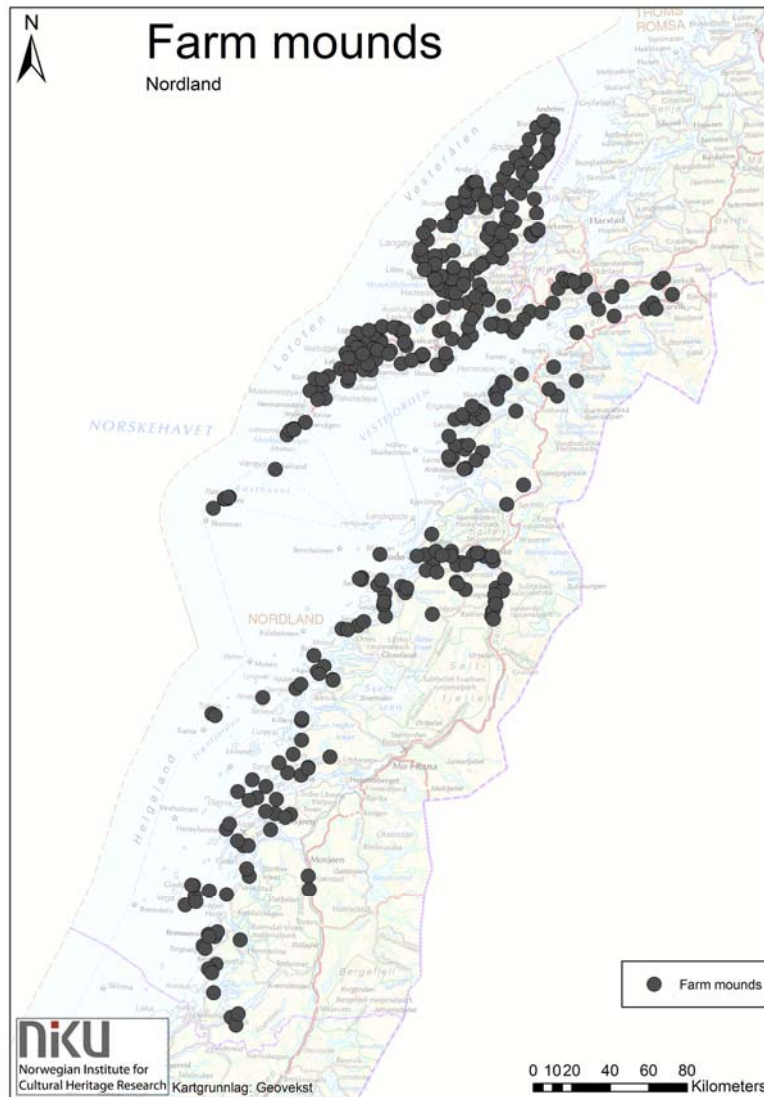


Figure 20 Map of farm mounds in Nordland County listed in Askeladden heritage database November 2015. Map by Nils Aage Hafsal/NIKU 2016.

At Bygdø Kongsgård (Bygdø Royal Manor House) in Oslo, excavations were carried out in the winter 2004-2005, when the building was to be renovated. This site is another example of high social position, since medieval written sources connect it to the King and the church. Since the excavations were carried out inside and beneath a standing building, the sequences of archaeological deposits were disturbed by younger building phases, and the deposits themselves were dry, but they were preserved in one to two metres depth and consisted of typical farm mound fill, household waste and building remains, dating mainly to the Middle Ages and the Renaissance (Karlberg & Simonsen 2009).

In 2010, an excavation was carried out at the farm Them in Vestfold County, beneath the oldest parts of the present-day main building. The building had been dated by dendrochronology to 1563. The archaeological remains beneath the floor consisted of household waste and building remains, most of which could be dated to the 15th century. The deposits were about 50cm deep. Beneath these was a deposit covering the whole site, dated to Late Viking Age, and underneath that layer were older settlement traces, dated to Early Viking Age, Roman Period, Bronze Age and the Neolithic (Johansson 2011). Deposits, building remains, artefacts and ecofacts were all consistent with typical farm mound fill, again underlining the importance of looking for medieval rural settlement remains in all of the country.

During the past 50 years, not a single farm mound has been excavated in total, only minor trenches have been investigated either for rescue or research purposes. The investigations have proved that the main elements of the farm mound deposits are house remains from houses built of turf sods and wood, and general household waste while dung only plays a minor role in the build-up of the archaeological deposits (Brox & Stamsø Munch 1965, Bertelsen 1984, 1989, Urbańczyk 1992, Bertelsen 2002, Lind 2002, Bertelsen2011). Reidar Bertelsen has been the single most active farm mound researcher in Norway, and his extensive research is referred elsewhere in this and other chapters of this text.

3.3 Voldstad and Saurbekken, farm mounds in Harstad municipality, Troms County

In conjunction with a research project on *in situ* preservation, research investigations have recently been carried out at two farm mounds in Northern Norway.

3.3.1 Voldstad

In 2013, a minor excavation was carried out at the farm mound Voldstad, Harstad, Troms (Fig. 21). The landowner who lives on the farm mound, Leif Andersen, generously communicated his knowledge about the farm and its history. At the redistribution and mapping of arable land in 1866, Voldstad consisted of 504,000m² inland, of which 75,000m² were non-arable. It also had large outfield areas of about 5,542 500m². The outfields were shared within an elk hunting team, but it still left the farm with considerable land. Obviously, this is stretching the term farm, since 35 main buildings existed (with eight different owners in the 1865 registry (Leif Andersen pers. comm., Lysaker 1956b)), meaning that Voldstad should rather be understood as a hamlet. This would also be a valid description for Voldstad in the medieval period, since at least three farmers were registered there (Lysaker 1956b), and the land was owned partly by Trondenes church (Harstad, Troms), and a small part by Bakke monastery (near Trondheim) at least after the Black Death (Lysaker 1956b:98) – but even before 1349, Trondenes church had received part of Voldstad as a gift.



Figure 21 Excavation at Voldstad farm mound August 2013. Ragnhild Myrstad, Keth Lind and Leif Andersen in conversation. VVM/NIKU.



Figure 22 Trench at Voldstad farm mound August 2013, dug down to bedrock. VVM/NIKU.

Voldstad was chosen as a site because it is a typical representative of farm mounds that are still in active use. During a week in August 2013, a small trench (70 cm by 2 metres) was hand dug from the grass turf surface down to the bedrock (110-120 cm below surface) (Fig. 22). The location of the trench was deliberately chosen to not interfere with any of the 35 buildings mapped in the 1866 land redistribution and was placed between the modern farm building, built in the 1950ies, and its predecessor, the 18th century main building which is in a state of near collapse and about to become part of the mound.

The archaeological deposits in the trench consisted of typical household waste; lots of wood and leather, a few shards of pottery and single objects of glass, iron and stone, in addition to large amounts of animal (cattle, sheep, pig) and fish bones (mainly cod/whitefish) and a few bird bones. The finds of animal, bird and fish bones confirm a mixed economic background, and in the rich farm soil of Troms County inner fiord areas, large amounts of cattle and sheep bones were to be expected. The two top deposits were artefact dated through pottery finds to the 18th C., the third to the 14th C. The artefacts in the fourth and deepest archaeological deposit were also medieval, but could not be exactly dated, consisting mainly of leather scraps and wood. In general, the deposits were humus rich and in a good state of preservation, which made them good sources of information. About 80 cm below the surface, the subsoil layers started, with decreasing amounts of in-washed humus until the bedrock was reached 110-120 cm below the surface. No house remains were found, but as known house sites were deliberately avoided, this was to be expected. The artefacts and ecofacts found during the investigation demonstrate that the main elements of a farm mound apart from building remains is household waste and not dung.

Since the overall aim of the project is the evaluation of state of preservation of the deposits, combined with sampling for soil macro fossils, pollen and geochemistry, monitoring equipment measuring temperature, soil humidity and redox was installed, before the trench was backfilled with its own material (Figs. 23 and 24).



Figure 23 Monitoring equipment installed. VVM/NIKU (left).

Figure 24 Trench backfilled, and data loggers secured in cabinets. VVM/NIKU (right).

Redox means a set of geochemical parameters studied to decide whether the conditions within the deposits are reduced or oxidised, indicating depositional stability or instability. Oxygen and oxidising conditions cause the most degradation of archaeological remains. The monitoring has continued throughout the project period until the end of 2015, and it has been decided to leave the equipment in place for as long as the equipment holds or the land owner permits. For further details on monitoring results, see Chapter 6.

3.3.2 Saurbekken

The farm mound Saurbekken in Harstad town, Troms County (Fig. 25), was chosen as a site for our project because it is a typical and well preserved example of a farm mound deserted after the Black Death with the added value of previous archaeological investigations. During two campaigns in 1970 and 1972, a five by five meter square was excavated in the farm mound Saurbekken. Undisturbed archaeological deposits were found 15 cm beneath the grass turf, continuing to a little more than one metre below the surface (Bertelsen 1973, Holm-Olsen & Bertelsen 1973:7, Bertelsen 2002).



Figure 25 Saurbekken farm mound seen towards south-west. KP/NIKU 2012.

It is known that this farm mound was deserted after the Black Death in 1349 (Lysaker 1956a:11), and the excavation turned up artefacts and five building phases from the 11th C. until the Black Death in the 14th century. The earliest and best preserved building remains are by Bertelsen (2002) compared to the late Viking Age/ early medieval house at the Stauran farm mound in Troms County (Urbańczyk 1992, Fig. 55).

The more than 40 year old excavation of the site gives valuable input to the state of preservation of the archaeological remains as they may be compared to the modern investigations for instance concerning the estimations of depth and extent of the archaeological deposits.

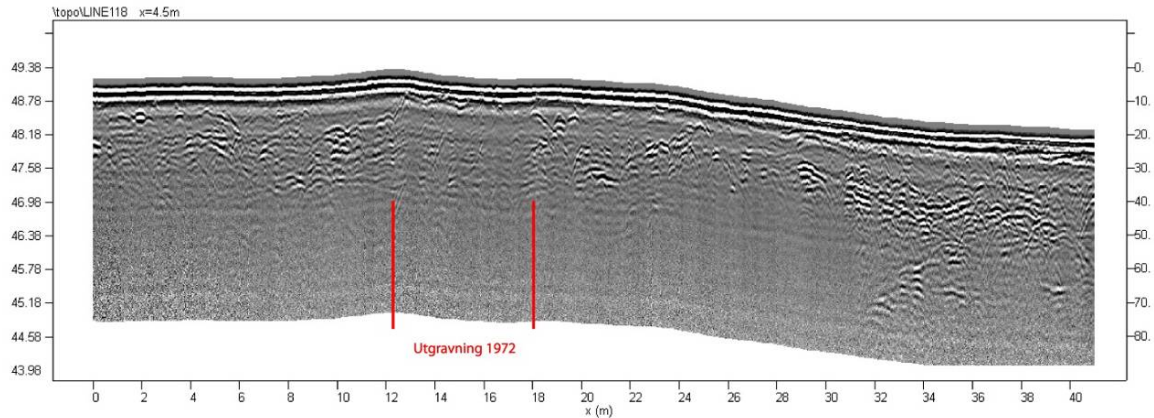


Figure 26 Cross section of GPR (ground penetrating radar) readings at Saurbekken farm mound. The 1972 excavation is seen as an anomaly. Estimated deposit depth from this section is circa 1 m. LG/NIKU. From Gustavsen 2013.

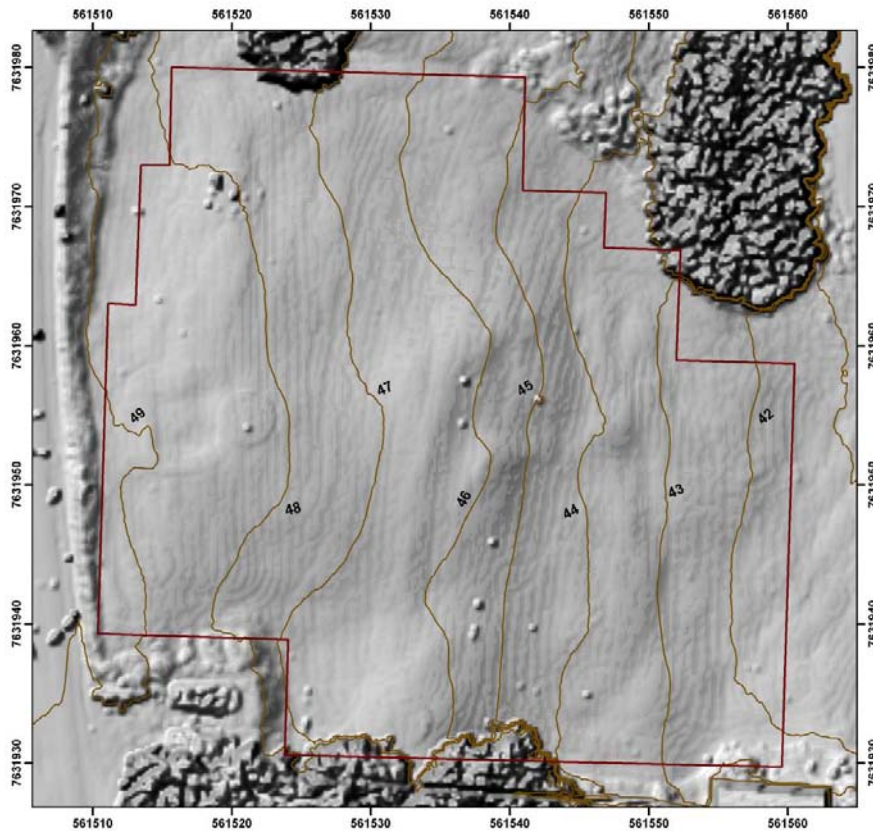


Figure 27 Hillshade + slope model of the area generated in Arc GIS based on a surface laser scan. LG/NIKU. From Gustavsen 2013.

In 2012, geophysical investigations consisting of a surface laser scan and georadar measurements were carried out (see Figs. 26 and 27, Gustavsen 2013). The surface model produced from the laser scan (Fig. 27) may also be used as a monitoring parameter in the future, since a consecutive scan will reveal changes in the surface, thus offering a potent instrument to observe possible future effects of the current planned infrastructure work in the street that will cut the western parts of the farm mound.

Judging from the georadar investigations the size of the preserved farm mound remains is estimated to ca. 1700 m² (Fig. 28), indicating that this must have been a solitary farm. The shape would indicate that parts of the mound may be found beneath the modern road St. Olavsgate in Harstad west of the listed monument. The estimated depth of the archaeological deposits from the georadar section (Fig. 26) is about one metre, which corresponds well with the excavation results from 1972 (Gustavsen 2013). It is notable that the old excavation is very visible in all the geophysical measurements, both in the surface model made from the laser scan and in the plan and section of the georadar measurements.

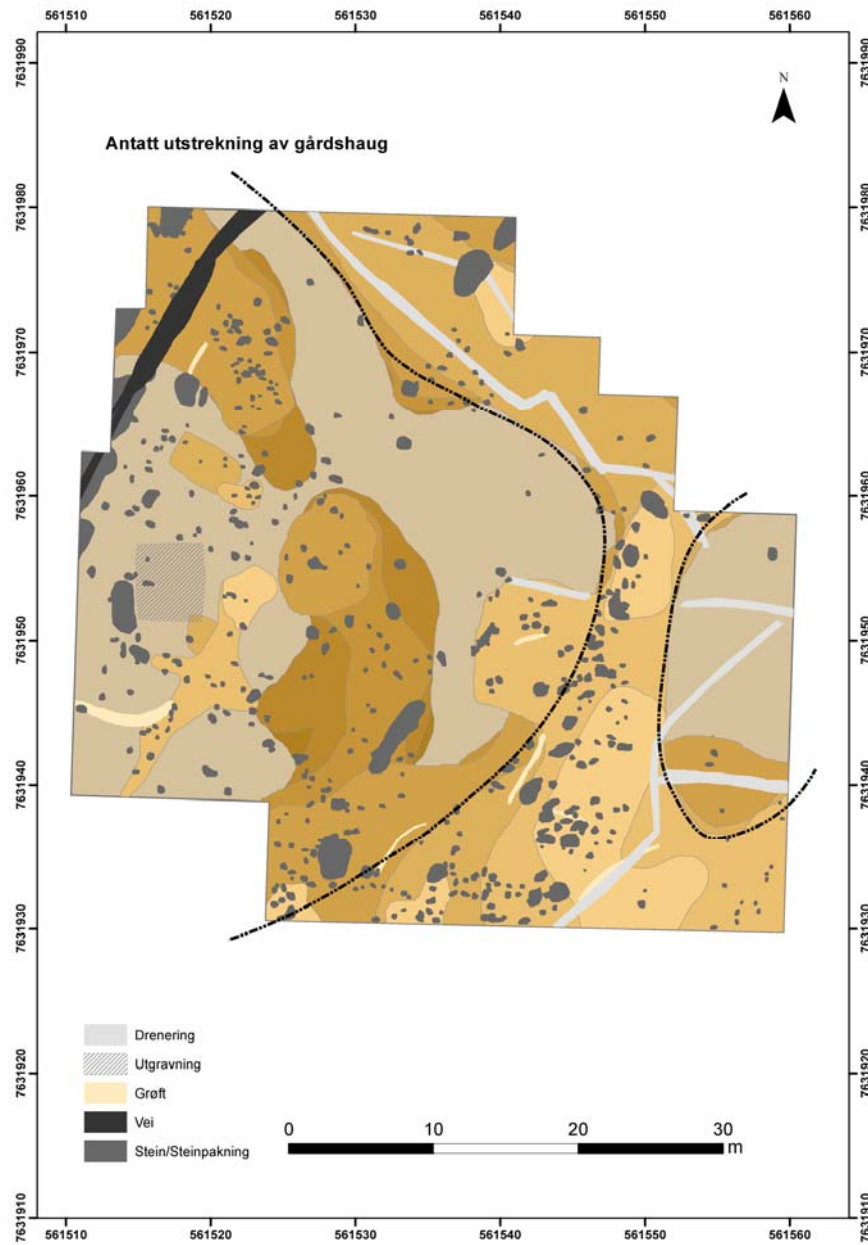


Figure 28 Suggested size of Saurbekken farm mound from interpreted GPR data. LG/NIKU. From Gustavsen 2013. Drenering=drainage; utgravning=excavation; grøft=trench; vei=road; stein=stone.

3.4 Economic background for rural settlements

The farm mounds are expressions of varied ethnic, economic and historical background; Norse farms, Sámi fiord settlements and medieval fishing villages. To encompass all these, the term settlement mound might be deemed more accurate (Bertelsen 2011, Wickler 2016). However, farm mound is the term under which the sites are listed in the national heritage database, and it is the term most widely used and understood. Additionally, the Norwegian for settlement mound (*'bosettingshaug'*) does not communicate the monument type as well as farm mound (*'gårdshaug'*), and it certainly does not roll off the tongue as easily. Some farm mounds were deserted after the Black Death in the 14th century, some in the 18th century. A large number were deserted after World War II, when the Norwegian government gave active support (re-housing and jobs) to leave farms and move to the towns to work in factories (Alnæs 1999). Some are used parts of the year as museums, re-using preserved farm buildings from the 17th and 18th centuries without modern infrastructure updates, but many are still inhabited today (see further in Chapter 2).

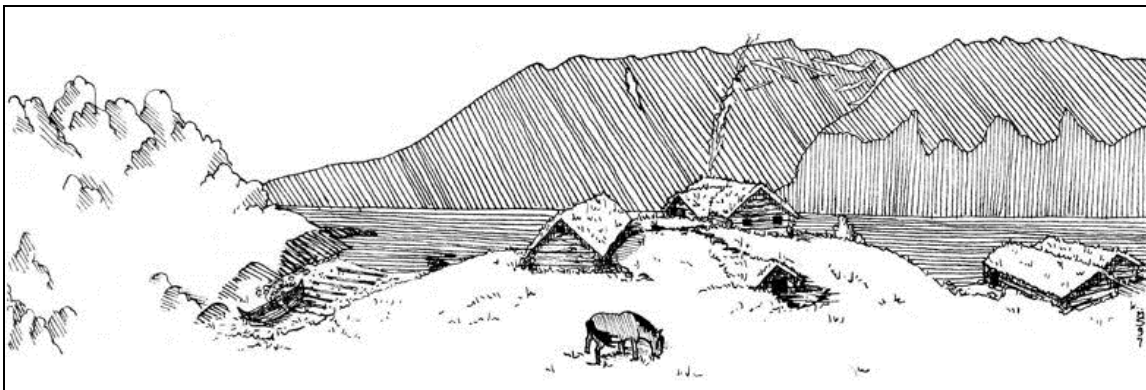


Figure 29 The farm mound Elgsnes in Harstad municipality. Reconstruction drawing by Marianne Skandfer 1997.

A farm mound or settlement mound may support only a single farm (Fig. 29), or several farms. The same type of settlement mounds are also found in Iceland, Greenland and the Orkney Islands (Bertelsen 1984, Urbańczyk 1992, Snæsdóttir 1993). Settlement mounds occur elsewhere, for instance in Jutland where they are known as *'byhøj'* (village mound), in the Middle East *tells* (village mounds) (Rosen 1986, Bertelsen 1989), in the western North Sea coastal region known as *terp*, *Wierde*, *Woerd*, *Warf*, *Werft*, *Wurt* or *værft* (farm/hamlet/village mound), but apparently the reasons for living at the same site for thousands of years and leaving a mound of archaeological remains differ. *'Byhøje'* and *tells* are often much larger and dated much earlier than the farm mounds. While the Dutch, German and Danish coastal settlement mounds are created in defence against the sea, with a deliberate build-up of deposits to raise the buildings out of reach of the tides, it seems that the North Norwegian farm mounds, like the Iron Age *'byhøje'*/settlement mounds of Jutland in Denmark (Runge 2009:161-165) were created more from a land use perspective – living on the non-arable land.

The first hypothesis put forward for the accumulation of farm mounds was Arthur Brox (Brox & Stamsø Munch 1965), who believed that farm mounds mainly existed because of the stock fish trade. It was the idea that the deposits must mainly consist of dung, because cereal production was not a main issue to these farmers, thus dung was not used to fertilize the fields but simply left to accumulate around the farm. Stock fish is Norway's longest sustained export commodity and socioeconomically the most profitable export over the centuries. Stock fish is first mentioned as a commodity in the Icelandic saga *Egils saga*, when allegedly the Chief Torolv Kveldulvsson in the year 875AD shipped stock fish from Helgeland in Norway to Britain. This product represented most of Norway's export and a large part of the economy from the Viking Age throughout the Middle Ages (Kurlansky 1997). It must be considered a valid hypothesis that the development of the Hanseatic trade and the Catholic need for a fish diet on fasting days all year around was a large part of the successful development of the stock fish trade (Simpson *et al.* 2000). However, there are indications that large scale fishing took

place in these waters even before that (Simpson *et al.* 2000), and there is no particular reason to assume that the rural economy of Northern Norway changed perceptibly in the transition to the medieval period.

Archaeological investigations of farm mounds from the past fifty years have proved that the main elements of the farm mound deposits are not dung, but house remains from houses built of wood and turf sods, and general household waste (Bertelsen 1984, Urbańczyk 1992, Lind 2002, Bertelsen 2011). This is comparable to the situation at the Iron Age settlement mounds in North Jutland. However, in this region it has been demonstrated that not only are flat settlements coexisting in the same regions but there are no remarkable construction differences between houses on the mounds and on the flat settlement. It may thus seem that the reason for the build-up of the archaeological deposits may be due to the use or lack of use of the fertile settlement ground for manuring the surrounding agricultural land (Runge 2009:161-165). Such a strategy would be understandable only if the economical emphasis was on husbandry rather than crops. In Jutland it is therefore seen as an indication of economical specialization; some settlements within a given area specialize on husbandry while others have emphasis on cultivation. In Northern Norway the mounds may be seen as a result of the climatic limitations for crop cultivation.

Bertelsen made a model for deposit accumulation of the farm mounds, with time and stability of location adding to the depth of the deposits, whereas natural breakdown, mobility of location and agricultural erosion contribute to the area it occupies (Bertelsen 1984:9). Even though the access to good fishing grounds and the increasing stock fish trade may be the direct cause of origin for some of the fishing villages and farm mounds, particularly in the Lofoten area, excavations have proven that this explanation does not hold true for all. In Iceland, the main economic subsistence factor was sheep and wool production (Snæsdóttir 1993). Through a lifetime of research on the North Norwegian farm mounds, Reidar Bertelsen has even proven that the main economical background for most farm mounds (with a possible exception for Lofoten) was not the stock fish trade but cattle (Bertelsen 1973, 1984, 2011). If one compares the findings of Bertelsen with those of Runge, it may be possible that husbandry as a main subsistence factor is more closely connected to the fixation of settlement and the building up of farm mounds.

3.5 Organisation of rural settlements

3.5.1 Farm mounds versus flat settlements

In most of Scandinavia, the prehistoric and medieval settlements are found archaeologically as one or possibly a couple of phases, leaving few raised traces, with the exception of fossil landscapes that have been left unaffected by modern land use. So what is the difference in case of the farm mounds? One major factor is certainly the use of turf sods as building materials. Urbańczyk suggests that when a turf house starts to disintegrate, it is not easily moved far away, since the sods are heavy, but quite easily spread out to form the basis of the next building phase (Urbańczyk 1992). Another fact is that the medieval household waste management consisted mainly of tossing waste outside, and eventually spreading it to form new flat activity surfaces. The pattern of deposit build-up is most obvious in the medieval towns, where many people lived in a limited space, but it is also seen in some Danish medieval villages, like Tårnby— which might perhaps also be termed a farm mound with its 1.3 metres of preserved medieval deposits (Svart Kristiansen 2004, 2005), and we see the same pattern on the Norwegian farm mounds, which are the largest assemblages of medieval archaeological deposits outside the towns. Since no excavations have been carried out in flat areas between farm mounds in Northern Norway, we do not know if any ordinary (i.e. flat) settlements exist at the same time as the farm mounds. It is therefore hard to assess whether the lack of flat medieval settlements in Northern Norway is reflecting reality or history of research. This is a hypothesis which ought to be tested.

In North Jutland in Denmark, flat settlements are found in the same areas as the settlement mounds, and often the two types of settlements are scattered between each other. The Danish village mounds ('byhøje') are defined as being raised settlement mounds of minimum 0.6m in height with settlement continuity of a minimum of 300 years (Runge 2009:161). The use of turf walls as opposed to wattle-and-daub was earlier explained by a lack of trees for building material in the landscape of Thy (Runge 2009:162-165).

The lack of available wood may likewise be a part of the explanation for the use of turf in Northern Norway, even though wooden house remains have also been found in the farm mounds (e.g. Lind 2002). However, in Jutland turf sods were used as wall building materials on many other sites, which were not transformed into mounds. Furthermore, in the eastern part of North Jutland wood was not as scarce a resource but even there, village mounds are found, with household waste as the major contributing factor to the build-up of deposits. Mads Runge therefore suggests that the reason for the formation of settlement mounds must be sought elsewhere and that the place continuity of 'byhøje' has its base in rights of property, economical specialization, and a strict social hierarchy, which again depended upon a need for optimal use of the arable land and building on the non-arable land (Runge 2009:162). Most of the settlement mounds in North Jutland have been dated to Late Bronze Age and Early Iron Age (including the Roman Period), and it is important to note that the typical contemporary settlement form in all of Southern Scandinavia is the flat settlement. It may therefore be, as Runge suggests, that the long lived settlements at the mounds represent a social upper stratum in the Prehistoric settlement. Whether this model may be transferred to the Norwegian farm mounds remains to be investigated, but the rich archaeological remains from the Roman and the Merovingian periods at the Åker mound indicate that it may be the case (Martens 2013).

3.5.2 *Single farms versus villages*

Of the two sites chosen in this study, Saurbekken is defined by its size as a single farm, while Voldstad with its cluster of farms in other countries and different research traditions would have been termed a hamlet. However, according to Norwegian research tradition the rural settlement was organized in single farms (cf. Øye 2016). Even when such farms are found in nucleated clusters it is generally denied that it reflects a village organization (Holmsen 1980). While this discussion is outside the scope of the present paper it is in its place to question why some farm mounds represent single farms, while others represent several. Rich economical resources on land or in the sea may be the foundation for larger communities, hamlets or villages, whereas a single farm does not need much to subsist. In Northern Norway two settlement mound types are actually called hamlets or villages, *fiskevær* (fishing hamlet) or *kirkevær* (village with church) (Bertelsen 1973, 2011), but using a different word for village than would have been used in the rest of the country (*vær*, instead of *klyngetun* or *landsby*). In the archaeological database of listed monuments in Norway, Askeladden, there is no clear pattern of single farms contra clustered farms (*klyngetun*), but that may be because of the Norwegian research tradition of not calling settlements with more than one farmer hamlets or villages, but rather calling all of them farms, some then separated into several households with individual owners/holders (with the above mentioned exception of fishing and church villages). It is important to note that the Norwegian term 'farm' differs from the continental in that it may cover more than one household. Still, in many cases it is hard to imagine that there was no cooperation between the single households in a nucleated cluster of farms.

3.6 **Economy and land use**

As indicated by ecofacts and climatic restraints, the economy of the farm mounds seems to base primarily on husbandry supplied with fishing and hunting. There are, however, regional differences.

If one looks at the spatial distribution of the listed farm mounds, it is notable that all the ones in Finnmark County are coastal locations (Fig. 18), indicating that an economy based on income from the sea is a likely deciding factor. The Finnmark farm mounds have large outfield areas, and the keeping of sheep and goats, possibly cattle, and possible keeping but certainly hunting of reindeer may have contributed to the economy, since this is so far north in the Arctic zone that cereal crops have no time to mature. Still, cereal may have been grown for cattle fodder, as is presently done. This theory is supported by plant macro fossil finds in stratigraphic investigations of farm mounds (Griffin 1985) and pollen studies of farm development in Northern Norway (Vorren 2009).

In Troms County (Fig. 19), the farm mounds are distributed along the inner fiord areas, with a notable concentration in the Harstad area. This area has much richer farming soil and a longer growth season, though it is still in the Arctic zone, making cereal production a possible though marginal income

source (Griffin 1985). However, even here cattle and sheep play a major role in the economy, and fishing is important, as evidenced by the ecofact finds from farm mound excavations (Bertelsen 1984). The largest concentration of listed farm mounds in any county occurs in Nordland (Fig. 20). Even this county is located almost completely in the Arctic zone. Here, the most intense concentration is in the Lofoten area, an archipelago to the north in the county. This area is characterized by steep mountains, small areas of arable land, and very good fishing grounds. It is a fair assumption that the stock fish trade is a major subsistence factor for these farm mounds. This landscape also exemplifies the land use question, since it would be logical to use the limited amount of arable land for agriculture, thus leading to settling on the non-arable land, and a build-up of settlement deposits creating the farm mounds. This process would then form a good parallel to the North Jutland settlement mounds in the Early Iron Age, as described above, though still leaving the question of why one does not use the well-manured settlement area for cultivation.

Even in the richer farming areas of Troms, there are few areas where it would have been possible to have the long strip fields which were ideal for the mouldboard plough, which was otherwise the revolutionary efficiency improving agrarian tool of Europe in the high middle ages. Archaeological traces of long, raised strip fields are very rare in Norway (see e.g. finds from Fyldpå in Vestfold County (Rødsrud *et al.* 2008). The archaeological evidence in the three northernmost Norwegian counties consists of ard marks, indicating that the use of the easier movable ard and, for the steep areas, spade and hoe cultivation, were most likely the preferred tools and cultivation methods throughout the medieval period (cf. Øye 2016).

3.7 Conclusion

A farm mound is a rural settlement containing archaeological remains from hundreds of years of settlement at the same site. The archaeological deposits have accumulated to form a mound, often making them distinct landscape features. They are listed monuments in the Norwegian national cultural heritage database, and they are the largest assemblages of medieval archaeological deposits outside the towns. The farm mounds are expressions of varied ethnic, economical and historical background and represent important sources to cultural history of both Norse and Sámi rural settlements in Northern Norway. Most of the farm mounds may be found in the counties of Nordland, Troms and Finnmark in Arctic Norway, but there are exceptions further south. However, they are so far few and far between. This may be partly a reflection of realities, but may also be a reflection on research traditions and investigation methods.

A farm mound or settlement mound may support only a single farm, or several farms clustered together (*klyngetun, fiskevær, kirkevær*). It is important to note that the Norwegian term farm differs from the continental in that it may cover more than one household. Some farm mounds were deserted at different points in history, others are still inhabited today.

Investigations have proved that the main elements of the farm mound deposits are house remains from houses built of turf sods and wood, and general household waste. As indicated by artefacts, ecofacts and climatic restraints, the economy of the farm mounds seems to base primarily on husbandry supplied with fishing, stock fish trade and hunting. It is suggested that husbandry as a main subsistence factor is the major reason for the fixation of settlement and the subsequent formation of the farm mounds due to the lack of use of the settlement soil as fertilizer on the arable land.

The fixation of the settlements and thus the creation of settlement mounds may further find its cause in more structured rights of property and a strict social hierarchy, which again depended upon a need for optimal use of the arable land and building on the non-arable land. The closest parallel to the Norwegian farm mounds may be found in the North Jutland settlement mounds (*byhøje*) from the Early Iron Age, which appear to be products of economic specialisation and social hierarchy. This may also be the case in Arctic Norway.

4 The Magnate Farm of Åker. Past, present and future of a farm with central functions³³

Abstract

Åker is one of few rural sites in southern Norway so far that may be classified as farm mounds, meaning that the settlement history is also indicated through preserved archaeological deposits or cultural layers. Spectacular finds indicate social stratification and make Åker stand out in the archaeological settlement investigations. This paper studies the site and focuses on methods for recognising magnate farms with preserved archaeological deposits with a minimum of destruction.

4.1 Introduction

In southern Norway, the site of Åker (Hamar, Hedmark County) holds a special status. Through archaeological investigations, settlement continuity has been documented dating from the present back to the third century AD. Åker farm is positioned at the lake Mjøsa between two river outlets, providing nautical transport possibilities south and north³⁴, and at two land crossroads, the old King's road from Oslo in the south, to the north through Gudbrandsdalen, and the road to Østerdalen (east-west) (Fig. 30). This paper intends to present the known site, the social position of the farm during the Middle Ages, and study methods for recognising magnate farms with preserved archaeological deposits, and to investigate these with a minimum of destruction (i.e. excavation).

Initially it has to be noted that the archaeological record concerning rural settlement from the Late Iron Age and the Middle Ages (6th-15th centuries AD) is very slender in Southern Norway (Martens 2004). In the museum district of Oslo which measures 2.5 times the area of Denmark only 36 medieval house sites on 18 locations had been investigated until 2004 (Martens 2009), and the number of house sites investigated from the Late Iron Age is even smaller (Martens 2007:102-103). The reasons for this are many, but no doubt research tradition is one of the main reasons. Another is legislation (Martens 2009: 13-14). Since it is traditional to explain the lack of Late Iron Age and Medieval settlement investigations with the hypothesis that it is because the present farms occupy the ground of their Medieval/Late Iron Age predecessors, it is of major concern that the legislation leaves these sites practically without protection³⁵. In 2004, a conference was held in Oslo in order to bring attention to this subject (Martens *et al.* 2009), but unfortunately it did not bring much change around. Thus the situation in the Oslo district is that archaeological excavations have only been carried out at a few farms which stand today: Åker in Hedmark (Hernæs 1989, Hagen 1992, Pilø 2005, Hildre 2006, Holseng 2006, Reiersen 2006), Fusk nordre in Østfold (Stene 2009), Rauland søndre in Buskerud (Tollness 1973), Them nedre in Vestfold (Johansson 2011), and Bygdø Kongsgård, Oslo (Karlberg & Simonsen 2009). The majority of the other excavated sites are situated in marginal areas seen from the perspective of agriculture (Martens 2009) and are consequently of limited comparative value.

³³ This chapter has been adapted and slightly modified with updated graphs and figures from Martens VV, 2013: The Magnate Farm of Åker. Past, present and future of a farm with central functions. In: J Klápště (ed.) Hierarchies in rural settlements. *Ruralia* 9, 329-339.

³⁴ Mjøsa is part of the Glomma River system, the longest river in Norway.

³⁵ This is due to an exception in the building legislation allowing farmers to erect new buildings on their farms without having to apply for building permission.

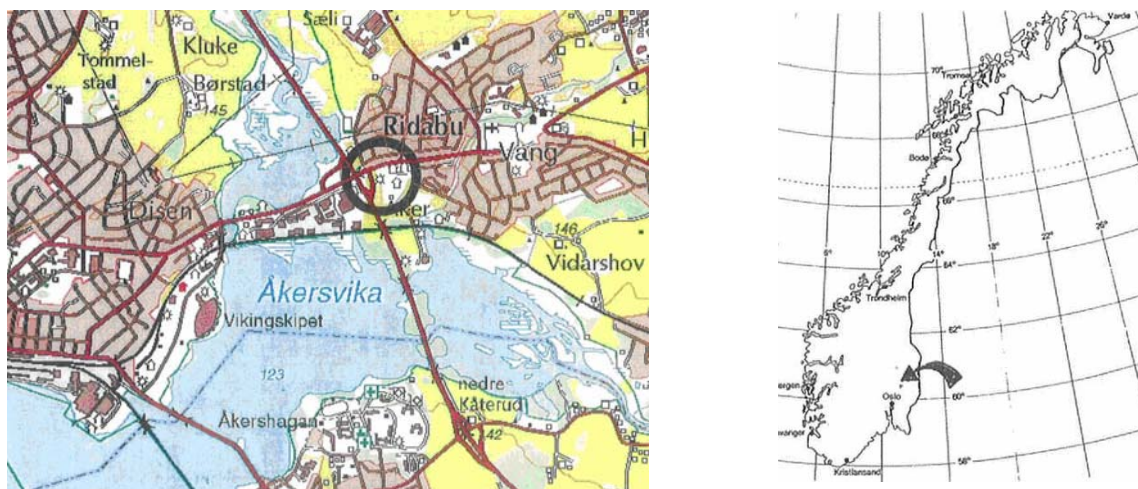


Figure 30 Åker farm encircled, at Lake Mjøsa east of Hamar, Hedmark, Norway. Map: MVH Multiconsult.

It is therefore difficult purely on the basis of excavated material to say anything certain about settlement hierarchy let alone rural settlements. However, there is a strong Norwegian tradition for settlement research but it is mainly based on indirect sources such as written documents, historical maps, place names, pollen diagrams, find distribution maps and the like (for a summary of this tradition see Pilø 2005, Martens 2009). Within this settlement research tradition it is believed that most of the medieval farms were founded in the late Roman Period. Even settlement hierarchy is being studied, for instance by means of studying historical taxation lists. The only problem is that from an archaeological point of view these studies have no material basis, meaning that there is little or no archaeological material to test the results against. So in reality we are at present not able to carry out a purely archaeological study on the topic, and the piecemeal material at hand may at best only serve as illustrative material of what kind of objects were in use at the time in question. Furthermore, the written sources and maps used for these studies are often of much later date, so in reality there are almost no first hand sources for the study of settlement hierarchy in the late prehistory and early medieval period.

4.2 Historical background

The name of the farm, Åker/Aker or Akr, indicates it as a possible pre-Christian cult site. However, the site is situated within an area crammed with cult names; Vang (with a 10th C church), Vidarhov, Torshov and Disen³⁶, just to mention the more obvious ones (Hagen 1992:13-17). A setting within a framework of cult names does not alone make it a cult site, but both oral tradition and written sources have often homed in on Åker as a special site. Åker is thought to have been a royal farm in the Scandinavian Viking Age (9th-10th C) and Early Middle Ages, i.e. 11th-mid 13th C, which was the period where Norway changed from a group of smaller kingdoms to a larger state. Historians believe that the Viking Age and Medieval thing site (Eidsivating) was situated at Åker (Aker) farm. In 1046, it is believed to be the site where the reconciliation between King Magnus and Harald Hardraade took place. The nearby town of Hamar which is the only inland medieval town of Norway was founded in the late 11th C at a place which was probably part of the same estate, but with a better harbour and easier to defend. Three coins minted by the king Harald Hardraade in Hamar ca. 1060 have been found at Åker (Sæther 1992). Thus, in the Late Iron Age and the Early Middle Ages Åker was a thing site, situated at an important communication crossroad, and most likely a royal seat. These central functions were subsequently transferred to the bishop's seat in Hamar in the High Middle Ages (ca 1250-1450 AD).

³⁶ Diser are Nordic mythology goddesses in Norway, Sweden and Iceland.

In accordance with this, written sources document that Åker farm was owned by the Hamar bishop from the mid 13th C (Sæther1992, Pilø 2005). In 1567, the Swedish army destroyed the town of Hamar, and a thing at Åker recognized the Swedish king as sovereign. Even in early modern times, Åker was owned by noble families, and later families with high official status, until it was taken over by the Norwegian Army after WW2. The southern main building burnt down in February 1947, and was reconstructed within the next year. Today it is owned by Statsbygg, the state building society. Still today two main roads meet next to the farm, E6 (N-S) and Rv25 (E-W).

4.3 Earlier archaeological investigations

Åker is one of few rural sites in southern Norway that may be classified as a farm mound, meaning that the settlement history is indicated through accumulated preserved archaeological deposits or cultural layers (see further in the previous chapters). Spectacular finds, particularly from the Merovingian period, are indications of social stratification that make it stand out in the archaeological record of Norway. It is the bad luck of this site to have been investigated, but only in parts, by archaeologists.

The archaeological finds that are most often connected to the site of Åker, the Aker hoard, were actually found on a hill with two grave mounds on a field belonging to the farm, but situated ca. 300 meters north of it (Nybruget 1992:29). Already in the late 19th C, from 1868-1912, finds from what is now termed the Aker hoard (Åkerfunnet) were given to the museum in Oslo (Museum of Cultural History/KHM, previously Oldsaksamlingen, University of Oslo). Unfortunately, these prestige finds were all found by local people and without archaeological investigations, so the proper find contexts are uncertain. They may come from a grave, or be a sacrifice at a holy place. Nybruget argues (1992) that it is more likely a depot find. Stylistically, all the finds belong to the late 5th to mid 7th C AD, the Merovingian period. In the 1990'ies, the find site was reinvestigated, and more parts of the hoard were uncovered, even bits completing some of the more spectacular finds (Hagen 1992, Nybruget 1992). Apart from parts of a sword hilt, a shield buckle, shield fittings and strap end buckles, the most spectacular single object is a belt buckle of gold covered silver and bronze, precious stones and enamel (Fig. 31), museum number C4901) (Nybruget 1992:24).



Figure 31 C4901. Photo: KHM, UiO.

Figure 32 C4901, detail. Photo: KHM, UiO.

The buckle shows a man with a moustache, possibly bearing a crown. His hair is combed neatly to the sides; he wears trousers and a long sleeved tunic (Figs. 31 and 32). Wild boars are at his feet, and above his head are eagle heads, and his hands are raised as if to protect himself against these. The belt buckle, the sword and the shield are prestige objects which are without parallel in 6th C Norway. The objects have high symbolic value, socially, religiously, politically and economically, and have therefore been interpreted as signs of a Scandinavian level of chieftains or small kings – definitely the top of the hierarchy. During the 1980ies and 90ies, parts of the areas N and W of the main farm buildings were excavated to allow the two main roads to expand to modern size (Fig. 33

Figure). In the same decades, cable trenches were dug from the medieval storehouses to the end of the long barn, and other trenches were dug from the southern main building, around the long barn, along the road to the north all the way to the building furthest to the northeast in the complex, the one called The Cube. Apart from these recue excavations a research excavation was carried out by Lars Pilø 1992-94 south of the long barn, southwest of the present main buildings and east of the road expansion.

The research excavation resulted in a Late Roman Period longhouse, which was later marked on the ground with concrete on site, to illustrate the earlier settlement phase to modern visitors (Fig. 34

Figure). From the Roman and Migration Periods, finds were made of smithies, jewellery – and comb production and several houses. In Late Merovingian Period/Early Viking Age, these longhouses were replaced by a 30-40 m long longhouse. Around this late house were found mounds of stones from brewery activities (Pilø 2005:111). Posts from a house dated to the Late Viking Age/Early Medieval Period were found close to the modern main buildings, along with masses of heat affected stones in thick layers. These stones are associated with brewing (Pilø 2005:111).

No archaeological remains from the late medieval or renaissance have been excavated, but it has been claimed that the main building which burned in 1947 (and was immediately reconstructed) contained medieval timber.

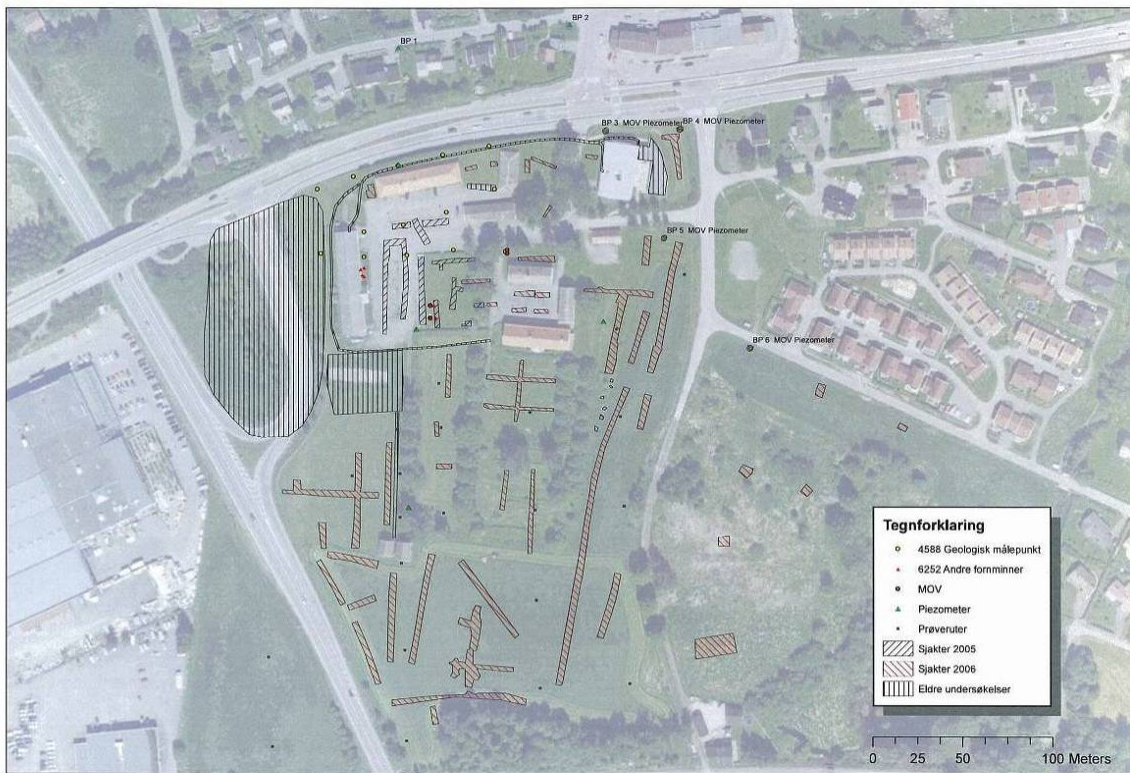


Figure 33 Map of archaeological investigations at Åker. Map: F. Hansen, Hedmark County 2008.



Figure 34 Aerial photo of Åker: Geodata. Red marking of Roman Period house by VVM.

About 1750 a baroque garden was made south of the main buildings and masses of brewery stones were cleared off and used in the garden planning (Fig. 35). Again in 2005 and 2006, the farm was pre-investigated to decide on whether or not it would be possible to develop it further, add new buildings and possibly even reconstruct the baroque garden (Hildre 2006, Holseng 2006). Despite the fact that previous investigations had provided ample evidence that the farm and the area around it included archaeological remains from the Roman Iron Age and onwards, and had preserved archaeological deposits up to two meters thick, a large number of search trenches were cut right down to the subsoil in search for dug in structures like post holes or fire places, even going very close to the known historical buildings and through the farm mound itself (Fig. 33). This method which may seem unnecessarily intrusive was at great costs to the archaeological deposits which were not documented or examined at that time³⁷. This is all the more grave since it is a well-known fact that medieval building structures in Norway were mainly laid out on the surface of the ground and not dug into the subsoil.

The present state of affairs is that the Åker farm is still today a stately site and the main buildings most probably stand on the same site as their medieval predecessors on top of a clearly defined settlement mound (Figs. 36 and 37). This mound is not a terp, as known from the Dutch, German and Danish marshland areas but more similar to the North Jutland ‘byhøje’ (see Chapter 3), as it consists of archaeological deposits that have been accumulated during a long settlement period, certainly dating back to the 9th century AD at this exact site (from the latest, unpublished finds), but further settlement covering the period from the Late Roman Period up to the 9th century AD has been documented only a few meters to the south west (Pilø 2005).

³⁷ It is important to note, that the registration was carried out by the county archaeologists in accordance with explicit instructions from and in dialogue with the Museum of Cultural History at the University of Oslo (KHM) and the Directorate of Cultural Heritage (RA).



Figure 35 Section through garden at Åker, showing compact layers of brewing stones. Photo: K. Reiersen.



Figure 36 Åker seen from the east. Main buildings on defined mound. VVM/NIKU.

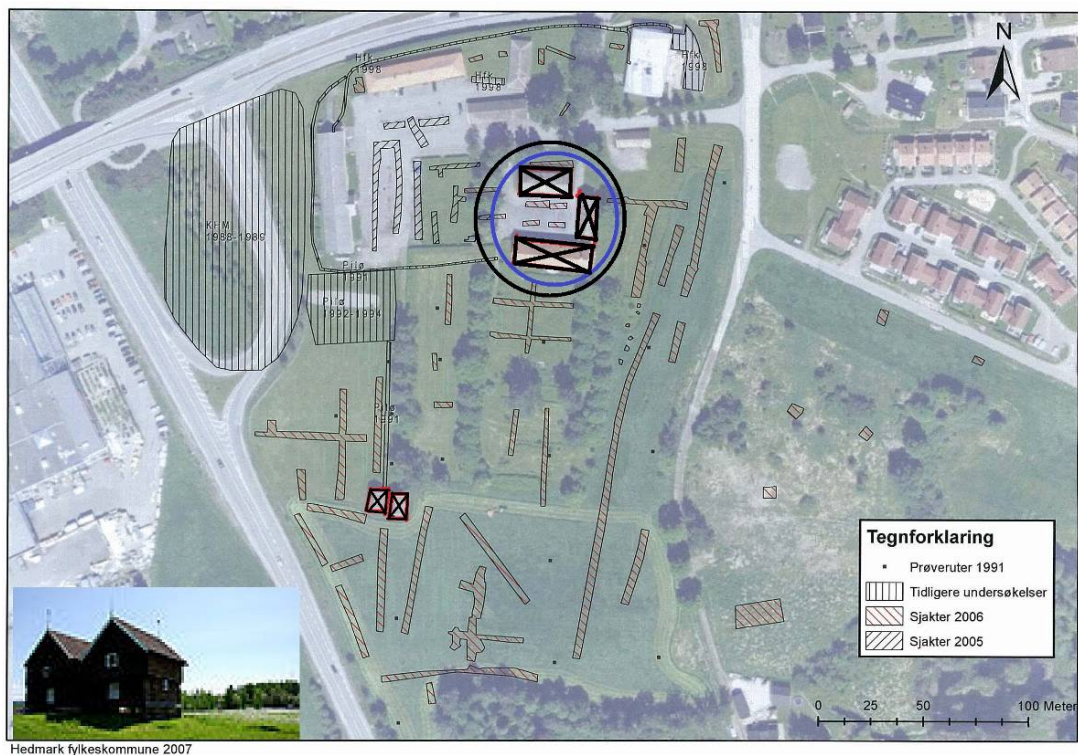


Figure 37 Overview of Åker, mound approximately marked by circle. Medieval buildings (lofts) and buildings with possible medieval origin (main buildings) marked with X. Storage lofts are also inserted in left hand corner. Map: F. Hansen, Hedmark County. Markings by VVM.

This type of archaeological monument has in Norway mostly been found in the far North (Bertelsen 1978; Bertelsen 1989), but investigations during the past two decades have shown that these farm mounds also exist in southern Norway (Karlberg & Simonsen 2009, Stene 2009, Martens 2010). If one looks at the archaeological artefacts found during the excavations at the farm itself, a few finds date back to the Late Neolithic/Early Bronze Age (Amundsen 1998). However, the overwhelming majority of the finds are from the Migration Period, Merovingian Period, Viking Age and Middle Ages (Hagen 1992, Sæther 1992, Pilø 2005, Holseng 2006; <http://www.unimus.no/arkeologi/forskning/sok.php>). Most of the finds could be considered typical settlement finds; spindle whorls, soapstone vessels, slag and other remains of smithy activities, and even the brewing stones. Still, the number of unusual finds is much higher than for most settlements; brooches and other jewellery, fragments of drinking glass, weaponry, riding equipment (spurs, stirrups, bridles, straps/buckles, horse shoes) and coins. Early medieval silver coins are very rare in Norway, and to find three of them on one site is unique outside the towns and known market places. Thus the archaeological artefacts from Åker support the theories of the site being something more than an ordinary farm, at least from the Migration, Merovingian, Viking and medieval periods, thus reminding of the Danish ‘metal detector’ sites.

At present the farm consists of the following buildings; the three main buildings, surrounding a court yard, a very long barn completing the farm to the west, and two storage lofts situated about a hundred meters south of this main building complex, plus a few modern buildings furthest to the north and north east. Of these the lofts are medieval and the main buildings may have medieval remains but are mostly 18th C AD. The long barn is 18th C AD but goes further back, possibly the same building but otherwise one placed at the same site, but this has not been investigated³⁸.

³⁸ This is due to legislation; the building is too young to be protected by the Norwegian Cultural Heritage Act and therefore also exempt from archaeological investigations.

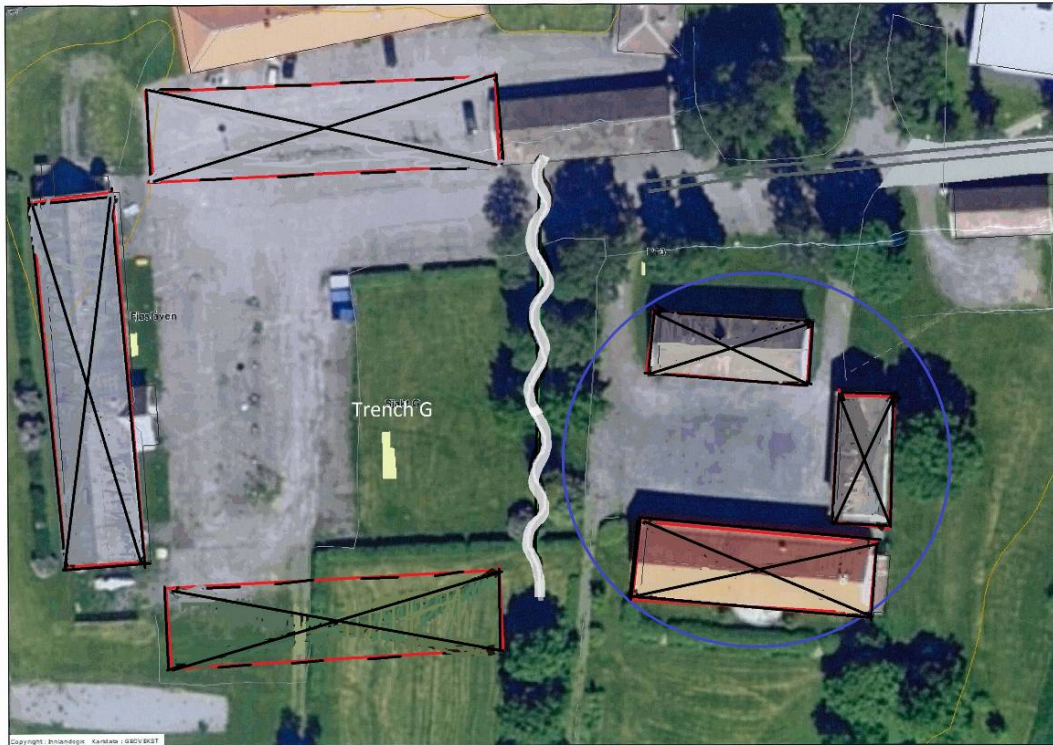


Figure 38 Aerial photo of Åker: Geodata. Markings of 17th C buildings (red/X) and fence (white squiggly line) by VVM. Note the position of trench G marked in light yellow.

We also know from written and pictorial sources, as well as excavations, that at least from the 17th C AD two further buildings had flanked the barn (Jerpåsen & Mehren 2006), so that the main complex consisted of 6 buildings surrounding a very large courtyard (Fig. 38). The western part of this was separated from the eastern part with a fence. This is an unusually large farm complex, underlining its high social status.

4.4 Geoarchaeological investigations

In 2007 and 2008, the latest investigations were made at Åker, to decide whether or not it would be possible to use the buildings for other purposes, specifically archive and library, and to erect more new buildings on the site to fulfil state requirements on archive safety. Before this could be realized a new prospection project was initiated. This time the aim was to apply the least possible intrusive methods, while still getting a maximum of information. Therefore excavation of a few small trenches was combined with a larger number of augered boreholes, in combination with geophysical investigations like measurements of electrical conductivity, measurements of ground water levels and the directions of the ground water streams, and instalment of monitoring equipment. Thorough descriptions of the archaeological deposits and their conditions when uncovered were made, and elements defining future preservation conditions were measured in soil samples.

The largest trench (trench G) was about 6 metres long and 1 metre wide, and it was placed between the main buildings and the long barn. This was a reopening of an earlier trench, extending it by 20cm in width in its whole length, thus avoiding and minimising further destruction of the archaeological deposits. In the trenches the deposits could be observed as rather coarse and porous layers, which were at the most just a little more than one metre thick (Figs. 39 and 40). Probes measuring soil temperature and humidity were installed in the section, attached to a datalogger in order to monitor crucial factors indicating changes in the local preservation conditions. This monitoring still continues.

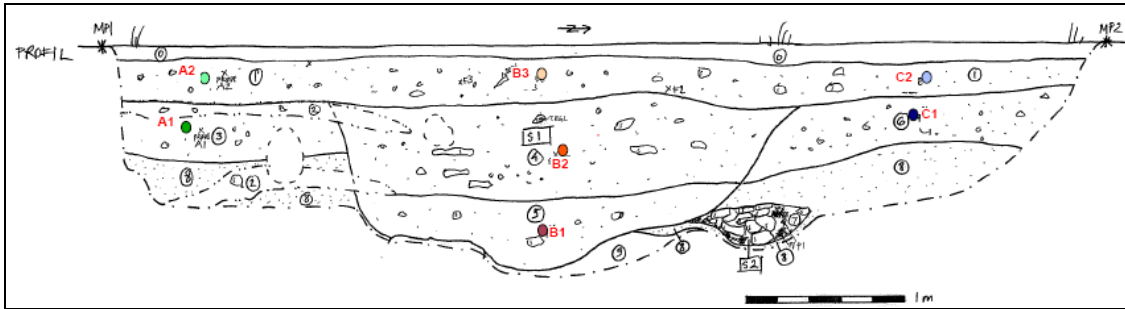


Figure 39 Trench G, Åker 2007. Section with probes measuring temperature and soil moisture. VVM/NIKU.



Figure 40 Section in trench G, Åker 2007, with soil probes installed. VVM/NIKU.

The boreholes were made with an auger of 10cm in diameter (Figs. 41 and 42). This is the minimum auger size if one is to get sufficient information about the deposits. Smaller diameter augers have more closely spaced windings, which distort the deposits beyond recognition. Besides, if the deposits are dry and porous, there is a risk that no material stays on the auger, making analyses impossible. After augering, archaeological evaluation and description and physical and chemical sampling, the boreholes were either used to install piezometers to check the ground water levels and ground water flow, or they were back filled and sealed with bentonite in order to minimize their influence on preservation conditions. All archaeological deposits were described and characterized from their biological, zoological, mineral and artefact components. The state of preservation noted at the time of the archaeological excavation varied from lousy to medium in the section (Table 8) (NS 9451:2009; Martens *et al.* 2007) and from poor to excellent in the augered boreholes (Martens *et al.* 2008, Martens 2010).

Table 8 State of preservation scale (SOPS) after RA&NIKU 2008 and NS9451:2009.

PRESERVATION SCALE		DEGREE OF PRESERVATION						
		NULL-VALUE	LOUSY	POOR	MEDIUM	GOOD		
POSITION IN RELATION TO GROUNDWATER	OVER	A0	A1	A2	A3	A4	A5	A
	OVER/IN	B0	B1	B2	B3	B4	B5	B
	IN	C0	C1	C2	C3	C4	C5	C
		0	1	2	3	4	5	
Fill etc. later than ca,1900		D0	D1	D2	D3	D4	D5	D

© RA & NIKU



Figure 41 Augering at Åker 2008. VVM/ NIKU.



Figure 42 Augered medieval deposits. VVM/ NIKU.

To characterize the conditions for further in situ preservation of the archaeological deposits, chemical measurements of iron, sulphate, sulphide, nitrate, ammonium and organic matter were made for each deposit. In addition physical parameters such as the distribution of water filled and air filled pores, water content, salinity and redox potential (Martens *et al.* 2007, 2008, Martens 2010).

The deposits were mostly dry and rather porous, allowing both airborne and waterborne oxygen to be transported into the deposits, and thus increasing the risk of degradation of organic matter and all organic artefacts. Porous deposits also allow intrusions of water which may degrade inorganic artefacts such as pottery or metal objects. The archaeological deposits at Åker are very similar in composition and content to those of the nearby medieval town of Hamar, and it is probably safe to conclude that the threats to Åker – continued degradation of deposits due to dewatering and ultimately loss of contextual information – also hold true for Hamar (Martens 2010:80).

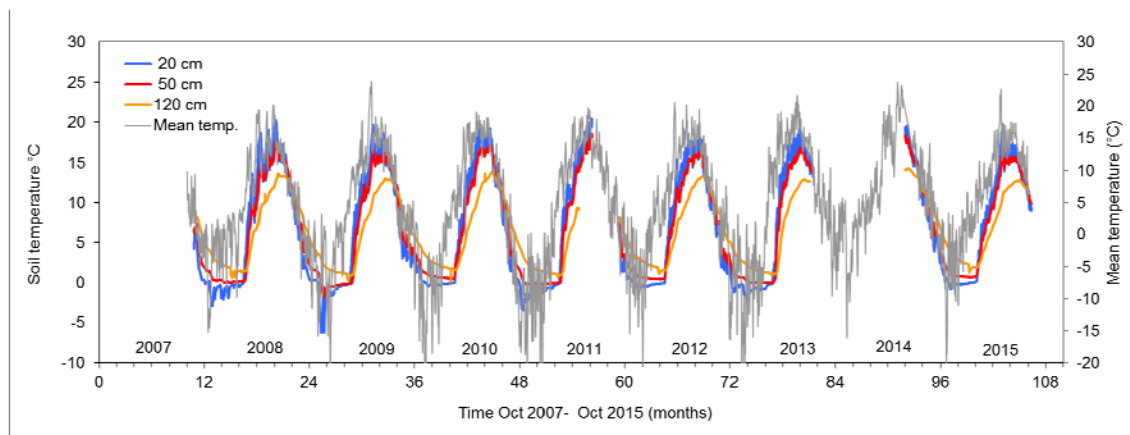


Figure 43 Åker farm mound, measurements soil temperatures compared to recorded air temperatures. Work by Ove Bergersen, NIBIO.

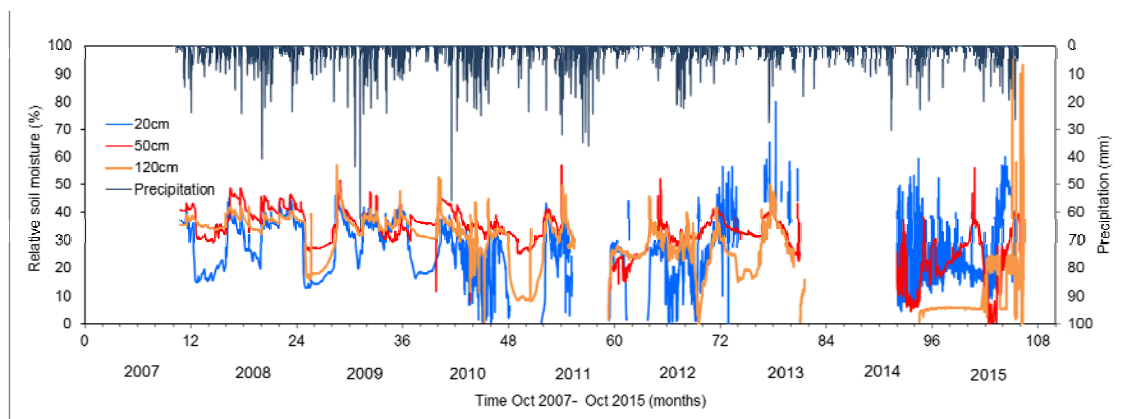


Figure 44 Åker farm mound, measurements of soil moisture compared to recorded precipitation. Work by Ove Bergersen, NIBIO.

Soil samples were analysed for redox parameters to define preservation conditions and these showed medium preservation conditions for metal objects, but lousy conditions for organic finds. This may not have been very surprising, but it was an important confirmation of the archaeological observations. Long-term monitoring equipment was installed in the exposed section, probes measuring soil humidity and soil temperature. These show that particularly the top deposits react directly to changes in air temperature and precipitation³⁹ (Figs. 43 and 44). The results were not unexpected, considering the nature of the deposits, but it is the first longer measurement series from a rural context in Norway. Unfortunately, battery failure has caused loss of data in shorter periods between 2007 and 2011, and from 2013 to 2014, but new data is continuously collected for as long as the equipment holds.

4.5 Geophysical surveys

A relatively simple geophysical method, measuring electrical resistivity was carried out by Esther Bloem, NIBIO, at Åker in 2008, and it gave surprisingly informative results. A system of lines was laid out with a distance of 1 metre between the electrodes. That way an area of 100x50 m was mapped, in addition to a line at the trench (G) that was investigated in 2007.

The measurements provided information on layering of deposits over a larger area and supplemented the physical, chemical and archaeological investigations from the augering (Martens *et al.* 2008:20). They showed that a thick layer of subsoil clay covered the whole site, just beneath the archaeological deposits. This ensured that soil humidity was kept in or at least not immediately drained away from the archaeological deposits even though these were all in the saturated zone, well above the groundwater level (Martens *et al.* 2008:20).

4.6 Conclusion

As mentioned in the introduction, little is known about the rural settlement of Late Iron Age and Early Medieval Norway. In Eastern Norway this is among other reasons due to the lack of investigations at existing farm sites (Martens 2009). It may therefore be hard if not impossible to assess the function of the Åker farm in the local context. It is a generally accepted but never really tested hypothesis that the farms known from the Medieval written sources are situated below their present successors and that they should have their roots in the Late Roman Iron Age or Migration Period. However, in the very large museum district of Oslo this has only been demonstrated in a few instances. Åker is one, others are the nearby deserted site Valum, also in Hedmark (Pilø 2005), further Fusk in Østfold (Stene 2009),

³⁹ Air temperature and precipitation data from www.yr.no

Bygdø kongsgård in Oslo (Karlberg & Simonsen 2009), Rauland søndre in Buskerud (Tollness 1973), and Them nedre in Vestfold (Johansson 2011). To these could be added sites such as Kjølberg søndre in Østfold (Martens 2007), Kvernås and Habberstad in Akershus (Skre 1998) and possibly even Moi in Aust-Agder (Reitan 2011) where Late Iron Age houses have been excavated very close to the present site of the farm.

It is therefore still the written sources and other indirect sources that form the back bone of Norwegian research on Medieval and Late Prehistoric settlement hierarchy. In the case of Åker and many other sites we may add illustrious stray finds or grave finds found in the vicinity but still we do not get a real grip of what was going on at the settlements and to what extent their position was reflected in their organisation, construction or living standard.

While shedding light on this is still a task for the future, there is no doubt that the farm Åker in itself represents something special and is worth attention. Since it is still in use for various purposes it is important to secure that it and its unique history is preserved.

Though the 2005-6 investigations at Åker may have been more damaging than fruitful they may at least have resulted in underscoring one thing; the importance of applying suitable methods for the purpose and the character of the object. Even the archaeologist must always keep in mind that cultural heritage is a finite resource, and this is especially important when dealing with a unique monument of national importance like in the case of Åker.

The latest investigations at Åker, both archaeological, geoarchaeological and geophysical, have confirmed the presence of archaeological deposits to an extent that is not usual for so-called ordinary settlements in South Eastern Norway, but which reminds more of the farm mounds of northern Norway and of the medieval towns. They have also shown the fragility of the site and a doubtful outcome of future *in situ* preservation, particularly due to the quite damaging and very large number of trenches that have been dug in search of subsoil structures but disregarding the known preserved deposits. The trenching also put limitations to future research at the site since their extent make it difficult to operate with longer unbroken sections.

The methods of augering to define the presence and state of archaeological deposits, combined with resistivity measurements to model deposits over larger areas, have proved highly efficient, giving a maximum of information with a minimum of destruction of already fragile archaeological remains. The monitoring of soil moisture content and soil temperature will continue for as long as the equipment allows.

To sum up the matter, all the indicators of a special position in the social and political hierarchy, combined with the investigations proving how fragile the site really is, led to the conclusion that it could not be used for the intended purposes; no new buildings could be erected there, especially none with basements, since that would disrupt the protective subsoil clay horizon. The future of Åker farm mound is therefore highly uncertain.

5 *In situ* site preservation in the unsaturated zone: case Avaldsnes⁴⁰

Abstract

*In recent years, attempts have been made to transfer systems of monitoring archaeological deposits outside the medieval towns. This paper presents the results of investigations and monitoring at the Royal manor site of Avaldsnes, Karmøy municipality, Rogaland County, Norway. Methods of measuring directly in soil are discussed and tested, as most sites with preserved archaeological deposits outside and even to a large extent within the medieval towns are in the unsaturated zone and thus require different tools and methods for measuring relevant parameters than sites with accessible groundwater. The state of preservation at Avaldsnes as observed during the excavation campaigns in 2011 and 2012 is presented and conditions for future *in situ* site preservation and site management are discussed.*

5.1 Introduction

The importance of the preservation of cultural heritage is stressed by international treaties and conventions. The European Convention on the Protection of the Archaeological Heritage (Council of Europe 1992), also known as the Malta or Valletta Convention, was designed to protect the archaeological heritage as a source of the European collective memory and as an instrument for historical and scientific study. The treaty calls for ‘the conservation and maintenance of the archaeological heritage, preferably *in situ*’. This means that archaeological sites must be actively maintained, or investigated, and not just left to natural deterioration or subject to anthropogenic destruction. From June 1st 2011, the Faro Convention (Council of Europe 2005) was implemented to focus on protection and sustainable use of cultural heritage to further human development and quality of life. The Norwegian Directorate of Cultural Heritage has proposed that it will undertake its statutory duty of preserving the national heritage primarily by seeking to preserve archaeological sites *in situ*. This is in accordance with the Norwegian Ministry of Environment’s stated aim to preserve the underground archives (MD 2005). It is also adhering to the guidelines in the national standard from 2009 (Norwegian Standard NS 9451) about ‘Cultural property. Requirements on environmental monitoring and investigation of cultural deposits’. It is an explicit aim to ensure long-term preservation of the archaeological remains (cf. MD 2010, 29-30), and that archaeological remains should not be reduced by more than 0.5% a year (MD 2005).

Archaeological deposits are a part of our cultural heritage containing physical evidence of our past practices and interactions with nature. Deposits of various ages present in the rural and urban landscapes are geo-ecosystems affected by environmental processes (Kars & Kars 2002, Huisman 2009). The changes to the environment caused by global warming and other environmental threats, including human activities such as intensive land use, continuous urban development and even archaeological excavations may put archaeological evidence at risk and are a challenge for present and future management of cultural heritage.

⁴⁰ This chapter has been adapted and slightly modified from Martens VV & O Bergersen 2015: *In situ* site preservation in the unsaturated zone: Avaldsnes. *Quaternary International* 368, 69-78. Concerning the distribution of responsibility between the authors, it has been agreed that 65% of this text is the work of VVM and 35% of OB, with each author having main responsibility for her/his subject, and VVM additionally for gathering it all together.

How fast do archaeological materials and soil features degrade? At which point will the contextual value of the deposits become unreadable and impossible to interpret? And what measures can we take in order to promote a sustainable *in situ* preservation? During the past decades, work on *in situ* preservation of archaeological remains has taken place as a consequence of the Valletta charter of 1992 (Willems 2008). However, much of the work so far has dealt with questions of the feasibility of *in situ* preservation without debating to what extent it is the desired solution, or if preservation through excavation and documentation could be a better option (Membery 2008, Martens 2010). *In situ* site preservation puts a large responsibility on future generations, as the concept implies that the deposits remain unchanged 'forever'. To ensure that *in situ* preservation fulfils the requirements of a sustainable strategy for archaeological remains, knowledge about the present state of preservation or conservation as well as the physical and chemical conditions for future preservation capacity is necessary.

5.2 Aims and goals of the main research project

The aims of the research project "*In Situ* Site Preservation in the Unsaturated Zone" (2011-2015, funded by The Research Council of Norway) are through selected cases to study *in situ* site preservation as a strategy, its possibilities, limitations and consequences, to test the relevance of analyses and methods required by the Norwegian Standard on sites other than saturated urban deposits, to develop methods to gain information on conservation state/ state of preservation and preservation conditions as tools for making informed decisions within cultural heritage management and to ensure long-term preservation of the archaeological remains (cf. MD 2010:29-30). It is important to further develop methods and work on data on monitoring preserved archaeological deposits from all periods, urban and rural. Quite a lot of work has been carried out concerning conservation state and preservation conditions in the saturated zone (i.e. below ground water level), in Norway particularly at the World Heritage Site of Bryggen in Bergen, but also the Netherlands and the UK have had extensive projects (see e.g. Christensson 2004, Smit *et al.* 2006, RA&NIKU 2008). The general conclusion is that archaeological deposits usually are very well preserved under waterlogged and strongly anoxic conditions (Caple & Dungworth 1998).

This project concentrates on the unsaturated zone, i.e. the deposits above the ground water table. That is because most preserved archaeological deposits outside the Norwegian medieval towns, and quite a large number of the deposits within the towns, are in this zone, and these deposits, along with those in the fluctuation zone between saturated and unsaturated, are the most vulnerable to changes and degradation. The hydrological conditions may vary considerably in these soil layers, resulting in heterogeneous conditions both horizontally and vertically in the deposits and an added risk of exposure to oxygen and thus accelerated degradation. To characterize the preservation conditions in dry or relatively dry layers, the presumed most important parameters are organic matter content (to indicate which artefacts and ecofacts may be preserved), oxygen content or redox parameters (to see if conditions are stable or not), soil temperature (to see to which extent the deposits are affected by air temperature; it is an assumption that lower soil temperatures are better for preservation), soil humidity (to indicate which artefacts and ecofacts may be preserved and to see to which extent the deposits are affected directly by precipitation) and soil porosity (to see how easily oxygen may penetrate into the deposits).

The project works with interdisciplinary methods to obtain a sustainable *in situ* management of urban and rural cultural heritage as expressed in the archaeological deposits, by the identification of the environmental and societal parameters affecting the present state of preservation and conditions for future preservation of archaeological deposits in the unsaturated zone. International and present Norwegian methodologies within archaeology, soil physics, soil chemistry and microbiology are identified and evaluated, and the suitability of the methods according to the set national Norwegian standards (RA&NIKU 2008; NS 9451) for measuring and description of the state of preservation and preservation conditions in archaeological deposits in the unsaturated zone are discussed. The standard specifies in great detail how archaeological deposits must be described to enable evaluation of preservation state. At the outset, the standard must be used on all urban archaeology and on all environmental monitoring projects, but it has been stated that the intent is to make it a national

requirement for all archaeological investigations. Since this was an environmental monitoring project, we were required to use the standard, but we also chose to test the relevance of the description systems and the geochemical analyses on this site, as part of an on-going evaluation of the standard. Since Norwegian heritage authorities work towards making it a European standard, we believe that such a test is highly relevant. We particularly wished to check the suitability of the national required methods for characterising redox sensitive parameters like the redox-pairs ammonium/nitrate ($\text{NH}_4^+/\text{NO}_3^-$), ferrous/ferric iron ($\text{Fe}^{2+}/\text{Fe}^{3+}$), sulphide/sulphate ($\text{S}^{2-}/\text{SO}_4^{2-}$), and organic matter content in the laboratory.

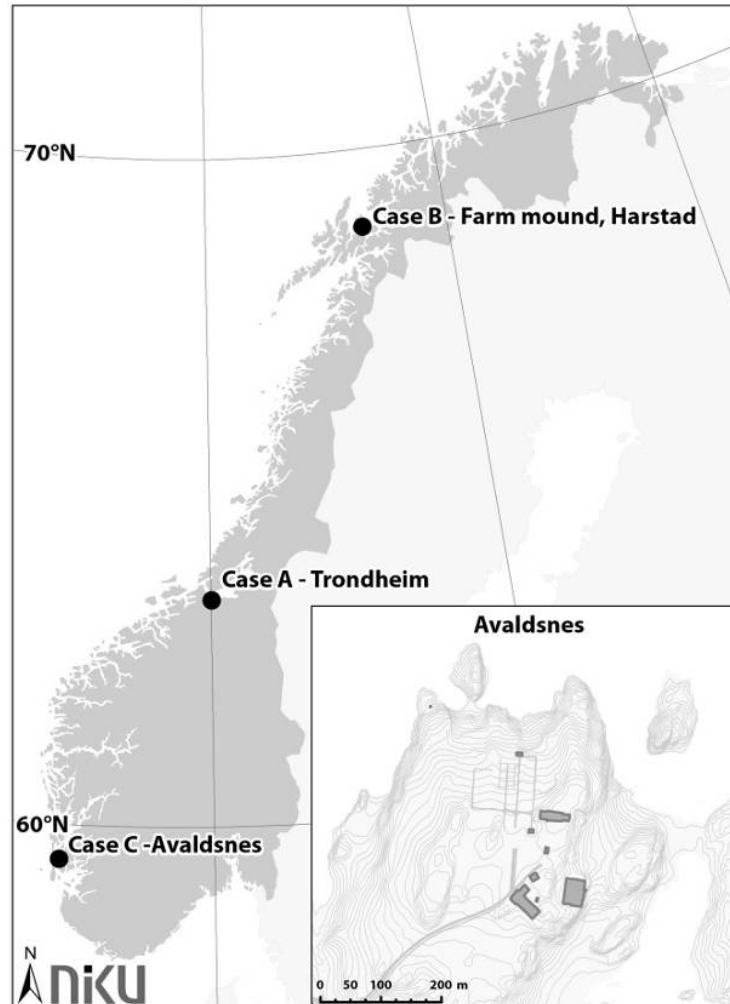


Figure 45 Map of Norway showing sites in the research project. TP/NIKU

5.3 Material and methods

Three different case sites were chosen, allowing for a section through the length of the country (Fig. 45 Figure).

Case A: Schultz gate, the medieval town of Trondheim, Mid-Norway. Urban unsaturated archaeological deposits. Archaeological investigations prior to building, augering September 2012, developer paid the project (Petersén & Bergersen 2009, 2012).

Case B: Medieval farm mounds in Troms County, North Norway. Saurbekken in Harstad, surface laser scan and geo radar investigation May 2012, rescue excavation and installation of monitoring

equipment November 2014, and Voldstad, Harstad, research excavation and installation of monitoring equipment August 2013.

Case C: Avaldsnes, Karmøy, Rogaland, West Norway. Preserved archaeological settlement remains from Bronze Age to medieval in a farmed and settled area.

Only case C will be presented in the present paper. The site has been partly excavated in 2011-2012 within the research project Kongsgårdsprosjektet Avaldsnes / The Avaldsnes Royal Manor Project led by the Museum of Cultural History in Oslo, and the environmental monitoring field work was carried out in cooperation and dialogue with the project leaders. To allow the research excavation at a site which was otherwise not threatened by development, it was a requirement from the Directorate for Cultural Heritage that the state of preservation of the disturbed archaeological remains was evaluated and that environmental sampling and monitoring of preservation conditions was carried out in accordance with the national standard, and it was specified that sampling should include all types of archaeological contexts, from preserved deposits to cooking pits. Long-term monitoring equipment was installed in three different contexts. Observations and conclusions about the state of preservation were compared to the conditions for future *in situ* preservation as a basis for present and future cultural heritage management of the site.

5.3.1 *Archaeological evaluation of state of preservation; geoarchaeological field work*

The archaeological remains at Avaldsnes span a wide range, giving information about the area from the Stone Age to the present. From the saga literature and written sources, the site is known as a royal seat from the 6th until the 15th century. Coupled with known rich archaeological finds this was the outset for the Avaldsnes Royal Manor project (<http://www.khm.uio.no/english/research/projects/avaldsnes/>) and the archaeological investigations in 2011 and 2012. Archaeological deposits from cultivation and settlement were found on several parts of the site, dating from Bronze Age, Iron Age, the Middle Ages and Renaissance and until the 19th century. Other finds covered the Roman and Migration Periods and Viking Age. For further information, see website and Bauer & Østmo (2013).

All archaeological contexts at Avaldsnes were measured, described and numbered by the Avaldsnes Royal Manor Project. However, the contexts singled out for sampling and monitoring were also recorded in a NIKU database for description of content, organic remains, metal objects and ceramics, and with an evaluation of state of preservation for all deposits in accordance with the Norwegian Standard NS9451. One of the central aspects was to investigate how strongly the archaeological deposits are exposed to oxygen and other degrading factors (NS9451, 12-41). Each deposit was separated into botanical, zoological and mineral components and artefacts. These four groups constitute 100% of each layer. The four groups were then specified in detail, following the instructions from the Monitoring Manual (RA & NIKU 2008, 29-31). As required by the Norwegian Standard (NS9451, 17-18), the state of preservation was evaluated by the archaeologist on site from the composition of the deposits and in relation to groundwater (A: unsaturated, B: fluctuation zone; C: saturated) and on a preservation scale of 1-5; lousy, poor, medium, good and excellent (

Table 9). The evaluation of the state of preservation was based on the following criteria as defined in the national standard (NS9451, 19); smell, structure/porosity, colour/colour change, mechanical strength of e.g. wood, general appearance and which artefact types were present.

In 2011, the following contexts were chosen; a Bronze Age/Iron Age grave cairn (ID 13902⁴¹), a cultivation area dated to Late Neolithic/Bronze Age/Pre-Roman Iron Age and continuing to Present (ID 1777 and 8855), a part of the parking lot just south of Avaldsnes church (ID 3658) with deposits from 16th-19th centuries⁴², an Iron Age cooking pit (ID 5049), a Renaissance deposit (ID 4854), and a particular type of stony subsoil (ID 1834) which was suspected to influence preservation conditions (Martens *et al.* 2012). In 2012, the above chosen contexts were completed with samples from the following; two Roman Period cooking pits (ID P44779 and P44780), medieval and younger

⁴¹ The ID numbers are used to identify the sample sites in Table 10.

⁴² The whole parking lot has a very complex stratigraphy with archaeological remains from Stone Age to Present, often at almost the same heights and just a few metres apart.

archaeological deposits adjacent to a medieval stone house (ID P44685, P45055, P45056 and P401306) and a Roman Period corn drying kiln (ID P45058) (Martens & Bergersen 2013). This meant that the areas with most archaeological remains disturbed by the excavations had been sampled.

Table 9 State of preservation scale (SOPS) after Norwegian Standard (NS 9451), and concentration levels for chemical parameters used to evaluate preservation conditions. © RA & NIKU; © Bioforsk.

		Preservation scale					
Position related to ground water		0	1	2	3	4	5
			Loisy	Poor	Medium	Good	Excellent
Unsaturated		A0	A1	A2	A3	A4	A5
Fluctuation zone		B0	B1	B2	B3	B4	B5
Saturated		C0	C1	C2	C3	C4	C5
Material later than 1900		D0	D1	D2	D3	D4	D5

Nitrate	Ammonia	Sulphide	Iron (II)	Iron (III)	Redox conditions	Preservation
NO ₃ ⁻	NH ₄ ⁺	S ²⁻	Fe ²⁺	Fe ³⁺		
Low	Low	Low	Low	High	Oxidizing	Lousy
High	Low	Low	Low	High	Nitrate to oxidizing	Poor
High	Low	Low	High	Low	Nitrate to iron reducing	Medium
Low	Low	Low	High	Low	Ironreducing	Medium
High	High	High	Medium	Low	Nitrate to sulphatereducing	Good
Low	High	High	Medium	Low	Sulphatereducing	Good
Low	High	High	High	Low	Sulphatered. to methane prod.	Excellent

	Reduced condition
	Oxidized conditions

In dialogue with the Avaldsnes Royal Manor Project group and in accordance with requests from the Norwegian Directorate for Cultural Heritage, a series of contexts were chosen for sampling, both simple and complex ones. Three of these contexts were chosen for monitoring with probes installed in sections and attached to automatic data loggers (Fig. 46).

5.3.2 Chemical analyses of samples

Soil samples from archaeological contexts were taken at various depths. All the samples were analysed according to the required parameters stated in the national standard (NS 9451, 12 and 21) as far as this was possible and practical to follow. The following analyses were performed on the Avaldsnes material; temperature (measured on site), humidity/soil water content (on site measurement), dry matter content (DM), loss on ignition (to measure organic matter content, cf. NS9451, 35), pH/acidity, electric conductivity, sulphate/sulphide, ferrous/ferric iron, ammonium/nitrate and redox evaluation (Table 9).

The soil samples were immediately packed in 500 ml zipper bags of which as much air as possible was squeezed out, before these were packed in additional zipper bags containing a sachet of Anaerocult A (VWR international).

The Anaerocult sachets are activated immediately on contact with air by using up oxygen in the zipper bag like an anaerobic vacuum. This ensures that the physical-chemical properties of the soil samples will be protected as much as possible against exposure to air. This is in accordance with the national standard (NS9451, 16). The soil samples were stored at 4 °C and opened in a nitrogen atmosphere in a glove box to keep anaerobic samples free from oxygen.

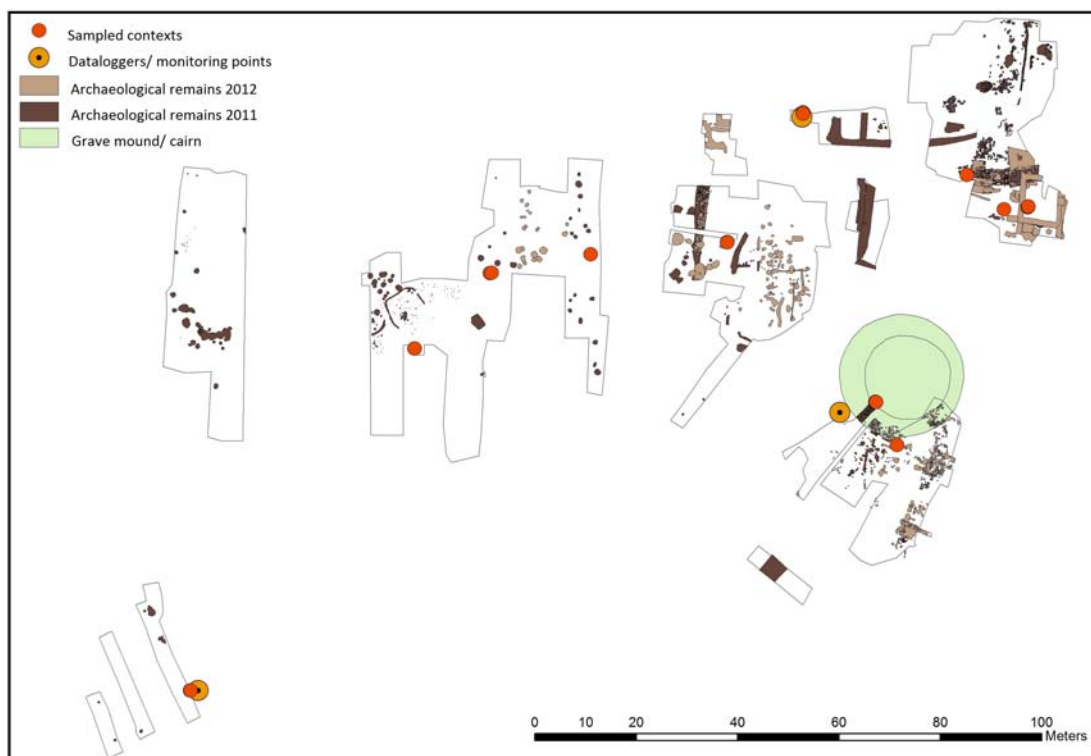


Figure 46 Map of the archaeological investigations at Avaldsnes. Red dots mark sample sites, larger orange dots encircling small black dot mark monitoring points/ data logger positions. © Avaldsnes Royal Manor Project.

The analysis extractions of redox sensitive parameters were all conducted in a nitrogen atmosphere. Dry matter content (105 °C for 24 hours) followed by loss on ignition (550 °C for 12 hours) was determined in half of each initial sample before analyses on redox sensitive parameters were conducted on another subsample. pH and electric conductivity (Shirokova *et al.* 2000) was measured by mixing subsamples with deionizer water (ratio 1:5 by volume). The pH and conductivity was measured after 30 minutes with Ross electrodes (Orion Instruments). The electric conductivity values from the soil samples were multiplied by 3.7 (Shirokova *et al.* 2000). The samples were analysed for nitrate (NO_3^-), ammonium (NH_4^+), reduced iron (Fe^{2+}) and oxidized iron (Fe^{3+}) (Stookey 1970), sulphate (SO_4^{2-}), (acid volatile) sulphide (S^{2-}) (Rickard & Morse 2005). Nitrate (NO_3^-), ammonium (NH_4^+) and sulphate (SO_4^{2-}) were analysed at Eurofins AS, Norsk Miljøanalyse AS⁴³. Ammonium and sulphide represent the major reduced species of nitrogen and sulphur in natural environments, while nitrate and sulphate are the oxidized species. The methods employed for iron measurement (Stookey 1970) only extract a small fraction of Fe^{3+} and Fe^{2+} . We used these methods to measure the ratio between the amount of reduced and oxidized iron. The ratio of molar concentrations of reduced and oxidized species can be used to assess the redox conditions in natural environments and addresses the predominant redox

⁴³ This is done systematically on all Norwegian monitoring projects, ensuring comparability between sites. It is also a time and cost efficiency question, using the laboratories which may perform the different analyses fastest and at the lowest cost.

processes at a certain sampling point. The scale of assessing and monitoring depositional stability and preservation conditions was performed in accordance with the Norwegian Standard (NS 9451; Table 9, Table 10). However, since the focus in the standard is on the organic and particularly botanical remains, we added an evaluation of the soil chemical preservation conditions for inorganic remains (mainly metals⁴⁴), since that was important for the overall evaluation of the site (Table 10). Other factors that may have impact on the preservation conditions of inorganic artefacts are temperature and soil moisture content, but for practical dissemination purposes these are presented separately and not in the table. The threats of breakage through physical exposure are discussed in the archaeological evaluation of the deposits (see Chapter 5.4.1).

The evaluation of the preservation conditions of the cultural deposits are based on the following concentration of reduced and oxidized species (cf.

Table 9):

- Good preservation conditions require high concentrations of e.g. $> 50 \text{ mg/kg DM (NH}_4^+)$, $> 100 \text{ mg/kg DM (S}^{-2})$, $> 500 \text{ mg/kg DM (SO}_4)$, and high percentage of the amount of reduced iron (Fe^{2+}) $> 80\%$.
- Poor preservation conditions are characterized by low concentrations, e.g. $> 10 \text{ mg/kg DM (NO}_3^-)$, $< 500 \text{ mg/kg DM (SO}_4^2)$ and low percentage of the amount of reduced iron (Fe^{2+}) $< 20\%$.

Table 10 Physical and chemical preservation conditions for organic and inorganic material in samples from different archaeological contexts compared to observed state of preservation. © NIKU & Bioforsk.

⁴⁴ Metal artefacts are the inorganic find types which are most sensitive to geochemical changes.

Samples	Depth (m)	Stratum	Organic matter (%)	Water content (%)	pH	Conductivity uScm ⁻¹	Preservation			
							Organic material	Inorganic material	Redox conditions *	Archaeological state *
2011										
Grave cairn										
13902-1	0.20	Top soil	19	30	4.4	1055	Lousy	Poor	A1	A2
13902-2	0.35	Gravel, stone	5	24	6.0	34	Lousy	Medium	A1	A3
13902-3	0.50	Subsoil	10	23	7.9	39	Lousy	Good	A1	A1
Cultivation area										
1777-2	0.47	Cultivation layer	4	23	6.5	36	Lousy	Medium	A1	A2 - A3
1777-3	0.77	Cultivation layer	12	24	6.4	72	Lousy	Medium	A1	A3
1777-4A	1.05	Arch. dep.	25	27	6.3	127	Lousy	Medium	A1	A3
1777-4b	1.05	Arch. dep.	6	28	7.7	67	Lousy	Good	A1	A3
1777-4c	1.05	Arch. dep.	5	28	6.7	68	Lousy	Medium	A1	A3
Parking lot										
3658-4-1	0.50	Gravel	7	26	4.0	1134	Poor	Poor	A2	A2
3658-4-2	0.76	Road fill	7	25	4.2	763	Poor	Poor	A2	A2
3658-4-3	0.98	Road fill	7	26	4.1	846	Poor	Poor	A2	A2
3658-5	1.26	Dungheap	7	27	4.5	1130	Poor	Poor	A2	A3
3658-7	1.70	Subsoil	1	8	6.7	117	Lousy	Medium	A1	A3
Other contexts										
5049-1		Cooking pit fill	4	19	6.3	70	Lousy	Medium	A1	A1
5049-5		Subsoil	3	18	6.3	24	Lousy	Medium	A1	A3
4854		Clay pipe dep.	6	22	7.0	7	Lousy	Medium	A1	A2
8855-2		Cultivation layer	4	23	6.5	27	Lousy	Medium	A1	A1
8855-3		Arch. dep. / cultivation	6	34	6.4	37	Lousy	Medium	A1	A2
1834		Subsoil	3	11	6.6	26	Lousy	Medium	A1	A1
2012										
P 44779	0.05	Cooking pit fill	11	31	6.3	91	Lousy	Medium	A1	A2
P 44780	0.20	Cooking pit fill	11	28	6.5	63	Lousy	Medium	A1	A2
P 44684	0.50	Arch. dep.	6	28	6.6	63	Lousy	Medium	A1	A2
P 45055	1.00	Arch. dep.	6	26	7.2	74	Lousy	Medium	A1	A2
P 45056	0.56	Arch. dep.	10	32	7.4	95	Lousy	Medium	A1	A3
P 401306	0.34	Arch. dep.	7	29	7.6	86	Lousy	Medium	A1	A3
P 45058	0.02	Oven fill	6	25	5.5	56	Lousy	Poor	A1	A1

Lousy to poor
Medium
Good to excellent

Oxidizing condition
Reduced condition
 *
 SOPS :
 NS 9451:2009

5.3.3 Equipment used for monitoring the unsaturated deposits

The sensors installed to measure soil temperature and soil moisture were TRIME-PICO 32 from IMKO Modultechnik GmbH (see p. 18 in [Trime-PICO 32 manual](#))⁴⁵. These sensors can be installed in the heterogeneous and sandstone-rich types of soil which are often found at archaeological sites. For each chosen installation point, the deposits were documented by the archaeologist, before the technician hand drilled a hole; going up to 50 cm into the section to ensure installation in undisturbed soil. The sensors had universal calibration for mineral soils as standard. All sensors were connected to an automatic logger from SEBA Hydrometrie GmbH. The data is accessible on a web site via mobile modem technology. After installation, the equipment was controlled by a second field instrument to ensure that correct values were measured. The data frequency was initially on an hourly basis but was

⁴⁵ Since the probes and data loggers used are not custom made but standard equipment, they are not depicted here.

later reduced to every six hours, i.e. four times per day, which was less battery consuming. This was also comparable to measurement frequencies at other monitored sites in Norway.

The sensors for monitoring soil temperature (°C) and moisture (%) were placed at different depths. In the grave cairn section, sensors were placed in the topsoil 0.2 m under the surface, 0.4 m in the middle part of the deposits and a third sensor in the subsoil at 0.6 m to see if precipitation would influence stability at different depths. At the parking lot, five different sensors were installed, in gravel at 0.5 m, road fill at 0.76 & 0.98 m, dung heap at 1.26 m and in the subsoil at 1.70 m below the surface. In the road fill the data was more or less similar and was calculated as mean values. High frequency of precipitation from Aug. to Dec. of 2012 gave high water levels in the excavation depression at 1.70 m, which caused reading errors in the automatic logger equipment.



Figure 47 Installation of monitoring equipment in the grave cairn. VVM/NIKU.

5.4 Results and discussion

Avaldsnes was the first case site in the research project ‘*In situ* site preservation in the unsaturated zone’ with field work carried out in 2011-2012. As described shortly above, the site holds partly very complex stratigraphy. However, the scope of this paper is only to go into detail of the sampled remains, with particular emphasis on those chosen for long-term measurements, coupled with an evaluation of the suitability of the strategies for description, evaluation and analyses required in the national standard.

5.4.1 Geoarchaeological results and observed state of preservation

All archaeological remains at Avaldsnes were in the unsaturated zone and were therefore labelled A (cf.

Table 9 and 10). The section made in the grave cairn (Figs. 47 and 48) showed top soil (13902-1) consisting of 5cm grass and a 20 cm deposit of half-compact, easily separated components of silt-mixed humus with inclusions of clay and stone. Its preservation state was perceived as poor (A2). Beneath this was a 40cm deposit of compact, block-like sandy silt-mixed humus (13902-2) of medium preservation (A3). This deposit was directly above a subsoil layer of very compact, block-like silt-mixed gravel with lousy preservation (A1), which was on top of the bedrock. The artefacts found in the trench opened for installation of monitoring equipment were all flint flakes (found in deposit 13902-2). These are insensitive to most geochemical changes, and they were not exposed to breakage. After the installation of monitoring equipment, the excavated materials were used to back-fill and cover the trench. Post-excavation heritage management of the site has not changed these conditions.

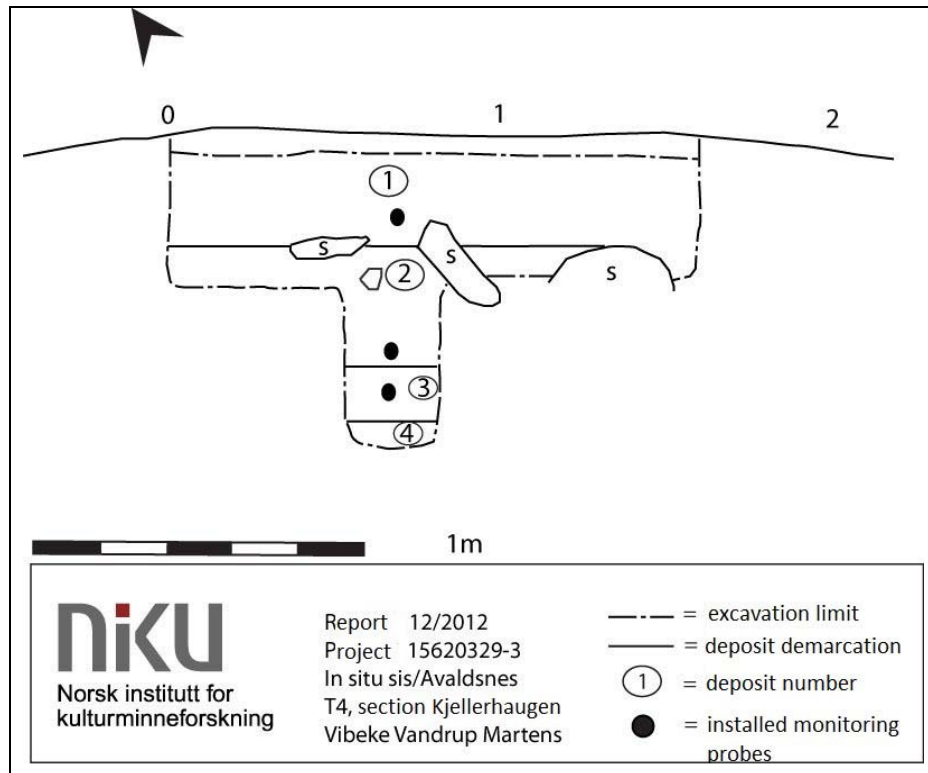


Figure 48 Section of grave cairn trench, monitoring points marked with black dots. VVM/NIKU.

At the parking lot, a trench for monitoring was dug west of the area with the highest concentration of archaeological remains (Figs. 46, 49 and 50). It turned out to be only newer deposits, from the 16th century to Present. The top deposit was 10cm of compact gravel (A0), beneath which was a modern compensation deposit of compact stone-mixed silt and humus, deemed lousily preserved (A1).



Figure 49 Sampling and installing monitoring equipment at the parking lot. VVM/NIKU.

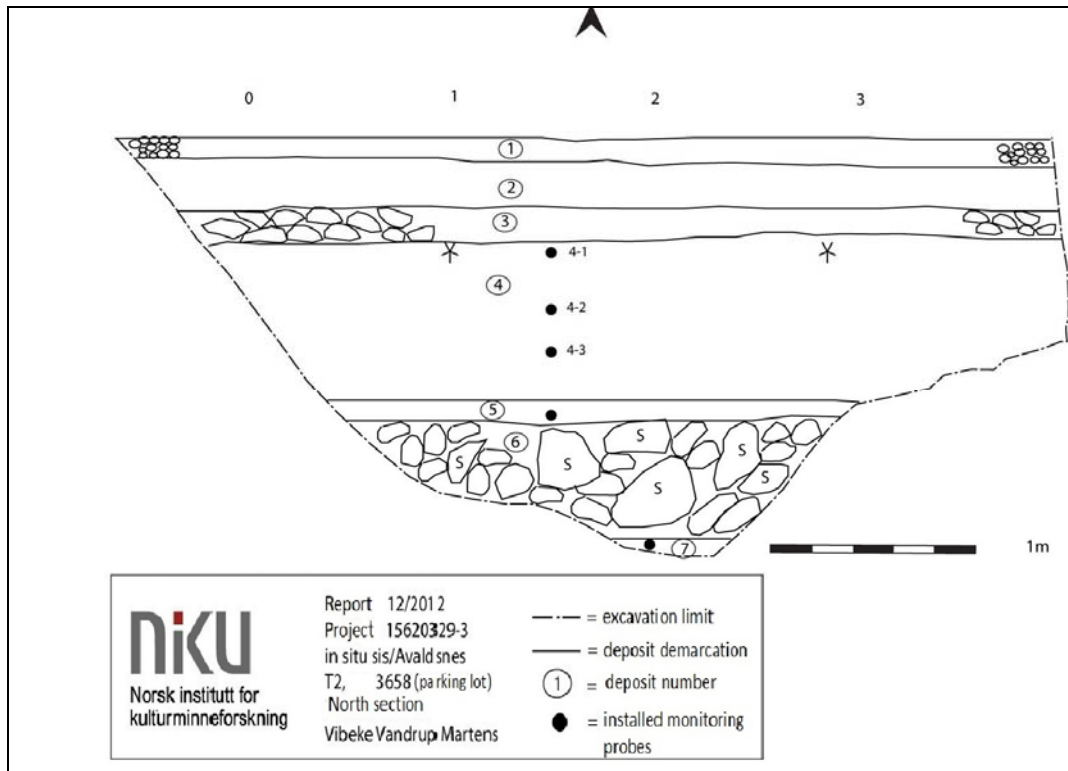


Figure 50 Section of parking lot trench, monitoring points marked with black dots. VVM/NIKU.

The next deposit was a compact road fill layer of rough stone (A0, i.e. outside the grading system because it contained no organic matter, cf.

Table 9), underneath which was an almost 80cm thick compact humus deposit whose conservation state was considered poor (A2). The following deposit was only 10 cm of loose, sandy humus, but very rich in artefacts; pottery, glass, iron, stone, leather and textile. This was interpreted as a midden and considered medium preserved (A3) (Table 10). The artefacts were protected from further breakage by the compact deposits above them. This protection should continue in the future unless the parking lot will be used for much heavier vehicles than has been the case so far. The midden was on top of a compact 50-60 cm layer of large stones, interpreted as part of a barn and graded A0 because there was no organic matter to evaluate. Directly beneath the barn remains, the subsoil consisted of extremely compact silt-mixed gravel (A1). After the archaeological field work was concluded, the excavated materials were used to back-fill the trench. In addition, an extra layer of gravel of minimum 20cm depth was added to even out the parking lot area. This has led to an increase in water penetration of the deposits, and at the same time the gravel stores heat, increasing the soil temperature. Thus, the post-excavation management of the site has led to poorer preservation conditions.



Figure 51 Installed probes in the cultivation area. VVM/NIKU.

The cultivation deposits (Figs. 46, 51 and 52; Table 10) investigated in a trench in the southern part of the site consisted of five layers. The topsoil was a 30cm modern cultivation layer of half-compact humus and a few stones, deemed to have poor to lousy preservation (A1-2). A 40-50cm thick older cultivation layer of half-compact humus mixed with silt and sand was considered poorly preserved (A2). Under this, the next cultivation/archaeological deposit was graded A2-3, medium to poor. It consisted of half-compact humus mixed with silt, sand, a little clay and a few stones. Beneath this was a medium preserved deposit of compact silt-mixed humus (A3), above compact gravel-mixed clay subsoil with a few bits of in-washed charcoal.

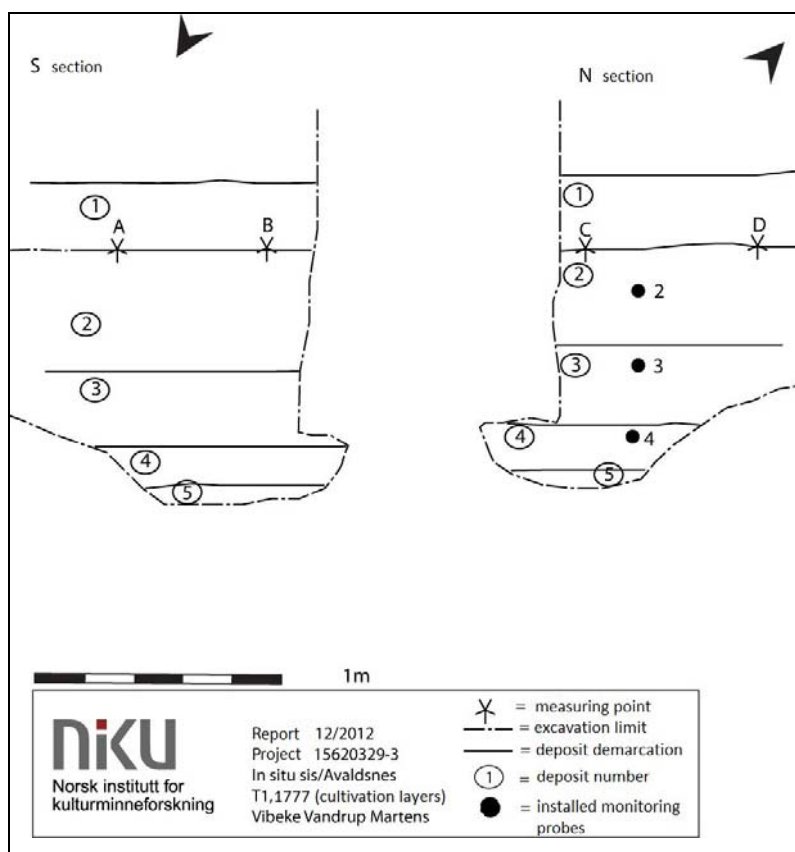


Figure 52 Section of cultivation area trench, monitoring points marked with black dots. VVM/NIKU.

Excavated materials were used to back-fill both this trench and the surrounding survey trenches. This work led to a settling of the whole southern investigation area, leaving this as the lowest point in a very large grazing field. This led to complications for the monitoring equipment, effectively drowning it as it was placed in a tank below the surface⁴⁶, and thus the post-excavation management has led to poorer preservation conditions even of this site.

The above observations on state of preservation of the cultivation deposits were confirmed in samples from the cultivation layers further north on the site, ID 8855-2 and 3 (corresponding to the two oldest cultivation/archaeological deposits described above), but were graded A1 and A2 respectively, i.e. lousy and poor, whereas the ones further south were considered better preserved and graded poor to medium (A2 to A3). The half-compact humus mixed with charcoal fragments that constituted the cooking pit fill was considered to be of lousy preservation (A1), though the compact moraine gravel subsoil was considered to have medium preservation capacity (A3). The Renaissance or clay pipe deposit, ID 4854, was deemed poorly preserved (A2), because the humus was very sandy and loose, but it still contained a large quantity of artefacts. These were highly exposed to further breakage, since only top soil had protected them before the excavation started. This state of threat will most likely continue in the future, since no extra covering layer or material was added when the site was back-filled after the excavation.

The loose sandy humus fill in the cooking pits sampled in 2012 were both evaluated as being in a poor state of preservation (A2) (Figs. 46, 53 and 54; Table 10), and the half-compact sandy fill in the corn drying kiln was considered to be in a lousy state of preservation (A1).

⁴⁶ It was a requirement from the land owner that all monitoring equipment should be concealed in tanks below the surface so as to not interfere with the use of the site or change the view of the grave cairn. Even though the automatic data loggers were placed in water tight cabinets, it was insufficient when the whole tank filled with water over longer periods.



Figure 53 Cooking pits investigated in 2012. VVM/NIKU.

The deposits in connection with the medieval stone house were all mixtures of half-compact to compact humus, sand and silt, and their state of preservation was considered poor (A2) to medium (A3), with the better preservation furthest down in the structure in the most compact deposits. The archaeological deposits in and around the ruins of the medieval stone house are threatened by the wish to expose the ruin to the public, and by plans for further archaeological investigations, leaving the future cultural heritage management of the site in a dilemma between wishes for *in situ* preservation and wishes for on-site communication of the excavation results.

The descriptive system (RA & NIKU 2008:29-31; NS9451:19), separating each deposit into its biological, zoological and mineralogical components and artefacts works well. It forces the archaeologist to evaluate the state of preservation of the different components and eventually reach a conclusion about the conservation state for the whole deposit. Separating the mineral components into stone, gravel, sand of varying coarseness, silt and clay gives good input on the compactness and porosity of the deposit. The descriptive system works equally well on heterogeneous unsaturated deposits and homogeneous saturated ones. Even though the results, with state of preservation varying between lousy and medium (A1-A3) might have been predicted, the thorough description gives sufficient additional information to justify the time spent on it, not least because of its comparability to other investigated unsaturated sites.

5.4.2 Geochemical results and measured preservation conditions

Soil samples from the archaeological contexts of the grave cairn and the parking lot from 2011 and the samples from 2012 have given physical and chemical data which made it possible to interpret the preservation conditions for each sample and at different depths.

Reduced and oxidized nitrogen species: Ammonium represents the major reduced species of nitrogen in natural environments, while nitrate is the oxidized species. The ratio of molar concentrations of reduced and oxidized species can be used to assess the redox conditions in natural environments and addresses the predominant redox processes at a certain sampling point. A ratio of 1 indicates that concentrations of reduced and oxidized species are equal. Nitrate concentrations in all samples from 2011 and 2012, were measured between below the detection limit < 0.1 and up to higher concentration of 20-40 mg/kg dry matter (DM), while ammonium concentration varied between 3 and

31mg/kg DM⁴⁷ (Table 11). The highest concentration of nitrate was detected at the parking lot which indicates more oxidizing conditions than in the samples from other contexts. In the other contexts the ammonium concentration was considerably higher than the nitrate concentration.

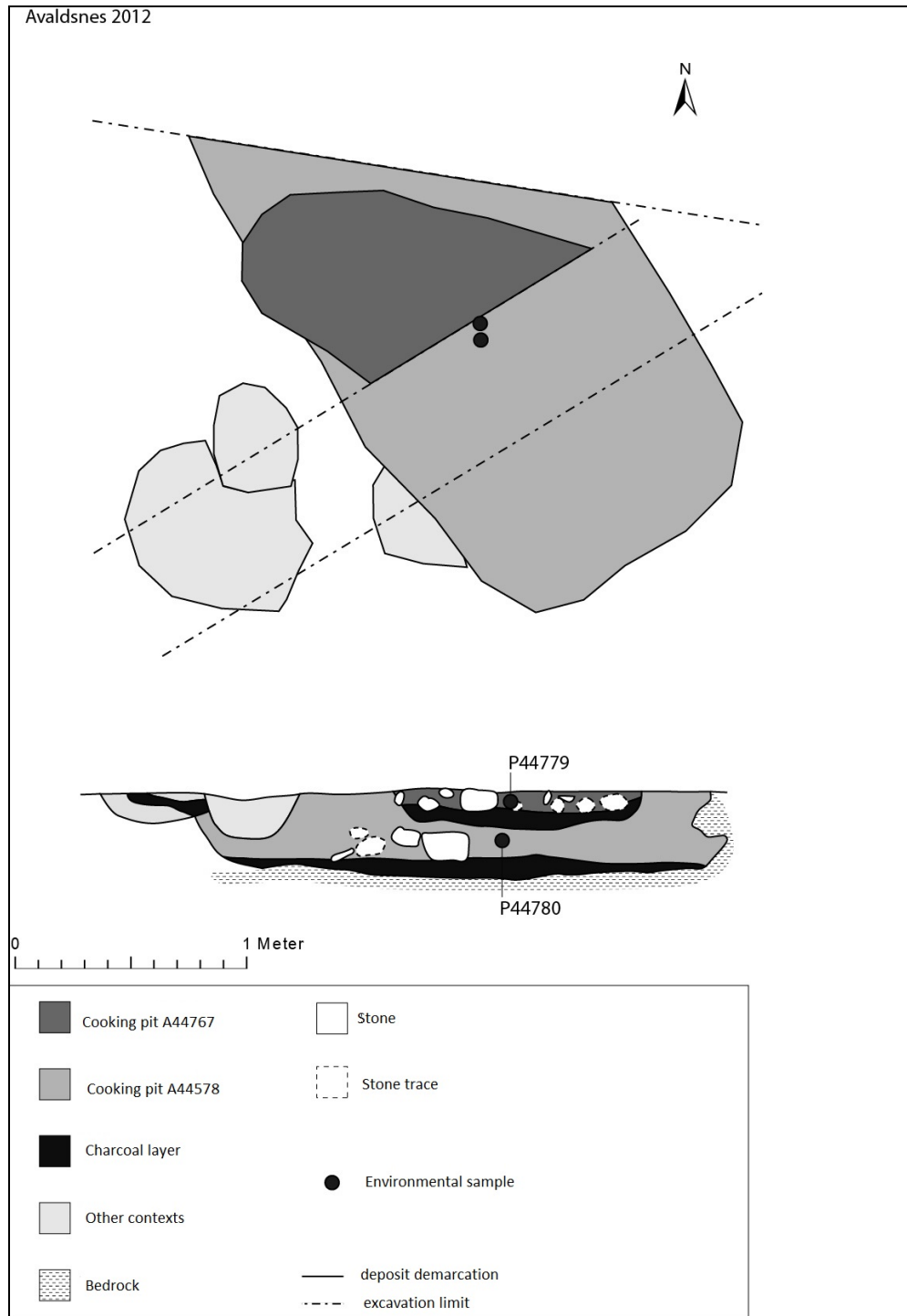


Figure 54 Plan and section of cooking pits investigated in 2012. © Avaldsnes Royal Manor Project.

⁴⁷ DM = dry matter

Reduced and oxidized iron species: All results obtained in samples collected and analysed from 2011 and 2012 show oxidizing conditions. The ratio of molar concentrations of reduced and oxidized iron, namely ferrous (Fe²⁺) and ferric iron (Fe³⁺) was found in all samples. In almost all samples the percentage of Fe²⁺ was found to be between 1% and 5% (Table 11). Therefore most of the iron contents extracted from the soil samples were found as oxidized iron (Fe³⁺). This is not surprising in the mineral rich soils at the site Avaldsnes where oxygen easily penetrates the archaeological deposits.

Reduced and oxidized sulphur species: Sulphide was detected in some of the samples but in low concentration between below the detection limit <0.1 and up to 48mg/kg DM⁴⁸ in the soil samples from 2011. The samples from 2012 were not analysed for sulphide because of the low amount of samples. The sulphide concentrations were found to be generally low compared to the content of sulphate. In the samples analysed from the parking lot, the concentration was considerably higher, between 314-771 mg/kg DM. Nevertheless, low concentration of sulphate was found in samples from other contexts, the cultivation area and all samples analysed in 2012.

Table 11 Measured chemical conditions in different archaeological contexts. © Bioforsk.

Samples	Depth (m)	Stratum	Nitrate - N	Ammonium-N	Sulphate	Sulphide	Iron (II)	Iron (III)	Percentage of	Redox conditions
			(mg/kg DM)	(mg/kg DM)	(mg/kg DM)	(mg/kg DM)	(mg/kg DM)	(mg/kg DM)	Iron (II)	
2011										
Grave cairn										
13902-1	0.20	Top soil	<0,1	21	14	<0,1	18	370	5%	Oxidizing
13902-2	0.35	Gravel, stone	<0,1	4	29	4	6.9	373	2%	Oxidizing
13902-3	0.50	Subsoil	0.7	3	24	<0,1	6.3	320	2%	Oxidizing
Cultivation area										
1777-2	0.47	Cultivation layer	<0,1	5	< 1	3	3.6	365	1%	Oxidizing
1777-3	0.77	Cultivation layer	<0,1	4	2	6	3.5	315	1%	Oxidizing
1777-4A	1.05	Arch. dep.	0.9	4	88	6	3.1	258	1%	Oxidizing
1777-4b	1.05	Arch. dep.	2.6	4	32	11	4.1	247	2%	Oxidizing
1777-4c	1.05	Arch. dep.	1.6	4	32	4	4.9	349	1%	Oxidizing
Parking lot										
3658-4-1	0.50	Gravel	19.6	31	653	34	11	273	4%	Oxidizing
3658-4-2	0.76	Road fill	32.0	10	314	48	13	373	3%	Oxidizing
3658-4-3	0.98	Road fill	41.7	7	415	0.3	11	327	3%	Oxidizing
3658-5	1.26	Dungheap	41.6	7	771	2	15	301	5%	Oxidizing
3658-7	1.70	Subsoil	<0,1	5	17	6	11	219	5%	Oxidizing
Other contexts										
5049-1		Cooking pit fill	<0,1	3	< 1	4	2.9	351	1%	Oxidizing
5049-5		Subsoil	0.6	5	2	11	7.7	298	3%	Oxidizing
4854		Clay pipe dep.	<0,1	5	< 1	31	15	170	9%	Oxidizing
8855-2		Cultivation layer	<0,1	4	5	15	3.4	384	1%	Oxidizing
8855-3		Arch. dep. / cultivation	<0,1	4	23	15	3.9	230	2%	Oxidizing
1834		Subsoil	0.9	3	< 1	8	8.4	191	4%	Oxidizing
2012										
P 44779	0.05	Cooking pit fill	1.0	4.0	< 1,6	n.d.	2.3	227	1%	Oxidizing
P 44780	0.20	Cooking pit fill	0.8	4.3	< 1,6	n.d.	3.5	225	2%	Oxidizing
P 44684	0.50	Arch. dep.	0.8	3.9	< 1,6	n.d.	4.3	149	3%	Oxidizing
P 45055	1.00	Arch. dep.	1.7	4.3	< 1,5	n.d.	12	78	15%	Oxidizing
P 45056	0.56	Arch. dep.	< 0,1	5.5	< 1,7	n.d.	8.9	148	6%	Oxidizing
P 401306	0.34	Arch. dep.	< 0,1	4.9	< 1,5	n.d.	19	159	12%	Oxidizing
P 45058	0.02	Oven fill	< 0,1	3.9	26	n.d.	15	421	4%	Oxidizing

n.d. Not analyzed

⁴⁸ DM = dry matter

Table 10 shows the evaluation of the geochemical preservation conditions for both archaeological organic and inorganic materials based on all data measured in 2011 and 2012. The investigations of soil samples from 2011 and all samples from 2012 showed that identifying the redox conditions by measurement of the redox sensitive parameters (nitrate, ammonium, oxidized and reduced iron, sulphate and sulphide) clearly illustrated oxidizing conditions and poor to lousy preservation conditions for organic archaeological material. This means that most of the archaeological organic material at Avaldsnes has decomposed. The organic matter from the grave cairn was measured to between 5 and 19%, while it was between 7 and 11% in samples from the parking lot 2011 and in all samples from 2012 (Table 10). The water content in most of the samples from 2011 and 2012 was relatively high and varied between 20 and 32% (Table 10).

The geochemical preservation conditions for inorganic archaeological materials (mainly metals, cf. Chapter 5.3.3 and note 44) were found to be poor at the top, medium in the middle and good in the deeper layers in the grave cairn, poor and lousy at the parking lot and poor to medium in samples from the cultivation area, in the other contexts from the same year and in the samples from 2012. The latter is explained by the often low pH and conductivity found in the soil samples. Low pH could give higher decomposition rate of archaeological materials such as bone and metals.

Even though the results of the geochemical analyses carried out at Avaldsnes in accordance with the national standard might have been predicted almost just by looking at the soil, they still give input making the site immediately comparable to other investigated sites. This was the first large test of using the standard methods outside the Norwegian medieval towns, and as such it has value.

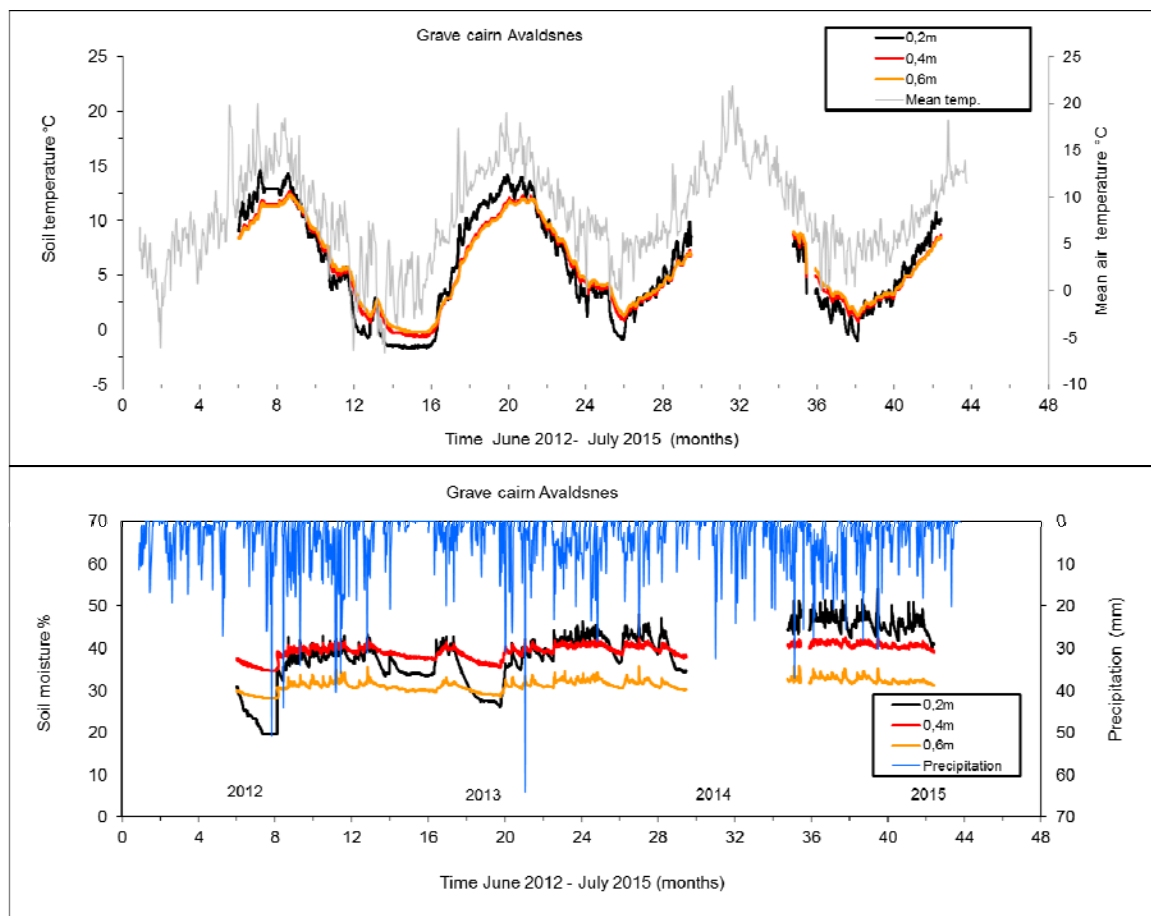


Figure 55 Soil temperature (above) and soil moisture (below) monitored at different depths compared to mean air temperature and precipitation from 2012 to 2015 at the grave cairn Kjellerhaugen at Avaldsnes. Gaps in measurements are caused by dead batteries. © Bioforsk.

We have found it necessary and useful to separate the preservation conditions between organic and inorganic, by the latter meaning the inorganic artefacts most susceptible to geochemical changes. We have not yet found other or better methods than the ones required by the standard to obtain information on preservation conditions.

5.4.3 *Monitoring the archaeological deposits in the grave cairn and at the parking lot*

The first data from sensors for measuring soil temperature and soil moisture are illustrated from June 2012 to July 2015 for the grave cairn, May 2012 to December 2013 for the parking lot.

Unfortunately, the measurement equipment at the parking lot malfunctioned after that, because it was placed in a concrete tank below the surface, and water leaked into the tank and into the data logger. Figure 55 shows the results of soil temperature monitored in the section of the grave cairn at three different levels 0.2, 0.4 and 0.6 beneath the surface compared to mean air temperature close to Avaldsnes (Yr.no).

The monitored temperatures followed the air temperature which varied between -1.7 and 15°C through summer, autumn, winter and spring conditions. It can be seen that the sensor closest to surface at 0.2 m was influenced more directly by mean air temperature winter and summer. The two others sensors at 0.4 and 0.6 m followed the mean air temperature variations with a slight delay. The average temperature from all three sensors was calculated to be between 8.2-8.4°C, and the difference in maximum temperature was 3°C between 0.2 and 0.6 m depth.

The minimum temperature between the different depths was only -1.7 and -0.7°C. Comparing this latter temperature with average temperatures measured at the same depth at the parking lot illustrated in Figure 56 the result there was found to be 2-4°C higher than at the grave cairn. Equal average temperature was only found at 1.7 m depth. That means that the upper part of the archaeological deposits at the parking lot are more exposed to temperature variation and have a higher risk of degradation of organic materials. All samples from the parking lot had lower contents of organic matter (see Table 10).

The soil moisture or water content illustrated in Figure 55 and Figure 56 was similar in both contexts. The moisture content was compared to the mean precipitation at Avaldsnes (Yr.no). Sensors at the parking lot in depths of 0.5-1.70 m below the surface show average soil moisture between 32 and 36% through the monitored period, while sensors at the grave cairn in depths of 0.2-0.6 m show moisture at 30-39% through the summer without changing with increased precipitation (Fig. 56). The archaeological deposits at 0.2 m were more directly affected by the precipitation. At the grave cairn the archaeological deposits seem to be more stable and less affected by high precipitation periods and temperature variations. Only small peaks were observed after precipitation periods. The temperature in the two deepest strata was also more stable than the upper part which fluctuated more with the mean air temperature; even though all average temperatures were found to be 2-4°C lower than at the parking lot.

In the deepest stratum at the parking lot at 1.70 m, high frequency of precipitation caused storage of water in the excavation depression which gave reading errors in the collected data; this was therefore excluded from the presentation of the moisture content (Fig. 56) The parking lot area was covered with new gravel which could influence the drainage of water. The gravel also increased the storage of solar heat. This could explain the higher temperatures measured in this area. A parking lot with a top cover of gravel is not a good strategy for preserving the cultural heritage beneath it. Excessive precipitation was considered the most likely explanation for losing contact with the parking lot monitoring equipment and therefore losing data after 2012.

Monitoring at the cultivation area was very difficult because of periods of very high precipitation, effectively drowning the equipment which was placed in a tank below the surface. However, the measurements that were obtained showed that the average value of soil moisture was similar to the grave cairn and at the parking lot at 38 % (data not shown). The temperature in the cultivation area was similar to the grave cairn, average 0.6°C, max 8.1°C and min -2.2°C (data not shown).

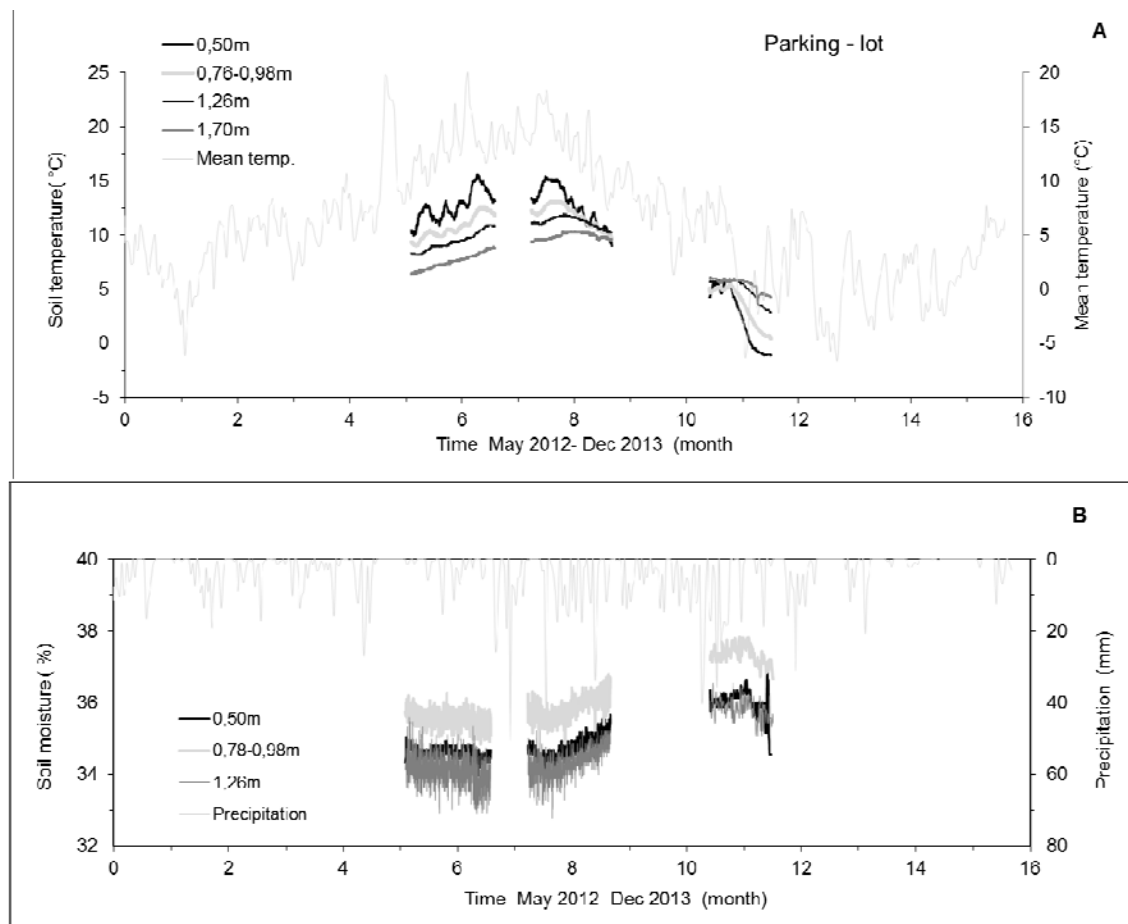


Figure 56 Soil temperature (A) and soil moisture (B) monitored at different depths compared to mean air temperature and precipitation in 2012 at the parking lot south of Avaldsnes church. Gaps in measurements are caused by dead batteries. © Bioforsk.

5.5 Conclusions

The general impression of the state of preservation of archaeological remains in the unsaturated deposits at Avaldsnes is that the relatively loose, mineral rich sandy soil has left things in a state of lousy to medium preservation. This is reflected in the measured redox conditions, which are all lousy, and in the measured preservation conditions for organic and inorganic material and artefacts. All chemical parameters in reduced form were found in low concentrations, while the oxidized forms were found in higher concentrations, especially iron. At the parking lot the concentration of nitrate and sulphate was also found to be abnormally high. The strata at the parking lot are quite different from the other unsaturated deposits at Avaldsnes. This may be because these deposits are of a younger date, or they may have been moved there from elsewhere. This new deposit material could cause higher concentration of sulphate. Still, the low concentration of sulphide compared to low content of reduced iron and ammonium gave evidence on the poor preservation conditions at the parking lot. The conditions for future preservation of organic material are all deemed poor or even lousy, whereas the conditions for preservation of inorganic matter, e.g. metal, are much better; most of them are medium, some poor, but a few are actually good (the subsoil deposit in the grave cairn and one of the samples from the deepest cultivation deposit). Particularly at the parking lot, low pH in all samples indicates that most of the degradation of organic archaeological remains has already taken place. Still, the archaeological remains at the parking lot are more vulnerable to decay, even though some of the deposits may have had slightly reducing conditions at some point (cf. Table 10). They seem less stable

and are more directly affected by precipitation and higher temperatures. This may be mostly because of the post-excavation management. The preservation conditions for archaeological remains in the grave cairn seem to be more stable and especially inorganic materials have better preservation conditions than organic materials. The deposits in and around the medieval stone house remains are very vulnerable to further excavations, and it would possibly be better to excavate and preserve *ex situ*, than try in vain to preserve *in situ*. For all the other parts of the site, a general conclusion is that they are already highly degraded, yet still contain high information potential, and the preservation conditions for inorganic artefacts are not too bad. To preserve these *in situ* for the future, the best cover is natural (soil, grass) rather than gravel, as has been exemplified with the monitored sites at the parking lot and the grave cairn. The post-excavation management of the site has led to poorer preservation conditions, certainly in some parts of the cultivated area which were left compressed so that they formed a water basin, and at the parking lot where gravel stores heat and allows for oxygen penetration. The remains of the medieval stone house were exposed for a longer period, drying out both the chalk mortar used in the walls and the deposits in and around the building. Only the grave cairn seems to have survived the investigations and subsequent heritage management unchanged.

The descriptive system (RA & NIKU 2008, 29-31; NS9451, 19), separating each deposit into its biological, zoological and mineralogical components and artefacts works well, giving good information about each deposit and enabling intra-site comparisons. We have found it necessary and useful to separate the preservation conditions between organic and inorganic, by the latter meaning the inorganic artefacts most susceptible to geochemical changes. In evaluation of the geochemical analyses, we have not yet found other or better methods than the ones required by the standard (NS9451) to obtain information on preservation conditions, and at least the use of the present ones allows for intra-site comparability. Future lab testing within the project may lead us to other parameters which will give sufficient information on preservation conditions in the unsaturated zone.

6 Research and monitoring on conservation state and preservation conditions in unsaturated archaeological deposits of a medieval farm mound in Troms and a late Stone Age midden in Finnmark, Northern Norway⁴⁹

Abstract

This paper presents archaeological observations and results of palaeoecological and geochemical analyses of archaeological deposits from two rural sites in northernmost Norway. These are combined with climate data and the first period of continuous monitoring of soil temperature, moisture and redox potential in sections. This data constitutes the basic research material for evaluations of conservation state and preservation conditions. The data has been collected in collaboration between the partners of an interdisciplinary project. This is an important Norwegian research initiative on monitoring of rural archaeological deposits and the results have consequences for heritage management of a large number of sites from all periods. Palaeoecological analyses and redox measurements have revealed ongoing decay that might not otherwise have been detected. Decay studies indicate that both site types may be at risk with the predicted climate change. Some mitigating acts are suggested.

6.1 Introduction

Archaeological sites in northern Norway are often characterized by remarkable preservation conditions due to low temperatures and favourable moisture conditions and are therefore important sources of organic remains. Degradation of archaeological materials depends on environmental conditions. Future climate change is expected to increase temperatures and change the overall precipitation patterns, with a potentially great negative effect on preservation conditions. Microbial decay of organic archaeological materials is known to increase exponentially with increasing soil temperature (Matthiesen *et al.* 2014, Hollesen & Matthiesen 2015), but at the same time, very dry and very wet conditions may hinder microbial processes (Hollesen & Matthiesen 2015). Soil parameters like pH, organic matter and water content, oxygen content and redox potential form the boundaries in which archaeological materials can be preserved (Huisman *et al.* 2009).

Oxygen is the most reactive and powerful oxidant and some decay processes such as fungal attack will only take place when oxygen is available (Froelich *et al.* 1979). When oxygen is depleted, for instance at waterlogged sites, the microbes in the soil will use other electron receptors in this process, and anaerobic degradation occurs at a much slower rate. A parameter that describes soil aerobicity is the redox potential (Mitsch & Gosselink 2000, Vorenhout *et al.* 2004, Pezeshki & DeLaune 2012). In cold areas, the temperature of the soil can be an overruling parameter. When the soil is frozen, nearly all degradation processes are presumed to halt (Hollesen *et al.* 2015a).

⁴⁹ This chapter has been adapted and slightly modified from Martens VV, O Bergersen, M Vorenhout, PU Sandvik & J Hollesen (2016): Research and monitoring on conservation state and preservation conditions in unsaturated archaeological deposits of a medieval farm mound in Troms and a late Stone Age midden in Finnmark, Northern Norway. *Conservation and Management of Archaeological Sites* 18, 116-125. Concerning the distribution of responsibility between the authors, it has been agreed that 40% of this text is the work of VVM, 15% OB, 15% MVH, 15% PUS and 15% JH, with each author having main responsibility for her/his subject, and VVM additionally for gathering it all together.

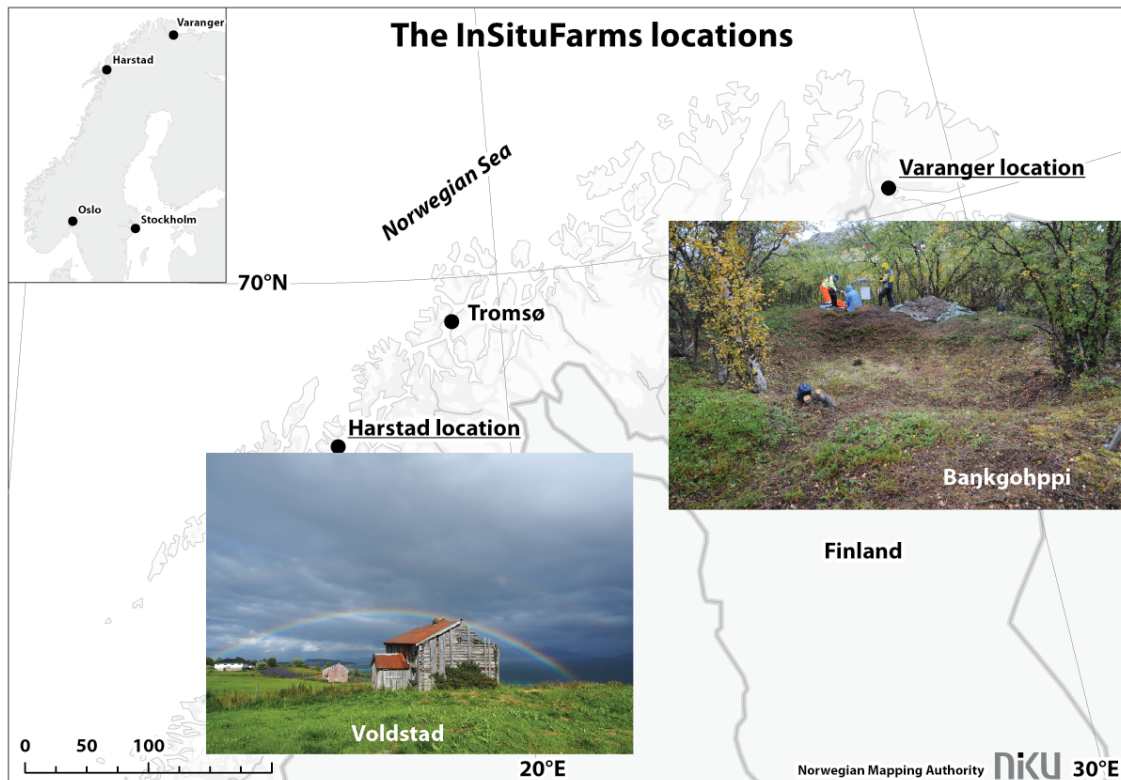


Figure 57 Map of chosen sites with inserted site photos.

This paper evaluates conservation state and preservation conditions at two different types of rural sites located north of the Arctic Circle in Norway, Gressbakken houses and farm mounds (Fig. 57). These two monument types were chosen as sites because of their high abundance, national importance and because they are located in a part of Norway where climate change is predicted to cause significant increase in temperature and precipitation rates.

The northernmost site, Banjgohppi by the Varanger fiord in eastern Finnmark, is a midden belonging to a Neolithic house of the Gressbakken type (Simonsen 1961), dated to approximately 2200 BC. The Troms site, Voldstad, is a farm mound dated to the medieval period (Bertelsen 1984). Field work at both sites was carried out late August 2013 and monitoring equipment was installed.

This paper combines archaeological research with the first results of environmental monitoring in Gressbakken houses and farm mounds. Furthermore, laboratory measurements of degradation rates are used to assess the vulnerability of the different deposits to changes in temperature and soil water content.

6.2 Study sites

6.2.1 Gressbakken houses

Approximately 900 Gressbakken houses found in northern Norway belong to a settlement type that was common in fiord areas in Finnmark and at the coast of the Kola Peninsula in Russia during the final phase of the Late Stone Age. Such houses had turf walls and central fireplaces and were located along the shoreline. They had two entrances, one of which was oriented towards the sea. Middens on both sides of the door contain bones of animal, bird and fish, shells, charcoal and other plant remains and artefacts. All these remains are information sources of great value, also at a national level, constituting the largest assemblages of preserved Neolithic deposits in the country. The relatively large size of the houses has promoted interpretations that they may have sheltered multi-families or extended family units (Schanche 1989, Myrvoll 1992).

The joint investigation led by NIKU of the Gressbakken house site at Banjgohppi, Unjárgga/Nesseby municipality, Finnmark County (ID7547), considered house 'n' (according to Simonsen 1961) representative for this site type since it was undisturbed by earlier archaeological investigations or other known encroachment. The surface remains indicated a typical layout of this heritage type (Simonsen 1961).

6.2.2 Farm mounds

Farm mounds are rural settlements dated mostly from late Iron Age to modern times (Brox & Stamsø Munch 1965, Bertelsen 1984, Myrstad 2001). Almost 900 farm mounds are listed monuments, and they are the largest assemblages of medieval archaeological deposits outside the towns. Deposits from centuries of settlement have accumulated to form a mound, making them distinct landscape features. The main elements of farm mound deposits are house remains of turf sods and wood and general household waste (Griffin 1985, Sandvik 1995, 2009). Husbandry as a main subsistence factor is the major reason for the fixation of settlement and the subsequent formation of the farm mounds (Bertelsen 1984, 1989, 2011, Lind 2002). The fixation of settlements may further find its cause in more structured rights of property and a strict social hierarchy, which again caused a need for optimal use of the arable land and building on the non-arable land (Martens 2016). A farm mound or settlement mound may support only a single farm, or several farms clustered together. Many farm mounds are still inhabited, while others were deserted in the past.

In this study we included the farm mound Voldstad, Harstad municipality, Troms County (ID9382). Voldstad was chosen as a site because it is a typical representative of farm mounds still in active use.

6.3 Materials and methods

6.3.1 Archaeology

Archaeological investigations were made at each of the sites. At Banjgohppi a 0.7 by 3 m hand dug trench from the edge of the northern wall cutting through the NW midden towards the sea, from the turf/forest surface through the midden layers and down to undisturbed natural subsoil, gave access to deposits for description, sampling and monitoring (Fig. 58). At Voldstad a 0.7 by 2 metres trench was hand dug from the grass turf surface to bedrock (Fig. 59). The trench was placed between the modern and the 18th century main buildings to not interfere with any previous buildings (Martens *et al.* 2015a, 2015b). Both sites were excavated stratigraphically with documentation and evaluation of the state of preservation in accordance with the Norwegian Standard (NS9451). Furthermore, at Banjgohppi a geophysical mapping was completed in autumn 2013 (data not shown here).

6.3.2 Palaeoecological analyses

Palaeoecological samples were taken from each deposit and at specific depths within the deposit (Figs. 58 and 59). The strategy for the analyses was to quantify the amount of inorganic and organic materials in each sample and reveal data sets for evaluation of the organic components and the preservation condition for these as a basis for comparison between the composition of each deposit and the preservation status of different types of material, (cf. NS9451:2009, 35). A sequential LOI as recommended by Heiri *et al.* (2001) was performed on subsamples from all deposits. The preparation of sediments for analysis of macroscopic sub-fossil (plant macro fossils) was according to Wasylkova (1986) and Griffin (1988). Samples for absolute analysis of microscopic sub fossils (pollen) were prepared according to Stockmarr (1971) and Fægri *et al.* (1989). These analyses (Fig. 60) were carried out by the Archaeological Museum, University in Stavanger.

6.3.3 Geophysical and geochemical analyses

Soil samples were taken from equipment installation points by NIBIO (Figs. 58 Figure and 59, Tables 12-15). Packaging and handling was according to the National Standard (see Martens & Bergersen 2015:70-72). The samples were analysed according to the required parameters stated in the national standard (NS9451, 12, 21) as far as this was possible and practical to follow, in this case temperature (measured on site), humidity/soil water content (onsite measurement), dry matter content (DM), pH/acidity, electric conductivity (Shirokova *et al.* 2000), sulphate/sulphide (Rickard &

Morse 2005), reduced/ oxidised iron (Stookey 1970), ammonium/nitrate and redox evaluation. The analyses were partly carried out at NIBIO, partly at Eurofins AS. For more detailed description and discussion of the methods, see Chapter 5.

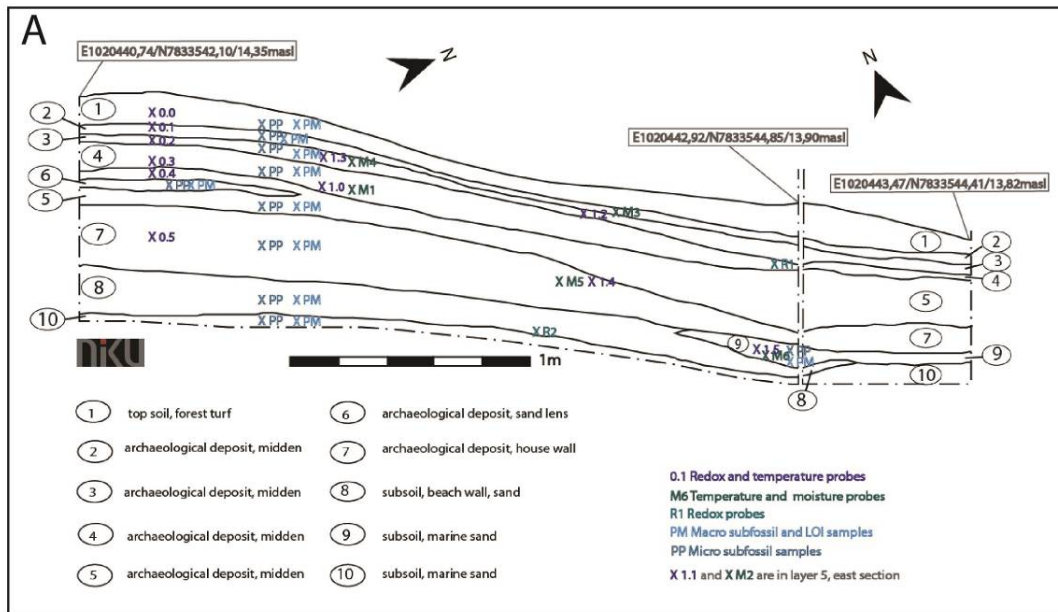


Figure 58 Banġoghppi. Section drawing (A) and site photos. B shells; C decorated antler; D installed equipment; E house 'n'.

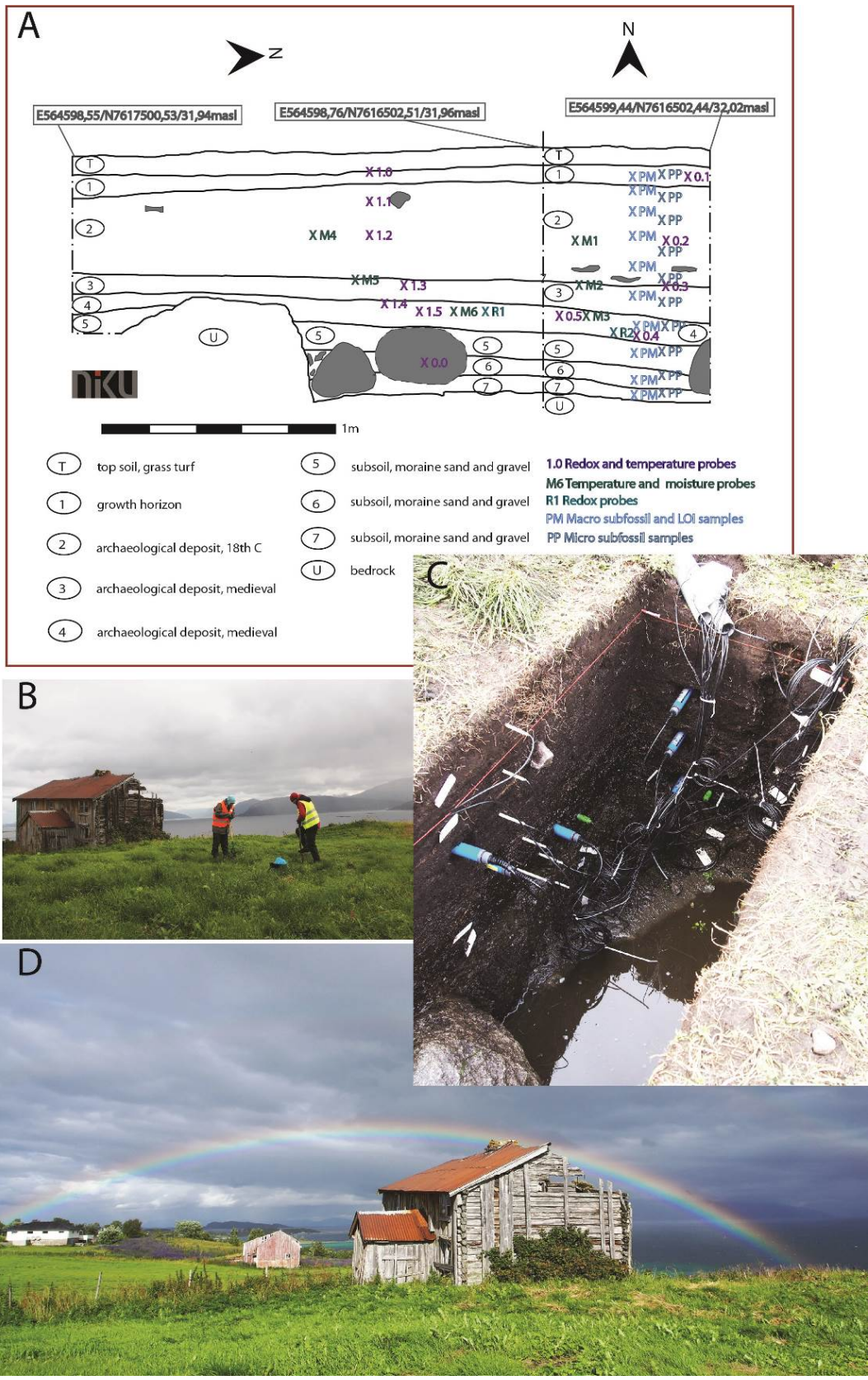


Figure 59 Voldstad section drawing (A) and site photos. B excavation start; C installed equipment; D old main building.

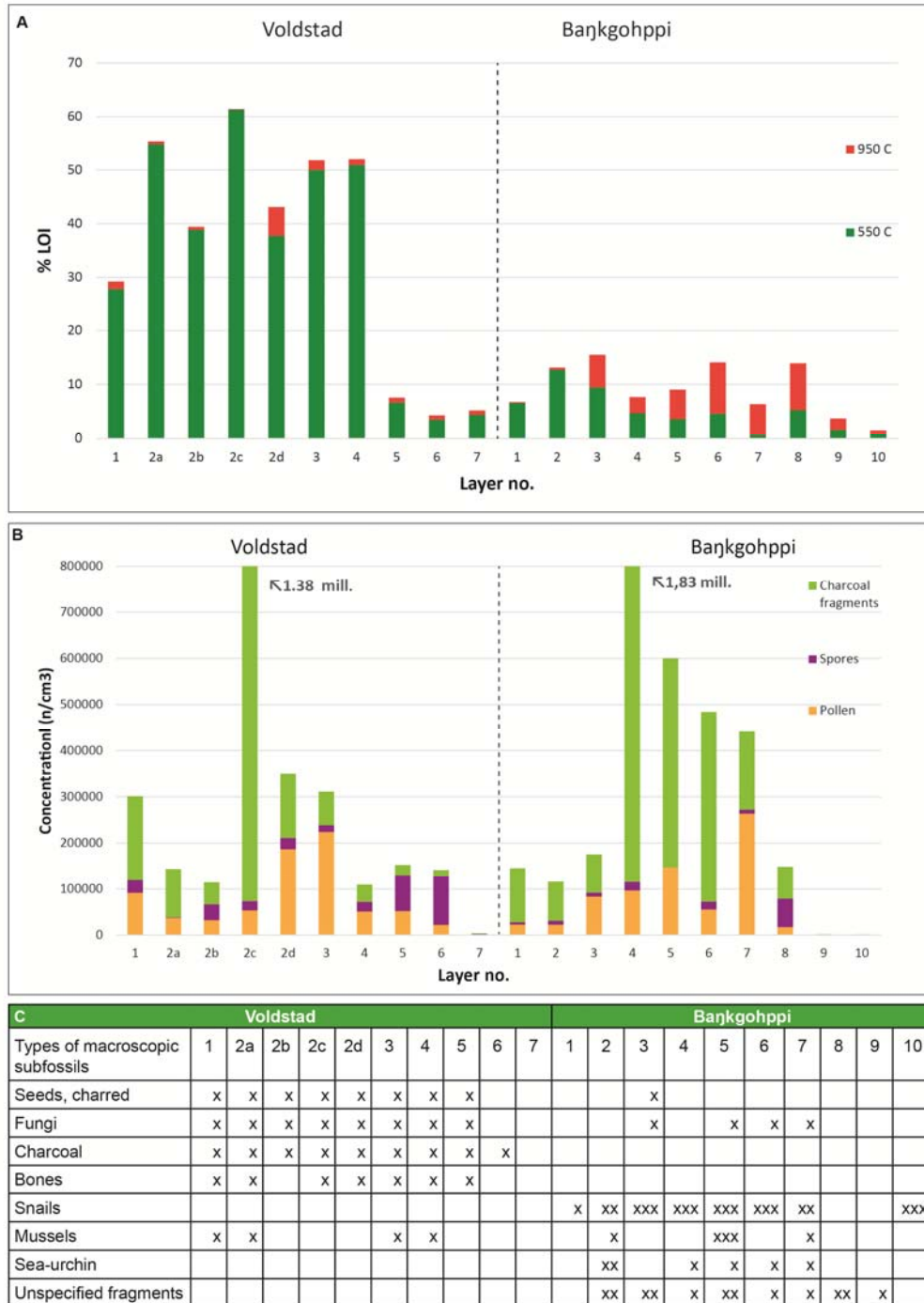


Figure 60 Results of the palaeoecological investigations. A: Loss-on-ignition (LOI %). B: Concentration (n/cm³ sample) of groups of microscopic subfossils. C: Groups of macroscopic subfossils. x=present, xx=common, xxx=abundant.

6.3.4 Long term monitoring equipment

Both sites were equipped with two sets of permanent probes, to test equipment efficiency at these site types and enable recommendations for the heritage management in future monitoring projects. One set consisted of 6 probes for soil moisture and temperature (TRIME PICO32 from IMKO Modultechnik GmbH) and two redox probes (Hanna instruments HI2930B/5). These probes were connected to an automatic logger from SEBA Hydrometrie GmbH (UniLogCom (MSD 115) with MET-Controller).

The second set consisted of 12 redox potential/temperature probes (Paleo Terra, Amsterdam) and one Ag/AgCl in 3M KCl reference probe (QM710X, Q-I-S, Oosterhout, NL), connected to a HYPNOS IV datalogger (MVH Consult, Leiden, NL) (Vorenhout *et al.* 2011). All probes were either pushed or installed approximately 25 cm into the section. Eh was calculated by adding 220 mV to the measured potential (Em), and for simplicity, no correction for pH was applied.

Information on precipitation and air temperatures was taken from the Norwegian meteorology website, Yr (www.yr.no).

6.3.5 Degradation studies

Decay rates of archaeological deposits were investigated by measuring oxygen consumption in soil samples from the two sites. The measurements were carried out at the National Museum of Denmark according to Matthiesen (2007). To investigate temperature dependency of the reactivity, measurements were made at 0.5, 5, 10 and 15°C on three replicate samples of each of the included archaeological layers (see Fig. 63). In addition, oxygen consumption rates were measured at different water contents to estimate the sensitivity of the decay processes to changes in soil water content (Møller *et al.* 2015, Hollesen *et al.* 2016).

6.4 Results

6.4.1 Archaeology

The trench at Banjgohppi (Fig. 58) had dry, porous deposits with a high content of marine remains. Bones from terrestrial and sea mammals, fish and birds were found with clams, shells and mussels, well-preserved antler artefacts and stone artefacts. Six archaeological deposits or contexts were identified in the midden (Fig. 58A), layers 2-7 (1: top soil, 8-10: subsoil). The archaeological deposits investigated belonged to parts of the wall and the midden. Layer 5 was particularly rich in information and in archaeological finds, including an antler artefact fragment decorated with incised lines, typical of the period (Fig. 58C).

Seven samples of charcoal of trees and heather from layers 4-8 processed at Beta Analytic gave dating results that span from 2460 to 1915BC (Beta 383557-383563, cal., 2 sigma). The dates are systematically older downwards in the midden layers (Martens *et al.* 2015a).

The Voldstad farm mound site (Fig. 59

Figure) had wet, humus-rich deposits dominated by terrestrial remains. The archaeological deposits consisted of typical household waste; wood and leather, a little pottery and single objects of glass, iron and stone, in addition to large amounts of animal and fish bones and a few bird bones. These finds confirm a mixed economic background of husbandry and fishing. Layer 2 (Fig. 59A) was artefact dated through pottery finds to the 18th C., layer 3 to the 14th C. Based on stratigraphy, layer 4 was also presumed to be medieval. In general, layers 2-4 seemed to be well-preserved and thus good sources of information. The subsoil layers (5-7) had decreasing amounts of in-washed humus until bedrock was reached. No house remains were found, because known house sites were deliberately avoided (Martens *et al.* 2015b).

6.4.2 Palaeoecology

Samples from each deposit at both sites were prepared for sequential LOI (Heiri *et al.* 2001), making it possible to distinguish between organic and inorganic carbon on loss-on-ignition at respectively 550°C and 950°C (Santisteban *et al.* 2004).

At Voldstad the total LOI is around 30% at the top while the values increase to 40-60% in deposits 2-4 (Fig. 59). The main part of LOI at this site is at 550°C, but some loss also occurs at 950°C. At Banjgohppi the total LOI never reaches more than 17% and is less than 10% for most layers.

Most LOI in the topsoil, (Fig. 58

Figure), occurs at 550°C, while LOI at 950°C increases in layers 3-4 and becomes dominant from layer 5 and towards the subsoil (Fig. 60

Figure A). The LOI analyses reveal significant differences between the sites as well as between the different deposits. The LOI at 550°C reveals the amount of macroscopic organic remains such as seeds, twigs and other plant remains and soft tissue and microscopic remains such as pollen, spores

and severely decomposed material, while LOI at 950°C occurs by loss of bone and shell. All these types of materials are sources of knowledge about the past that might be lost for researchers in the future.

The microscopic and macroscopic subfossils (Fig. 60B,C) reveal further differences between the sites. Absolute analyses of microscopic subfossils (Stockmarr 1971) enable calculation of the concentration of microfossils for each identified type.

Figure

Figure 60B presents concentration values for the groups of microscopic subfossils; pollen, spores and charcoal fragments, and these are the most abundant finds at both sites. Charred remains have high resistance towards biological degradation and might be present in archaeological deposits of all ages, even when no other organic remains are preserved. Another observation shown in Figure 60B is the relatively high concentration of spores from ferns and fungi in layers 5 and 6 at Voldstad (Martens *et al.* in prep.). Fungi participate in the decay of organic material while fern in the genus *Polypodium* is resistant and thus preserved even when most organic remains are decayed.

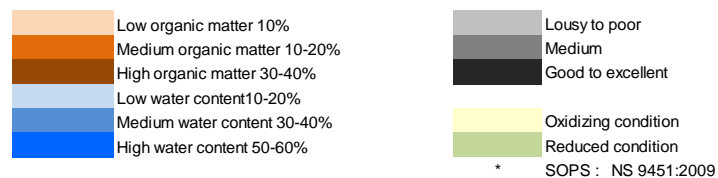
Macroscopic subfossils differ between the sites (Fig. 60C). Despite the promising organic matter content at Voldstad, remains of botanical origin were present, but not abundant. Identified finds are one single charred grain of barley *Hordeum vulgare*, small amounts of the fungi *Cenococcum geophilum* and some charcoal, while most organic remains seem to be decayed to a level where identification is impossible. At Banġgohppi shells of snails, clams, mussels and fragments of sea urchins dominate the deposits (Martens *et al.* in print). Earlier investigation of Gressbakken sites (Soot-Ryen 1968) reported no finds of sea urchin.

6.4.3 Geophysical and geochemical analyses and monitoring

The analysed deposits at Banġgohppi had low organic content and low water content (Table 12). All deposits had low conductivity < 350 uScm-1, and pH was slightly alkaline to alkaline/basic (8-9). The high pH was caused by the large amount of zoological content. Poor to medium preservation conditions for organic (botanical) matter were measured in all samples (medium where conditions were iron reducing). For inorganic materials (here including bones and shells) high pH and low conductivity cause good to excellent preservation conditions. Both reduced (Fe^{II}) and oxidised iron (Fe^{III}) was present in all deposits in varying quantities (Table 13).

Table 12 Geophysical, geochemical and archaeological evaluations of preservation conditions and state of preservation in the monitored deposits at Banġgohppi. In this context, inorganic includes bones.

Samples / sensors	Depth		Layer	Organic matter (%)	Water content (%)	pH	Conductivity uScm ⁻¹	Preservation			
	(m)	(masl)						Organic material	Inorganic material	Redox conditions *	Archaeological state *
Sensor 4 west	0,30	14,10	Layer 3	4	6	8,3	226	poor	excellent	A2	A3-4
Sensor 3 west	0,05	13,75	Layer 2	10	16	7,7	365	poor	good	A2	A3
Redox 1 west	0,20	13,60	Layer 4	12	12	8,2	297	medium	excellent	A3	A4
Sensor 1 west	0,37	13,53	Layer 4	4	1	8,8	209	poor	excellent	A2	A4
Sensor 5 west	0,34	13,46	Layer 7	5	11	8,7	221	poor	excellent	A2	A3
Redox 2 west	0,63	13,17	Layer 8	3	11	9,2	168	poor	excellent	A2	A3
Sensor 6 west	0,86	13,04	Layer 9	2	6	8,9	144	poor	excellent	A2	A2
Sensor 2 east	0,38	13,52	Layer 5	3	9	8,9	210	medium	excellent	A3	A3
Profile south	0,70	13,10	Layer 8	10	18	8,5	252	medium	excellent	A3	A3



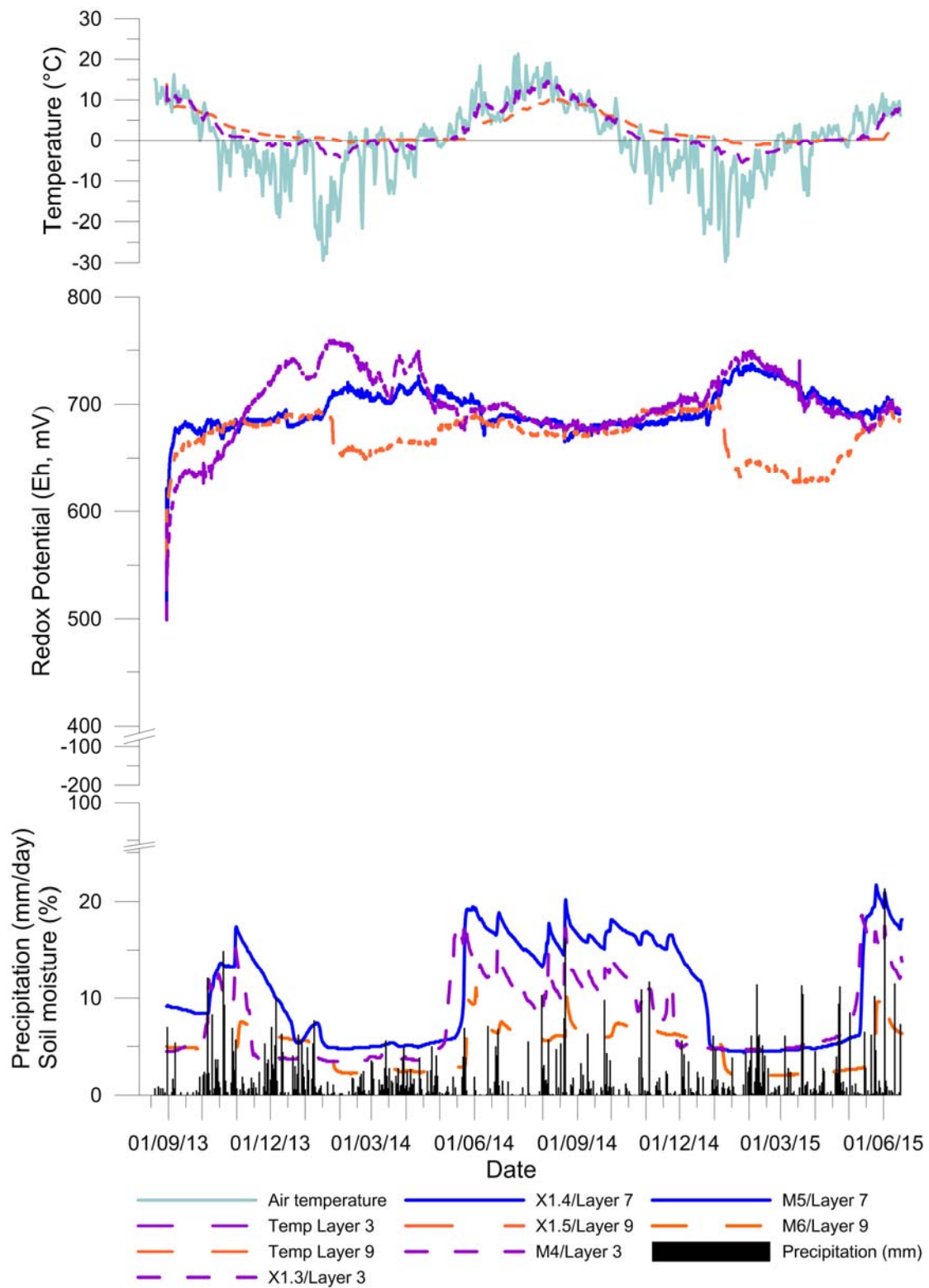


Figure 61 Selection of soil temperatures, redox potentials (Eh) and soil moisture values as measured in the Western profile of Banġgohppi. Coding follows

Figure 58 Banġgohppi. Section drawing (A) and site photos. B shells; C decorated antler; D installed equipment; E house 'n'. The complete profile is oxic, and shows freezing during winter times. Precipitation (black bars) influences moisture content only in summer periods.

Table 13 Geochemical composition of soil samples from Banġgohppi.

Banġgohppi, Varanġer										
Samples / sensors	Depth (m)	Depth (masl)	Layer	Nitrate - N (mg/kg DM)	Ammonium-N (mg/kg DM)	Sulphate (mg/kg DM)	Sulphide (mg/kg DM)	Iron (II) (mg/kg DM)	Iron (III) (mg/kg DM)	% of Iron (II)
Sensor 4 west	0.30	14.10	Layer 3	< 0.1	3.9	< 1.2	n.d	124	128	49%
Sensor 3 west	0.05	13.75	Layer 2	< 0.1	4.9	< 1.6	n.d	1.9	1.9	50%
Redox 1 west	0.20	13.60	Layer 4	< 0.1	3.8	< 1.3	n.d	76	37	67%
Sensor 1 west	0.37	13.53	Layer 4	< 0.1	11.6	< 4.4	n.d	3.1	2.5	56%
Sensor 5 west	0.34	13.46	Layer 7	< 0.1	2.9	< 1.3	n.d	0.9	1.3	40%
Redox 2 west	0.63	13.17	Layer 8	< 0.1	2.8	< 1.3	n.d	0.9	0.9	50%
Sensor 6 west	0.86	13.04	Layer 9	< 0.1	2.5	< 1.2	n.d	84	178	32%
Sensor 2 east	0.38	13.52	Layer 5	< 0.1	2.8	< 1.2	n.d	1.4	0.3	80%
Section south	0.70	13.10	Layer 8	< 0.1	2.8	< 1.4	n.d	215	52	81%

DM= dry matter

n.d. not detected because of high pH and lots of shells (from snails, clams and mussels).

Monitored data at Banġgohppi from August 2013 to January 2015 show an average soil temperature of around 2°C. Most of the time, the temperatures in the deposits were below zero. Snow cover insulated the deposits during periods with low air temperatures. Maximum measured temperatures in summer were 10-14°C in the upper parts of the section. Even with oxygen present in the deposits, low temperatures will mean low chemical and biological activity. Soil moisture content has been consistently low, 4-8%, excepting the top soil with 16%. Low water content means oxidising conditions, and the redox potential measurements show full aeration of the soil profile (Fig. 61).

At Voldstad, all analysed deposits had high organic matter content and high water saturation (Table 14). This should in general lead to good preservation conditions. Conductivity was low, < 400 uScm⁻¹, and pH was neutral to slightly basic (7-8). The amount of reduced iron (Fe^{II}) was high compared to oxidised iron (Fe^{III}) (Table 15) and the nitrate content was low, whereas the amount of ammonium and sulphide were high. The conditions were overall reduced, sulphate reducing to methanogenic.

Mean soil temperature at Voldstad was 4°C (Fig. 62). Temperatures below zero were only found in the top deposits during a few weeks, whereas the rest of the section seems not to freeze. Mean air temperature was also above zero for large parts of the winter 2014-15. Maximum temperatures measured in the upper deposits were 9-13°C. Soil temperatures were slightly higher in the Western section than in the Northern section, probably because it is affected by precipitation flow. Soil moisture in the upper deposits in the W section averages 49%, while the lower ones reach 69-73%. In the N section, the upper deposits average 65% water content, the lower ones 78%. Fluctuations caused by precipitation were observed, but always slightly delayed. Water content was lower during winter than during summer. The values measured just above the bedrock show high redox potentials there that follow the patterns found higher up in the section (Fig. 62).

6.4.4 Degradation studies and sensitivity to temperature and soil water content

The samples from Voldstad consumed 25.2–60.5 µg O₂/day/g dry soil at 5°C and *in situ* water content, and the decay rate increased by 8.7–14.0% per 1°C increase in temperature (Hollese *et al.* 2016). At *in situ* water contents the samples from Banġgohppi consumed oxygen at a very low rate (<0.1% saturation per day) and were below or very close to the detection limit of the method. Thereby the results show that at *in situ* water content the decay of the samples from Banġgohppi is close to negligible. However, the rates of oxygen consumption increased significantly when adding water to

the samples. At 5°C, the samples from Bankgohppi consumed 1.7–4.4 µg O₂/day/g dry soil and the decay rate increased by 3.8–5.0% per 1°C increase in temperature.

Table 14 Geophysical, geochemical and archaeological evaluations of preservation conditions and state of preservation in the monitored deposits at Voldstad.

Samples / sensors	Depth		Stratum	Organic matter (%)	Water content (%)	pH	Conductivity µS cm ⁻¹	Preservation			
	(m)	(masl)						Organic material	Inorganic material	Redox conditions *	Archaeological state *
Sensor 4 west	0,24	30,91	Layer 2	68	72	7,2	166	excellent	medium	A5	A3-4
Sensor 5 west	0,40	30,75	Layer 3	47	68	7,4	166	excellent	medium	A5	A4
Sensor 6 west	0,56	30,59	Layer 4	59	69	7,6	379	good	good	A5	A4-5
Redox 1 west	0,57	30,58	Layer 4								
Sensor 1 north	0,26	30,89	Layer 2	57	69	7,3	65	excellent	medium	A5	A3-4
Sensor 2 north	0,44	30,71	Layer 3	57	69	7,7	291	good	good	A4	A4
Sensor 3 north	0,52	30,63	Layer 4	43	61	7,3	424	excellent	medium	A5	A4-5
Redox 2 north	0,50	30,57	Layer 4-5								
Sample A east	0,51	30,64	Layer 3-4	35	60	7,8	218	good	good	A4	A4-5
Sample B east	0,57	30,58	Layer 4	42	62	8,0	443	good	excellent	A5	A4

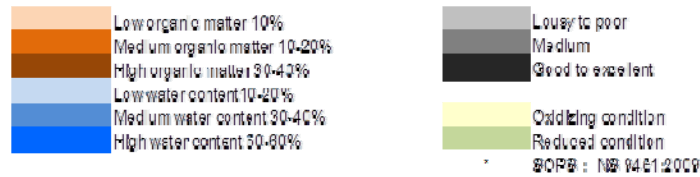


Table 15 Geochemical composition of soil samples from Voldstad.

Voldstad, Harstad										
Samples / sensors	Depth (m)	Depth (masl)	Layer	Nitrate - N (mg/kg DM)	Ammonium-N (mg/kg DM)	Sulphate (mg/kg DM)	Sulphide (mg/kg DM)	Iron (II) (mg/kg DM)	Iron (III) (mg/kg DM)	% of Iron (II)
Sensor 4 west	0,24	30,91	Layer 2	< 0.1	18,2	< 3.8	124	317	10	97 %
Sensor 5 west	0,40	30,75	Layer 3	< 0.1	13,9	< 3.7	109	395	0,1	100 %
Sensor 6 west	0,56	30,59	Layer 4	< 0.1	5,6	478	382	761	0,1	100 %
Redox 1 west	0,57	30,58	Layer 4							
Sensor 1 north	0,26	30,89	Layer 2	< 0.1	17,8	140	181	371	38	91 %
Sensor 2 north	0,44	30,71	Layer 3	3,68	12,3	< 3.6	28	534	94	85 %
Sensor 3 north	0,52	30,63	Layer 4	< 0.1	19,5	272	611	1204	31	98 %
Redox 2 north	0,58	30,57	Layer 4-5							
Sample A east	0,50	30,64	Layer 3-4	< 0.1	13,3	< 2.9	51	443	65	87 %
Sample B east	0,57	30,58	Layer 4	< 0.1	9,1	< 3.1	120	495	19	96 %

DM= dry matter

At both sites the decay rate was limited at high water contents and very strongly limited at dry conditions (Fig. 63). At Voldstad the decay rate was at its maximum at a water content of 40–75%

volume (40–95% of saturation), and at Banġgohppi the decay rate was greatest at a water content of 20–30% volume (40–60% of saturation).

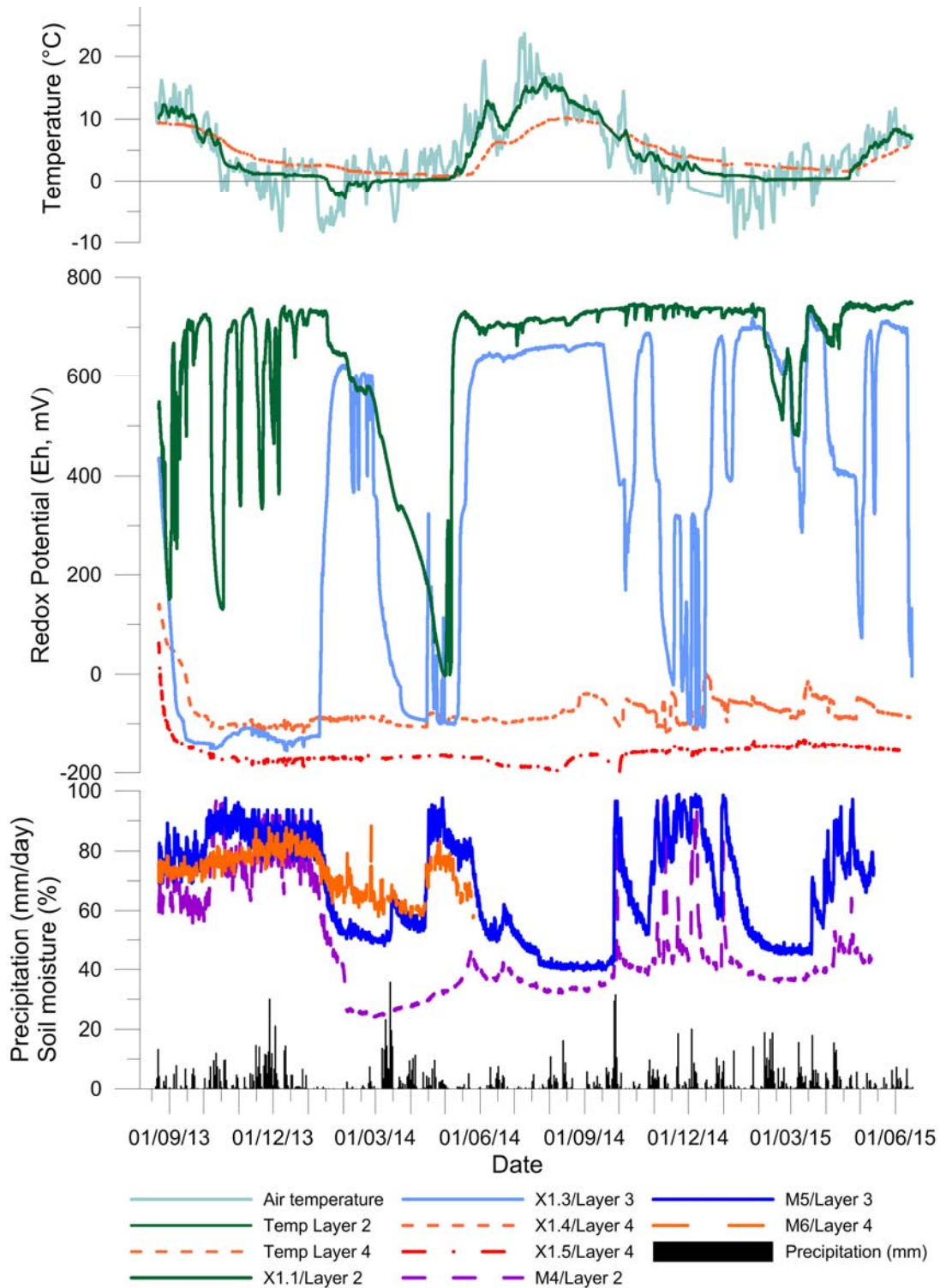


Figure 62 Selection of soil temperatures, redox potentials (Eh) and soil moisture values as measured in the Western profile of Voldstad. Coding follows Figure 59. During the two winter periods, the Eh in intermediate layers show a drop, but in non-freezing periods the Eh is relatively high and variable. Precipitation (black bars)

appears to influence the Eh in layer 2 only in the first month after the excavation and not so much after the first winter, even though there is a strong link with soil moisture content (bottom part).

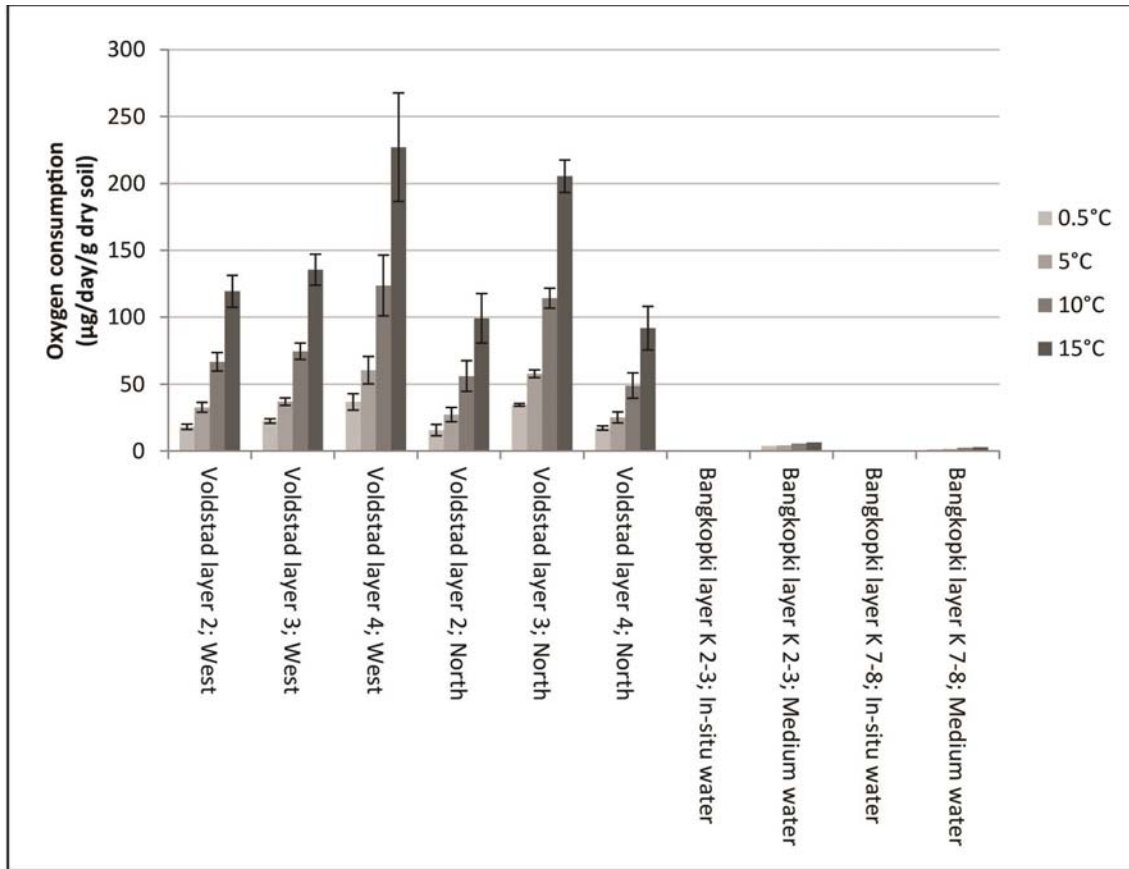


Figure 63 Oxygen consumption rates at variable temperatures in soil samples from Voldstad and Bangkopi. Bars mark ± 1 standard deviation.

6.5 Discussion

The overall archaeological evaluation of state of preservation at Bangkopi shows well preserved and varied artefacts of bone, antler and stone, because the site is dry and cold. The zooarchaeological finds are kept stable by a high pH caused by the sheer number of shells in the midden. This is confirmed by the palaeoecological analyses. If conditions like the present will continue stable in future, continued *in situ* preservation should be possible.

Monitoring of the site has so far shown stable low humidity and low temperatures in the deposits. Redox potential measurements have shown that oxygen is present throughout the section year round.

This correlates well with the type of finds at this site; only the calcareous parts of the organic remains are well preserved. Increase in precipitation because of higher temperatures/ climate change, could be detrimental for the site, as zooarchaeological remains might be damaged by dissolution due to water flow. The decay experiments also showed that decay will increase with increased moisture content. Other threats might come from the physical disturbance caused by rooting from encroaching vegetation, unless a physical heritage management plan of the site is applied, reducing vegetation.

At Voldstad farm mound, the state of preservation was deemed good to excellent by the archaeologist, and this was confirmed by the geochemical analyses of deposits with high organic matter content and high water saturation. The conditions in the soil samples were overall reducing (sulphate reducing to methanogenic). All these factors indicate good conditions for *in situ* preservation. However, soil water content is controlled at this site by infiltration of precipitation into the deposits. The redox potential

measurements show large fluctuations, which indicate that oxidizing conditions are occurring even in the lower layers. Reduction occurs in spring time. The change in redox potential in spring 2014 shows that the site responds to the thawing of the top soil, which stimulates microbial (reducing) activity resulting in a decreasing redox potential.

Reducing conditions can only occur when soil moisture content is high enough and limits the oxygen diffusion, showing the need for enough water infiltration, which at Voldstad probably occurs at higher areas, not just at the test pit. Overall, the preservation conditions at Voldstad are perhaps not as excellent as perceived on site. The variation in redox potential and the high amount of partly degraded organics show that this site has active though slow degradation. The degradation has probably occurred throughout the complete lifespan of the site, but will continue in future. In order to preserve this site, the water supply to the soil should not be hindered. This water is crucial in maintaining a reduced environment. Due to the slope, it will be very hard to reduce water flow itself.

The use of two sets of equipment have ensured that even if some probes fail, information will be secured, and palaeoecological analyses and redox measurements have revealed ongoing decay that might not otherwise have been suspected.

For both Voldstad and Banġgohppi the mean annual temperature is expected to increase with approximately 3.0°C within the period 2017-2100 (relative to 1961-1990) and the mean annual precipitation sum is expected to increase by approximately 30% (Norwegian Meteorological Institute, Yr). This may have a direct effect on the preservation conditions. The measurement of oxygen consumption showed that the decay rate could increase by 8.7–14.0% for Voldstad and 3.8–5.0% Banġgohppi per 1°C increase in temperature. The soil at Voldstad is much wetter than the soil at Banġgohppi. For this reason, the decay of the organic materials at Voldstad is primarily limited by the high water contents and the resulting exclusion of oxygen. On the other hand, the decay of the organic materials at Banġgohppi is limited by the dryness of the soil. Consequently, the decay rates in the archaeological deposits of the two sites are likely to react very differently to future changes in precipitation. At Voldstad the expected increase in precipitation could help to keep the deposits wet and counteract the direct effect of a warmer climate. However, a decrease in net precipitation (precipitation minus evaporation) could threaten the continued preservation of the archaeological deposits, as more oxygen would diffuse into the soil. At Banġgohppi the expected increase in precipitation is likely to accelerate the decay rate, as it would no longer be limited by the dry conditions in the soil.

6.6 Conclusion

If continued *in situ* preservation is to be possible at these site types with the predicted climate changes, heritage management plans should be applied that reduce encroaching vegetation on the Stone Age sites and possibly added chalk to keep an alkaline environment. The calcareous remains may not be affected much by changes in temperature, but increased precipitation may wash out the chalk and will accelerate decay of the deposits themselves, making site interpretation more difficult.

For the farm mounds, increasing precipitation may actually help preserve the sites even if temperatures rise. The worst possible scenario for organic deposits is increased temperatures but less water, since that would accelerate decay there. Covering sites with clay to help preserve soil humidity and protect from higher temperatures might be a possible mitigation act.

The two sites presented here constitute a small selection of their respective sites, making it difficult to draw general conclusions for all these sites. Given the general morphology at the Banġgohppi site, that can be said to be representative of a typical dwelling. For the farm mounds, more monitoring projects have started, enabling scaling up at a later stage.

If not all sites can be preserved, should they then be excavated and preserved *ex situ*, or should they simply be left to decay? It may be necessary for the cultural heritage management to choose between sites. This should preferably be an informed choice, made in collaboration between research and management.

7 Synthesis; Implications for archaeological heritage management

The focus of this thesis work is on three complex topics: 1) *in situ* preservation of unsaturated archaeological deposits, 2) rural medieval archaeology, and 3) climate change, all within the context of Norwegian Cultural Heritage management and research. The outset is the question whether and under which circumstances *in situ* preservation is possible and what happens to heritage sites and archaeological deposits chosen for *in situ* preservation. Through five case-studies from different areas of Norway, different types of sites, various chronology and different climatic zones it is demonstrated that not only do these sites face the effects of general pollution and the changing climate, but since many sites are situated in areas with modern activities like agriculture or settlement, their conditions are constantly changing and their scientific potential thus endangered by gradual degradation. In order to deal with these problems, this thesis has been based on cooperation between several institutions and disciplines. A series of research questions were asked in the introductory chapter (1.1). These are repeated below in italics and marked with bullet points, and the answers given are results of the thesis work.

7.1 Cultural heritage and *in situ* preservation

Uninvestigated archaeological sites are hidden resources with information potential about human history. By a thorough archaeological investigation of such sites, archaeologists may interpret past circumstances and actions. At their disposal stand an almost infinite and ever growing number of disciplines and methods and the outcome is therefore often as much a product of economic limitations and preservation conditions as it is a matter of deliberate priorities.

Since the introduction of the Malta Convention in 1992, the main strategy of the cultural heritage management authorities in Norway as in most of north-western Europe has been to preserve as much of these hidden sources as possible *in situ*. However, it is difficult to preserve something without a clear idea of what type of archaeological remains are present, their current state of preservation and of possible threats to this preservation. Simultaneously the pressure from agriculture and the development industry is hard, trying to reduce costs by adhering to *in situ* preservation. In many towns both in Norway and abroad there are now several cases where it has been permitted to build on top of archaeological remains on piles augered into the deposits, a solution which is often much cheaper than paying for full-scale excavations. Obviously the sites are evaluated before piling is allowed. In the countryside, Norwegian legislation to a great degree gives the farmers free hands to develop their lands, and if a heritage site is discovered in an area which is already under cultivation, this cultivation is allowed to continue with little or no limitations. It is true that societal development cannot and should not always be stopped, but the question is what consequences these actions have for the deposits and their information value. Will they stay intact or will they gradually degrade and their information value be lost forever without being recorded? One may ask whether ‘preservation *in situ*’ is just an easier, cheaper and less painful way for the heritage management of discarding archaeological deposits without admitting doing it? It is much easier to decide for a monitoring of preservation conditions of built-over archaeological remains than to ask for a removal of the built project if and when the measurements start showing alarming results. It would most likely end in legal conflicts, if heritage authorities should demand full excavation of a site which may be covered by a brand new housing project or a main road. The best outcome one could hope for is therefore that, if such results should occur and be measured, the experiences will be a lesson learned and influence future decisions on managing heritage at developing sites.

The work in this thesis has concentrated on archaeological deposits in the unsaturated zone, i.e. the deposits above the ground water table. That is because most preserved archaeological deposits outside the Norwegian medieval towns, and quite a large number of the deposits within the towns, are in this zone. These deposits, along with those in the fluctuation zone between saturated and unsaturated, are the most vulnerable to changes and degradation. Besides, not only in Norway, research on *in situ* preservation has so far mainly focussed on the saturated zone. The hydrological conditions may vary considerably in the unsaturated soil layers, resulting in heterogeneous conditions both horizontally and vertically in the deposits and an added risk of exposure to oxygen and thus accelerated degradation. To characterize the preservation conditions in dry or relatively dry layers, the presumed most important parameters are:

- organic matter content (to indicate which artefacts and ecofacts may be preserved),
- oxygen content or redox parameters (to see if conditions are stable or not),
- soil temperature (to see to which extent the deposits are affected by air temperature; it is an assumption that lower soil temperatures are better for preservation),
- soil humidity (to indicate which artefacts and ecofacts may be preserved and to see to which extent the deposits are affected directly by precipitation),
- soil porosity (to see how easily oxygen may penetrate into the deposits), and
- vegetation encroachment (to see if physical disturbances are a likely occurrence).

The scale of assessing and monitoring depositional stability and preservation conditions on all sites was performed in accordance with the Norwegian Standard (NS 9451, 2009). However, since the focus in the standard is on the organic and particularly botanical remains, an evaluation of the soil chemical preservation conditions for inorganic remains was added, since that gave additional input to the overall evaluation of the sites (see Chapters 4 and 5). Threats of breakage through physical exposure are discussed in the archaeological evaluation of the deposits. The descriptive system (RA & NIKU, 2008:29-31; NS9451, 2009:19), separating each deposit into its biological, zoological and mineralogical components and artefacts has turned out to work relatively well. It forces the archaeologist to evaluate the state of preservation of the different components and eventually reach a conclusion about the conservation state for the whole deposit. Separating the mineral components into stone, gravel, sand of varying coarseness, silt and clay gives good information about the compactness and porosity of each deposit. The descriptive system works equally well on heterogeneous unsaturated deposits and homogeneous saturated ones. With a little training and supervision, this description and evaluation of state of preservation may be carried out by any archaeologist. The thorough description gives sufficient information to justify the time spent on it, not least because it enables comparability to other investigated sites.

7.2 Cultural heritage and climate change

- *When archaeological observations are coupled with environmental parameters, can one define which parameters most affect the present conservation state and conditions for future in situ preservation of archaeological deposits in the unsaturated zone?*
- *What may be the effects of climate change on these parameters?*

The results of the research presented here have demonstrated that it is possible to define the parameters that most affect preservation of archaeological sites and it is possible to see effects of climate change on these parameters. Degradation of archaeological materials depends on environmental conditions. Future climate change is expected to increase temperatures and change the overall precipitation patterns, with a potentially great negative effect on preservation conditions. For northern Norway in particular, the temperature rise and the change in precipitation from snow to (heavier) rain will most likely cause the greatest problems for continued preservation of cultural heritage sites because of increased risks of erosion in addition to increased decay. Microbial decay of organic archaeological materials is known to increase exponentially with increasing soil temperature, but at the same time, very dry and very wet conditions may hinder microbial processes (Hollesen &

Matthiesen 2015). In Chapter 6, laboratory degradation studies on deposits from Banjgohppi (Neolithic) and Voldstad (medieval) are presented. For both Voldstad and Banjgohppi the mean annual temperature is expected to increase with approximately 3.0°C within the period 2017–2100 (relative to 1961–1990) and the mean annual precipitation sum is expected to increase by approximately 30% (Norwegian Meteorological Institute). This may have a direct negative effect on the preservation conditions. The measurement of oxygen consumption showed that the decay rate could increase by 8.7–14.0% for Voldstad and 3.8–5.0% Banjgohppi per 1°C increase in temperature. The soil at Voldstad is much wetter than the soil at Banjgohppi. For this reason, the decay of the organic materials at Voldstad is primarily limited by the high water contents and the resulting exclusion of oxygen. On the other hand, the decay of the organic materials at Banjgohppi is limited by the dryness of the soil. Consequently, the decay rates in the archaeological deposits of the two sites are likely to react very differently to future changes in precipitation. At Voldstad the expected increase in precipitation could help to keep the deposits wet and counteract the direct effect of a warmer climate. However, a decrease in net precipitation (precipitation minus evaporation) could threaten the continued preservation of the archaeological deposits, as more oxygen would diffuse into the soil. At Banjgohppi the expected increase in precipitation is likely to accelerate the decay rate, as it would no longer be limited by the dry conditions in the soil. Thus, important parameters for *in situ* site preservation may actually be measured through observations made at the meteorological offices, namely temperatures and precipitation types and amounts. However, a basic archaeological knowledge of site types and soil porosity is necessary, and the measurements of soil moisture content, soil temperatures and redox parameters coupled with the decay studies carried out in this research project are essential to understanding the possible impact.

7.3 Rural archaeology in Northern Norway

- *To which extent is archaeological contextual readability retained in rural archaeological deposits at different stages of degradation?*

Among the multitude of archaeological remains in the rural landscape in Arctic Northern Norway, two special types of settlements stand out; the so-called Gressbakken houses from Late Neolithic, and the so-called farm mounds from late prehistory and the Middle Ages. Both site types are present in abundance and have been perceived as veritable treasure troves, being the largest assemblages of prehistoric and early historic archaeological deposits outside the towns. They are visible and unique monuments, and the investigations that have been carried out on sites of these two monument types have provided much new or complementary information to add to the cultural history of the whole country and of northern Norway in particular. The Gressbakken houses are originally coastal settlements, and apart from remains of the turf walls, the best preserved parts of these settlements are the middens outside the coastal entrance. The farm mounds are archaeological remains from centuries of settlements in the same location, and a mound may represent a single farm or several farms or holdings clustered in a hamlet or a village. They represent diverging subsistence strategies, caused by different conditions in landscape or societal structures.

If one looks at the spatial distribution of the listed farm mounds, it is notable that all the ones in Finnmark County are coastal locations, indicating that an economy based on income from the sea is a likely deciding factor (Fig. 64). The Finnmark farm mounds have large outfield areas, and the keeping of sheep and goats, possibly cattle, and possible keeping but certainly hunting of reindeer may have contributed to the economy, since this is so far north in the Arctic zone that cereal crops have no time to mature, though grass is grown for hay production. More than half of these have no buildings on them at present, indicating that they are no longer in use (see also table 5, Chapter 2.3).

In Troms County, the farm mounds are distributed along the inner fiord areas, with a very high concentration in the Harstad area (Fig. 65). The area has rich farming soil and a longer growth season, though it is still in the Arctic zone, making cereal production a possible though marginal income source. Cattle and sheep play a major role in the economy, and hay is produced as fodder, and fishing is very important, as evidenced by the ecofact finds from farm mound excavations.

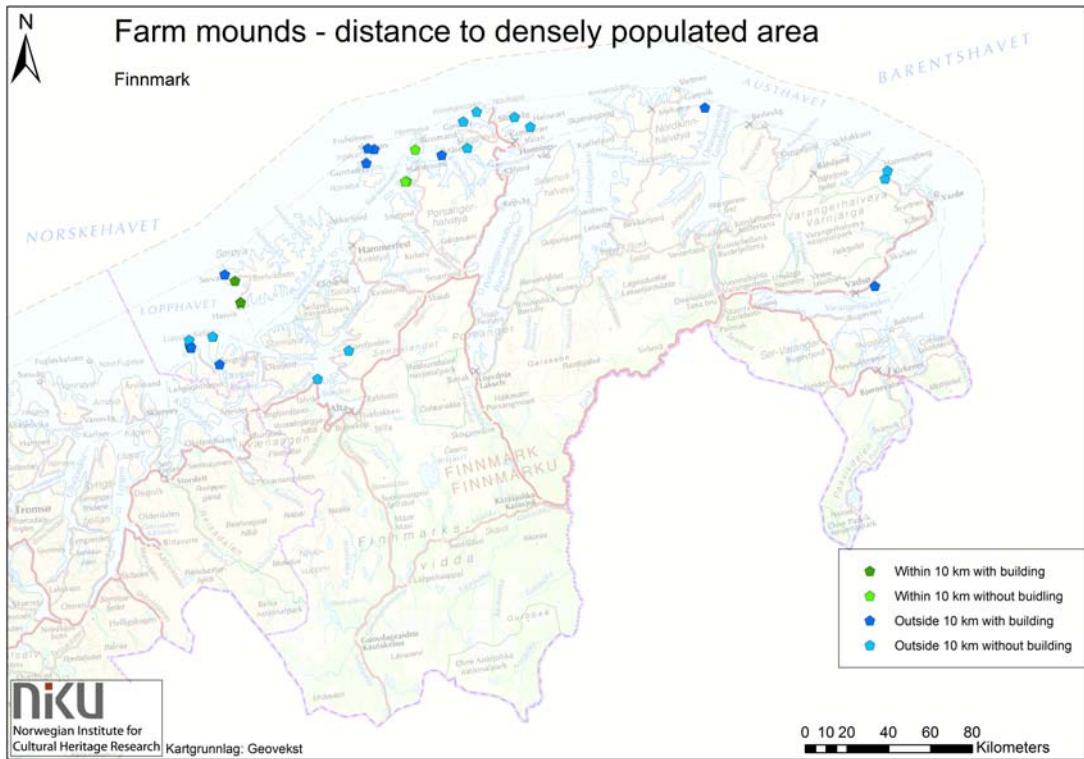


Figure 64 Map of listed farm mounds in Finnmark, with or without buildings, with marked distance to nearest densely populated area (Norwegian ‘tettsted’). Map by Nils Aage Hafsal/NIKU 2016.

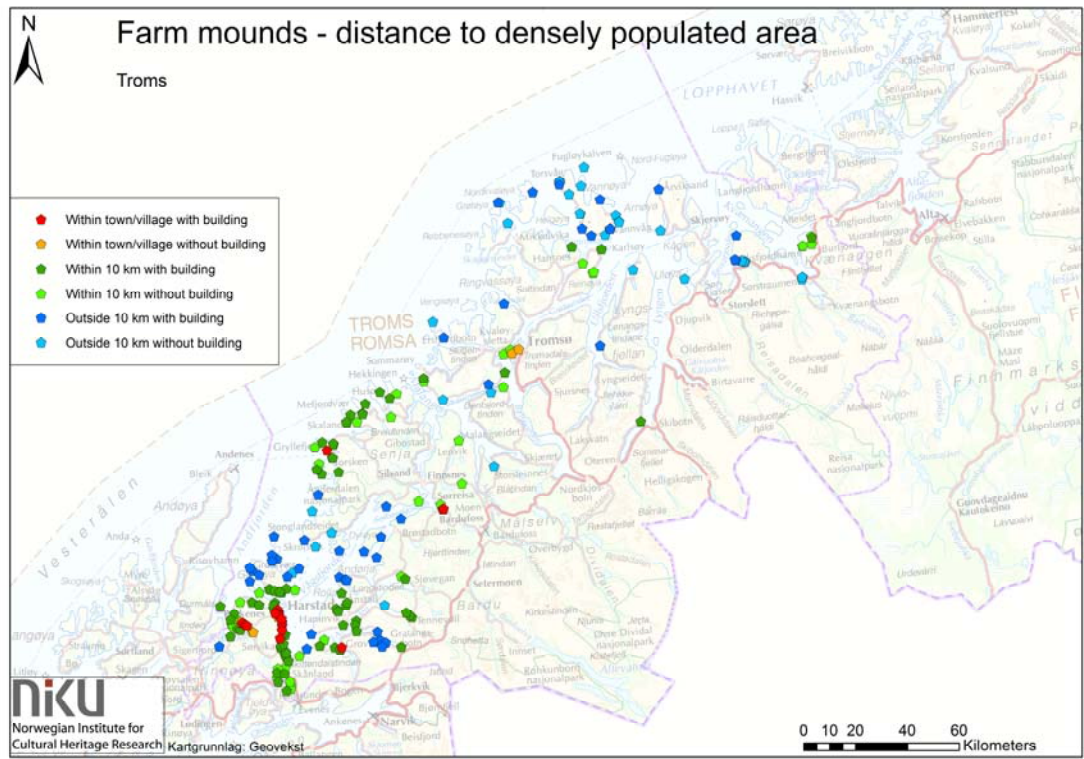


Figure 65 Map of listed farm mounds in Troms, with or without buildings, with marked distance to nearest densely populated area (Norwegian ‘tettsted’). Map by Nils Aage Hafsal/NIKU 2016.

The largest number of farm mounds without buildings and thus not in active use are found more than 10 km from the towns and densely populated areas (see further in Chapters 3, 4 and 6). The largest concentration of listed farm mounds in any county occurs in Nordland, with the highest site concentration in the Lofoten area, an archipelago to the north in the county (Fig. 66). That area is characterized by steep mountains, small areas of arable land, and very good fishing grounds. It is a fair assumption that the stock fish trade is and has been a major subsistence factor for these farm mounds, at least from the Middle Ages and onwards. The uninhabited farm mounds may be found on some of the most exposed islands, but mostly along the mainland coast of the county. Some of the more exposed sites are so close to good fishing grounds that they remain densely populated to this day.

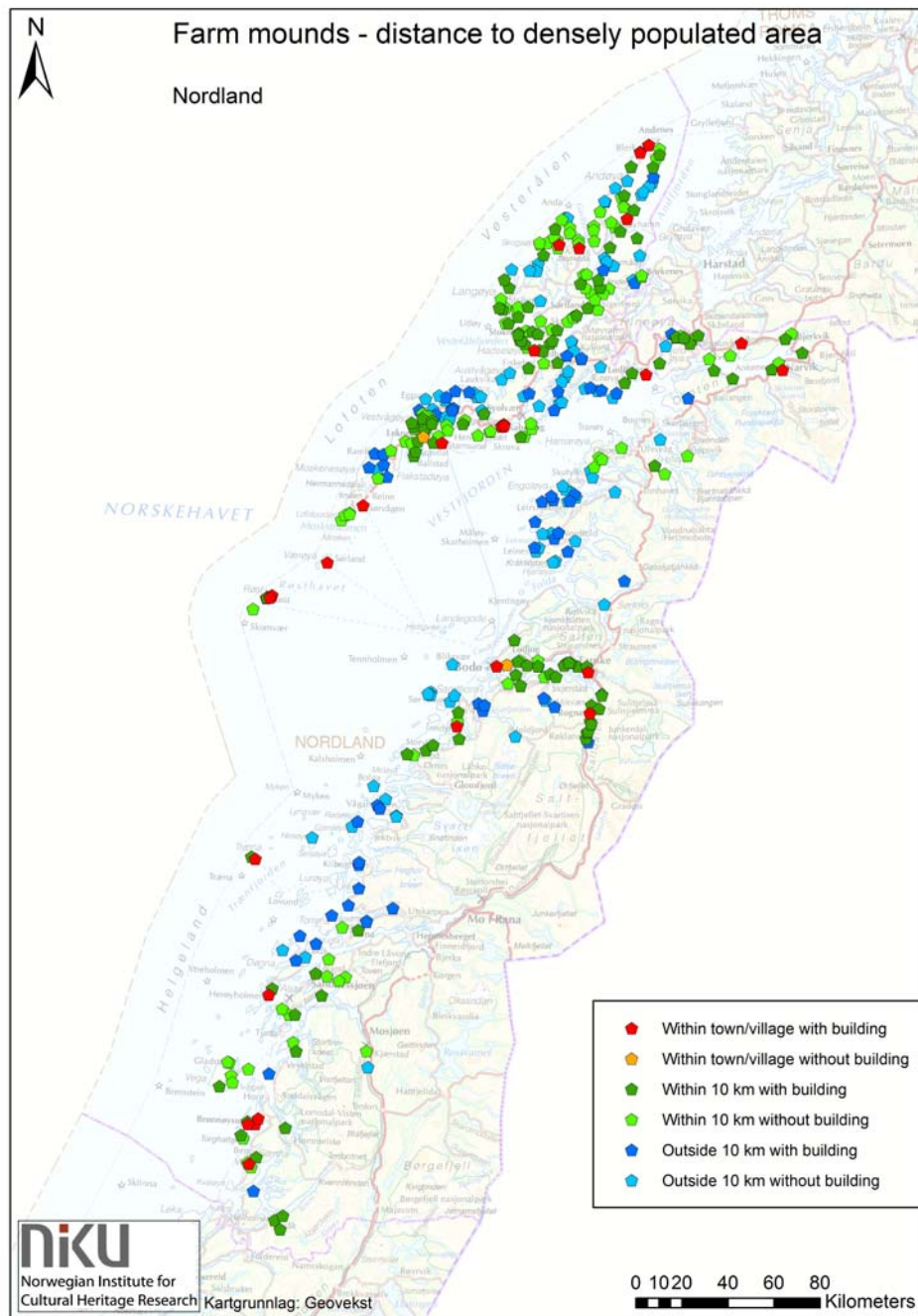


Figure 66 Map of listed farm mounds in Nordland, with or without buildings, with marked distance to nearest densely populated area (Norwegian 'tettsted'). Map by Nils Aage Hafsal/NIKU 2016.

In southern Norway it has been an established but untested truth that due to unbroken settlement continuity from Late Prehistory to present day at the central farmsteads, nothing has been preserved for archaeological research. The extreme bias in resource use on urban versus rural sites as demonstrated in Chapter 2 also plays a major role in the understanding or lack of the same of these heritage resources. In spite of this, minor excavations at a few sites have proved that even outside the northernmost counties settlement mounds with considerable preserved archaeological deposits may be found. Raised awareness may uncover more, even if awareness does not guarantee a position as listed monuments. Åker in Hamar municipality, Hedmark County, is one of few rural sites in southern Norway that with certainty may be classified as a farm mound. Spectacular artefact finds are indications of a high position in social stratification already as early as the Migration Period that makes it stand out in the archaeological record of Norway. Avaldsnes in Karmøy municipality, Rogaland County is another site which stands out through its mentions as a Royal Manor in historical sources from Viking Age and medieval times, and with preserved archaeological settlement remains from Bronze Age to the Middle Ages in a farmed and settled area. The already raised awareness of these special sites makes them good starting points for rural investigations of state of preservation and preservation conditions for this part of the country.

As demonstrated, the environmental climate zones of the studied objects differ considerably. All the studied sites have contained contextual readability. However, since they differ so much in type, a true comparison can hardly be carried out. Still, the farm mounds Saurbekken and Åker and the different archaeological remains at Avaldsnes may be compared (see Chapters 2, 3, 4 and 5). They were all in approximately the same stage of degradation, and all had relatively dry deposits with only little organic matter still preserved. The farm mound Voldstad (see Chapters 3 and 6) had high legibility where that of Saurbekken (Chapters 2 and 4) was reduced. That may be partly because the section at Saurbekken was placed at the very edge of the farm mound, while the Voldstad trench was placed centrally, but the geophysical investigations carried out in 2012 also enabled comparison to an earlier excavation (Holm-Olsen & Bertelsen 1973, Gustavsen 2013). The new section and the geophysics combined indicate that the Saurbekken mound may have shrunk up to 10cm in height during the past 40 years. To monitor this for the future, a laser surface scan was made of the whole site. The overall archaeological evaluation of state of preservation at Banjgohppi shows well preserved and varied artefacts of bone, antler and stone, because the site is dry and cold, though the legibility of the remains is reduced, because they now consist mainly of compacted zooarchaeological finds (see Chapter 6).

7.4 Threshold levels

- *Is it possible to define threshold levels in the archaeological deposits?*

The present study is affirmative and demonstrates that it is possible to define threshold levels of change, though so far very few attempts have been made to put any numbers on these. That is quite likely because there could be reason to fear that setting limits might endanger the automatic protection of sites that are found to be below these limits (see Chapter 2.4). For soil moisture levels, we may use those percentage changes in soil moisture level presented by Richard Hughes in 1999 (Hughes 1999, Reed & Martens 2008:270). 0-5% change signalling safe conditions (green), 6-10% indicating potentially threatening conditions (amber/yellow) and 11% and higher (red) signalling immediately threatening change rates, the red values calling for immediate mitigating actions. It is not possible to give a fixed number of soil moisture which may be deemed 'wet enough', since it is site dependant how wet it needs to be to keep preservation stable, but a feasible parameter could be a percentage change as indicated in Table 16.




If these levels of change in soil moisture can hold true, then similar threshold levels could be defined for preservation of whole sites, to be used as indicators of when to apply mitigating actions or decide when to preserve by record rather than *in situ*. In Norway, systems are actually in place with control registrations of a limited number of archaeological sites in a few municipalities spread across the country, a sequential monument's watch system checking on their physical state and possible changes that have occurred since the last inspection (Sollund & Holm-Olsen 2013). However, one must stress that this indeed only covers a limited number of sites, and only visible ones. Also, defining actual

threshold levels as basis for actions has not been done, further than the 0.5% loss defined as a maximum by the government. My suggestion would be that the same numbers as for change in soil moisture levels might be applied here, i.e. 0-5% signalling safe conditions (green), 6-10% indicating potentially threatening conditions (yellow/amber) and 11% and higher (red) signalling immediately threatening change rates. The physical state would be very important in evaluating e.g. erosion damage caused by raised sea levels.

Soil decay rate threshold levels could be also defined like the percentage changes in soil moisture level, though perhaps modified a bit so that 0-10% change signals safe conditions (green), 11-20% change indicating potentially threatening conditions (yellow/amber) and 21% and higher changes (red) signalling immediately threatening change rates that call for heritage management reactions, either mitigation or excavation.

Similar threshold levels are set for loss of or damage to a cultural heritage site because of continued use, whereas new use or development causing damage to sites should have lower threshold levels before mitigation acts are enforced.

Table 16 Threshold levels defined as change in preservation conditions.

	% change of soil moisture	% change of surface damage	°C change of temperature	% change of decay rate	% loss/damage to site caused by continued use	% loss/damage to site caused by new use/development
	11-	11-	2-	21-	21-	11-
	6-10	6-10	1-1.9	11-20	11-20	6-10
	0-5	0-5	0-0.9	0-10	0-10	0-5

7.5 Mitigating actions

- *Can degradation processes be curbed or mitigated? If so, which mitigation strategies may be required for the investigated sites?*

As mentioned above, the investigated sites differ in both age and state of preservation, and they therefore require different strategies to mitigate or curb degradation, also depending on whether or not predicted climate changes will take place. Besides climate change causing changes in temperature and precipitation, and possible increasing erosion caused by raised sea levels, storms and flash floods, other factors that may require mitigating actions are infrastructure projects (see Chapter 2). Further, possible changes in the Cultural Heritage Act reducing the automatic protection of archaeological remains (and thus deviating from the Valletta Treaty) may in future be the greatest cause to call for mitigating actions. However, the examples of that may vary so greatly that predicting possible mitigation acts for all are not feasible.

If continued *in situ* preservation is to be possible at the site types investigated for this thesis, heritage management plans should be applied that reduce encroaching vegetation on the Stone Age sites and possibly added chalk to keep an alkaline environment. The calcareous remains may not be affected much by changes in temperature, but increased precipitation will accelerate decay of the deposits themselves, making site interpretation more difficult (see Chapters 2 and 6). For the various archaeological remains at Avaldsnes, a general conclusion is that although most are already highly degraded, they still contain high information potential, and the preservation conditions for inorganic artefacts are not too bad. To preserve these *in situ* for the future, the best cover is natural (soil, grass) rather than gravel, as has been exemplified with the monitored sites at the parking lot and the grave cairn (see Chapter 5). For Åker, the deposits were mostly dry and rather porous, allowing both airborne and waterborne oxygen to be transported into the deposits, and thus increasing the risk of degradation of organic matter and all organic artefacts. Porous deposits also allow intrusions of water which may degrade inorganic artefacts such as pottery or metal objects (see Chapters 2 and 4). However, that does not mean that they do not have a value or scientific potential. For all the farm mounds, increasing precipitation may help preserve the sites even if temperatures rise. The worst possible scenario for organic deposits is increased temperatures but less water, since that would accelerate decay there.

Covering sites with clay to help preserve soil humidity and protect from higher temperatures might be a possible mitigation act (Chapter 6), although this is a strategy which is at present in conflict with the heritage act which prohibits coverage of monuments. However, that is a practical problem which should be possible to solve. At Saurbekken, a mitigation act was implemented during the investigation, securing the exposed section with clay (see Chapter 2).

Mitigating actions should be sustainable, i.e. should be fairly easy to carry out and not cost a fortune. They should also be immediately distinguishable from the original archaeology, so that future archaeological investigations at a site can easily tell them apart. Mitigation may be fairly simple if one deals with a limited object with unlimited funding, but that is hardly ever the case. Mostly, there are unlimited numbers of sites to protect and very few resources to obtain that objective.

7.6 Heritage value theory

- *Which are the possible effects of the rates of degradation on contextual readability?*

Contextual interpretation of a site increases with the number of anthropogenic traces preserved such as soil features (e.g. post holes or ditches) and deposits, and of the complexity of eco- and artefact categories. However, even the highly degraded Stone Age deposits contributed with new information simply because contextual readability was a focal point. The interdisciplinary investigation team also meant that observation rates were very high. However, it is true that a heritage site may suffer so severe degradation that it becomes almost illegible and thus contextual interpretations are rendered impossible. Hopefully the decay should be observed before it gets that far, and mitigation acts carried out, or the site should be excavated and preserved *ex situ* (see Chapter 7.7). Value should be ascribed to sites using the DIVE method or similar systems as suggested in Chapters 2.6 and 7.7, and illustrated by the defined threshold levels and threats in Table 16 and Table 17. To ensure that at least parts of our archaeological heritage will be preserved *in situ* for the future, we may have to accept that some must be lost or preserved *ex situ*, i.e. by record. Ascribed values to sites should be the deciding factor of heritage management strategies.

7.7 Cultural heritage management

- *How may knowledge on degradation rates and climate change contribute to a decision support system for cultural heritage management?*

The work carried out in this thesis project and the adjoining research project on monitoring of rural archaeological deposits has contributed greatly to increased knowledge, and the results have consequences for heritage management of a large number of sites from all periods. Using the descriptive system of the national standard allows for intra site comparisons and reminds the archaeologist to be observant of all details. The data thus collected can be used to give input to a risk assessment system. The work carried out in the research projects presented in this thesis has demonstrated the importance of cooperation between institutions and interdisciplinary approaches. The method of augering to define the presence and state of archaeological deposits on a known listed monument, combined with geophysical investigation methods to model deposits over larger areas, have proved highly efficient, giving a maximum of information with a minimum of destruction of already fragile archaeological remains (see Chapter 4). Surface laser scans of sites are also an efficient monitoring method in a long-term perspective. If monitoring data, decay studies and modelling indicate a likely loss of sites, this can be used as an argument for implementing mitigation strategies where possible, or for carrying out full-scale excavations at some of the threatened sites to preserve the information *ex situ*.

To enable such an evaluation, the table below may be used as a heritage management tool, preferably built into the National Heritage database (Askeladden). A GIS position should be indicated in a free text/numbers field. The type of monument should be chosen from a dropdown menu, using the same types as the national cultural heritage database. From the same database, one gets the unique heritage

ID number. An important evaluation tool for threats is whether or not a site is lived on, something which could be indicated by a simple yes/no field. Another important factor is distance to densely populated area, which may be registered in a free text or numbers field. Since some sites are now monitored, that also contributes to the overall threat evaluation and may be indicated by a simple yes or no field. Possible threats may be chosen from a dropdown menu, using the same indicators as the control registrations with added climate change factors. Threshold levels for the different threats are indicated in Table 16, and here they could be chosen from a dropdown menu. Possible mitigation actions should be a free text field.

Table 17 Heritage management threat evaluation table/database.

GIS position	Monument type	ID	Lived on	Distance to populated area	Monitored	Possible threats	Threshold levels	Possible mitigation actions
Free text/ numbers field	Dropdown menu from national CH database	Nr. from database	Y/N field	Free text/ numbers field	Y/N field	Dropdown menu of fields below + free text	Dropdown menu (see Table 16)	Free text field
						use (continued)		
						development/ new use		
						infrastructure		
						erosion/ surface		
						temperature change (air/ soil)		
						precipitation change (less/ more, other)		

The table or database should then have one row for each site, or possibly one for each likely threat to a specific site. If a specific site has many threats where the threshold levels are either yellow or red, this could be used as indications to e.g. allow development there, rather than at a site where all indicators are within the green range. This could be used in the value criteria for every site. It would also work as a warning system of when information potential of a site is endangered, coupled with threshold levels (Table 16) calling for either mitigation or *ex situ* preservation.

- *How can studies of artefact preservation and microscopic and macroscopic microfossils contribute to evaluations of state of preservation?*

The descriptive system (RA & NIKU, 2008:29-31; NS9451, 2009:19), separating each deposit into its biological, zoological and mineralogical components and artefacts works well, giving good information about each deposit and enabling intra-site comparisons. I have found it necessary and useful to separate the preservation conditions between organic and inorganic, by the latter meaning the inorganic artefacts most susceptible to geochemical changes. Breakage levels of artefacts have been studied whenever applicable, and have proven important evaluation factors (see further in Chapters 3, 5 and 6). Palaeoecological analyses have revealed ongoing decay that might not otherwise have been detected (see Chapter 6), and they are particularly useful since palaeoecological remains are almost always present in some form in most archaeological deposits independent of conservation state.

8 Conclusion and further perspectives

Since the introduction of the Malta Convention in 1992, the main strategy of the cultural heritage management authorities in Norway as in most of north-western Europe has been to preserve as much of the archaeological heritage as possible *in situ*. *In situ* preservation is not only a matter of preventing a certain monument from being destroyed by development work or other changes in the use of its environment. The Malta Convention states that sites intended for *in situ* preservation must not just be left to themselves but should be actively monitored and taken care of in order to ensure that the protection results in preservation and not gradual deterioration.

A stable environment is of crucial importance for preservation, and many factors influence the conditions for *in situ* preservation. One important factor is the climate. 2015 was the year a global temperature rise of 1°C above the average temperature of the pre-industrial world was reached. A climate change such as this affects hydrology, temperature, erosion etc., which again affect the conditions of preservation. For northern Norway in particular, the temperature rise and the change in precipitation from snow to (heavier) rain will most likely cause the greatest problems for continued preservation of cultural heritage sites because of increased risks of erosion in addition to increased decay. Pollution, fertilizers and pesticides as well as development work and agriculture likewise affect the environment, hydrology and chemical balances in an ever increasing magnitude. Even areas remote from modern industrial plants or farmland are today affected by these activities. Studies comparing artefacts found at the same site but with a 100 years interval demonstrate the alarming fact that the decay of the hidden material record is under stress and shows unmistakable signs of increased decay.

The results of the research presented here have demonstrated that it is possible to define parameters that most affect preservation of archaeological sites and it is possible to see effects of climate change on these parameters. That accentuates the importance of preparing strategies to deal with the effects of climate change on the preservation of cultural heritage sites.

Though societal development cannot and should not always be stopped to avoid disturbance of archaeological remains, the question is what consequences actions such as continued cultivation or building on piles on top of archaeological remains have for these remains and their information potential. Will they stay intact or will they gradually degrade and their information value be lost forever without being recorded? One may ask whether ‘preservation *in situ*’ is just an easier, cheaper and less painful way for the heritage management of discarding archaeological deposits without realising doing it?

The work in this thesis has concentrated on archaeological deposits in the unsaturated zone because these deposits, along with those in the fluctuation zone between saturated and unsaturated, are the most vulnerable to changes and degradation. The focus has been on rural sites, because they constitute a major part of all heritage sites in Norway. The extreme bias in resource use on urban versus rural sites as demonstrated in Chapter 2 also plays a major role in the understanding or lack of the same of these heritage resources and the future possibilities or limitations of preserving them for the next generations.

In this work a systematic descriptive system of parameters important for *in situ* preservation is used in accordance with a Norwegian national standard from 2009 (NS 9451), assessing and monitoring depositional stability and preservation conditions on all sites and using a scale from 1 to 5 to distinguish between bad and good state of preservation. However, since the focus in the standard is on the organic and particularly botanical remains, an evaluation of the soil chemical preservation conditions for inorganic remains was added, since that gave additional input to the overall evaluation

of the sites. The descriptive system works well, separating each deposit into its biological, zoological and mineralogical components and artefacts. It gives good information about each deposit and enables intra-site comparisons. Breakage levels of artefacts have been studied whenever applicable, and have proven important evaluation factors (see Chapters 3, 5 and 6). Palaeoecological analyses have revealed ongoing decay that might not otherwise have been detected, and they are particularly useful since palaeoecological remains are almost always present in some form in most archaeological deposits independent of conservation state.

The work carried out in this thesis project and the adjoining research project on monitoring of rural archaeological deposits has contributed greatly to increased knowledge, and the results have consequences for heritage management of a large number of sites from all periods. Using the descriptive system of the national standard allows for intra site comparisons and reminds the archaeologist to be observant of all details. The data thus collected can be used to give input to a risk assessment system.

The use of geophysical investigations combined with laser surface scans have proven excellent tools for future monitoring of possible shrinkage of a site. This non-invasive method may then replace re-excavation, at least if site size and depth are the only questions to answer in a particular case. If repeated scans indicate changes, then control excavations and eventually mitigating actions or rescue excavations can be carried out. Augering as a method to obtain information about deposit depths and state of preservation has also proved a useful tool (see Chapter 4), but it cannot replace full archaeological investigations if one wishes to write cultural history.

A system of threshold levels to indicate threatening changes in preservation is suggested (see Table 16 and Chapters 2 and 7), with change factors for;

- percentage change in soil moisture,
- percentage change in surface damage (as e.g. caused by erosion),
- temperature change (measured in °C),
- percentage change in decay rates,
- percentage loss or damage to a site by continued traditional use, and
- percentage loss or damage caused by new use or development

Focus for future research should be on refining these threshold levels and corresponding mitigating actions to enable defining a point when one should go from *in situ* to *ex situ* preservation. The threshold levels suggested in this thesis should be tested further through laboratory and on site experiments.

This work advocates the necessity for the development of sustainable mitigating actions for a number of different threat situations as exemplified in the threshold levels. These actions should be fairly easy to carry out and not cost a fortune. They should also be immediately distinguishable from the original archaeological remains. One practical example of mitigation by securing a section with clay to avoid drainage is demonstrated in Chapter 2. Other mitigation acts may be to hinder encroaching vegetation, allow site coverage if that is necessary for continued preservation, add chalk or other chemicals to sites like cemeteries and shell middens to preserve desired burial environmental conditions and similar actions. However, a combination of laboratory and site tests (the latter combined with monitoring schemes) are future tasks to carry out.

Further it is suggested that the national heritage database in the future should include the risk assessments and threshold levels (see Table 17). This should be an attainable goal, if the central heritage management agrees with the research that these factors hold essential information.

The author suggests that before sites are regulated to *in situ* preservation in the future, one needs to make sure that their scientific information potential will not be lost, meaning that *in situ* preservation is not just leaving a site or a monument alone, but management strategies must be made to monitor possible change. Contextual interpretation of a site increases with the complexity of the anthropogenic remains. Value may be ascribed to sites using the DIVE method or similar systems as suggested in Chapters 2.6 and 7.7, and illustrated by the defined threshold levels and threats in Table 16 and Table 17. Site evaluations are essential for deciding which ones to actively preserve and which ones may be left alone in the hope that they may survive the predicted changes, and finally which ones must be excavated to preserve their information *ex situ*. These deliberations must be communicated to all

levels of cultural heritage management, from field archaeologist to policy makers. To ensure that at least parts of our archaeological heritage will be preserved *in situ* for the future, we may have to accept that some must be lost or preserved *ex situ*, i.e. by record. Ascribed values to sites should be the deciding factor of heritage management strategies.

References

- Alfsen KH, DO Hessen & E Jansen 2013: *Klimaendringer i Norge: forskernes forklaringer*.
- Alnæs K 1999: En ny arbeidsdag. *Historien om Norge*, bind IV. Gyldendal.
- Amundsen C-E, 2012: Grunnvannskvalitet i kulturlag i Stavanger. Sammenstilling av data 2005-2010. *Bioforsk Rapport* Vol. 7 Nr. 51/2012, 15 pp.
- Amundsen H, 1998: Innberetning – arkeologisk registrering/overvåking av graving av grøft. Åker gård, gnr. 7/bnr. 201, Hamar kommune, Hedmark. *Hedmark fylkeskommune. Top.ark. Unpublished report*. 3 pp.
- Askeladden*: <https://askeladden.ra.no/>. Site accessed latest on November 13th 2015.
- Avaldsnes Royal Manor project*: (<http://www.khm.uio.no/english/research/projects/avaldsnes/>). Site accessed latest on November 13th 2015.
- Bagge S & K Mykland 1987: *Norge i dansketiden: 1380-1814*. Cappelen, Oslo.
- Bauer EM & MA Østmo 2013: Kongsgårdsprosjektet Avaldsnes: Stolpebygde hus, produksjonsplass, dyrkingsspor, steinkonstruksjon, kokegroper og naust fra jernalder og ruin fra middelalder. Avaldsnes prestegård, 87/6/1, Karmøy kommune, Rogaland. *Rapport arkeologisk utgravning, Kulturhistorisk museum, UiO*, 27/3 2013. 634 pp.
- Bazelmans J, 2012: Serving two masters: Dutch archaeology since the Valletta Convention. In: R Bradley, C Haselgrove, M Vander Linden & L Webley (eds.): *Development-led Archaeology in North-West Europe*, 9-21. Oxbow Books.
- Beer J de, A Seither, VV Martens, H Matthiesen & M Vorenhout 2015: Monitoring and modelling in Urban WATCH. In: K Harvold & K Larsen (eds.): *Protecting the Past and Planning for the Future. Results from the project 'Cultural Heritage and Water management in Urban Planning' (Urban WATCH)*. CIENS-report 1-2015. Oslo. https://www.researchgate.net/publication/278031856_Protecting_the_Past_and_Planning_for_the_Future_Results_from_the_project_Cultural_Heritage_and_Water_Management_in_Urban_Planning_Urban_WATCH 50 pp.
- Bergersen O, T Hartnik, A Petersén, & PB Molaug 2009: Tilstandsanalyse og vurdering av bevaringsforhold i kulturlag fra gårdshaug. *Oppdragsrapport NIKU* nr 299-2009, Bioforsk Vol 4 Nr 117 2009. 65 pp.
- Bertelsen R, 1973: *Gårdshaugene i Harstad kommune. Et bidrag til områdets økonomiske historie i middelalderen*. Thesis (magistergrad), archaeology, University of Bergen.
- Bertelsen R, 1978: *Gårdshaugene i Nord-Norge: kommentarer til de siste 15 års forskningsvirksomhet*. Stensilserie Universitet i Tromsø, Institutt for samfunnsvitenskap.
- Bertelsen R, 1984: Farm mounds of the Harstad area. Quantitative Investigations of Accumulation Characteristics. *Acta Borealia* 1, 7-25. Tromsø.
- Bertelsen R, 1989: Gårdshaugene i Nord-Norge. Eksempler på Nordatlantiske teller, *Hikuin* 15, 171-182.
- Bertelsen R, 2002: Saurbekken i Harstad. In: P. Simonsen (ed.): *Mellomalderarkeologi mellom Salten og Senja. Tromsø* 35, 15-20. Tromsø.
- Bertelsen R, 2007: The Possible Advantage of Living in Turf Houses on Settlement Mounds. *Acta Borealia* 24, 84-97. Tromsø.
- Bertelsen R, 2009: Tapt historie på landsbygda. *Aftenposten* 27. april 2009. <http://www.aftenposten.no/meninger/debatt/Tapt-historie-pa-landsbygda-6615593.html> Site accessed latest on November 13th 2015.
- Bertelsen R, 2011: Tilkomsten av fiskevær, med særlig bikk på kysten mellom Vestfjorden og LoppHAVET. In: LI Hansen, R Holt & S Imsen (eds.): *Nordens plass i middelalderens Europa. Samfunnsomdanning, sentralmakt og periferier. Speculum Boreale* 16, 78-88. Stamsund.
- Bintliff J & M Pearce (eds.) 2011: *The Death of Archaeological Theory?* Oxbow Books.
- Bjerking SE, 1981: Medeltidsstaden: Grundläggning för nya hus på kulturlager. *Riksantikvarieämbetet och Statens historiska museer, Rapport*, Stockholm.
- Bjerking SE, 1984: Bygga på kulturlager: förundersökningar och grundläggningsmetoder. *Riksantikvarieämbetet och Statens historiska museer, Rapport*, Stockholm.
- Bleicher N & C Schubert 2015: Why are they still there? A model of accumulation and decay of organic prehistoric cultural deposits, *Journal of Archaeological Science*, doi: 10.1016/j.jas.2015.06.010.

- Boogaard FC, 2015: Stormwater Quality and Sustainable Urban Drainage Management. In: J Rytter & I Schonhowd (eds.): *Monitoring, Mitigation, Management. The Groundwater Project – Safeguarding the World Heritage Site of Bryggen in Bergen*, 135-149.
- Borg GCh, L Johnsson, A Lagerlöf, E Mattsson, I Ullén & G Werner 1994: Nedbrytning av arkeologisk material i jord. *Konserveringstekniska studier*. Riksantikvarieämbetet och Statens historiska museer, Rapport RIK 9, Stockholm.
- Brox A & G Stamsø Munch 1965. Gårdshauger og tuftegrupper. *Ottar* 43. 23 pp.
- Bue Johansen, LM & VV Martens 2014: 'Modern Urban Archaeology in Norway'. Paper presented at the session T02S022: C. Andersson, D de Jager, E Kars & VV Martens (org.). Preservation *in situ* or excavation? at the *European Association of Archaeologists (EAA) 2014 conference in Istanbul, Turkey*.
- Caple C, 1998: Parameters for monitoring anoxic environments. In: M Corfield, P Hinton, T Nixon & M Pollard (eds). *Preserving archaeological remains in situ*, Proceedings from the conference of 1st-3rd April 1996. Museum of London Archaeology Service. 113-123.
- Caple C & D Dungworth 1998: Waterlogged Anoxic Archaeological Burial Environments. *Ancient Monuments Laboratory Report* 22/98.
- Caple C (ed.) 2016: *Preservation of Archaeological Remains In-Situ: A Reader*. Routledge.
- Christensson A, 2004: *Safeguarding Historic Waterfront Sites – Bryggen in Bergen as a Case Study*. Szczecin/Bergen: Stiftelsen Bryggen.
- Christensson A, AR Dunlop, JA Jensen & T Hartnik 2008: Peleprosjektet. Volum 1. FOU-prosjekt Riksantikvaren 2005–2007. *Riksantikvaren Research report*; Permanent link: <http://hdl.handle.net/11250/175916> Site accessed latest on November 13th 2015.65 pp.
- Christensson A & R Dunlop 2015: Management of Archaeological Heritage in Norway's Medieval Cities. In: Baug I, J Larsen & SS Mygland (eds.): *Nordic Middle Ages – Artefacts, Landscapes and Society. Essays in Honour of Ingvild Øye on her 70th Birthday*. UBAS 8 2015, 77-91. Bergen.
- Corfield M, P Hinton, T Nixon & M Pollard (eds.) 1998: *Preserving archaeological remains in situ*. Proceedings from the conference of 1st-3rd April 1996. Museum of London Archaeology Service.
- Council of Europe, 1992, *European Convention on the Protection of the Archaeological Heritage*, <http://conventions.coe.int/Treaty/en/Treaties/Html/143.htm> Site accessed latest on November 13th 2015.
- Council of Europe, 2000, *The European Landscape Convention*, <http://www.coe.int/en/web/landscape/home>. Site accessed latest on February 29th 2016.
- Council of Europe, 2005, *The Framework Convention on the Value of Cultural Heritage for Society*, http://www.coe.int/t/dg4/cultureheritage/heritage/Identities/default_en.asp Site accessed latest on November 13th 2015.
- CMAS 2016: *Conservation and Management of Archaeological Sites* 18, issue 1-3.
- Cultural Heritage Act of Norway* <https://www.regjeringen.no/en/dokumenter/cultural-heritage-act/id173106/>. Site accessed latest on November 15th 2015.
- Doneus M & W Neubauer 2005: Laser scanners for 3D documentation of stratigraphic excavations. In: Baltsavias *et al.*(eds): *Recording, Modeling and Visualization of Cultural Heritage*, Taylor & Francis, London, 2005, 193-203.
- Dries MH van den 2014: Community Archaeology in the Netherlands. *Journal of Community Archaeology and Heritage* 1, 69-88.
- Duineveld M, KV Assche & R Beunen 2013: Malta's Unintentional Consequences: Archaeological Heritage and the Politics of Exclusion in the Netherlands. *Public Archaeology* 12, 139-154.
- Durham B, R van der Noort, VV Martens, & M Vorenhout 2012: Organic Loss in Drained Wetland Monuments: Managing the Carbon Footprint. *Conservation and Management of Archaeological Sites* 14, 85-98.
- English Heritage see: Historic England
- Egil's saga* (translated by Bernard Scudder, edited with an introduction and notes by Svanhildur Óskarsdóttir, Penguin Books version 2004).
- Eriksson J-EG, 2006: Monitoring urban deposits. A full scale experiment in Tønsberg. In: R Engelmark & J Linderolm (eds.): *Archaeology and Environment* 21, 101-110. Umeå.
- French C, 2015: A handbook of geoarchaeological approaches for investigating landscapes and settlement sites. *Studying Scientific Archaeology* 1.
- Froelich PN *et al.* 1979: Early oxidation of organic matter in pelagic sediments of the eastern equatorial Atlantic: suboxic diagenesis. *Geochimica et Cosmochimica Acta* 43, 1075-1090.
- Fægri K, PE Kaland & K Krzywinski 1989. *Textbook of Pollen Analysis*, IV Edition.
- Gardelin G, 2002: *Nedbrytning av urbana kulturlager. En översiktlig sammanställning av erfarenheter och kunnskapsläge*. Kulturen i Lund.
- Gregory D & H Matthiesen (eds.) 2012: *Special Issue: Preserving Archaeological Remains in Situ. Conservation and Management of Archaeological Sites* 14, 486 pp.
- Griffin K, 1985: Stratigraphic studies of farm mounds in northern Norway. *ISKOS* 5, 191-204.

- Griffin K, 1988. Plant remains. In Schia (ed.) 1988: *De arkeologiske utgravningene i Gamlebyen, Oslo*. Bd. 5; 15-108.
- Gustavsen L, 2013: Georadarundersøkelse ved Saurbekken. *NIKU oppdragsrapport 19/2013*. 54 pp.
- Hagen A, 1992: Kort innføring i Åkerområdets arkeologi. In: E Mikkelsen & JH Larsen (eds.): Økono-miske og politiske sentra i Norden ca 400-1000 e. Kr. Åkerseminaret, Hamar 1990. *Universitetets oldsaksamlings Skrifter, Ny rekke* 13, 13-22. Oslo.
- Hamdi S, F Moyano, S Sall, M Bernoux & T Chevallier 2013. Synthesis analysis of the temperature sensitivity of soil respiration from laboratory studies in relation to incubation methods and soil conditions. *Soil Biol. Biochem.* 58: 115-126.
- Hanssen-Bauer I, EJ Førland, I Haddeland, H Hisdal, S Mayer, A Nesje, JEØ Nilsen, S Sandven, AB Sandø, A Sorteberg & B Ådlandsvik (eds.) 2015: *Klima i Norge 2100. Kunnskapsgrunnlag for klimatilpassing oppdatert i 2015*. ISSN nr. 2387-3027 Rapport nr. 2/2015. https://cms.met.no/site/2/klimaservicesenteret/rapporter-og-publikasjoner/_attachment/6530?_ts=14fda4d0c9d
- Hartley IP & P Ineson 2008: Substrate quality and the temperature sensitivity of soil organic matter decomposition. *Soil Biol. Biochem.* 40, 1567-1574.
- Hartnik T, S Andersen, T Vesterager & O Nordal 2000: *Characterisation of redox-conditions in the unsaturated zone*. Proceedings of the ConSoil-Conference, Leipzig, 18–22 September 2000, 216–217.
- Heiri O, AF Lotter & G Lemcke 2001: Loss on ignition as a method for estimating organic and carbonate content in sediments: reproducibility and comparability of results. *Journal of Paleolimnology* 25, 101-110.
- Henriksen MB, 2001: Fynske jernaldergrave – en udryddelsestruet gruppe af fortidsminder. In: A Nørgård Jørgensen & J Pind (eds.): *Før landskabets erindring slukkes – Status og fremtid for dansk arkæologi*, 75-84.
- Hernæs P, 1989: De arkeologiske undersøkelserne på Åker i Vang 1988-89. *Fra Kaupang og bygd*. Hedmarks-museet og Domkirkeodden, Hamar.
- Herteig AE, 1969: *Kongers havn og handels sete. Fra de arkeologiske undersøkelser på Bryggen i Bergen 1955-68*. Aschehoug, Oslo.
- Herteig AE, 1985: The archaeological excavations at Bryggen, 'The German Wharf', in Bergen, 1955-68. Excavation, stratigraphy, chronology, field-documentation. In: AE Herteig (ed.): *The Bryggen Papers. Main Series*, Vol. 1, 9-46. Norwegian University Press, Bergen.
- Hildre NS, 2006: Innberetning. Arkeologisk registrering av Åker gård (gnr.7/bnr.201), Hamar kommune, Hedmark, i forbindelse med reguleringsplan for Åker gård (Prosjekt 10772). Delrapport 2. *Hedmark fylkeskommune. Top.ark. Unpublished report*. 71 pp.
- Historic England* (<http://historicengland.org.uk/>) Piling and Archaeology (2007, updated 2015 <https://www.historicengland.org.uk/images-books/publications/piling-and-archaeology/>), The use of science to enhance our understanding of the past (2009, <http://historicengland.org.uk/images-books/publications/nhss-rep2-use-of-science-to-enhance-understanding-of-past/>); Waterlogged Wood (2010 <https://www.historicengland.org.uk/images-books/publications/waterlogged-wood/>), Environmental Archaeology (2011 <https://www.historicengland.org.uk/images-books/publications/environmental-archaeology-2nd/>), Waterlogged Organic Artefacts (2012 <https://www.historicengland.org.uk/images-books/publications/waterlogged-organic-artefacts/>), Preservation In Situ in prep. 2015 (<https://www.historicengland.org.uk/advice/technical-advice/archaeological-science/preservation-in-situ/>). All sites accessed latest on November 13th 2015.
- Hodder I & S Orton 2003: *Reading the past. Current approaches to interpretation in archaeology*. Cambridge University Press. Cambridge.
- Hollesen J, B Elberling & PE Jansson 2011: Future active layer dynamics and carbon dioxide production from thawing permafrost layers in Northeast Greenland. *Global Change Biology* 17, 911-926.
- Hollesen J & H Matthiesen 2015: The Influence of Soil Moisture, Temperature and Oxygen on the Oxidic Decay of Organic Archaeological Deposits. *Archaeometry* 57, 362-377.
- Hollesen J, H Matthiesen, AB Møller & B Elberling 2015a: Permafrost thawing in organic Arctic soils accelerated by ground heat production. *Nature Clim. Change* 5, 574-578.
- Hollesen J, AB Møller, VV Martens & H Matthiesen 2016: Making better use of monitoring data. *Conservation and Management of Archaeological Sites* 18, 116-125.
- Holm-Olsen IM & R Bertelsen 1973: Gårdshaugen Saurbekken i Harstad. *Nikolay* nr. 13 1973, 6-8.
- Holmsen A, 1980: *Gård og gods i Norge i eldre tid*. Oslo.
- Holseng O, 2006: Innberetning for arkeologisk forundersøkelse i forbindelse med prosjekt 10772 Statsarkivet i Hamar, Åker gård – Varsel om oppstart av planarbeid. Delrapport 1, reguleringsplan for Åker. *Hedmark fylkeskommune. Top.ark. Unpublished report*. 32 pp.
- Hughes R, 1999: *The development of capping technologies for the in situ preservation of archaeological sites*. Paper presented at the European Association for Archaeologists 5th Annual Meeting, Bornemouth, UK, September 1999.

- Huisman DJ (ed.) 2009: *Degradation of Archaeological Remains*. Staatsdrukkerij, Den Haag.
- Huisman DJ, M Vorenhout, A Smit, BJH van Os & MR Manders 2009. Preservation and Monitoring of Archaeological Sites. In: DJ Huisman (ed.) *Degradation of Archaeological Remains*, 177–212. Den Haag.
- IPCC 2015 Intergovernmental Panel on Climate Change <http://www.ipcc.ch/report/ar5/>
- Jerpåsen GB, 2013: *Between the rural and the urban – alternative approaches for analysing the historic dimension in urban fringe areas*. PhD thesis, Department of Landscape Architecture and Spatial Planning, Norwegian University of Life Science.
- Jerpåsen GB & A Mehren 2006: Åker gård, Hamar. Reguleringsplan og KU. Tema kulturmiljø og kulturminner. NIKU Oppdragsrapport Arealplan 14/06 (07.11.2006). Norsk institutt for kulturminneforskning, Oslo. Unpublished report. 27 pp.
- Johannessen L & J-EG Eriksson (eds.) 2015: *Faglig program for middelalderarkeologi. Byer, sakrale steder, befestninger og borger*. Riksantikvaren, Permanent link: <http://hdl.handle.net/11250/279069>
- Johansen J, IC Rynning, A Skullerud & J Martens 2003: Et oppløyd gravfelt på Odberg i Lågendalen (a ploughed up Roman Iron Age cemetery). *Nikolay* 91 (2003), 46-58. https://www.academia.edu/11356569/Et_oppl%C3%B8yd_gravfelt_p%C3%A5_Odberg_i_L%C3%A5gendalen_a_ploughed_up_cemetery_Roman_Iron_Age_cemetery_. Accessed latest March 19th 2016.
- Johansson J, 2011: Hus och bosättningsspår. Them Nedre, 42/1, Tønsberg, Vestfold. *Rapport Arkeologisk Utgravning*, KHM, UiO. Oslo. (Unpublished excavation report).
- Karlberg I & MF Simonsen 2009: Bygdø Kongsgård – en gårdshaug med bebyggelsesspor fra middelalder og renessanse. In: J Bergstøl. (ed.): *Arkeologiske undersøkelser 2003-2004. Varia 77*, 189-205. Oslo.
- Kars EAK & H Kars (eds.) 2002: *The Degradation of Bone as an Indicator for the Deterioration of the European Archaeological Property*. Amersfoort.
- Kars H, MJ Collins, M Jans, A Nord, P Arthur & E. Kars 2004: Bone as an indicator in the in situ degradation of archaeological heritage : two examples : Apigliano, Italy, and Aartswoud, the Netherlands. In: T Nixon (ed.): *Preserving Archaeological Remains In Situ. Proceedings from the 2nd conference 12th–14th September 2001*. Museum of London Archaeology Service.
- Kars H & RM van Heeringen (eds.) 2008: *Preserving Archaeological Remains In Situ. Proceedings from the 3rd conference 7th -9th December 2006, Amsterdam*. Geoarchaeological and Bioarchaeological Studies 10, Amsterdam.
- KD 2009 = Kunnskapsdepartementet 2009: White Paper 30 (2008-2009).Oslo.
- Keever G, D Hogan, M Davis & D Howell 2004: Waterlogged archaeological remains, environmental conditions and preservation in situ: a case study from the Tower of London. In: T. Nixon (ed.) *Preserving Archaeological Remains In Situ?* Proceedings of the 2nd conference 12-14 September 2001:137-142. London: Museum of London Archaeology Service 12-9-2001.
- Kjærsum P, 1969: Jættestuen Jordhøj/ The Passage-grave Jordhøj. *KUML*, 9-66.
- Klápště, J (ed.) 2013: Hierarchies in rural settlements. *Ruralia* 9, Brepols.
- Klápště, J (ed.) 2016: Agrarian Technology in the Medieval Landscape. *Ruralia* 10, Brepols.
- Kurlansky M, 1997: *Cod: A Biography of the Fish That Changed the World*. New York: Walker.
- Lind KE, 2002: Gårdshaugen på Skutvik, Hamarøy kommune. In: P. Simonsen (ed.): *Mellomalderarkeologi mellom Salten og Senja. Tromura* nr. 35, 21-26, Tromsø.
- Lysaker T, 1956a: Harstad nedre, øvre og nordre. *Trondenes Bygdebok* II, 9-14. Harstad.
- Lysaker T, 1956b: Vollstad med Svartvatnet. *Trondenes Bygdebok* III, 93-113. Harstad.
- Martens J, 1991: Gensyn med Borremose - om baggrunden for genoptagelsen af udgravningerne på Borremose-fæstningen. *LAG* 2, 30-35.
- Martens J, 1994: Borremose - Refuge - Fortified Settlement - Central Place? *Ethnographisch-Archäologische Zeitschrift* 35, 241-276.
- Martens J, 2004: *Jordbruksbebyggelsen i østnorsk forhistorie og middelalder. Faglig program*. Kulturhistorisk museum, Universitetet i Oslo. Circulated manuscript. https://www.academia.edu/17763071/Jordbruksbebyggelsen_i_%C3%98st-Norge_4000_BC-1537_AD_The_rural_settlement_in_East_Norway_4000_BC_-_1537_AD_. 119 pp. Accessed latest February 29th 2016.
- Martens J, 2007: Kjølberg søndre - en gård med kontinuitet tilbake til eldre jernalder? *Varia* 62, 89-109. Oslo.
- Martens J, 2009: Middelalderens jordbruksbebyggelse i de sentrale strøk. Den tapte middelalder? *Varia* 71, 7-22. Oslo.
- Martens J, VV Martens & K Stene (eds.) 2009: Den tapte middelalder? Middelalderens sentrale landbebyggelse. *Varia* 71. Oslo. 205 pp.
- Martens J & M Ravn (eds.) 2016: *The Plow Zone as Context*. Oslo.
- Martens VV, A Haugen & HR Amundsen 2007: Forprosjekt miljøovervåking Åker gård gnr.7/bnr.201, Hamar, Hedmark. Vurdering av bevaringsforhold for kulturlag. Samlerapport for Bioforsk, Multiconsult og NIKU. *Oppdragsrapport Miljøovervåking 4/2007. Unpublished report, NIKU Oslo*. 138 pp.

- Martens VV, A Haugen, HR Amundsen, T Hartnik, E Bloem & JA Finstad 2008: Forprosjekt 2, miljøovervåking Åker gård gnr.7/bnr.201, Hamar, Hedmark. Arkeologisk, jordfaglig og jordteknisk vurdering. Grunnundersøkelser og tilstandsvurdering av bevaringsforhold for kulturlag og fredet/verneverdig bygningsmasse på Åker gård. Samlerapport for NIKU, Bioforsk og Multiconsult. *Oppdragsrapport Arkeologi 60/2008. Unpublished report, NIKU, Oslo*. 135 pp.
- Martens VV, 2010: Environmental monitoring of archaeological deposits. In: Trow S, V Holyoak & E Byrnes (eds.): *Heritage Management of Farmed and Forested Landscapes in Europe. EAC Occasional Papers 4*, 75-82. Budapest.
- Martens VV, 2010a: Arupsgate, Gamlebyen, Oslo. Arkeologisk undersøkelse og overvåking i forbindelse med utskifting av vannledning. *NIKU Oppdragsrapport* nr. 111/2010. 251 pp.
- Martens VV 2011: Environmental monitoring and in situ preservation of urban archaeological deposits. An information resource and a preservation challenge. *SKAS 2/2010,5-10*, Sällskapet för Medeltidsarkeologi i Finland.
- Martens VV, C-E Amundsen & O Bergersen 2012: Research on Conservation State and Preservation Conditions in Unsaturated Archaeological Deposits in Oslo. *Conservation and Management of Archaeological Sites 14*, 72-84
- Martens VV, O Bergersen & CE Amundsen 2012: Avaldsnes, Karmøy kommune, Rogaland. Arkeologisk kartlegging av bevaringstilstand og bevaringsforhold for arkeologiske kulturminner i forbindelse med Kongsgårdsprosjektet Avaldsnes. Delrapportering 1. *NIKU oppdragsrapport* nr 12/2012. 59 pp.
- Martens VV 2013: The Magnate Farm of Åker. Past, present and future of a farm with central functions. *Ruralia 9*, 329-339.
- Martens VV & O Bergersen 2013: Avaldsnes, Karmøy kommune, Rogaland. Arkeologisk kartlegging av bevaringstilstand og bevaringsforhold for arkeologiske kulturminner i forbindelse med Kongsgårdsprosjektet Avaldsnes. Delrapportering 2. *NIKU oppdragsrapport* nr. 12/2013. 39 pp.
- Martens VV 2014: Plan för säkring av kulturlager vid Enköping Torg. Kv. Fältskäraren, Enköping. *NIKU Oppdragsrapport* 46/2014. 14 pp.
- Martens VV & O Bergersen 2015: In situ site preservation in the unsaturated zone: Avaldsnes. *Quaternary International* 368, 69-78.
- Martens VV 2016: North Norwegian Farm Mounds – economic resources and landscape conditions. *Ruralia 10*, 173-184.
- Martens VV, O Bergersen, M Vorenhout, PU Sandvik & J Hollesen 2016: Research and monitoring on conservation state and preservation conditions in unsaturated archaeological deposits of a medieval farm mound in Troms and a late Stone Age midden in Finnmark, Northern Norway. *Conservation and Management of Archaeological Sites 18*, 8-29.
- Martens VV, ER Myrvoll, O Bergersen, M Vorenhout, PU Sandvik & S Denham (in prep.): InSituFarms. Archaeological Deposits in a Changing Climate. Case Banjkgohppi, Unjårgga gielda/Nesseby k., Finnmark. *NIKU rapport 77*.
- Martens VV, O Bergersen, M Vorenhout, PU Sandvik, J Hollesen (in prep.): InSituFarms. Archaeological Deposits in a Changing Climate. Case Voldstad, Harstad k., Troms. *NIKU rapport*.
- Martens VV, O Bergersen, M Vorenhout, PU Sandvik, J Hollesen (in prep.): InSituFarms. Archaeological Deposits in a Changing Climate. Case Saurbekken, Harstad k., Troms. *NIKU rapport*.
- Matthiesen H, 2004: In situ preservation and monitoring of the cultural layers below Bryggen. In: A Christensson (ed.) *Safeguarding historic waterfront sites. Bryggen in Bergen as a case study*: 71-75. Szcecin/Bergen: Stiftelsen Bryggen.
- Matthiesen H, 2007: A novel method to determine oxidation rates of heritage materials in vitro and in situ. *Studies in Conservation 52*, 271-280.
- Matthiesen H, R Dunlop, JA Jensen. & A Christensson 2006: *Monitoring of Cultural Deposits below Bryggen in Bergen, Norway*. <http://www.natmus.dk/graphics/bevaring/arkaeologi/pdf-filer/HenningMatt/matt2004woamposterbryggen.pdf>.
- Matthiesen H, R Dunlop, JA Jensen, J de Beer & A Christensson 2008: Monitoring of preservation conditions and evaluation of decay rates of urban deposits - results from the first five years of monitoring at Bryggen in Bergen. In: H Kars & RM van Heeringen (eds.) *Proceedings from Preservation of Archaeological Remains in situ 3*, Amsterdam, December 2006. *Geoarchaeological and Bioarchaeological Studies 10*, 163-174.
- Matthiesen H, JB Jensen, D Gregory, J Hollesen & B Elberling 2014: Degradation of archaeological wood under freezing and thawing conditions – effects of permafrost and climate change. *Archaeometry 56*, 479–495.
- MD 2005 = Miljøverndepartementet 2005: *Living with our Cultural Heritage*. White paper 16 (2004-2005). Oslo.
- MD 2010 = Miljøverndepartementet 2010: Miljøvernforvaltningens prioriterte forskningsbehov 2010-2015. Oslo.

- Membership S, 2008: Is in-situ preservation always the right strategy, or are flexible approaches beneficial to both developer and archaeologist? *Geoarchaeological and Bioarchaeological Studies* 10, 311–316. Amsterdam.
- MET Office, <http://www.metoffice.gov.uk/research/news/2015/global-average-temperature-2015>
<http://www.metoffice.gov.uk/hadobs/hadcrut4/> Sites accessed latest November 21st 2015.
- Mikkelsen E & JH Larsen (eds.) 1992: Økonomiske og politiske sentra i Norden ca 400-1000 e. Kr. Åkerseminaret, Hamar 1990. *Universitetets oldsaksamlings Skrifter, Ny rekke* nr. 13. Oslo.
- Mitsch WJ & JG Gosselink 2000: *Wetlands*. 3rd ed.
- Morice CP, JJ Kennedy, NA Rayner & PD Jones 2012: Quantifying uncertainties in global and regional temperature change using an ensemble of observational estimates: The HadCRUT4 dataset, *Journal of Geophysical Research*, 117,
- Myrstad R, 2001: *Gårdshaugprosjektet i Troms 2000/2001*. Troms fylkeskommune.
- Myrvoll ER, 1992: *Stil og samfunn. En analyse av materiell symbolisme og sosiale relasjoner i Varanger 2200 f.Kr.-Kr.f.* Mag.art.avh. Tromsø.
- Møller AB, H Matthiesen & J Hollesen 2015: The effect of temperature and soil moisture on the decomposition of organic material in archaeological deposits at two contrasting sites in northern Norway. *National Museum of Denmark, Report* 11031962.
- Neubauer W, 2007: Laser Scanning and Archaeology – Standard Tool for 3D Documentation of Excavations. *GIM international – The global magazine for Geomatics* 21, 14-17.
- Nilsen JEØ, K Larsen, VV Martens, T Rauken & K Harvold 2013: *Kulturminner og havnivåstigning*. CIENS-rapport 1-2013. 52 pp.
- Nilsson B, 2011: Archaeology and the unstoppable excavation machine. A Swedish point of view. *Archaeological Dialogues* 18, 26-29.
- Nixon T (ed.) 2004: *Preserving Archaeological Remains In Situ. Proceedings from the 2nd conference 12th – 14th September 2001*. Museum of London Archaeology Service.
- Nord AG, K Tronner & I Ullén 2002: On the deterioration of archaeological iron artefacts in soil. *Fornvännen* 97/4: 298-300.
- Nord AG, H Kars, I Ullén, K Tronner & E Kars 2005: Deterioration of archaeological bone – a statistical approach. *Journal of Nordic Archaeological Science* 15, 77-86.
- Norwegian Heritage Act* 1978 (<https://www.regjeringen.no/en/dokumenter/cultural-heritage-act/id173106/>) Site accessed latest on November 13th 2015.
- NS9450, 2003: Norwegian Standard: Automatically protected cultural heritage sites and monuments – Registration of loss and damage. NS9450, 2003 (withdrawn and replaced by 9450, 2012).
- NS9450, 2012: Norwegian Standard: Automatically protected archaeological heritage and ship finds – Requirements for condition assessment and recording. NS9450, 2012. <http://www.standard.no/no/Nettbutikk/produktkatalogen/Produktpresentasjon/?ProductID=524900>. Site accessed latest February 26th 2016.
- NS9451, 2009: *Norwegian Standard: Cultural Property. Requirements on Environmental Monitoring and Investigation of Archaeological Deposits*. NS9451,2009. http://brage.bibsys.no/xmlui/bitstream/handle/11250/176273/Requirements_eng_versjon_Norwegian_National_Standard_2012.pdf?sequence=1&isAllowed=y Site accessed latest on November 13th 2015.
- Nybruget P-O, 1992: Åkerfunnet. Grav eller depot. In: E Mikkelsen & JH Larsen (eds.): Økonomiske og politiske sentra i Norden ca 400-1000 e. Kr. Åkerseminaret, Hamar 1990. *Universitetets oldsaksamlings Skrifter, Ny rekke* nr. 13: 23-40. Oslo.
- Nørgård Jørgensen A & J Pind (eds.) 2001: *Før landskabets erindring slukkes – Status og fremtid for dansk arkæologi*.
- Olsen O, 1968: Om at udgrave stolpehuller. *Nationalmuseets Arbejdsmark*, 155-170.
- Peacock EE, 2002: Monitoring the In Situ Archaeological Deposits at Schultzgt. 3-7, Trondheim, Norway (1996-2001). *NTNU, Vitenskapsmuseet. Rapport Arkeologisk serie: 2002-1*, 121 pp.
- Peacock EE, 2005: Conservation of severely deteriorated wet archaeological leather recovered from the Norwegian Arctic. Preliminary results. *Proceedings of the 9th ICOM Group on Wet Organic Archaeological Materials Conference*, In: P Hoffmann; K Strætkvern; JA Spriggs & D Gregory (eds.). Bremerhavn: WOAM, 565-578.
- Peacock EE & G Turner-Walker 2009: Reburial and Analysis of Archaeological Remains (RAAR): investigation of the effects of burial on non-wood organic materials. Preliminary results. *Proceedings of the 10th ICOM Group on Wet Organic Archaeological Materials Conference*. In: K Strætkvern & DJ Huisman (eds.) *Nederlandse Archeologische Rapporten* 37, 197-213.
- Peacock EE, T Bergstrand; I Nyström Godfrey; C Bjørndal, C Bohm, E Christensson, D Gregory, I MacLeod, T Nilsson, V Richards & G Turner-Walker 2008: The Marstrand Reburial Project - overview, phase I and future work. *PARIS3 Preserving Archaeological Remains in Situ. Geoarchaeological and Bioarchaeological Studies* 10. Amsterdam, 253-263.

- Petersén A & O Bergersen 2009: Forundersøkelse med grunnboring for tilstandsanalyse av bevaringsforhold for kulturlag, Munkhaugveita 3-7, Trondheim. Arkeologisk og jordfaglig vurdering. *NIKU Oppdragsrapport 37/2009*, Bioforsk vol 4 nr 29 2009.
- Petersén A & O Bergersen 2012: An assessment of the status and condition of Archaeological remains preserved in situ in the medieval town of Trondheim based on archeochemical investigations conducted during the period 2007–2010. *Conservation and Management of Archaeological Sites*, 14, 228–238.
- Petersén A & J Taylor 2015: *Can preservation conditions of soil be determined reliably?* Conference presentation, European Association of Archaeologists (EAA), Glasgow, UK, Sept 2015.
- Pezeshki SR & RD DeLaune 2012: Soil Oxidation-Reduction in Wetlands and Its Impact on Plant Functioning. *Biology* 1, 196–221.
- Pilø L, 2005: Bosted - urgård - enkeltgård: en analyse av premissene i den norske bosetningshistoriske forskningstradisjon på bakgrunn av bebyggelsesarkeologisk feltarbeid på Hedemarken. *Oslo arkeologiske serie* nr. 3. Institutt for arkeologi, kunsthistorie og konservering, Universitetet i Oslo.
- Pocock C, D Collett & L Baulch 2015: Assessing stories before sites: identifying the tangible from the intangible. *International Journal of Heritage Studies* 21, 962-982.
- RA & NIKU 2008: *The Monitoring Manual. Procedures and Guidelines for Monitoring, Recording and Preservation Management of Urban Archaeological Deposits*. Riksantikvaren & Norsk Institutt for Kulturminneforskning.
- RAÄ 2015: Plattform kulturhistorisk värdering och urval. Grundläggande förhållningssätt för arbeta med att definiera, värdera, prioritera och utveckla kulturarvet. *Rapport från Riksantikvareämbetet*, 2015-01-19. <http://samla.raa.se/xmlui/bitstream/handle/raa/8235/RA%C3%84%20Plattform%20Kulturhistorisk%20v%C3%A4rdering%20och%20urval%20version%2020150119.pdf?sequence=1> Site accessed latest on November 13th 2015.
- Reed I & VV Martens 2008: Preservation Capacity of Urban Archaeological Deposits Beneath Modern Buildings in Norway. *Proceedings from PARIS3, Preserving Archaeological Remains in situ 3, Amsterdam 2006*, Geo and Bioarchaeological Studies 10, Amsterdam.
- Reiersen K, 2006: *Rapport, hagearkeologisk registrering. Åker gård, gnr. 7, bnr. 201. Hamar kommune*. Unpublished report.
- Reinar DA & AM Westerlind 2010: *Urban Heritage Analysis: A Handbook about DIVE*. Riksantikvaren.
- Reitan G, 2011: Moi – ett jorde, en gård, mange faser? Fra bronsealder til vikingtid og middelalder i Bygland, Setesdal. *Viking LXXIV*, 165-191.
- Rickard D & JW Morse 2005: Acid volatile sulfide (AVS). *Marine Chemistry* 97,141-197.
- Rolfsen P, 2000: Innberetning om arkeologisk etterundersøkelse av grav V på Snartemo nedre, 4/1, Hægebostad kommune, Vest-Agder, 31. august-02. september 1999. *Universitetets kulturhistoriske museer, Oldsaksamlingen, Topografisk arkiv*, Oslo.
- Rosen AM, 1986: *Cities of Clay. The Geoarchaeology of Tells*. Chicago and London.
- Runge M, 2009: Nørre Hedegård. En nordjysk byhøj fra ældre jernalder. *Jysk Arkæologisk Selskabs Skrifter* 66. Højbjerg.
- Rytter J & I Schonhowd (eds.) 2015: *Monitoring, Mitigation, Management. The Groundwater Project – Safeguarding the World Heritage Site of Bryggen in Bergen*.
- Rødsrud CL, VV Martens, A Lislrud & LE Gjerpe 2008: Kapittel 15. Fyldpå 1, Emmerød 4, Gulli 6, Eikeberg 7, Tveiten 9 og Bakskjul 11. *Varia* 73, 329-332. Oslo.
- Sandvik PU 1995: Analyse av makrofossil frå Tjøtta og Blomsøy, Nordland. In B. Berglund: *Tjøtta-riket – En arkeologisk undersøkelse av maktforhold og sentrumsdannelse på Helgelandskysten fra Kr. F. til 1700 e. Kr. F.* Dr. phil. thesis Trondheim, 81-83.
- Sandvik PU, 2009: *Analyse av makrofossil i sedimentprøver frå Bergsodden, Harstad kommune, Troms*. AM Oppdragsrapport 2009/32.
- Sandvik PU & A Petersén 2010: Anthropogenic sediments as cultural heritage: An archive of objects, fossils or molecules. *Poster presented at the EAA conference, NL*, 2010.
- Santisteban JI, R Mediavilla, E López-Pamo, CJ Dabrio, MBR Zapata, MJG. García, S Castaño & PE Martínez-Alfaro 2004: Loss on ignition: a qualitative or quantitative method for organic matter and carbonate mineral content in sediments? *Journal of Paleolimnology* 32, 287-299.
- Schanche K, 1989. Nye funn fra yngre steinalder i Varanger. *Viking* 52, 53-71
- Selsing L (ed.) 1995: Sources for climatic data in Norden, mainly in the period 1860-1993. *AmS-Varia* 24.
- Seren S, A Eder-Hinterleitner, W Neubauer, K Löcker & P Melichar 2007: Extended comparison of different GPR systems and antenna configurations at the Roman site Carnuntum. *Near Surface Geophysics*, 389-394.
- Shirokova Y, I Forkutsa & N Sharafutdinova 2000: Use of electrical conductivity instead of soluble salts for soil salinity monitoring in Central Asia. *Irrigation and Drainage Systems* 14, 199-205.

- Simonsen P, 1961: Varangerfunnene II. Fund og utgravninger på fjordens sydkyst. *Tromsø museums skrifter* Vol. VII, Hefte II. Tromsø.
- Simpson IA, S Perdikaris, G Cook, JL Campbell & WJ Teesdale 2000: Cultural Sediment Analyses and Transitions in Early Fishing Activity at Langenesværet, Vesterålen, Northern Norway. *Geoarchaeology* 15, 743-763.
- Simpson MJR, JEØ Nilsen, OR Ravndal, K Breili, H Sande, HP Kierulf, H Steffen, E Jansen, M Carson & O Vestøl 2015: Sea Level Change for Norway. Past and Present Observations and Projections to 2100. *NCCS report no. 1/2015*.
- Skre D, 1998: Herredømmet. Bosetning og besittelse på Romerike 200-1350. *Acta Humaniora* 32, Oslo.
- Smit A, RM van Heeringen & EM Theunissen (eds.) 2006: Archaeological Monitoring Standard. Guidelines for the Non-Destructive Recording and Monitoring of the Physical Quality of Archaeological Sites and Monuments. *Nederlandse Archeologische Rapporten (NAR)* 33, Amersfoort.
- Smits V 2006: *The conflict between in situ and ex situ conservation due to the Valetta treaty; exemplified in the Netherlands, Sweden and England*. MA thesis. Papers Göteborgs Universitet, Institutionen för kulturvård 1101-3303 2006:3. Gothenburg.
- Snæsdóttir M, 1993: *Icelandic Farm Mounds and their Accumulation*. MA thesis (D-uppsats), medieval archaeology, University of Lund.
- Sollund M-LB & IM Holm-Olsen 2013: Monitoring Cultural Heritage in a Long-Term Project: The Norwegian Sequential Monitoring Programme. *Conservation and Management of Archaeological Sites* 15, 137-151.
- Soot-Ryen T, 1968: Evertebratrestere frå hustufter og møddinger. Simonsen (ed.): Varangerfunnene VI. *Tromsø museums skrifter* Vol. VII, hefte VI, 37-43. Tromsø.
- ssb.no (*Statistics Norway*), site accessed September 2015.
- Stene K, 2009: En gårdshaug i Østfold. Undersøkelser av kulturlag fra middelalder på gården Fusk i Askim kommune. In: J Martens, VV Martens & K Stene (eds.): Den tapte middelalder? Middelalderens sentrale jordbruksbebyggelse. Artikkelsamling. *Varia* 71, 191-202. Oslo.
- Stockmarr J, 1971. Tablets with spores used in absolute pollen analysis. *Pollen et Spores* 13, 615-621.
- Stookey LL, 1970: Ferrozine - A New Spectrophotometric Reagent for Iron. *Analytical Chemistry* 42, 779-781.
- Svart Kristiansen M, 2004: Arkæologiske undersøgelser af den middelalderlige landbebyggelse – metodiske problemer og prioriteringer i fortiden, nutiden og fremtiden. *Bol og by. Landbohistorisk tidsskrift* 2003:1-2, 9-29.
- Svart Kristiansen M, 2005 (ed.): Tårnby. Gård og landsby gennem 1000 år. *Jysk Arkæologisk Selskabs Skrifter* 54. Højbjerg.
- Sæther T, 1992: Forholdet mellom Åker og Hamarkaupangen. In: E Mikkelsen & JH Larsen (eds.): Økonomiske og politiske sentra i Norden ca 400-1000 e. Kr. Åkerseminaret, Hamar 1990. *Universitetets oldsaksamlings Skrifter, Ny rekke* nr. 13, 71-78. Oslo.
- Tollnes R, 1973: Hustuft på søndre Rauland i Numedal. *Nicolay* 13, 3-5.
- Ullén I, AG Nord, M Fjaestad, E Mattsson, GCh. Borg & K Tronner 2004. The degradation of archaeological bronzes underground: evidence from museum collections. *Antiquity* 78, 380-390.
- Urbańczyk P, 1992: *Medieval Arctic Norway*. Institute of the history of material culture. Polish Academy of Sciences. Warszawa.
- Van de Noort R, 2011: Conceptualising climate change archaeology. *Antiquity* 85, 1039-1048.
- Vorenhout M & M Smit 2006: *Continuous redox and temperature measurements for archaeological monitoring*. Poster presented at the Preserving Archaeological Remains In situ Conference. Amsterdam 2006.
- Vorenhout M, 2010: Upscaling Monitoring Results of in situ Preservation. Poster presented at LAC 2010.
- Vorenhout M, HG van der Geest & ER Hunting 2011: An Improved Datalogger and Novel Probes for Continuous Redox Measurements in Wetlands. *International Journal of Environmental Analytical Chemistry* 91, 801-810.
- Vorenhout M, HG van der Geest, D van Marum, K Wattel, & HJP Eijsackers 2004: Automated and Continuous Redox Potential Measurements in Soil. *Journal of Environment Quality* 33, 1562-67.
- Vorren K-D, 2009: Farm Development in the Malangen Area, Northern Norway – A Pollen-Analytical Case Study. *Acta Borealia* 26, 156-174.
- Wasylikowa K, 1986. Macrofossils. In: B. Berglund (ed). *Handbook of Holocene Palaeoecology and Palaeohydrology*.
- Wickler S, 2016: The Centrality of Small Islands in Arctic Norway From the Viking Age to Recent Historic Period. *The Journal of Island and Coastal Archaeology*, 00:1-24.
- Wikipedia, https://en.wikipedia.org/wiki/Arctic_Circle#/media/File:Arctic_circle.svg. Site accessed latest on November 13th 2015.
- Willems WJ, 2008: Archaeological resource management and preservation. *Geoarchaeological and Bioarchaeological Studies* 10, 283-90. Amsterdam.

- Willems W, 2014: *Preservation in situ as a dangerous dogma*. Paper presented at the session T02S022: C Andersson, D de Jager, E Kars & VV Martens (org.). *Preservation in situ or excavation?* at the European Association of Archaeologists (EAA) 2014 conference in Istanbul, Turkey.
- Williams J, 2009: The use of science to enhance our understanding of the past. *NHSS report 2*, <http://-historicingland.org.uk/images-books/publications/nhss-rep2-use-of-science-to-enhance-understanding-of-past/>) Site accessed latest on November 13th 2015.
- Yr.no: <http://www.yr.no/place/Norway/Rogaland/Karm%C3%B8y/Avaldsnes/> Site accessed latest on November 13th 2015.
- Yr: http://www.yr.no/sted/Norge/Finnmark/Nesseby/Varangerbotn/detaljert_statistikk.html;
http://www.yr.no/sted/Norge/Nordland/Evenes/Harstad%c2%a4002fNarvik_lufthavn,_Evenes/detaljert_statistikk.html Sites accessed latest on November 13th 2015.
- Øye I, 2015: Fra felt til fag. Hvor står middelalderarkeologien i Norge i dag?. *Vitark* 9 (Inn i fortida – ut o verden – i museet!), 18-27.
- Øye I, 2016: Agrarian technology and land use in Scandinavian landscapes c. 800-1300 AD. *Ruralia* 10, 157-172.

Personal communications

- Leif Andersen (to Vibeke Vandrup Martens), Voldstad, August 2013 & January 2014
Reidar Bertelsen (to Knut Paasche), Tromsø, May 2011
Ola Storsletten (to Vibeke Vandrup Martens), Oslo, February 2016

Summary

Since the adoption of the Malta Convention (Council of Europe 1992), the strategy of cultural heritage management in many countries has changed from *ex situ* to *in situ* preservation of archaeological remains. The question is whether this change in strategy increases the protection or the risk of losing the undocumented heritage it was meant to protect? The strategy puts a large responsibility on present and future generations, as the concept of *in situ* preservation implies that the heritage sites remain unchanged 'forever'. To ensure that *in situ* preservation may be considered a possibility, knowledge about the present state of preservation as well as the physical and chemical conditions for future preservation capacity is necessary. This accumulated knowledge is called environmental monitoring. The alternatives to *in situ* preservation are to simply let sites deteriorate and eventually disappear, or to preserve through detailed archaeological investigation and documentation, also called *ex situ* preservation or preservation by record. The possibilities, limitations and consequences of *in situ* site preservation are main topics of this work.

The focus of this thesis is on three complex topics; *in situ* preservation of unsaturated archaeological deposits (discussed in chapters 2, 4, 5, 6 and 7), rural medieval archaeology (discussed in chapters 3, 4, 6 and 7) and effects of climate change on archaeological remains (discussed in chapters 2, 4, 5, 6 and 7), all within the context of Norwegian Cultural Heritage management and research.

Chapter 1, Outline and Scope of this Thesis, introduces the central questions and problems, study methods, case sites, project framework and project partners, the legal and management framework and conventions. Specific aims of the present study are;

- To which extent is archaeological contextual readability retained in rural archaeological deposits at different stages of degradation?
- Which are the possible effects of the rates of degradation on their contextual readability?
- Is it possible to define threshold levels in the archaeological deposits?
- When archaeological observations are coupled with environmental parameters, can one define which parameters most affect the present conservation state and conditions for future *in situ* preservation of archaeological deposits in the unsaturated zone?
- What may be the effects of climate change on these parameters?
- How can studies of artefact preservation and microscopic and macroscopic subfossils contribute to evaluations of state of preservation?
- Can degradation processes be curbed or mitigated? If so, which mitigation strategies may be required for the investigated sites?
- How may this contribute to a decision support system for cultural heritage management?

Chapter 2, General Introduction, briefly discusses the background for evaluations of *in situ* preservation of archaeological sites, includes an introduction to rural medieval archaeology in Norway, the North Norwegian farm mounds as archaeological monuments, and discusses their role compared to that of the medieval towns. Modern Norwegian cultural heritage management adheres at least partly to the Malta Convention, though within the set time frames of the Norwegian Heritage Act, meaning that the intention is to preserve as many archaeological sites and as much of each individual site as possible *in situ*. Heritage evaluation and climate change is also discussed, with a brief overview of predicted climate change for the study area of Northern Norway. The chapter includes suggestions for threshold levels and some possible mitigating actions.

Chapter 3, North Norwegian Farm Mounds - landscape conditions and assumed agrarian technologies required for their existence, is a paper on farm mounds as an archaeological object. It puts the farm mounds into a research context and discusses the parameters that have affected their existence over time.

Chapter 4, The Magnate Farm of Åker. Past, present and future of a farm with central functions, presents a south Norwegian farm mound as comparative material to those in northern Norway. This particular farm mound has played an important role as a central place in southern Norway for centuries, and it has been exposed to severe infringement and changes from modern infrastructure projects. Probes monitoring temperature and moisture were installed at the site in 2007, and the monitoring has continued since then, with a few breaks because of battery failure.

Chapter 5, In situ site preservation in the unsaturated zone: case Avaldsnes, gives a thorough description of the methods and equipment used in the monitoring projects, and an explanation of the methods and requirements advocated by the Norwegian Standard concerning deposit monitoring, and potential problems following that. This is another type of comparative site on the west coast of Norway with preserved rural archaeological deposits, in a climate that differs from the ones presented in chapters three and four, and gives some insight into how archaeological remains are preserved in a wet and wild climate.

Chapter 6, Research and monitoring on conservation state and preservation conditions in unsaturated archaeological deposits of a medieval farm mound in Troms and a late Stone Age midden in Finnmark, Northern Norway, contains the results from farm mounds and high north investigations, archaeological, geophysical, and geochemical and palaeobotanic analyses written with InSituFarms project partners. It also includes laboratory experiments on preservation of deposits in different temperature and moisture scenarios to give input to possible climate change effects, tying together the theories and heritage management aspects.

Chapter 7, Synthesis; Implications for archaeological heritage management, discusses the lessons learned from the thesis work and the InSituFarms research project. It is structured in accordance with the research questions posed in Chapter 1, on how climate changes may affect the studied objects (through decay studies and climate predictions), aspects of preservation, and ultimately the implications for archaeological heritage management of these sites and all rural archaeological sites with preserved deposits, independent of site type or dating. This chapter exemplifies definitions of threshold levels for different types of threats to continued preservation and suggests an improvement to the national heritage database including these considerations.

Chapter 8, Conclusion and Further Perspectives. This final chapter gathers the findings of the previous ones and points to future work. The results of the research presented here have demonstrated that it is possible to define parameters that most affect preservation of archaeological sites and it is possible to see effects of climate change on these parameters. That accentuates the importance of preparing strategies to deal with the effects of climate change on the preservation of cultural heritage sites. Focus for future research should be on refining these threshold levels and corresponding mitigating actions to enable defining a point when one should go from *in situ* to *ex situ* preservation. The threshold levels suggested in this thesis should be tested further through laboratory and on site experiments. This work advocates the necessity for the development of sustainable mitigating actions for a number of different threat situations as exemplified in the threshold levels, and to evaluate the scientific potential of sites chosen for *in situ* preservation.

Sammenheng

Siden man vedtok Malta-konvensjonen (Europarådet 1992) har kulturminneforvaltningen i mange land endret strategi fra *ex situ* til *in situ* bevaring av arkeologiske kulturminner. Spørsmålet er om denne endrede strategi øker beskyttelsen av eller risikoen for tap av de udokumenterte kulturminner som den skulle beskytte? Strategien legger et stort ansvar på nåværende og fremtidige generasjoner, ettersom begrepet *in situ* bevaring antyder at kulturminnene vil bevares uendret 'for alltid'. For å sikre at *in situ* bevaring vil kunne betraktes som en mulighet, er det nødvendig å ha kunnskap om nåværende bevaringstilstand så vel som de fysiske og kjemiske forhold for fremtidig bevaringskapasitet. Denne akkumulerte kunnskap kalles miljøovervåking. Alternativene til *in situ* bevaring er enten helt enkelt å la en lokalitet brytes ned og til slutt forsvinne, eller å bevare den gjennom detaljert arkeologisk undersøkelse og dokumentasjon, også kallet *ex situ* bevaring. Mulighetene, begrensningene og konsekvensene av *in situ* bevaring utgjør hovedtemaer i dette arbeidet.

Fokus i denne avhandlingen er tre komplekse temaer; *in situ* bevaring av arkeologiske kulturlag i umettet sone (diskutert i kapitlene 2, 4, 5, 6 og 7), middelalderarkeologi på landsbygden (diskutert i kapitlene 3, 4, 6 og 7) og effekter av klimaendringer på arkeologiske kulturminner (diskutert i kapitlene 2, 4, 5, 6 og 7), alle innen for rammene av norsk kulturminneforvaltning og kulturminneforskning.

Kapittel 1 introduserer de sentrale spørsmål og problemstillinger, studiemetoder, utvalgte lokaliteter, prosjektramme og prosjektdeltakere og juridisk ramme i form av lover og konvensjoner. Spesifikke spørsmål som søkes besvart er;

- I hvilken grad bevares arkeologisk kontekstuell lesbarhet i arkeologiske kulturlag på landsbygden i ulike nedbrytningsstadier?
- Hva er mulige effekter av ulik nedbrytningsgrad på den kontekstuelle lesbarheten?
- Er det mulig å definere grenseverdier for kulturlagene?
- Når arkeologiske observasjoner kombineres med miljøparametre, er det da mulig å definere hvilke parametre i størst grad påvirker bevaringstilstand og forhold for fremtidig *in situ* bevaring av kulturlag i umettet sone?
- Hvordan påvirkes disse parameterne av klimaendringer?
- Hvordan kan studier av gjenstandsbevaring og mikroskopiske og makroskopiske subfossiler bidra til vurdering av bevaringstilstand?
- Kan nedbrytningsprosesser bremses eller avbøtes? I så fall, hvilke avbøtende tiltak vil kreves for de undersøkte lokalitetene?
- Hvordan kan dette bidra til et beslutningssystem for kulturminneforvaltningen?

Kapittel 2 diskuterer kort bakgrunnen for vurdering av *in situ* bevaring av arkeologiske kulturminner, inkluderer en introduksjon til middelalderarkeologi på landsbygden i Norge, nordnorske gårdshauger som arkeologiske lokaliteter og diskuterer deres rolle i forhold til middelalderbyene. Moderne norsk kulturminneforvaltning etterlever i det minste delvis Malta-konvensjonen, men innen for de tidsrammer som er fastlagt i kulturminneloven, hvilket innebærer at man skal forsøke å bevare flest mulige arkeologiske kulturminner og mest mulig av hver enkelt arkeologisk lokalitet *in situ*. Verdisetting av kulturminner og klimaendringer diskuteres også, med en kort presentasjon av forventede klimaendringer i Nord-Norge. Kapitlet inneholder også forslag til grenseverdier og noen mulige avbøtende tiltak.

Kapittel 3 omhandler gårdshauger som arkeologiske objekter. De settes inn i en forskningskontekst, og det diskuteres hvilke parametre som har hatt betydning for deres utvikling.

Kapittel 4 presenterer den sørnorske gårdshaugen Åker som komparativmateriale til de nordnorske gårdshaugene. Denne lokalitet har hatt en viktig rolle som sentralplass i Sør-Norge i århundrer, og den

har vært utsatt for voldsomme inngrep og endringer som følge av moderen infrastrukturprosjekter. Utstyr som overvåker temperatur og vanninnhold i kulturlagene ble installert der i 2007, og overvåkingen løper fortsatt med noen brudd forårsaket av batterisvikt.

Kapittel 5 gir en grundig beskrivelse av utstyr og metoder som er brukt i overvåkingsprosjektene i tillegg til en beskrivelse av de potensielt problematiske metoder og analysekrav som er formulert i Norsk standard (9451) for kulturlagsovervåking. Avaldsnes er en annen type komparativ lokalitet med bevarte kulturlag på Norges vestkyst, med andre klimaforhold – våtere og villere – enn de som er beskrevet i de to foregående kapitler.

Kapittel 6 inneholder resultatene fra tverrvitenskapelige undersøkelser av en gårdshaug i Troms og en Gressbakken-tuft i Finnmark: arkeologiske, geofysiske, geokjemiske og paleobotaniske. Dette kapitlet er skrevet sammen med de fleste prosjektpartnere. Det inkluderer laboratorieeksperimenter om kulturlagsbevaring i ulike temperatur- og fuktighetsscenarier som ledd i undersøkelsen av mulig påvirkning fra klimaendringer, og det binder sammen teoriene og forvaltningsaspektene.

Kapittel 7 diskuterer erfaringene fra avhandlingsarbeidet og InSituFarms forskningsprosjektet. Det er strukturert i samsvar med de forskningsspørsmål som ble formulert i kapittel 1, om hvordan klimaendringer vil kunne påvirke de utvalgte lokaliteter (gjennom nedbrytningsstudier og forutsagte klimaendringer), bevaringsaspekter, og endelig implikasjoner for forvaltningen av disse kulturminnelokaliteter og alle arkeologiske lokaliteter på landsbygden med bevarte kulturlag, uavhengig av type eller datering. Dette kapitlet gir eksempler på definerte grenseverdier for ulike typer trusler mot fortsatt bevaring og foreslår en utbedring av den nasjonale kulturminnebasen til også å omfatte disse hensyn.

Kapittel 8 er avhandlingens siste, og heri samles resultatene fra de foregående og det foreslås videre forskningsarbeid. Resultatene av forskningen som er presentert her har vist at det er mulig å definere hvilke parametre som i størst grad påvirker bevaring av arkeologiske kulturminner og at det er mulig å se effekt av klimaendringer på disse parametrene. Det understreker betydningen av å forberede strategier som kan håndtere effektene av klimaendring i forhold til bevaring av kulturminnelokaliteter. Fokus for fremtidig forskning bør være videreutvikling av grenseverdier og tilsvarende utvikling av avbøtende tiltak, for å nå til det punkt der man kan avgjøre om man bør endre strategi fra *in situ* til *ex situ* bevaring. De grenseverdier som her er foreslått bør testes videre gjennom laboratorie- og feltstudier. Denne avhandling tar til orde for nødvendigheten av å utvikle bærekraftige avbøtende tiltak for en rekke ulike trusselbilder som eksemplifisert i de definerte grenseverdiene, samt å foreta reelle vurderinger av vitenskapelig potensiale i de lokaliteter som utses til *in situ* bevaring.

Samenvatting⁵⁰

Sinds de goedkeuring van het Verdrag van Malta (Raad van Europa 1992), is de strategie van het beheer van het cultureel erfgoed in vele landen veranderd van *ex situ* naar een *in situ* behoud van de archeologische resten. De vraag is of deze strategieverandering leidt tot een betere bescherming of dat deze het risico verhoogt dat het erfgoed ongedocumenteerd verloren gaat. Deze strategie legt een grote verantwoordelijkheid neer bij huidige en toekomstige generaties, als het concept van *in situ* behoud impliceert dat archeologische sites 'voor altijd' onveranderd dienen te blijven. Om *in situ* behoud als een serieuze optie te beschouwen, is kennis van de huidige conserveringstoestand en van de fysische en chemische omstandigheden nodig om de capaciteit voor duurzaam behoud te bepalen. Deze opgebouwde kennis wordt monitoring van het bodemmilieu genoemd. De alternatieven voor *in situ* behoud zijn om de sites gewoon achteruit te laten gaan en uiteindelijk te laten verdwijnen, of te behouden door middel van gedetailleerd archeologisch onderzoek en documentatie, ook wel *ex situ* behoud of conservering door documentatie genoemd. De mogelijkheden, beperkingen en gevolgen van *in situ* behoud zijn de belangrijkste thema's van dit onderzoek.

De focus van dit proefschrift is gericht op drie complexe onderwerpen: i) *in situ* behoud van onverzadigde archeologische afzettingen in de onverzadigde zone (besproken in de hoofdstukken 2, 4, 5, 6 en 7), landelijke middeleeuwse archeologie (zie hoofdstukken 3, 4, 6 en 7) en de gevolgen van klimaatverandering op archeologische resten (besproken in de hoofdstukken 2, 4, 5, 6 en 7), allemaal binnen de context van het beheer en onderzoek van het Noorse cultureel erfgoed.

In Hoofdstuk 1 van dit proefschrift worden de centrale vragen en problemen, onderzoeksmethoden, case sites, projectkader en projectpartners, het juridische en management framework en de regelgeving beschreven. De specifieke doelstellingen van het onderzoeksproject zijn:

- In welke mate is de leesbaarheid van de archeologische context behouden in verschillende stadia van degradatie in landelijke archeologische afzettingen?
- Wat zijn de mogelijke gevolgen van de snelheid van de degradatie met het oog op de leesbaarheid van de context?
- Is het mogelijk om drempelwaarden te definiëren in de archeologische afzettingen?
- Wanneer archeologische waarnemingen worden gekoppeld aan milieu-parameters, kan men dan bepalen welke parameters de meeste invloed hebben op de huidige staat van behoud en de voorwaarden voor het toekomstig *in situ* behoud van de archeologische afzettingen in de onverzadigde zone?
- Wat kunnen de effecten van klimaatverandering op deze parameters zijn?
- Hoe kunnen artefactstudies en bestudering van microscopische en macroscopische organische resten bijdragen aan evaluaties van de staat van conservering?
- Kunnen afbraakprocessen worden afgeremd of beperkt? Als dat zo is, kan dit dan leiden tot mitigatiestrategieën voor de onderzochte locaties?
- Hoe kan dit bijdragen aan een beslissingsondersteunend systeem voor het beheer van cultureel erfgoed?

In Hoofdstuk 2 wordt kort ingegaan op de achtergrond van de waardering van *in situ* behoud van archeologische vindplaatsen en bevat een inleiding op de middeleeuwse archeologie op het platteland in Noorwegen en de Noordnoorse boerderijterpen als archeologische monumenten en bespreekt hun rol in relatie tot die van de middeleeuwse stadjes. Het huidige Noorse cultureel erfgoedbeheer houdt

⁵⁰ This has been translated by prof. dr. Henk Kars with an outset in the English and Norwegian summaries.

zich waar mogelijk aan het Verdrag van Malta, hoewel binnen de gestelde doelen van de Noorse erfgoedwet, die inhoudt dat het de bedoeling is om zoveel mogelijk archeologische vindplaatsen *in situ* te behouden en zoveel mogelijk van elke afzonderlijke vindplaats. De waardering van erfgoed en klimaatverandering wordt besproken, met een kort overzicht van de voorspelde klimaatverandering voor het studiegebied van Noord-Noorwegen. Het hoofdstuk bevat suggesties voor drempelwaarden en een aantal mogelijke mitigerende acties.

In Hoofdstuk 3 worden de boerderijterpen in Noord-Noorwegen als archeologisch object besproken in relatie tot de landschappelijke voorwaarden en de agrarische technologieën die nodig zijn voor hun voortbestaan. Het zet de boerderijterpen in een onderzoekscontext en bespreekt de parameters die hun behoud in de loop der tijd hebben beïnvloed.

Hoofdstuk 4 beschrijft het verleden, heden en toekomst van een Zuidnoorse boerderijheuvel met centrale functies te Åker, als vergelijkingsmateriaal met die in het noorden van Noorwegen. Deze bijzondere boerderijheuvel heeft eeuwenlang een belangrijke rol gespeeld als een centrale plaats in het zuiden van Noorwegen, maar is blootgesteld aan ernstige bedreiging en aantasting door moderne infrastructuurprojecten. Temperatuur en vochtigheid op de site werden gemonitord vanaf 2007 en zijn sindsdien slechts kort onderbroken geweest door batterijproblemen.

Hoofdstuk 5 omvat de case Avaldsnes en geeft een uitgebreide beschrijving van de voor de monitoring gebruikte methoden en apparatuur en een uitleg van de methodes en eisen die worden voorgeschreven door de Noorse Standaard betreffende monitoring van afzettingen en de problemen die kunnen optreden. Dit is een andersoortige site ter vergelijking aan de westkust van Noorwegen met goed behouden landelijke archeologische afzettingen in een klimaat dat verschilt van dat beschreven in de hoofdstukken drie en vier en geeft inzicht in hoe archeologische resten worden bewaard in een nat en sterk wisselend klimaat.

In Hoofdstuk 6 wordt het onderzoek en de monitoring van de staat van behoud en behoudsomstandigheden in de onverzadigde archeologische afzettingen van een middeleeuwse boerderijheuvel in Troms en een late steentijd midden in Finnmark, Noord-Noorwegen beschreven. Dit omvat de resultaten van archeologisch, geochemisch en palaeobotanisch onderzoek, samen geschreven met de InSituFarms projectpartners. Het omvat ook laboratoriumexperimenten met betrekking tot behoud van de afzettingen bij verschillende temperaturen en vochtscenario's om inzicht te krijgen in mogelijke gevolgen van klimaatverandering in relatie tot theorieën en aspecten van het erfgoedmanagement.

In de synthese in Hoofdstuk 7 worden de implicaties voor het archeologisch erfgoedbeheer besproken aan de hand van de lessen die uit dit proefschrift en het InSituFarms onderzoeksproject geleerd zijn. Het is gestructureerd volgens de onderzoeksvragen die in hoofdstuk 1 zijn gesteld: hoe kunnen klimaatveranderingen de bestudeerde objecten beïnvloeden (door middel van vervalstudies en klimaatvoorspellingen), wat zijn de diverse aspecten van het behoud en wat zijn uiteindelijk de gevolgen voor het archeologisch erfgoedbeheer van deze sites en alle archeologische sites op het platteland met goed bewaarde afzettingen, onafhankelijk van het type site of datering. Dit hoofdstuk geeft voorbeelden van definities van toelaatbare drempelwaarden van verschillende soorten bedreigingen voor duurzaam behoud en stelt een verbetering voor van de nationale erfgoeddatabase met deze definities.

Hoofdstuk 8 biedt naast de conclusie een visie op toekomstig erfgoedbeheer. De resultaten van het hier gepresenteerde onderzoek hebben aangetoond dat het mogelijk is om parameters, die de meeste invloed hebben op het behoud van archeologische vindplaatsen, te definiëren en het bleek mogelijk om de effecten van klimaatverandering op deze parameters vast te stellen. Dat benadrukt het belang om strategieën te ontwikkelen om de gevolgen van klimaatverandering voor het behoud van cultureel erfgoed te kunnen beheersen. Focus voor toekomstig onderzoek moet het verfijnen van de drempelwaarden zijn en het ontwikkelen van de bijbehorende mitigerende maatregelen om vervolgens een punt te kunnen definiëren wanneer men moet overgaan van *in situ* behoud naar *ex situ* behoud. De drempelwaarden die in dit proefschrift worden voorgesteld moeten verder worden getest door middel van experimenten in het laboratorium en op de site. Dit project bepleit de noodzaak van de ontwikkeling van duurzame mitigerende maatregelen voor verschillende situaties van bedreiging, gerelateerd aan de drempelwaarden en het evalueren van de wetenschappelijke waarde van locaties die voor *in situ* behoud gekozen zijn.

Appendix I The Malta Convention

Definition of the archaeological heritage⁵¹

Article 1

- 1 The aim of this (revised) Convention is to protect the archaeological heritage as a source of the European collective memory and as an instrument for historical and scientific study.
- 2 To this end shall be considered to be elements of the archaeological heritage all remains and objects and any other traces of mankind from past epochs:
 - i) the preservation and study of which help to retrace the history of mankind and its relation with the natural environment;
 - ii) for which excavations or discoveries and other methods of research into mankind and the related environment are the main sources of information; and
 - iii) which are located in any area within the jurisdiction of the Parties.
- 3 The archaeological heritage shall include structures, constructions, groups of buildings, developed sites, moveable objects, monuments of other kinds as well as their context, whether situated on land or under water.

⁵¹ <http://www.coe.int/nb/web/conventions/full-list/-/conventions/rms/090000168007bd25>

Appendix II The Faro Convention

Article 1 – Aims of the Convention⁵²

The Parties to this Convention agree to:

- a: recognise that rights relating to cultural heritage are inherent in the right to participate in cultural life, as defined in the Universal Declaration of Human Rights;
- b: recognise individual and collective responsibility towards cultural heritage;
- c: emphasise that the conservation of cultural heritage and its sustainable use have human development and quality of life as their goal;
- d: take the necessary steps to apply the provisions of this Convention concerning:
 - the role of cultural heritage in the construction of a peaceful and democratic society, and in the processes of sustainable development and the promotion of cultural diversity;
 - greater synergy of competencies among all the public, institutional and private actors concerned.

Article 2 – Definitions

For the purposes of this Convention,

- a: cultural heritage is a group of resources inherited from the past which people identify, independently of ownership, as a reflection and expression of their constantly evolving values, beliefs, knowledge and traditions. It includes all aspects of the environment resulting from the interaction between people and places through time;
- b: a heritage community consists of people who value specific aspects of cultural heritage which they wish, within the framework of public action, to sustain and transmit to future generations.

⁵² <http://www.coe.int/en/web/conventions/full-list/-/conventions/rms/0900001680083746>

Appendix III The Norwegian Cultural Heritage Act

§ 1 Purpose of the Act⁵³

The purpose of this Act is to protect archaeological and architectural monuments and sites, and cultural environments in all their variety and detail, both as part of our cultural heritage and identity and as an element in the overall environment and resource management.

It is a national responsibility to safeguard these resources as scientific source material and as an enduring basis for the experience of present and future generations and for their self-awareness, enjoyment and activities.

The intention of this Act must also be taken into account in any decision taken pursuant to another Act that may affect the cultural heritage.

Amended by Act of 3 July 1992 No. 96.

§ 2 Monuments and sites, and cultural environments - definitions

The term «archaeological and historical monuments and sites» is defined here as all traces of human activity in our physical environment, including places associated with historical events, beliefs and traditions.

The term «cultural environment» is defined here as any area where a monument or site forms part of a larger entity or context.

Monuments and sites and cultural environments which are valuable architecturally or from the point of view of cultural history may be protected under the present Act.

Amended by Act of 3 July 1992 No. 96.

§ 3 Prohibition against disturbing monuments and sites

No person shall, unless this is lawful pursuant to Section 8, initiate any measure which is liable to damage, destroy, dig up, move, change, cover, conceal or in any other way unduly disfigure any monument or site that is automatically protected by law or to create a risk of this happening.

If the ground above any monument or site that is automatically protected by law or in an area as described in Section 6 has previously been used for grazing or cultivation, it may continue to be used in this manner unless the competent authority decides otherwise. The soil must not be ploughed or otherwise worked more deeply than previously without the permission of the competent authority.

Amended by Act of 3 July 1992 No. 96 and Act of 3 March 2000 No. 14.

§ 4 Monuments and sites which are automatically protected

The following monuments and sites earlier than AD 1537 are automatically protected:

- a. settlement sites, caves, natural rock shelters with evidence that people have lived or worked there, sites of dwellings or churches, churches, houses and structures of all kinds, and remains or parts of these, artificial mounds marking ancient farming settlements, farms, homesteads, courtyard sites or any other groups of structures, such as market sites and trading places, town sites and the like or remains of these.
- b. sites and remains of workshops and other places of work of all kinds, such as quarries and other mining sites, iron extraction sites, charcoalburning and tarmaking sites, and other traces of crafts or industry.

⁵³ <https://www.regjeringen.no/en/dokumenter/cultural-heritage-act/id173106/>

- c. traces of land cultivation of any kind, such as clearance cairns, ditches and plough furrows, fences and enclosures, and hunting, fishing and trapping devices.
- d. road and tracks of any kind, whether unpaved or paved with stone, wood or other material, dams and weirs, bridges, fords, harbour installations and crew-change stations, landing places and slipways, ferry berths and portages or their remains, obstructions in fairways, road markers and navigation markers.
- e. defences of any kind such as hill-forts, entrenchments, ramparts, moats, fortifications and remains of these and beacons, cairns, etc.
- f. thingsteads, cult sites, cult deposition sites and cairns, wells, springs and other places associated with archaeological finds, traditions, beliefs, legends or customs.
- g. stones and outcrops with inscriptions or images such as runic inscriptions, rock carvings and rock paintings, cup-marks, grooves and other rock art.
- h. standing stones, crosses and similar monuments.
- i. stone settings, stone paving, etc.
- j. burials of any kind, singly or in groups, such as burial mounds, burial cairns, burial chambers, cremation burials, urn burials, coffin burials, churchyards and their enclosures, and sepulchral monuments of all kinds.

The same applies to Sami monuments and sites of the kinds described above that are over 100 years old.

Unless the competent authority decides otherwise, standing structures confirmed at any time as originating in the period 1537-1649 are automatically protected by law. Correspondingly, the third and fourth paragraphs of Section 15 apply to automatically protected structures from the period 1537-1649. Exemption from protection may be granted under Section 15a.

The provisions of Sections 16-18 apply to all structures automatically protected by law as described in the first three paragraphs in so far as this is appropriate.

An object or area registered by the competent authority or marked off in the GAB register (the official Norwegian register for property, addresses and buildings), cf. Section 4-1, fourth paragraph, of Act of 23 June 1978 No. 70 relating to Surveying, Subdivision and Registration of Real Property (the Land Subdivision Act) as a monument or site automatically protected by law shall always be regarded as a monument or site automatically protected by law, unless evidence is submitted to the contrary.

In cases of doubt the Ministry shall decide whether or not a monument or site is automatically protected by law according to this provision. The Ministry's decision is binding.

Amended by Act of 3 July 1992 No. 96 and Act of 3 March 2000 No. 14.