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Out of the Ice

Glacial Archaeology in central Norway

Thesis for the degree of Philosophiae Doctor

Trondheim, October 2014

Norwegian University of Science and Technology
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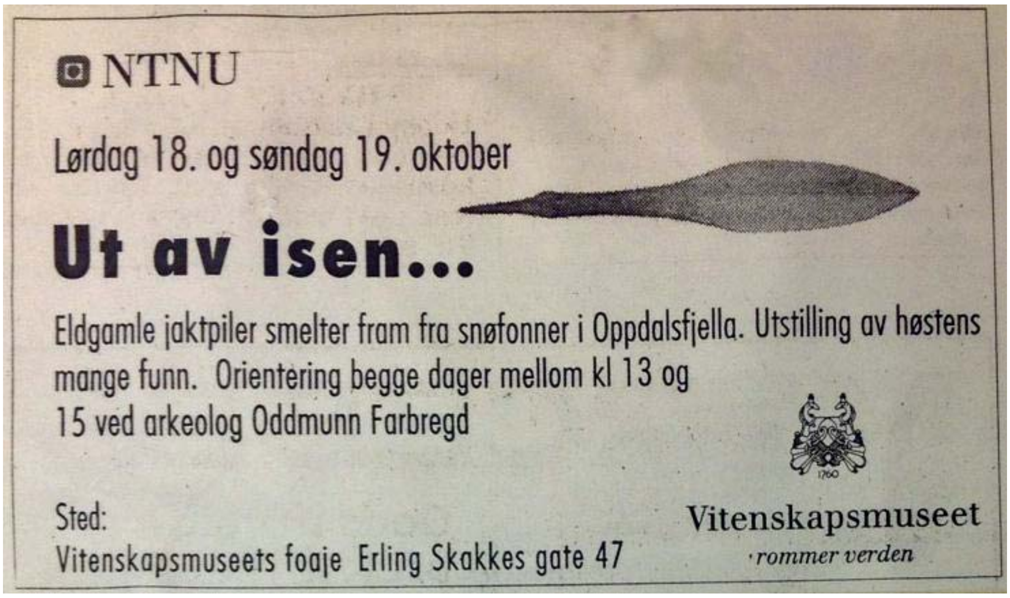

The title of this thesis is taken from a snow patch exhibition of the same name that opened at the NTNU-Museum of Natural History and Archaeology, Trondheim in October 2003. (Source: Adresseavisen 17.10.2003.)

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Finally, this thesis is dedicated to my Mother and Father Philomena and Bertie Callanan, for their love and support down through the years and for the wonderful life I have.

Trondheim 20th January 2014

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Corrigendum

Due to an oversight, one of the numbers presented in Callanan 2012a: table 1 is incorrect.

The error consists of two parts. In the original table the site 'Vegskardet' was listed as having produced five artefacts. The correct number is four. The artefact in question was discovered at the site 'Håråkollen' which was omitted from the original table.

A revised table is presented below.

Snow Patch	Latitude (N)	Longitude (E)	Elevation masl	Orientation	No. of Finds
Storbreen	62° 21' 51"	9° 24' 48"	1810	NE	48
Kringsollfonna	62° 30' 51"	9° 44' 38"	1520	NNE	43
Leirtjønnkollen	62° 27' 25"	9° 44' 37"	1560	NE	35
Brattfonna	62° 28' 38"	9° 46' 25"	1470	N-E	32
Løpesfonna	62° 22' 11"	9° 22' 27"	1730	NE	18
N. Knutshø	62° 19' 31"	9° 40' 26"	1630	NE	8
Vegskardet	62° 21' 56"	9° 19' 35"	1500	NE	4
Løftingfonnkollen	62° 22' 32"	9° 23' 20"	1680	NNE	3
Tverrfjellet	62° 28' 33"	9° 20' 55"	1270	NE	3
Bekkfonnhøa	62° 32' 9"	9° 41' 34"	1360	NNV	3
Kaldvellkinn	62° 30' 47"	9°44' 49"	1550	ENE	3
Sandåfjellet/ Svorundfjellet	62° 37' 46"	9° 11' 37"	1530	E	2
Langfonnskarven	62° 27' 1"	9° 38' 59"	1330	E	2
Kinnin	62° 21' 24"	9° 26' 40"	1720	E	2
Kringsollfonna+	62° 30' 52"	9° 45' 33"	1400	NNE	1
M. Knutshø	62° 18' 42"	9° 40' 49"	1545	E	1
Hesthågåhøa	62° 23' 59"	9° 35' 18"	1530	N	1
Snøhetta	62° 19' 61"	9° 17' 29"	2000	E	1
Skiråtangan, Sunndal	62° 26' 41"	9° 5' 50"	1450	NE	1
Råstu, Sunndal	62° 31' 18"	8° 47' 24"	1547	NE	1
N. Svarthammaren, Sunndal	62° 26' 55"	8° 44' 59"	1700	NE	1
Grovåbotn, Nesset	62° 21' 58"	8° 12' 55"	1390	N	1
Sissihøa	62° 33' 4"	9° 43' 36"	1360	N	1
Gravbekkfonna	62° 27' 8"	9° 30' 9"	1300	NNE	1
Namnlauskollen	62° 22' 25"	9° 25' 19"	1750	NE	1
Skirådalskardet	62° 26' 32"	9° 11' 47"	1765	E	1
Svartdalskardet	62° 28' 29"	9° 17' 15"	1585	NE	1
Håråkollen	62° 21' 54"	9° 21' 30"	1675	N	1
Sissihøa-Leirtjønnkollen	10x2 km	>1400masl	-	-	14
				Total	234

As a result of this error, the total number of snow patch sites in central Norway is cited a number of times as 27 instead of the correct total of 28. The total number of artefacts remains the same. Relevant passages in the unpublished chapters have been corrected. Published chapters remain in their original, uncorrected form.

Martin Callanan

Trondheim 20th January 2014

Chapter 1 Introduction

1.1 Why Snow Patch Archaeology?

Snow patches are areas of perennial snow and ice found in alpine regions around the world. In the past, people frequented snow patches for a number of different reasons and sometimes the tools, clothes and objects that people either lost or discarded on snow patches have survived in the snow and ice. This is largely due to the frozen conditions on these sites. During warm or hot weather conditions snow patches melt and reduce in size. Sometimes when a particularly hard melt occurs, ancient objects some of which are very fragile melt out from the snow patches (*e.g.* fig. 1.1, 1.2 & 1.3). From time to time we are lucky enough to find these objects before they disintegrate and are lost forever. These are the basics of snow patch archaeology and the focus of this thesis.

Figure 1.1 When the surface snow has melted and the ice core becomes exposed, artefacts are sometimes exposed around alpine snow patches. Storbreen, Oppdal. 21st August 2010. Photo: Martin Callanan.

The material culture that emerges from alpine snow patches has a number of characteristics that makes it a particularly interesting and current area of archaeological research.

Firstly as with other archaeological sites and finds, discoveries from snow patches give us important information about human activity in the past. Snow patches are usually found in remote and inhospitable parts of the landscape. These are areas from which the archaeological record is not particularly rich when compared with more central areas such as valley bottoms and coastal zones. Remains of the past recovered from remote alpine sites can help us answer fundamental questions about human activities and strategies in remote landscapes- How long have people been using these sites? Why were people drawn to these areas? What were they doing there?

In addition, objects recovered from snow patches are often well preserved. Snow patch artefacts allow us a detailed glimpse of certain aspects of the material past. Under normal circumstances the organic components of most artefacts have usually rotted away and are unavailable to us for study. By studying the components of ancient artefacts made from wood, sinew, bone, leather, textiles or antler we can gain a better insights into the techniques and traditions from which these objects originated. This type of knowledge is of value well beyond the frozen sites and alpine landscapes from which they originate.

Figure 1.2 Snow patch archaeology in central Norway in a nutshell- Summer sun, melting ice and a pair of sharp eyes in the right place at the right time. Iron Age arrowhead (T25174) found at Kaldvellkinn, Oppdal 8th September 2010. Photo. Arne Johs Mortensen.

Besides being the source of valuable information on human activities in the prehistoric and historic past, snow patches are of interest to archaeologists in other ways too. For example their physical properties and the processes by which objects are integrated and later extirpated from snow patches are both closely linked to the forces of weather and climate. This makes snow patch archaeology especially relevant, when seen from the perspective of a society faced with the realities of extreme and erratic weather events and long-term climate change. With an increased focus on the immediate effect of these developments, ancient archaeological discoveries that emerge from melting alpine ice are quick to catch the eye and make the headlines.

However, while it is obvious that snow patches have an intimate link with the forces of weather and climate, there is much about this relationship that we do not understand at present. Naturally formed structures made from complex and intertwining layers of snow and ice are not familiar contexts for archaeologists. Nor are we accustomed to dealing with the naturally driven cycles of growth and degradation of snow patches that dictate the timing and rate at which artefacts emerge from contexts of deposition. Indeed, archaeology might not be the right science from which to approach these questions that are largely glaciological in nature. However, ancient organic artefacts that appear on melting snow patches may prove to be a valuable source of information about the complex relationships between weather, climate and snow patches in the past and present. The ancient layers and structures at the core of archaeological snow patches are being exposed more regularly now than before. These are structures that were formed over hundreds and thousands of years and are non-renewable. If we are going to better understand the complexities of snow patches as physical structures and processes, the time to study them is now while they still exist.

What are needed are systematic, archaeological analyses of the artefacts that have emerged from sites in the region in recent years. Overviews that map relevant temporal or spatial patterns within the snow patch collection would be of great value in this regard, but also in relation to other questions too. The overviews will give us clearer picture of the cultural historical background for when and how these sites were used in the past. Up-to-date overviews are also vital for planning and prioritizing where and when to survey productive sites in attempts to recover valuable artefacts. Therefore this thesis focuses on a set of specific questions in relation to the chronological and geographical distribution of snow patch artefacts and sites in central Norway.

Figure 1.3 Ancient ice at the core of alpine snow patches is now being exposed more frequently. When the old ice is exposed, hunting artefacts sometimes appear. (T25165. C. AD900-1100. 20th August 2010. Storbreen, Oppdal. Photo. Ingolf Røtvei.

1.2 Research Background

Ancient objects have been collected from around snow patches in the mountains of the interior of central Norway since 1914. The finds in this part of the country consist mainly of arrowheads, arrow shafts and occasionally, bow fragments. A small number of other finds such as knives, snares and other objects have also been recovered. Through the years, these finds have been the subject of detailed archaeological study. One of the important research questions running through this research has been how old are the earliest finds, how old are the snow patches themselves and how long have people been hunting on snow patches? In 1938, Knut Fægri suggested that the oldest finds we could hope to discover on alpine snow patches would be around 1600 years old (Fægri 1938:14). He reached this conclusion based on an analysis of the archaeological finds from snow patches and of pollen diagrams that were available at that time. A much more detailed archaeological analysis of the arrows and points from the region's snow patches followed in the 1970s, 80s and 90s. But despite a large increase in the number of finds available for study, the maximum age of archaeological finds from snow patches was still estimated to around 1700-1900 years old (Farbregd

1972:95; 1983; 33; 1991; 6-7). Again this hypothesis built on the fact that despite new discoveries, no finds older than c. 300 AD existed at the time.

Stone Age	**Mesolithic Period**	9500-4000BC
	Neolithic Period	4000-1800BC
Bronze Age	**Bronze Age**	1800-500BC
Iron Age	**Early Iron Age**	500BC-AD570
	Late Iron Age	AD570-AD1030
Medieval Period	**Early Medieval Period**	AD1030-AD1350
	Late Medieval Period	AD1350-AD1536
Historical Times	**Historical Period**	AD1536-present

Table 1.1 The chronological framework for central Norway that is referred to throughout this thesis. Source: Bjerck et al 2008; tab 3.3.

In 2007 this age limit was called into question with the publication of radiocarbon dates from snow patches artefacts from the region (Åstveit 2007). These finds had been recovered as part of a new wave of finds that started in 2001. In particular, two slate arrowheads and an arrowshaft dated to the Bronze Age (1800-500BC) indicated that artefacts much older than the previous 1700-1900 year boundary had begun to appear on snow patches in the region. The discovery of a *c.* 3300-year-old shoe from the Early Bronze Age, at Kvitingskjølen in Jotunheimen in 2006 gave further indications that artefacts of great antiquity were appearing on melting alpine sites over quite a large area (Finstad & Vedeler 2008). The great age of archaeological discoveries in other regions, found under circumstances similar to those in Norway, demonstrated that finds as ancient as 10,000 years old could survive on mountain sites, as long as suitable conditions existed on the sites where artefacts had been deposited (*e.g.* Hare *et al* 2004; Lee 2010). Were the Neolithic and Bronze Age finds reported in 2007 anomalies that had been preserved on sites? Or could there be other artefacts of a similar age among the newly recovered material?

Finding the answer to these questions could provide new and important information. Proving that snow patch hunting was a stable tradition that dated further back than the Iron Age could have a bearing on our view of prehistory in the region. The age of the oldest organic artefacts recovered from a snow patch might give an indication of the age of the ice at the patch's core. In general a new understanding of the age of these alpine structures might also impact upon the way we look at the snow patches' potential as scientific sources of information.

1.3 Thesis Research Questions

Against this background, the primary objective of this thesis is to investigate the chronological and geographical distribution of artefacts recovered from snow patches in central Norway in recent years. Towards this objective the main research questions addressed in this thesis are:

- What is the age of the oldest artefacts recovered from snow patches in central Norway in recent years?
- What other chronological or geographical patterns can be documented in the current snow patch collection?
- Are new developments limited to single finds and sites or are they systematic across the whole region?
- What do these finds tell us about possible developments on these sites and the potentials for snow patch archaeology in the future?

1.4 Theoretical and methodological profile

Archaeological materials can be approached from a variety of theoretical and methodological angles. This is particularly true of snow patch artefacts where well-preserved organic components open for a whole range of different material and theoretical analyses and interpretations. The fact that the snow patch collection from central Norway is so heavily centred around alpine hunting in the past means that these finds have particular potential. A whole suite of physical analyses have already been successfully carried out on comparable materials elsewhere (*e.g.* Dove *et al* 2005, Helwig *et al* 2008, Kuhn *et al* 2010). Alternatively one could choose to address issues related to technical traditions, production and handcrafts (*e.g.* Knecht 1997, Pétrequin 1993, Stark 1998). The arrows and bows also open for interpretations of long-term human/animal relations, as expressed through the act of hunting on snow patches (*e.g.* Ingold 1994, Knight 2012, Oma 2010, Speth 2013). However this thesis focuses largely on fundamental empirical questions related to structuring and ordering the data-set at hand. There are a number of reasons for prioritising in this way.

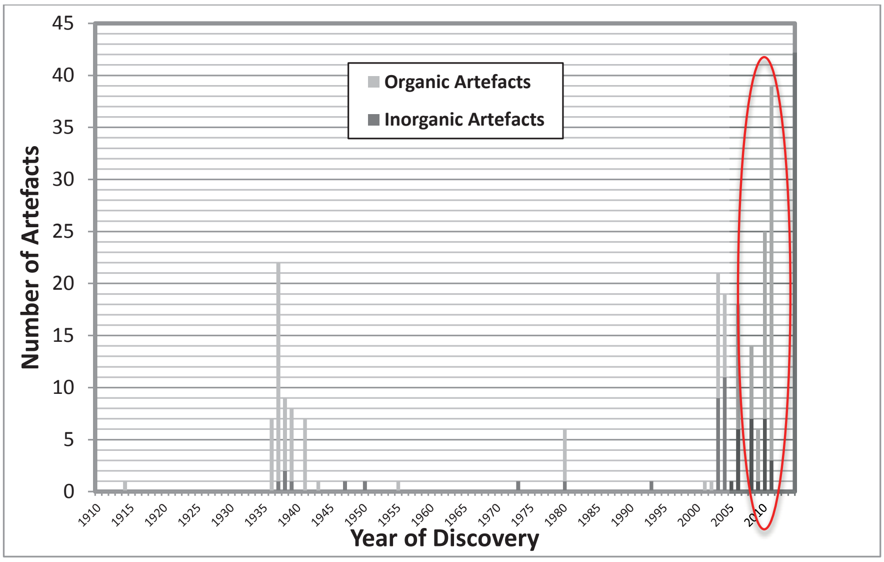


Figure 1.4 Overview of when archaeological finds have appeared on snow patches in central Norway since 1914. The current project period is highlighted. It takes place during one of the more active periods in the history of snow patch archaeology in the region.

Firstly, this project has taken place during a particularly dynamic period in the history of snow patch archaeology in the region. The period has been marked by a number of extreme melting events, with large numbers of exciting finds being recovered from year to year (fig. 1.4). It is almost as if we are in the middle of a large, naturally driven excavation of the region's snow patches. As in any other archaeological situation, the first step is to take stock of the new material at hand. This entails structuring the data in an orderly and systematic fashion and this is the approach taken in this thesis. The analysis stops at the end of the 2011 season, which was the season with the highest number of finds recovered until now. Stopping at this benchmark year, we take the opportunity to look back and take stock of what has happened on the region's snow patches from a long-term perspective.

The second reason for choosing an empirical focus for this thesis is the challenge posed by snow patches as archaeological contexts. Perennial snow patches are surprisingly complex structures that are not fully understood as yet. A basic understanding of how snow patches form, how they are maintained and how they diminish is crucial if we are to be able to interpret the material culture that emerges from them. In addition, as snow patches are so intimately linked to weather and climate conditions, they are potentially useful indicators of how climates have changed in the past as well as in the present. Answering these questions will require specialised multidisciplinary studies from disciplines such as glaciology and meteorology. Snow patch archaeologists have much to gain from any advances in our understanding of these structures and processes. However, before archaeology can take part in any multidisciplinary (*sensu* Stock and Barton 2011) assault on these questions, a firm empirical base needs to be in place. Therefore the greatest contribution archaeology can make at this stage to the long term goal of unravelling the intricacies of snow patches as physical structures is to provide monodisciplinary analyses and overviews (Nyseth *et al* 2007:22-23).

Towards this goal, a wide range of traditional archaeological methods have been employed.

The study began by focusing on the large archive related to snow patch finds at the NTNU-Museum of Natural History and Archaeology, Trondheim, Norway. The archive covers many of the finds discovered during the period 1914-2011 in the form of photos, letters, notes and reports. All information relevant to individual finds, in particular the timing and circumstances of their discovery were referenced, controlled and gathered in a dedicated database. In addition, present-day collectors were consulted for supplementary information relating to their finds from 2001 and onwards when necessary. The information gathered in this database forms the basis for the chronological and geographical analyses in this thesis.

All 234 snow patch finds in the collection have been viewed and studied. Of particular interest were the 147 artefacts recovered between 2001 and 2011. In a few cases it has been possible to refit disassociated fragments of finds recovered on different occasions.

Based on these analyses, a limited number of finds were then selected for radiocarbon dating. A series of 19 ^{14}C dates were carried out as part of the study and are central to this thesis.

Typological dating of artefacts has also played a central role in this work. This part of the study has been conducted in close collaboration with Oddmunn Farbregd (*emeritus*) of NTNU-Museum of Natural History and Archaeology.

Colleagues with the necessary expertise also carried out a number of raw material analyses. These include wood species analysis of 66 artefacts that was carried out by Helge Irgens Høeg and Helene Løvstrand Svarava (NTNU). The analysis and identification of the antler and bone points in the collection carried out by Gordon Turner Walker (National Yunlin University of Science and Technology), and a DNA analysis of 4 bone and antler artefacts carried out by Jørgen Rosvold (NTNU) and Knut H. Røed of the Norwegian School of

Veterinary Science in 2011. The results of these analyses are integrated into the results chapters and appendices of this thesis.

1.5 Thesis Structure

The aim of this introductory chapter is to present the main elements of the thesis and to give an overview of the path it will follow.

Chapter two serves as a general introduction to snow patch archaeology. Here, the history of snow patch research in central Norway is described in detail. The relationship between archaeological discoveries on snow patches and other kinds of ancient frozen finds is explored. A heuristic model used to disentangle the different factors involved in snow patch hunting and trapping is presented. Chapter two was published after peer review in 2010 (Appendix 4).

In chapter three the focus turns to the 234 finds and 28 snow patch sites that make up the data-set for this thesis. This is the first comprehensive presentation of the whole snow patch collection from this region since the new series of finds began in 2001. Special attention is paid to the composition of the finds, and when and how they were recovered. Finds discovered between 1914 and 2011 are divided into three phases based upon when the artefacts were recovered. Variations in survey intensity are discussed as a potential source-critical issue. Chapter three was published in 2012 after peer review (Appendix 4).

Chapter four is a discussion of the methodological challenges that have arisen while analysing the snow patch collection and how these have been dealt with.

The first set of results from the project's dating program is presented in chapter five. The focus in this chapter is on Neolithic hunting implements that were identified during the study. The artefacts are described in detail with reference made to other finds of a similar character elsewhere in Europe. The chapter ends by drawing attention to other environmental changes that are taking place in the sub-alpine and alpine areas in which snow patches are situated. Chapter five was published in 2013 after peer review (Appendix 4).

The second set of results is a group of eight Bronze Age arrows which are presented in the chapter six. The focus of this article is on the arrows' material and technical composition. Chapter six was accepted for publication in 2013 after a peer review process and is due to appear in 2014

In chapter seven, the newly dated finds are reintegrated and synthesised with the rest of the collection in a series of broader analyses. The aim here is to uncover any relevant chronological and geographical patterns that exist in the large number of artefacts that have emerged from the region's snow patches between 1914 and 2011. This presentation builds on the three-phase structure described in chapter three. This chapter has not been published earlier.

Chapter eight consists of a short discussion of what lies ahead for snow patch archaeology in central Norway and further afield. The further scientific potential and possible contribution of snow patches to other sciences in the future is also discussed. Chapter eight has not been published previously.

As can be seen from the preceding, the thesis consists of both published and unpublished chapters in a hybrid solution that lies somewhere between a traditional monograph on the one hand and an article-based thesis on the other. In particular an additional method chapter (*i.e.* Chap. 4) has been included in the main body of the thesis along with the articles already published. This allowed for the insertion of a more thorough method discussion than was possible within the confines of published articles. The hope is that this insertion will bind the published and unpublished chapters better together.

Chapter 2 -Northern Snow Patch Archaeology

Introduction

The term 'Snow-patch Archaeology' refers to the study and management of a set of particular alpine contexts that appear in a number of different regions. Snow-patches are areas of perennial snow and ice, sometimes containing organic arte- and eco-facts that in some cases have survived annual melts for thousands of years. Perennial snow-patches are usually found in mountain areas and differ considerably in size and form (*e.g.* Lewis 1939). During the last 90 years, hundreds of archaeological finds have been reported from snow-patches from different areas of Norway (Hougen 1937, Farbregd 1972; 1983; 2009, Åstveit 2007, Finstad & Vedeler 2008, Finstad 2009). The frozen conditions associated with mountain snow-patches make for excellent preservation when compared to other contexts commonly found in Northern areas. As a result, the artefacts recovered from snow-patches are often very well preserved.

In this article I wish to give a brief overview of snow-patch finds from Central Norway and other regions in Norway. The archaeological research history and cultural background for snow-patch hunting is also presented. This is followed by a brief description of similar finds in other circumpolar areas. The aim is to draw attention to emerging evidence that snow-patch hunting might be viewed as a new example of a circumpolar convergence based on the interplay of a particular set of faunal, environmental and cultural factors. We begin by looking at the snow-patch finds from Central Norway. The materials and their chronology are described in brief, as is the state of preservation and the manner in which they have been collected.

'Out of the Ice'- An overview of finds from Central Norwegian Snow-patches

The archaeological material from Central Norwegian snow-patches consists mainly of artefacts connected with prehistoric hunting and trapping activities. The main find-categories are iron arrowheads, complete and fragmented arrow shafts and hand-bow fragments. A handful of bone arrowheads and a device thought to be related to bird trapping have also been discovered (Farbregd 1972: 89). Of the over 200 individual artefacts recovered until now, complete and fragmented arrow-shafts make up more than half (c.125) of the total. A detailed chronological scheme for artefacts recovered from Central

Norwegian snow-patches has been developed in a number of works presented during the last 30 years (Farbregd, 1972; 1983; 1991 & 2009). In general, the material is dominated by finds from intermediate periods of the Iron Age (300AD-1030AD), the Medieval Period (1030 AD -1536AD) and historical times up until the introduction of firearms during the 1600's (Farbregd 2009:161-165).

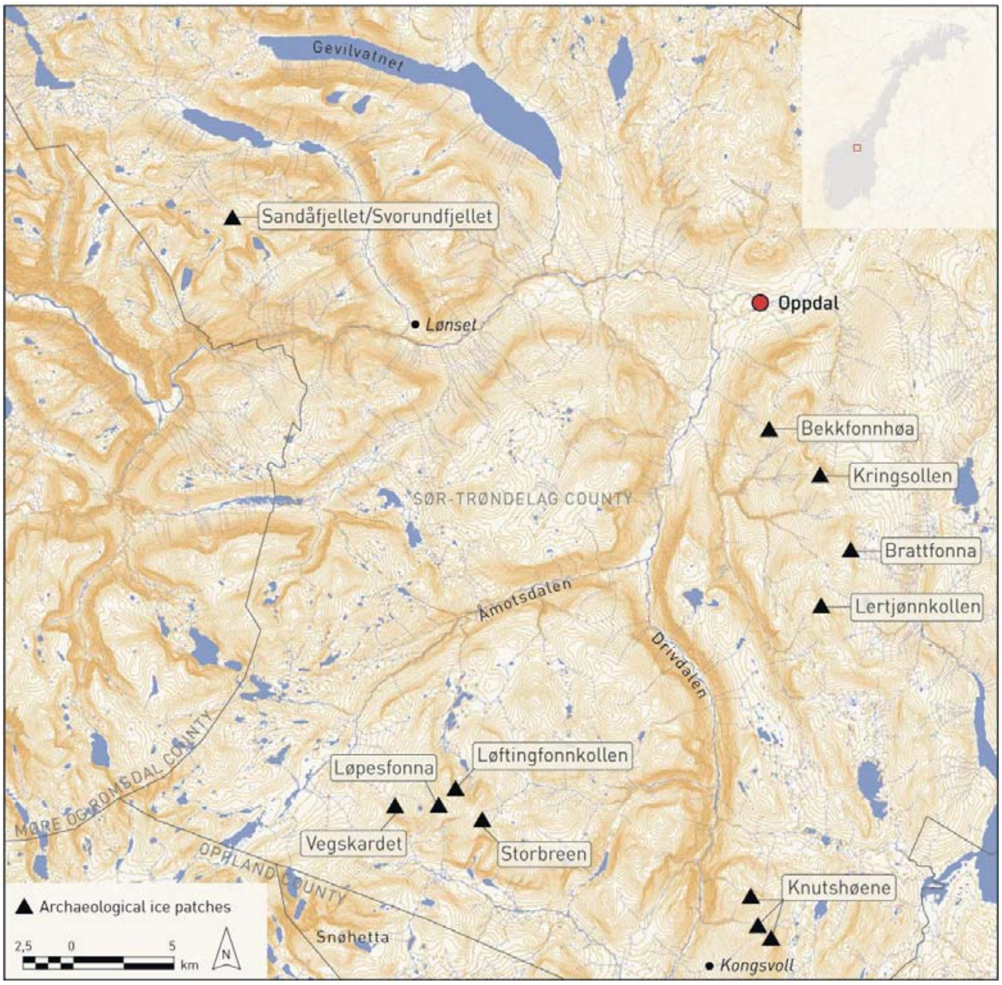


Figure 2.1 Overview of the location of find-bearing snow-patches in Central Norway.

However the oldest finds found in association with snow-patches are considerably older than this. Adhesive recovered from a slate arrowhead found close to one of the traditional find-bearing patches was recently dated to between 2480-2340 cal. BC (Åstveit 2007: 15-16). From the same patch, an incomplete arrow-shaft was dated to between 1740-1600 cal. BC (*ibid.).* These and other recent finds support the thesis that increasingly older finds are now appearing as the inner cores of snow-patches continue to ablate (Farbregd 2009: 167). Interestingly, arrow finds are rare from the two periods between 600AD-700AD and 1000AD-1100AD. Warmer conditions at the time of deposition have been suggested as a possible cause of these distinct *lacunae* (Farbregd 2009: 161).

There is a scale of preservation along which recovered objects can be placed. At one end are single, badly rusted arrowheads that are found, usually without shafts, in the vicinity of snow-patches. At times these artefacts are covered by sediments and debris and can only be recovered with the aid of metal-detectors (*e.g.* Åstveit 2007: Fig. 2). At the other end of the scale we find a few fully preserved arrows with arrowheads, shafts, fletchings, adhesive and bindings (*e.g.* Farbregd 2009: Fig. 7 & 8). The majority of finds can be placed somewhere in between these two poles. The degree of preservation exhibited by individual artefacts is subject to a complex of factors that run from the moment of deposition until final discovery and stabilisation. These include the degree and extent to which artefacts have been exposed to mechanical forces associated with both the ice and sub-surfaces, as well as the effects of short and long term weathering as artefacts are extirpated from the ice for shorter or longer periods of time.

Figure 2.2 Iron arrowhead and fragmented shaft found at Storbreen, Oppdal in 2008. c. 5-7th century. The relatively poor state of preservation indicates that this artefact has been exposed to weathering on numerous occasions. Photo: Kari Dahl/ NTNU-Vitenskapsmuseet.

One of the special features of the snow-patch collection In Trondheim is the long time-span over which the materials have been collected. The first snow-patch find was made at Løpesfonna, Oppdal in as early as 1914 (Farbregd 1972; 1983:7). Following on from this, waves of finds from mountain snow-patches have appeared at different periods. The main waves occurred during the 1930's and the early 1980's. The low number of finds in the intervening period is real, as surveying activities continued unabated during this time (Farbregd 1983:8). Since the turn of the new millennium, a new wave of finds has begun (Farbregd 2009: 158).

There are two important differences between the current and earlier waves of finds. The first relates to changing viewpoints on the potential for making archaeological discoveries on snow-patches. The second relates to changes in our understanding of the perceived role of weather and climate in the process of snow-patches' melting and archaeological finds appearing. Previous snow patch discoveries were understood as chance-finds and/or the result a series of unusual weather conditions. It was initially not at all certain whether this phenomenon would repeat itself or not. Indeed, in the early 1980's it was still unclear whether one could expect to recover artefacts on snow-patches in the same manner as had occurred in the 1930's (Farbregd 1983:8). Today however, as increasingly older finds are regularly being made on both old and new sites, it remains an open question as to how long these processes will continue before mountain patches are exhausted for prehistoric materials. With regard to the relationship between the environment and the continued appearance of prehistoric finds, the ablation of mountain snow-patches is now viewed in relation to more general climatic warming processes, rather than as a result of chance variations in year-on-year weather conditions.

Another feature of the Oppdal material is the manner in which much of it has been recovered. Since the 1930's, a tradition of snow-patch surveying based on the initiative of a handful of local individuals has emerged in Oppdal. This tradition developed in close contact with the Museum in Trondheim, where new finds and details concerning their discovery were regularly collected and archived. The artefact and archival collection, together with much of the knowledge we have about find-bearing snow-patches in the region, is largely a product of the efforts of these collectors. The collection was gathered through countless of hours of hiking and searching on the part of a few men who had a close relationship to mountain-life and who were rightly proud of their achievements and finds. And this tradition continues today. The current generation of collectors has in recent years made a number of important finds that continue to contribute to the local body of snow-patch knowledge (Bretten 2003, Bretten & Røtvei 2004).

Having reviewed the nature, chronology and state of preservation of local snow-patch finds, as well as looking at the manner in which the present collection has been assembled, the following is a short review of the archaeological literature produced during over 70 years of Norwegian snow-patch research. The vast majority of this research has been based on snow-patch finds from Central Norway.

A Short Research History

While early snow-patch finds were reported in the museums' annual catalogues and in newspaper reports, it was not until the late 1930's that the first snow-patch publication appeared (Hougen 1937). In this article a small number of well-preserved arrows were presented. The main focus was on the arrows' state of preservation and questions related to the dating of the artifacts themselves. The discoveries were interpreted as chance finds and one failed to grasp the significance of snow-patches as favored hunting sites where finds might be made on a regular basis. Up until that point, it appears as if snow-patch finds were being interpreted as stray arrows from warm periods that had subsequently been covered by snow-patches during colder spells (Petersen 1937). However this was to change in the course of 1937. In that year, many new finds were made in the Oppdal Mountains. In the same season, important fieldwork was carried out by Johannes Petersen at the behest of the museum in Trondheim. Petersen visited three of the snow-patches in the Eastern mountains of Oppdal, accompanied by one of the pioneer-collectors Martin S. lo. Petersen made important observations of both the sites and the contexts from which finds were being recovered (*e.g.* Farbregd 2009: fig. 6). It was Petersen who for the first time observed that recovered arrows must have originated from within the patches themselves (Petersen 1937). As a result, in a publication from the following year, the focus turned more towards the development of snow-patches as true contexts. In addition, the emergence of archaeological finds from these sites was now being discussed against the backdrop of long- and short-term climatic variations (Fægri 1938). It is unclear when the link between past hunting activities and reindeers' summer behaviors was made for the first time. But given that finds were mostly being collected by local men who were intimately familiar with the mountains, animals and local hunting traditions, this was probably implicitly understood from the start, at least by the collectors.

These initial publications were followed by a 30 year long hiatus, which corresponds with a lull in snow-patch finds. In a short article from 1968, Farbregd used the term 'Glacial Archaeology' to describe similarities between snow-patch finds from Central Norway and other glacial and permafrost discoveries made in Alaska and Siberia (Farbregd 1968). This article marks the beginning of a new period of Trondheim-based snow-patch research in the form of papers, reports and articles that continues until today. The bulk of this research was carried out by archaeologist Oddmunn Farbregd based at the Museum of Natural History and Archaeology in Trondheim (*e.g.* Farbregd 1968, 1972, 1983, 1991, 2009). Farbregd's research has focused largely on finds recovered in the mountain regions around Oppdal, although related finds from other areas are often treated too. The following is an overview of the main research themes pursued through Farbregd's snow-patch publications. With the exception of individual summaries and a recent synthesis (Farbregd 2009), these publications are all published in Norwegian.

- Analyses of chronological and functional patterns in the arrow material (1972, 1991, 2009).
- Geographical/temporal distribution patterns within material from different sites (1983, 1991).
- Aspects of snow patches as archaeological contexts (1973, 1983, 1991, 2009).
- The relationship between snow-patch hunting and other hunting/trapping systems (1983, 1991).
- The relationship between snow-patch finds and long term climate data (1972, 1983, 2009).
- Long term developments in archery and cross-bow technologies (1972, 1991, 2009).

In addition to these works, a number of articles and reports have also been produced locally on topics related to snow-patch finds and archaeology in the region (Farbregd & Beverfjord 2000, Bretten 2003, Bretten & Røtvei 2004, Stuedal 2006, Åstveit 2007, Hoel 2009).

This concludes both the review of snow-patch materials and the history of snow-patch research in the Trondheim region. Up until this point, our attention has been focused on snow-patch finds from the Oppdal area. It is important to note however, that similar discoveries have been made in other areas of Norway both to the North and South of the Oppdal mountains.

Snow-patch finds in other Regions of Norway

Another important area for Norwegian snow-patch archaeology lies in the County of Oppland, to the South of Oppdal (See Fig. 1). Despite some early discoveries, it is not until recently that prehistoric artefacts have been recovered in Oppland with the same intensity as in the mountains further to the North. The Oppland finds have a number of parallels with the Oppdal material. Arrows and shafts of the same chronological and technological background have been recovered from a number of snow patches in Oppland. There are however some striking contrasts too. In general the snow-patch find-complex from Oppland is somewhat broader and includes items such a wooden spades, textiles and a well-preserved 2000 year old leather shoe (Finstad & Vedeler 2008; Finstad 2009). At Juvassfonna a unique, multi-phase hunting system has been discovered in direct association with a large snow patch. This system comprises of a series of stone-set hunting blinds and the remains of a number reindeer leads composed of well-preserved sewels[1].

Figure 2.3 A c. 70cm long fragmented sewel in situ at the base of the large snow-patch at Juvassfonna, Oppland August 2009. Note the carved notch used to affix the flap. Photo: Martin Callanan.

[1] A sewel is a thin pole with an attachment on top that flaps in the breeze. The flapping movement catches the attention of the reindeer. These tend to move away from the sewels that are often set up in rows leading towards waiting hunters or pitfalls (see Spiess 1979: 128).

The sewels themselves consist of thin wooden poles with organic ties affixed to wooden or bark flaps. At Juvassfonna, whole and fragmented sewels have been recovered in large numbers (Finstad 2009, OFK 2009). Stone-set leads are not uncommon in mountain areas in Norway and through the years a small number of individual flaps have been recovered from different sites (Bevanger & Jordhøy 2004: 18, Weber *et al* 2007: 56). However the discovery of a well-preserved system of scaring fences is an exciting development. Interestingly, at this time there are no parallels between this discovery and finds from the region around Oppdal. Emerging regional differences of this character appear to point towards distinct local traditions within hunting and trapping strategies associated with snow-patches.

In 1999, a pair of new finds was discovered in a region of Norway far from the southern mountain areas usually connected with snow-patch archaeology. At Seilandsjøkulen (70° 23' 60"N 23° 06' 37" E), Seiland, Finnmark, a 2-3000 year old decorated bone arrowhead was discovered near a snow-patch at approximately 700masl. (Johansen 2002: 14). There are also reports of another find from the same year consisting of an iron arrow head and wooden shaft recovered near a retreating snow-patch. With regard to latitude, these new discoveries may be compared to a pair of earlier Swedish snow patch finds from Låktatjåkkastugan (68° 24' 23"N 18° 27' 41"E) and Kåppastjårro (68° 22’ 07"N 18° 31’ 16" E) in Lappland, Sweden, where a pair of complete arrows was recovered in 1962 and 1961 respectively (Lundholm 1976). Seen together, these northern finds point to the uncharted potential that may exist for future snow-patch discoveries in suitable locations over a much wider area than the present distribution might suggest.

We can now turn our attention to the past activities that lie behind the deposition of these artefacts on snow-patches. As we have seen, hunting artefacts have been deposited in these peculiar contexts with a certain regularity over a long time span. In the following we look more closely at snow-patch hunting as a past cultural activity. More specifically we identify the natural and cultural factors that have converged to result in the snow-patch archaeological record as it appears to us today.

Snow-patch hunting as a cultural historical activity

Snow-patches are unusual in that they are true kill-sites, something unusual within the archaeological record (Speiss 1979:103). As a past cultural activity, snow-patch hunting can be seen as dependent upon the interaction of number of interdependent factors. At least 3 important factors can be identified within this interaction. These are:

- Particular and regular behavioral traits on the part of specific faunal species, mainly reindeer.
- A specific interplay of landscape and climate that gives rise to alpine snow-patches.
- Cultural and historical conditions that make snow-patch hunting a viable technological and economic activity.

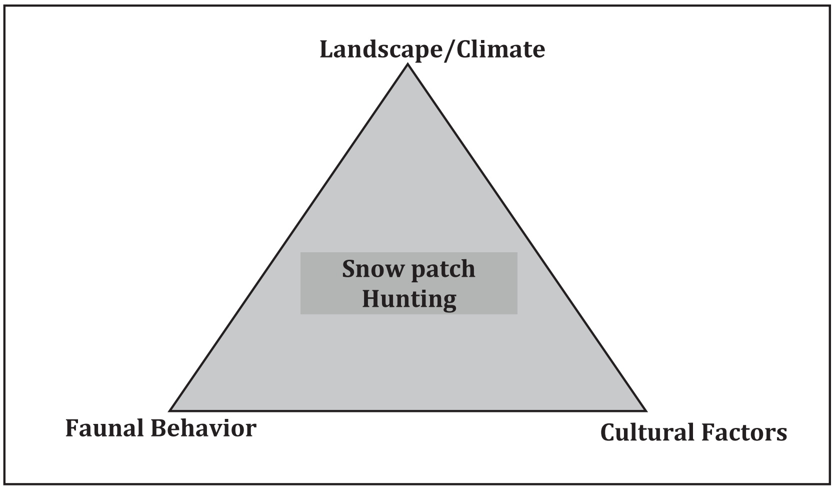


Figure 2.4 Descriptive model of the factors involved in snow-patch hunting in the past.

This is first and foremost a descriptive model and the following presentation of these three sets of factors is schematic. This model is not unique to snow-patch hunting and could indeed be applied to a whole series of different hunting and trapping situations. However, snow-patches, their prehistoric use and archaeological inventories are complex in nature and some organizational format is necessary when describing or analyzing the factors involved. Therefore the model provides a useful preliminary framework within which the phenomena of snow-patch hunting can be broadly approached. Although based on the Central Norwegian *casus,* the model is not chronologically or spatially specific.

Faunal Behavior

Wild reindeer are today dispersed widely throughout the mountains of Southern Norway. They number ca. 30,000 in total and are split into distinct and separate herds (Bevanger &

Jordhøy 2004:30). The herd that today populates mountain areas around Oppdal is the *Snøhetta* herd. Our knowledge of past migration patterns is based both on the study of prehistoric hunting and trapping systems and on analogy with observed present day behaviours. For example, the scale and distribution of prehistoric trapping systems indicate that prehistoric herds were considerably larger and roamed in regular annual migrations over a much wider area than is the case at present (Mølmen 1995; Jordhøy 2001; Bevanger & Jordhøy 2004).

Today through the spring and summer months, reindeer in the Snøhetta region seek out protein/rich grazing grounds in areas newly freed from snow cover (Jordhøy 2008:84). In mountain areas around Oppdal this has meant a spring migration following the wave of green plant production from winter grounds that lie towards the East, to summer calving and grazing grounds further west with the Driva valley forming an axis between these seasonal areas. (see Fig. 2.1). The landscape varies on both sides of this axis with higher, more alpine areas towards the west. The reindeers' spring/summer migration westwards is thus both spatial and altitudinal. High alpine areas offer reindeer limited grazing possibilities but serve as important cool niches during the summer (*ibid*). Reindeer often congregate on snow-patches in late summer in order to avoid the nuisance of parasitic insects and for the purpose of thermo-regulation (Åstveit 2007:9-10, Jordhøy 2008: 84). Interestingly, archaeological snow patches are found on both sides of this proposed axis.

Landscape/Climate

The alpine areas in which snow-patches are found are often desolate spaces that even today remain largely untouched by human activities. At these altitudes, the combination of landscape and climate play a crucial role in providing the conditions necessary for perennial snow-patch formation and maintenance. In the early summer there are literally thousands of large and small snow-patches to be seen in these mountain areas. However, it is only at higher altitudes (*c.* >1400masl) that certain snow-patches survive through normal summers and only a handful of these again will survive through particularly warm summers. Based on the evidence of ancient artefacts recovered so far, archaeological snow-patches in a number of regions have shown themselves to be remarkably resilient to both long and short term climatic variability and variation. Little is known for certain about what governs the long term survival of certain high altitude snow patches in different areas. But important factors are thought to be altitude, orientation, local topography, local subsurface conditions (i.e. permafrost) as well as local annual weather regimes (precipitation, temperature, wind & sunshine). But this is only one side of the coin. Another matter is the set of factors that have influenced the use of specific snow-patches by reindeer and other animals in the manner described above. Of obvious importance is the location of snow-patches in relation to specific topographical features and migration routes. The permanence (and thus reliability) of certain longeval patches within annual ranges was probably an important factor in this regard too.

Cultural Factors

Reindeer have thus adapted to the seasonality of the sub-arctic region by seeking out high-alpine cold niches during the warmer periods of summer. Interesting though it is, this is largely a natural phenomenon that would hardly be of any archaeological significance at all had it not been for the evidence of regular human utilization of certain snow-patches as favoured hunting grounds over long periods of time.

In general terms we can identify a set of varied human factors that must have influenced the way in which snow-patch hunting and trapping activities were carried out. These include wide-reaching elements such as technology, social and economic structures, scheduling and trade specialisation to mention but some. We can also be sure that some, if not all of these human factors will have varied and developed through time and space. It is beyond the scope of this paper to begin to broach each of these topics in depth, however the following is an attempt at a broad summary of some key cultural elements related to past snow patch hunting based on the current evidence.

In the case of Norwegian snow-patches, the deposition of arrowheads, shafts and other implements in these high alpine contexts appears intimately linked to reindeer hunting. But why should that be the case? Why would hunters choose to use such desolate and remote sites as favoured hunting grounds? Although it is possible to some extent to predict reindeer movements and migrations on a macro scale, they are a difficult prey to track and hunt at close quarters. Groups of animals congregating on snow-patches with a certain regularity seem to have presented prehistoric hunters with a more advantageous situation when compared with a more opportunistic tracking animals in open countryside.

As prey, reindeer offer a number of different products to hunters. These products include meat, blood, marrow, antler, sinew and skin. Differences in the quality of reindeer skins throughout the year might have been a factor that influenced the scheduling of small scale hunting trips on snow-patches to the late summer. Perhaps there was a need for hides of a certain quality that was only available at specific times of the year? Based on North-American ethnography, Speiss describes how skins suitable for clothing were best taken at the end of the summer, when shedding was completed and warble fly holes had healed. Winter skins are described as having been too heavy for use as clothing (Speiss 1979: 27-28). Attempts at finding relevant Scandinavian literature on this matter have until now been unsuccessful, but in time an examination of snow-patch hunting from the perspective of scheduling may prove to be a fruitful line of enquiry.

We might also ask how snow-patch hunting was carried out? Was there one form to this type of hunting or were there several alternative forms? Based on the Norwegian evidence, snow-patch hunting was based mainly on the use of hand bows and crossbows. The hunt probably involved stalking groups of animals gathered on the patches. This form of hunting may have been carried out by individual hunters. Bretten (2003) suggests that on patches that are steep or that lie beneath over-hangs it was probably an advantage to be positioned above the animals on the patch below. In this form, snow-patch hunting represents a simple strategic adaptation on the part of the prehistoric hunter to observed behavioral traits amongst animals within a specific and natural landscape setting. Based on the present evidence, this seems to have been the form of snow-patch hunting most common in the Oppdal region.

In contrast, in the case of larger more open patches such as Storbreen, the animals may have been driven into the arms of waiting hunters in a form of collective hunting (*ibid).* Another possible strategy may have been the construction of temporary hunting-blinds of snow on the patches themselves. Although no direct evidence of this strategy exists, the recent recovery of a number of discarded wooden-spades on snow-patches in Oppland might support this interpretation (Finstad 2009). Alternatively, the presence of spades may indicate that snow walls functioned as leads that were integrated with other elements to form a trapping system of some kind (Speiss 1979: 106). The recently discovered system of sewels and hunting blinds at Juvassfonna appears to be a system of this kind, where the snow-patch functioned as an integrated part of a larger system. In these cases, we move beyond simple strategic adaption, towards a more active intervention in the natural environment. This involved the construction of a planned kill-situation that was probably more predictable and thus favourable for prehistoric hunters. From this it can be seen that snow-patch hunting as a past activity appears to cover a range of inter-related hunting strategies from simple through hybrid hunting/trapping forms.

Although reindeer appear to have been the main focus of past hunting activities on these sites, other prey have also been hunted and trapped. A small number of finds indicate that reindeer hunting was complemented by the hunting and trapping of fur and feather too. These finds include club-headed arrows thought to have been used on furred animals and a wooden device apparently related to the setting of snares (Farbregd 1972: 89-90, Åstveit 2007). These finds add another dimension to our understanding of alpine snow-patches as kill-sites.

Glacial Archaeological Finds from other Regions

As noted earlier, the term 'glacial archaeology' was used already in 1968 in order to relate artefacts recovered from Central Norwegian snow patches to the appearance of frozen prehistoric materials in other regions (Farbregd 1968). The term has been used again recently to describe the present day emergence of a set of inter-related finds from a number of different regions and contexts (Dixon *et al* 2007). These finds range from human remains recovered from true glaciers to single prehistoric and historic artefacts recovered from melting snow patches. Looking beyond Norway, the geographical spread of glacial archaeological finds is wide. The best known of these finds are the remains of The Neolithic Iceman (*Ötzi*) who was discovered in the early 1990's in the Ötztal Mountains on the border between Italy and Austria (Bortenschlager & Oeggl 2000). However in recent years, a number of other glacial discoveries have been made in regions as far apart as Alsaka (Dixon *et al* 2005; 2007, VanderHoek *et al* 2007a & b), Canada (Kuzyk *et* al 1999, Beattie *et al* 2000, Farnell *et* al 2004, Hare *et al* 2004, Dove *et al* 2005, Keddie & Nelson 2005, Helwig *et al* 2008, Andrews *et al* 2009), United States (Lee *et* al 2006), Greenland (Hansen & Gulløv 1989), Peru (Ceruti 2004, Reinhard 2005), Sweden (Lundholm 1976), Switzerland (Suter *et al* 2005; Grosjean *et al* 2007). These disparate discoveries are bound together by a number of common factors. Their association with cryospheric contexts is often related to their location in high latitude and/or high altitude areas (Dixon 2005: 129). This said, new discoveries on high altitude/ low latitude sites in Colorado underline the presence of high-potential glacial contexts in other regions too (Lee *et al* 2006).

Conditions of preservation on these sites are often extremely good and the recovery of well-preserved organic materials is characteristic for this group. Another commonality apparent in recent years is that many of these contexts have shown themselves sensitive to both short-term weather events as well as long term climatic variations. The complex nature of both the contexts and discoveries associated with this group of sites has presented archaeology with unique analytical possibilities and serious methodological challenges. Glacial archaeology today has a strong multidisciplinary dimension and is closely linked to conservation sciences (Farnell *et al* 2004: 250-251, Dixon *et al* 2005: 141, VanderHoek *et al* 2007a:82).

However, the commonality that the term Glacial Archaeology attempts to express is related first and foremost to the physical properties of this set of sites. If we instead shift the focus to the kind of materials recovered, as well as to the activities that lie behind their deposition other sub-groups emerge. For example based on the physical properties of sites, the closest international parallels to the Norwegian snow-patch sites are found in Alpine sites such as that at Schnidejoch, Switzerland and the group of archaeological snow-patches discovered in Alaska and Northwestern Canada. However once we begin to consider the types of finds recovered from the different sites, further differences emerge. The accumulation of finds at Schnidejoch appears to have been the result of that site's position within a transport network rather than due to regular hunting forays. As a result, the find complex found there is much broader and has been deposited at more irregular intervals that are thought to be connected to specific climatic conditions (Suter *et al* 2005; Grosjean *et al* 2007). In contrast, alpine snow-patches from Alaska, Canada and Norway appear to share a fundamental commonality in respect to both the type of archaeological finds recovered and the manner in which these artefacts have been deposited in the past. By looking closer at the commonalities between the materials from these regions, we can begin to see the contours of a new circumpolar convergence in the form of snow-patch hunting.

Northern Snow-Patches- A Circumpolar Convergence?

The first North-American snow-patch discoveries were made in 1997 in the Yukon, Canada (Kuzyk *et* al 1999). Since that time, a large number of new finds and sites have been discovered in various regions within a large area from Alaska in the west to North West Territories, Canada in the east (Farnell *et* al 2004, Hare *et al* 2004, Dixon *et al* 2005; 2007, Dove *et al* 2005, VanderHoek *et al* 2007a & b, Keddie & Nelson 2005, Helwig *et al* 2008, Andrews *et al* 2009). The following overview of North American finds and sites is based primarily upon the published literature.

North American snow-patches appear similar to the Norwegian sites with respect to a number of key factors such as size, form and elevation (Farnell *et al* 2004: 248-250 Hare *et al* 2004: 261, VanderHoek *et al* 2007a, Andrews *et al* 2009). Well-preserved prehistoric and historic organic materials have been recovered from a number of sites across the region. This material includes both archaeological artefacts and faunal remains. The recovered archaeological material is dominated by various kinds of projectiles. The main find-groups are throwing darts and to a lesser degree arrows (Hare *et al* 2004:262, Keddie & Nelson 2005, Dixon *et al* 2007: 136-139, VanderHoek *et al* 2007b: 186-195). The projectile materials recovered have been dated to between ca. 8300-90 ^{14}C yrs. B.P. (*ibid.*).

Faunal remains associated with the North-American snow-patches includes bone, antler and fecal material. Especially noteworthy is the appearance of massive black dung layers on North-American sites during the ends of warm summers. These materials have in some cases proved quite ancient and are an important source of information about many aspects of caribou in the past, often in areas where they are today absent (*e.g.* Kuzyk *et al* 1999, Farnell *et al* 2004).

The accumulation of hunting projectiles on these sites is interpreted by a number of researchers primarily as the result of caribou hunting on snow-patches. These are viewed as seasonal hunting trips into mountain areas. In some cases snow-patch hunting was probably combined with other activities such as fishing, trapping and berry-picking (Hare *et al* 2004: 261; VanderHoek *et al* 2007a: 78-79).

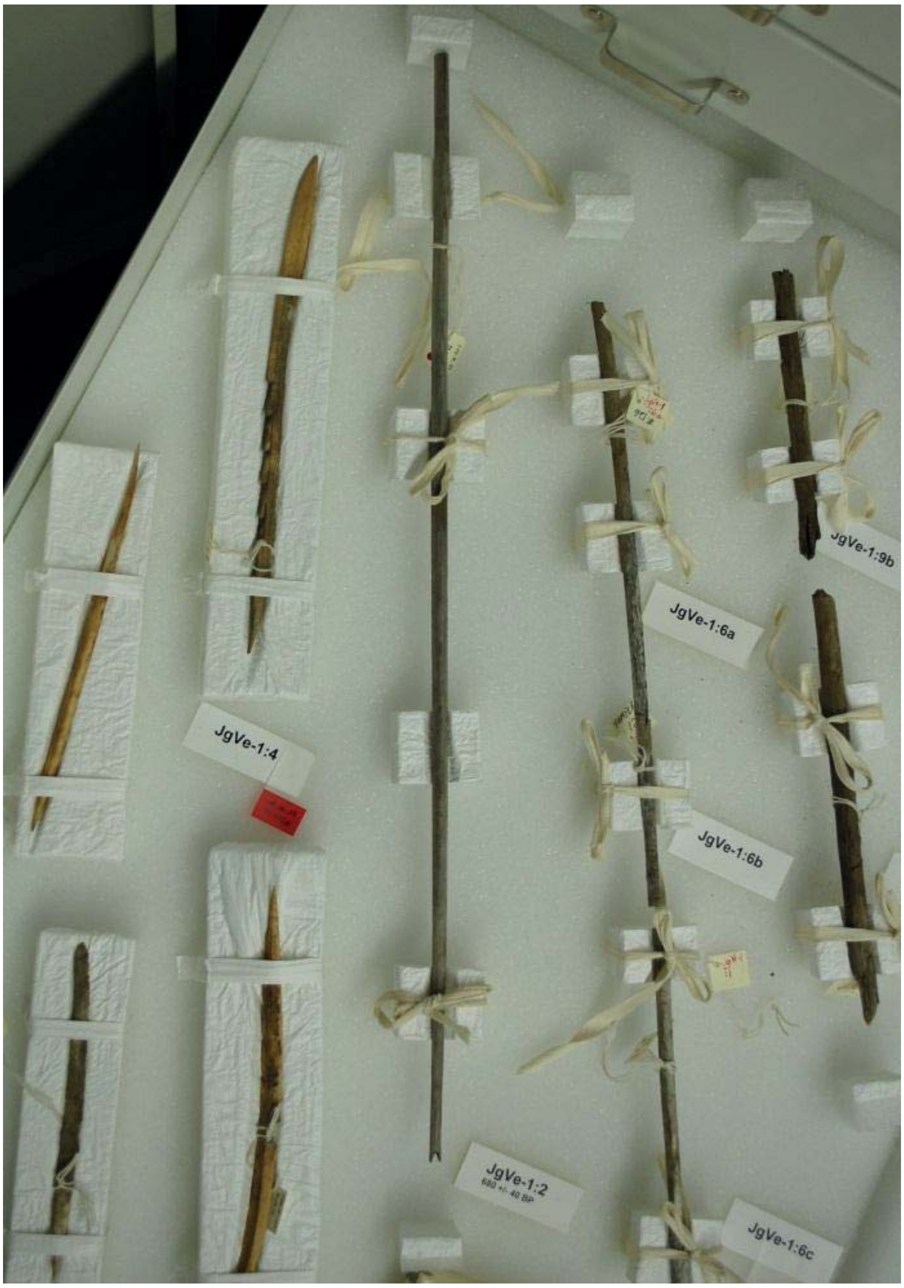


Figure 2.5 An example of some of the artefacts recovered from snow-patches in the Yukon, Canada. Photo: Martin Callanan.

There are a number of striking parallels and similarities between the North-American and Norwegian snow-patches. In both cases the phenomena of archaeological artefacts appearing on high alpine snow-patches has its base in an apparently common adaptation to specific landscape and faunal conditions. In both regions, this adaptation appears to have involved the interplay of faunal behavioral patterns, topographical and climatic conditions and a range of human factors as described in the model above. Despite obvious differences in both technological and cultural trajectories between these areas, the use of snow-patches as favored seasonal hunting grounds appears to be a striking example of adaptive convergence between two unconnected areas of the Circumpolar North. Interestingly, snow-patch hunting does not appear in Speiss' survey of the various human-reindeer interactions in the circumpolar region (1979). Thus the identification of snow-patch hunting and trapping as an example of circumpolar convergence appears to be a new observation.

This observed commonality opens the way for a number of new possibilities and perspectives. Future comparative studies and exchanges will help to further develop our methods and understanding both of snow-patches as particular archaeological contexts but also of snow-patch hunting as a past cultural phenomenon. Another interesting question is related to the possibility of a wider distribution of this hunting strategy. At present, the regions where evidence of past snow-patch hunting has been discovered are separated by some 5-6000 kilometers. However when we look at the vast map of the northern circumpolar region and in particular at the spread of reindeer within this space, it seems reasonable to suggest that snow-patch hunting was probably practiced in other high altitude areas of this region too. The descriptive model presented in this article might prove useful in identifying new regions where a similar interplay of faunal, environmental and cultural factors would have made snow-patch hunting possible. Perhaps there are other well-preserved hunting artefacts similar to those from Central Norway and North-America waiting to be discovered in other circumpolar regions?

Chapter 3 -Central Norwegian Snow Patch Archaeology: Patterns Past and Present

Introduction

The large collection of snow patch artifacts housed at the Norwegian University of Science and Technology (NTNU) Museum of Natural History and Archaeology in Trondheim has been the subject of many years of research (Farbregd 1972, 1983, 1991, 2009). Yet no detailed overview of the entire snow patch collection from central Norway exists at present. A collection of this kind, having been assembled over such a long time-frame (1914 – 2011), has great potential for both archaeology and other disciplines, especially in light of the current focus on melting alpine snow patches and their perceived relationship with shifting weather patterns and global climate change. A detailed presentation of the collection is an important first step towards more detailed archaeological and multidisciplinary research in the future. Some of the issues raised in this treatment may be relevant for similar collections from other regions as well.

This article presents in detail the snow patch sites and finds discovered in central Norway during the period 1914 – 2011, focusing on both the composition of the collection and the time when the artifacts were discovered. It seeks to uncover relevant patterns within the snow patch collection as a whole and to identify any methodological issues that may lie behind the patterns that emerge. The central question in this regard is the following: Can this collection be viewed as a cohesive long-term record, or should it be seen as representative of a series of disjointed periods of discovery?

Snow patch archaeology in Norway

At present, archaeological snow patch discoveries are known from four different regions of Norway. The most comprehensive finds come from two southern regions: the municipality of Oppdal in Sør-Trondelag County and the area centered on the municipality of Lom, in Oppland County. Oppdal is a municipality in the county of Sør Trøndelag, while Oppland is a large inland county that lies farther to the south (Fig. 3.1). A handful of individual finds have been recovered in inner mountain areas along the west coast (Shetelig 1917; Åstveit 2010). Two arrows discovered in 1999 at Seiland, Finnmark, are the northernmost finds in the country to date (Johansen 2002).

Roughly 50 snow patch sites and find spots are known in Norway at present. Sites are usually found at elevations of 1400 masl or above. However, the arrows from Seiland were recovered from sites lying at ca. 700 masl, which underlines the possibility of making new snow patch discoveries at lower elevations in higher latitudes (Johansen 2002).

Figure 3.1 Location of the four snow patch regions in Norway: 1) Oppdal, 2) Oppland County, 3) Vik, Sogn, and Fjordane, and 4) Seiland, Finnmark.

On the basis of the current evidence, two types of sites are associated with archaeological snow patches in Norway: arrow sites and larger hybrid hunting/trapping sites. Both of these snow patch types have a number of particular characteristics, potentials, and challenges associated with them.

Arrow Sites

Arrow sites are the most common type of snow patch site and are present in all four regions outlined in Figure 3.1 (*e.g.* Shetelig 1917; Farbregd 1972; Johansen 2002; Finstad & Pilø 2010). Materials recovered from arrow sites consist mainly of iron, bone, antler, and lithic arrowheads and wooden arrow shafts. Other objects such as bow fragments, knives, and snare- setters are occasionally recovered on arrow sites too.

The state of preservation of the recovered artifacts varies from whole arrows with fletchings and adhesive to disassociated arrowheads and shaft fragments (Fig. 3.2). Artifacts found on arrow sites are interpreted as being largely the result of past reindeer hunting, although prey such as grouse and certain furred animals were trapped and possibly hunted too on these sites (Åstveit 2007; Farbregd 2009; Callanan 2010).

Archaeological materials on arrow sites are found either on, around, or below melting snow patches (*e.g.* Farbregd 1972). Earlier research has shown that artifacts were deposited on some arrow sites over long time periods of prehistory (Farbregd 2009) and thus offer valuable insights into past technical traditions and hunting activities over long time spans. The arrow sites of central Norway form the main focus of this article.

Figure 3.2 This well-preserved arrow shaft and iron point was discovered lying directly on the ground close to Storbreen, Oppdal, on 21 August 2010. This kind of context is typical for the majority of finds in the central Norwegian collection. Photo: Martin Callanan.

Hybrid Hunting/Trapping Sites

A number of discoveries made in Oppland County since 2006, including that of a well-preserved hunting/trapping system close to a snow patch at Juvfonna, have added a new dimension to Norwegian snow patch archaeology in recent years. The site at Juvfonna (1835 masl) is likely the result of a hybrid form of hunting and trapping, in which reindeer were led or driven toward hunters hiding in carefully positioned blinds (Wammer 2008). The archaeological remains recovered at Juvfonna consist of both organic finds and stone-set structures. Organic elements include large numbers of whole and fragmented sewels. A sewel is a thin branch or pole, with a light attachment of wood or bark fixed to the top (See Speiss 1979:128). Lines of sewels were arranged in corridors that led reindeer to kill zones, where hunters were waiting behind stone-set hunting blinds.

Hybrid sites offer a different kind of information compared with arrow sites, producing a large number of organic finds that were probably deposited during single episodes. The organic elements recovered are the result of chronologically contiguous structures and activities and offer evidence of events restricted in time. That said, the indications are that hybrid systems were established and then reestablished on individual sites over considerable time spans. For example, elements of the hunting system at Juvfonna have been radiocarbon-dated to two distinct periods of the Iron Age (Finstad & Pilø 2010). Since 2006, a number of additional sites of both arrow and hybrid types have been discovered in adjacent areas (Jotunheimen, Breheimen, and Reinheimen) (Finstad & Pilø 2010). The artifacts recovered from snow patches in Oppland cover a broader range than those from the Oppdal area. Besides arrows and sewels, the Oppland finds include items such as wooden spades, textiles, and even a 3500-year-old shoe (Finstad & Vedeler 2008; Finstad & Pilø 2010).

Snow Patch Management in Norway

Cultural heritage management in Norway is organized at county and regional levels, ostensibly under the administration of the Norwegian Directorate for Cultural Heritage. Approaches toward managing archaeological snow patches have evolved differently in counties where the snow patch phenomenon has been identified. Local conditions, available resources, traditions, and not least, the initiative of local curators and managers have all been important factors underlying the various local approaches to snow patch management. In the municipality of Oppdal, snow patch archaeology is based largely on the efforts of local collectors, who survey sites and recover finds in collaboration with the NTNU Museum of Natural History and Archaeology in Trondheim. In the county of Oppland, on the other hand, snow patch management and field surveys are the responsibility of county archaeologists, who also engage actively in public and political outreach activities that help to create an awareness of the significance and fragility of the archaeological heritage appearing from melting snow patches.

Snow patch archaeology in central Norway

Arrow Sites in Central Norway

The term “central Norway,” as used in this article, refers to a large, mountainous, inland area that lies roughly between 62° and 63° N. The area includes a number of municipalities within Sør Trøndelag and Møre & Romsdal County Authorities. The landscape in the region is characterized by a generally east-west gradient with respect to glacial resculpturing of the pre-Quaternary land surface. The western areas have high relief from deeply scoured major glacial valleys and alpine topography between these valleys, whereas large parts of the eastern areas are still dominated by pre-Quaternary surfaces of low relief and gentle slopes. Some glaciers are present in the region, but the altitude of the equilibrium line rises above the topography east of the Snøhetta mountain massif (2268 masl).

Wild mountain reindeer still populate portions of this region, and the hunting of reindeer and other prey is still practiced throughout the autumn.

At present, there are 27 archaeological snow patches in this region (Table 3.1). The majority are found in alpine areas to the south and east of the mountain town of Oppdal (Fig. 3.3). Find-bearing sites are located at elevations between ca. 1350 and 2000 masl. Archaeological snow patches vary greatly in size, from large patches such as Storbreen and Evighetsfonna at Sandåfjellet, which measure up to 1500 m along the slope and several hundred meters downslope, to smaller patches such as that at Kaldvellkinn, which measures as little as 100 m by 50 m during the melting season.

A map-based survey shows that most of the region’s archaeological snow patches are oriented towards the northeast or east. As can been seen from Table 3.1, the snow patch collection is dominated by finds from five patches. These lie in two areas close to one another to the south and east of Oppdal (Fig. 3.3).

Snow patches often lie laterally along or under mountainsides, ridges, or tops. Some patches appear almost as if draped or wedged onto the underlying topography, and as a result, they can become very steep, particularly in a reduced state. Such is the case on the patches at

Leirtjønnkollen and Løpesfonna, whereas on other larger patches, surfaces are more expansive and relatively flat. Measurable altitude differences on individual patches range from ca. 5 to 250 m.

Snow Patch	Latitude (N)	Longitude (E)	Elevation (masl)	Orientation	No. of Finds
Storbreen	62° 21' 51"	9° 24' 48"	1810	NE	48
Kringsollfonna	62° 30' 51"	9° 44' 38"	1520	NNE	43
Leirtjønnkollen	62° 27' 25"	9° 44' 37"	1560	NE	35
Brattfonna	62° 28' 38"	9° 46' 25"	1470	N-E	32
Løpesfonna	62° 22' 11"	9° 22' 27"	1730	NE	18
N. Knutshø	62° 19' 31"	9° 40' 26"	1630	NE	8
Vegskardet	62° 21' 56"	9° 19' 35"	1500	NE	5
Løftingfonnkollen	62° 22' 32"	9° 23' 20"	1680	NNE	3
Tverrfjellet	62° 28' 33"	9° 20' 55"	1270	NE	3
Bekkfonnhøa	62° 32' 9"	9° 41' 34"	1360	NNV	3
Kaldvellkinn	62° 30' 47"	9°44' 49"	1550	ENE	3
Sandåfjellet/ Svorundfjellet	62° 37' 46"	9° 11' 37"	1530	E	2
Langfonnskarven	62° 27' 1"	9° 38' 59"	1330	E	2
Kinnin	62° 21' 24"	9° 26' 40"	1720	E	2
Kringsollfonna+	62° 30' 52"	9° 45' 33"	1400	NNE	1
M. Knutshø	62° 18' 42"	9° 40' 49"	1545	E	1
Hesthågåhøa	62° 23' 59"	9° 35' 18"	1530	N	1
Snøhetta	62° 19' 61"	9° 17' 29"	2000	E	1
Skiråtangan, Sunndal	62° 26' 41"	9° 5' 50"	1450	NE	1
Råstu, Sunndal	62° 31' 18"	8° 47' 24"	1547	NE	1
N. Svarthammaren, Sunndal	62° 26' 55"	8° 44' 59"	1700	NE	1
Grovåbotn, Nesset	62° 21' 58"	8° 12' 55"	1390	N	1
Sissihøa	62° 33' 4"	9° 43' 36"	1360	N	1
Gravbekkfonna	62° 27' 8"	9° 30' 9"	1300	NNE	1
Namnlauskollen	62° 22' 25"	9° 25' 19"	1750	NE	1
Skirådalskardet	62° 26' 43"	9° 12' 33"	1765	E	1
Svartdalskardet	62° 28' 29"	9° 17' 15"	1815	NE	1
Sissihøa-Leirtjønnkollen	10 x2 km	>1400masl	-	-	14
				Total	234

Table 3.1 Overview of Archaeological Snow Patches in central Norway.

Snow patches follow irregular annual cycles of accumulation in winter and ablation in summer. Archaeological finds are usually recovered during years of large negative mass balance, towards the end of the summer melt. Under such conditions, patches often appear as areas of snow or ice with dirty surfaces, at times surrounded by halos of lighter, lichen-free ground that outline the patches' previous extent. The archaeological season usually ends towards the end of autumn, once temperatures drop and snowfall returns.

Snow patches are dynamic contexts. Densification processes occur as new snow becomes compacted and transformed from snow through firn to ice, or as meltwater or water-soaked snow re-freezes (Nesje 1995). During the course of these cycles, the horizontal and vertical form of snow patches varies considerably on an annual basis but especially over longer time scales. During summer months, layers of new snow retreat along the surface of the snowpatch. Patches also contract inwards from the outer edges (Farbregd 1983). At times, melting beneath the upper and lower edges, which is probably due to heat-transfer from meltwater, makes it possible to peer under the edges of the snow patch. Meltwater is frequently observed flowing out from under the lower edges of snow patches and may also flow internally along denser layers that formed earlier. On larger patches, meltwater gullies often form on the surface and at times cut deeply into the upper snow layer (Farbregd 1983). The ground directly below snow patches is often severely waterlogged, as frozen ground conditions inhibit meltwater infiltration.

Much of the observable annual and multi-annual variation in the size of mountain snow patches is related to recent layers of new snow. These layers are renewable and shield the central ice core in some way. Changes in the relationship between the upper snow layer and the inner ice core probably play an important role with regard to the transportation of archaeological materials on both long and short time scales (Farbregd 1983).

The "dirty" surfaces of exposed ice cores appear in years when melting is great. These dark grey, dark brown, and black surfaces are one of the key characteristics used to identify advanced melting on archaeological snow patches. The emergence of dirty surfaces on local snow patches has been documented over a number of years in the photographic and correspondence archive in Trondheim. Surface materials are often explicitly described by collectors as sludge (NOR. *slam).* The indications are that this material is a combination of reindeer feces, sediments carried downslope by meltwater, and wind-blown floral material (*cf.* Warren Wilson 1958). From descriptions of snow patch surfaces in the 1930s, it appears that episodes of dense sludge cover were more common in the past than now (Farbregd, 2009: Fig. 3.6). However sludge layers have occasionally appeared on local snow patches in recent times (Fig. 3.4). Within a Norwegian context, surface sludge from melting snow patches has not been sampled, and it remains to be demonstrated whether this material is of minerogenic, faunal, or floral origin.

Snow Patch Finds

A total of 234 individual artifacts have been recovered from the 27 patches registered in the period 1914 – 2011. The central Norwegian snow patch collection comprises arrows, arrowheads, and arrow fragments in addition to a small number of related artifacts: bow fragments, knives, and other tools, such as a snare-setter. A number of unidentified but modified wood and bone fragments are also part of the collection. Until quite recently, unmodified faunal material had not been collected from sites in the region. As preservation of organic components is one of the main characteristics of the snow patch collection, the material composition of individual artifacts forms the basis for this presentation.

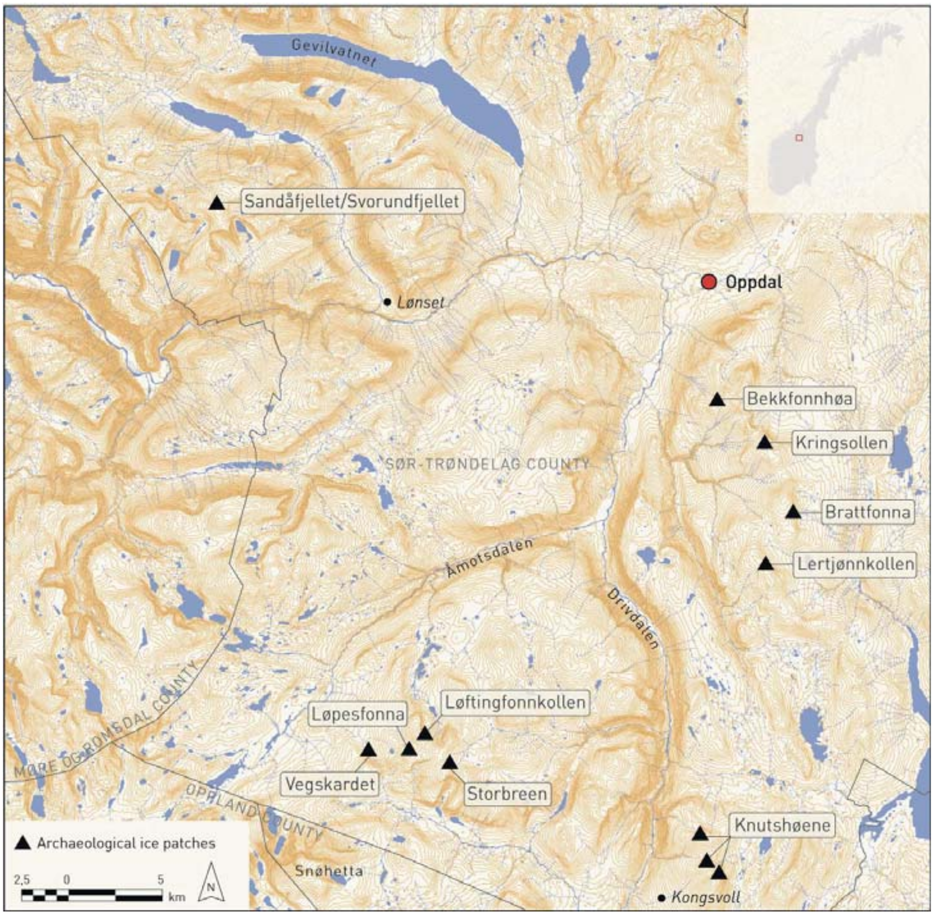


Figure 3.3 Location of the principal snow patches in central Norway

In Table 3.2 the collection is divided into two main groups; organic and inorganic finds. The organic group comprises artifacts made of wood, bone, antler, or with preserved accompanying organic adhesive or sinew lashings. This group also includes composite artifacts with both organic and inorganic elements, and in these cases, the organic element has taken precedence for classification purposes. For example, a find comprising a complete wooden shaft and iron arrowhead is sorted under “organic finds” within the present system. The material composition of all arrow- heads, such as iron, stone, bone, or antler, is also listed under “organic finds.” All finds are counted only once in Table 3.2. For example, the collection contains a total of three bone arrowheads. Two of these are listed under different subgroups as shafts with points, while the third is listed as a loose point. Organic finds dominate the collection, representing 70% of recovered materials. The group “inorganic finds” is dominated by disassociated iron arrowheads. Moreover, a slate arrowhead, a knife, and a disassociated metal fixture belonging to a club- headed arrow are included in this group. Inorganic elements represent 30% of the present collection.

Basic information regarding the condition of recovered artifacts is also presented in Table 3.2. As the majority of finds are prehistoric and historic arrows, the completeness of individual arrows forms the basis for organizing recovered shafts into three distinct groups: whole arrows, shaft sections, and shaft fragments. Artifacts are considered whole arrows if the entire shaft, including both the distal and proximal ends is present. Contiguous or refitted portions of shafts measuring more than 40 cm in length are classified as shaft sections. Contiguous, discontinuous, or refitted portions of shafts less than 40 cm long are classified as shaft fragments. Extant shaft fragments are grouped in this way because previous research has shown that whole shafts rarely exceed 75 cm in length (Farbregd 2009: Fig. 9). Setting a metric border between sections and fragments at 40 cm allows us to highlight arrows of which more than half of the shaft is present.

The collection includes a total of 38 complete shafts and 43 arrow sections. The remaining 54 arrows are present as fragments. The general condition of the arrow group as a whole points in two different directions. First, the fact that so many whole arrows and arrow sections have been recovered appears to indicate that snow patches are relatively static environments that allow complex and delicate organic artifacts such as arrows to survive in relatively good condition. On the other hand, the large number of fragments also reminds us that some arrows are being exposed to destructive mechanical or environmental forces, or both.

Figure 3.4 Sludge layer along the upper slope at Kringsollfonna, Oppdal, on 15 September 2003. Photo: Ingolf Røtvei.

Dating the Snow Patch Collection

The age of the Trondheim collection of snow patch artifacts has been the subject of a number of studies (Farbregd 1972, 1983, 1991, 2009; Åstveit 2007). The chronological framework for snow patch finds has been developed typologically by comparing recovered iron arrowheads with well-established regional chronologies of finds from closed pagan graves. The result is a detailed regional chronology of arrow and crossbow projectile development for the approximate period AD 200 – 1700 (cf. Farbregd 2009: Fig. 9). The large majority of snow patch finds can be assigned to two distinct periods: ca. AD 400–600 and ca. AD 1200–1700 (Farbregd 2009). In recent years, the radiocarbon-dating of a number of atypical artifacts has considerably broadened the collection's chronological horizon. At present, the earliest radiocarbon-dated snow patch find from central Norway is dated to between 2480 and 2340 cal BC. The date is derived from organic adhesive remains recovered from the tang of a slate arrowhead (Åstveit 2007: Fig. 5).

Patterns in Artifact Recovery

Source Critical Issues

The Trondheim snow patch collection presents its own particular problems as research questions, perspectives, documentation routines and especially equipment have changed over time. Today, many people carry mobile telephones with integrated GPS units and digital cameras that can record and send digital photos and accurate GPS positions instantaneously. These capabilities were unthinkable even a few years ago. As a result, one of the challenges in working with the Trondheim collection as it continues to grow lies in aligning contextual information from older finds with that from newer ones, so that the collection forms one cohesive unit.

Fortunately, most of the source-critical work has already been carried out by Farbregd in his 1972 publication. However, there are still some holes in the records. For example, precise geographical information on a group of 14 finds from the area between Sissihøa and Leirtjønnkollen in the eastern mountains has been lost (Table 3.1). For this reason, the sample numbers vary in the presentation that follows, as finds with incomplete contextual information have been omitted where appropriate.

Three Phases of Snow Patch Artifact Recovery in central Norway

The year of discovery can be identified for 211 of the total 234 finds (Fig. 3.5). The distribution over time of these discoveries, separated into organic and inorganic elements, is presented in Figure 3.5. The history of snow patch artifact recovery in central Norway during the period 1914 – 2011 can be divided into three main phases, which are defined by the numbers of finds recovered and important developments in the way they were collected. Following an initial discovery in 1914, the first phase is marked by a large number of finds that were recovered during the late 1930s and early 1940s. There followed a second phase of almost 60 years with relatively few discoveries. The third phase during which large numbers of finds are again being recovered, has lasted from 2001 until today.

Phase 1: 1914 – 1943

Following an initial discovery in 1914, the vast majority of finds from this first phase were made during seven seasons between 1936 and 1943. This was a period of variable weather with a series of mild winters and extremely warm summers in quick succession, during which many of the large maritime and continental glaciers retreated (Fægri 1938). It was during this phase that the tradition of snow patch surveying and collection first began in Oppdal, in cooperation with the Museum of Natural History and Archaeology in Trondheim (Farbregd 1972, 1983; Callanan 2010). A small number of local people began recovering arrows and other artifacts from snow patches in the mountain areas of Oppdal where they hunted and hiked.

During Phase 1 (1914 – 43), a total of 69 finds were collected from eight sites in the southern and eastern mountains, as well as at Sandåfjellet in Trollheimen (Fig. 3.3). Judging by the records in the archive at NTNU Museum of Natural History and Archaeology in Trondheim, the intensity of surveying activities varied during this phase.

Class	Group			
Organic Finds	Whole shaft with point	Iron	19	
N=165		Antler	2	
		Shell	1	
		Slate	1	23
	Whole clubheaded arrows			2
	Clubheaded arrow-section			1
	Shaft section with point	Iron	12	
		Shell	1	13
	Shaft fragment(s) with point	Iron	13	
		Bone	1	
		Slate	2	16
	Whole shaft			13
	Shaft Section			29
	Shaft Fragment(s)			38
	Bow Fragments			5
	Bone Points			1
	Wood Fragments			23
	Bone Fragments			1
Inorganic Finds	Metal Points			66
N= 69	Stone Point			1
	Other			2
	Total			**234**

Table 3.2 Inventory of the central Norwegian snow patch collection (n = 234).

There is no evidence of surveys being carried out as a result of the initial discovery in 1914. However, starting in 1929, a small number of finds were recovered from mountain areas in and around some of the large snow patches, which seems to indicate a certain level of surveying.

The main period of regular snow patch surveying in the mountains around Oppdal appears to have begun in the mid 1930's, with intense surveying carried out by a handful of local collectors. Artifacts recovered include iron and bone arrowheads, complete arrows and shafts, and shaft sections and fragments as small as 4 cm long (Farbregd 1972). The collectors also provided detailed descriptions and observations of sites and contexts, which proved vital in helping archaeologists understand the prehistoric background for these discoveries and the connection between artifact and snow patch. Phase 1 ended with the last snow patch discovery made by a member of the pioneer group of collectors in 1943.

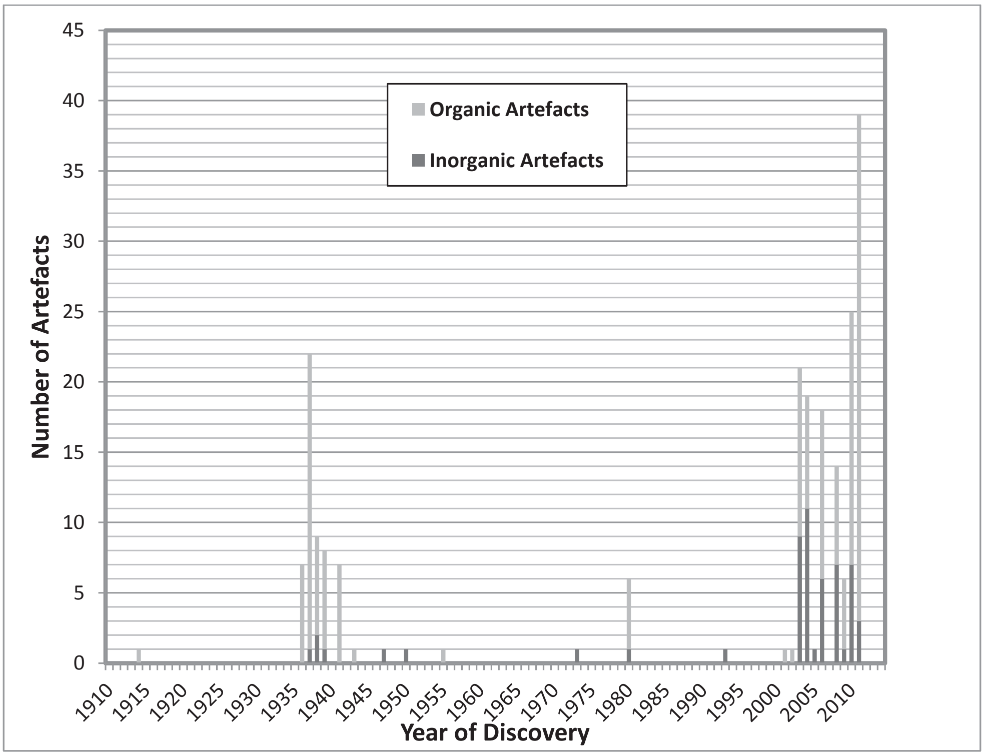


Figure 3.5 Central Norwegian snow patch finds (n = 211) by year of discovery.

Phase 2: 1944 – 2000

Phase 1 was followed by a 60-year period in which few new finds or sites were discovered. From 1944 to 2000, only 12 finds were recovered and two new snow patches added to the list of known sites. New finds included both organic and inorganic finds (Fig. 3.5, Table 3.3). The key question relating to this second phase is why so few finds were recovered. Did collectors stop surveying sites, or are there other factors that could explain the decline in the number of finds recovered?

Members of the pioneer group of collectors eventually retired or passed away, and new names began to appear on find lists. The general impression one gets from the records of Phase 2 is that surveying activities were not as intense as during the late 1930s. But there are signs of continuity too. The collectors of the second phase were younger associates of their predecessors. Some even hunted together with their older colleagues around classic snow patch sites (T. Bretten & I. Røtvei, pers. comm. 2010). It seems unlikely that local awareness of the region's snow patch tradition would be forgotten within such a short time. In support of this view, a search of the Museum's catalogue for this period reveals that of the 29 stray, non-snow patch finds recovered in Oppdal municipality during 1943 – 2001, a total of 17 were recovered in alpine locations or altitudes. The fact that hunters and hikers continued to make archaeological discoveries from time to time in relevant alpine areas lends further credence to the argument that snow patches were indeed being surveyed during this phase, but that the finds or the conditions suitable for their recovery were not present.

	No. of Recovered Finds				
Period	**Total**	**Organic (n)**	**Organic (%)**	**Inorganic (n)**	**Inorganic (%)**
1914-1943	69	60	87%	9	13%
1944-2000	12	6	50%	6	50%
2001-2011	145	97	67%	48	33%

Table 3.3 Number of recovered finds in the snow patch collection through three phases in the period 1914–2011.

A key development during Phase 2 was Oddmunn Farbregd's engagement in snow patch archaeology in the region. Farbregd was based at the NTNU Museum of Natural History and Archaeology in Trondheim from the early 1970s, and his involvement has been central to both the continuation and the development of snow patch archaeology in the region.

From 1968 on, Farbregd carried out a number of small-scale surveys of central snow patches during the late summer melt season. In addition, by conferring with local hunters and other informants he monitored annual developments on local snow patches during the melting season. Advanced melting is reported to have taken place in 1955, 1970, 1980, and 1986, and some finds were recovered as a result (O. Farbregd, pers. comm. 2011). In 1980, in response to reports of advanced melting, an extensive survey of the region's classic snow patches was mounted. This survey resulted in the recovery of a number of artifacts (Fig. 3.5,

Table 3.3), the identification of a new site in the southern mountains, and the publication of survey results (Farbregd 1983).

Farbregd's second important contribution during this phase was his role in continuing and renewing the local network of collectors based in Oppdal. A number of the pioneer collectors were interviewed in the late 1960s (Farbregd 1972). Towards the end of Phase 2, new members joined the collector group. And thus an important continuity from the pioneer group of collectors was ensured through this second phase.

Other strands of evidence indicate that the paucity of finds during Phase 2 was probably more a result of the general conditions at the time, rather than a break in the snow patch surveying tradition. Regional meteorological records for 1944 – 2000 show generally colder temperatures compared to a high point in the 1930s, while precipitation levels remained relatively stable during the same period (Hanssen-Bauer 2005: Figs. 2 and 9). In general, we should be wary of applying such regional data uncritically to local snow patches. But these data appear to suggest that the extreme conditions documented in the mid-1930s gave way to conditions more favorable to the maintenance of positive mass balances during the period 1944 – 2000.

Phase 3: 2001 – 2011

The third phase of snow patch archaeology in central Norway is again a period of regular advanced melting, with large numbers of finds being recovered. The 2010 and 2011 seasons in particular have produced a record-breaking number of artifacts.

A total of 145 artifacts, both organic and inorganic, have been recovered from local snow patches during Phase 3, and 17 new sites have been identified, bringing the regional total to 27 sites (Fig. 3.4, Table 3.3). New sites have been identified both within the core areas around Oppdal and in the neighbouring municipalities of Sunndal and Nesset farther to the west.

The traditional network of local collectors has been renewed and expanded during this phase, building on efforts in the previous phase. Since 2003, site surveys have been more regular and systematic, with collectors spurred on by the increased numbers of finds and repeated advanced melting (T. Bretten, pers. comm. 2010). The period has been characterized by unstable weather conditions, with extreme melting taking place on certain sites in 2003, 2004, 2006, 2010, and 2011.

	2003	2004	2005	2006	2008	2009	2010	2011
Total Number of finds	21	19	1	18	14	6	25	39
Metal Detector Finds	4	9	1	6	6	4	3	1

Table 3.4 Overview of metal detector finds recovered during Phase 3 (2001–11).

A new development during Phase 3 has been the regular use of metal detectors to recover iron arrowheads. One of the current collectors has specialized in surveying areas adjacent to snow patches with the aid of a metal detector. The widespread use of iron arrowheads throughout the late prehistoric period in Norway makes metal-detecting a very effective method for recovering artifacts buried in sediments and gravels at the base of snow patches. This approach has proved very successful and has produced significant results during Phase 3 (Table 3.4). The vast majority of the metal detector finds consist of disassociated arrow-heads (See Åstveit 2007: Fig. 2, for a notable exception).

Many important questions need to be asked about these finds and their contexts. When did they emerge from the snow patches? Are there any patterns in the age of metal detector finds? How and at what rate did they become buried? And what might the artifacts' locations tell us about the patches' previous extent and development? At present, the hypothesis is that some of these finds were released from snow patches during melting events that probably predate the initial 1914 discovery. The fact that some arrowheads have been recovered with metal detectors as far as 50 m from the edge of current snow patches lends support to this hypothesis. An overview of metal detector finds for the relevant years during Phase 3 is presented in Table 3.4.

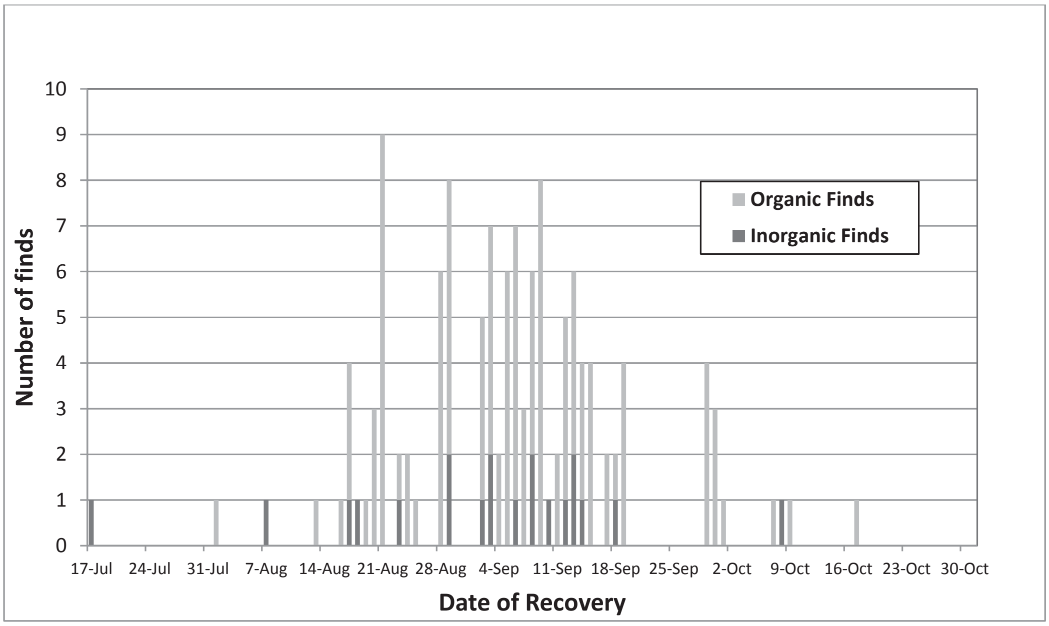


Figure 3.6 Date of discovery of 128 artifacts found in the snow patches of central Norway.

A Cohesive Long-Term Record?

Continuity?

The central question behind this review was whether the central Norwegian snow patch collection can be viewed as a cohesive long-term record, or whether it should be looked upon as representing a series of disjointed periods of discovery.

The review indicates that while there may have been some periodic variation in the level of surveying activity on and around snow patches, there was also a strong element of continuity between the three phases.

With regard to the 1944-2000 phase, the fact that from 1968 onward sites were being visited and regularly monitored, and that focused surveys were carried out when suitable conditions presented themselves, indicates that the demonstrated find hiatus cannot be explained by lack of surveying. There is, however, one final piece of evidence in this regard.

Surveying and Reindeer Hunting?

The dates of recovery for individual snow patch finds in the region are presented in Figure 3.6. The sample for this analysis is reduced (n = 128) as the precise date of recovery was not always recorded, especially during Phase 1. However, all three phases are represented, and the results are clear: the vast majority of snow patch finds in the region are recovered during a four-week period between the middle of August and the middle of September. This short window of opportunity for making discoveries is characteristic for snow patch archaeology. The period of maximal melting towards the end of the season is the time when one is most likely to recover artifacts. But it is also the time when bad weather and snow can cause problems for collectors in the field and ultimately bring an end to the surveying season (Farbregd 2009). At first glance, one might easily conclude that it is this short window that is depicted in Figure 3.6—the period between the release of finds from patches, on the one hand, and the end of the season, as the first snow of winter falls, on the other. In reality, something else is also contributing to this distribution.

The vast majority of finds from central Norway are found by private collectors, many of whom are reindeer hunters. And many of the find-bearing patches lie in areas that are active hunting zones today. Reindeer hunting in Norway is heavily regulated, and there are restrictions on when, where, and how many animals may be felled each year. Although rules and practices have varied through the years, certain levels of regulation have been in place in the area in question since the early 1900s (Jordhøy 2001). At present, reindeer hunting in central Norway is regulated to the period from the middle of August to the middle of September. This has long been the tradition. Thus it becomes clear that the pattern presented in Figure 3.6 is as much a record of hunters' activity in areas around snow patches as it is a record of the optimal find window. Reindeer hunting was the key factor drawing hunters up to the alpine zone, where they also made archaeological discoveries. From this perspective, Figure 3.6 is a clear illustration of the close link between reindeer hunting and snow patch discoveries in central Norway.

This link is highly relevant when trying to assess the changing levels of survey activity around alpine snow patches in Phase 2 (1944 – 2000), during which few finds were recovered. The history of local reindeer hunting shows that there was a large increase in the number of reindeer hunted in the region between 1950 and 1970 (Jordhøy 2001). Increased hunting activity probably meant that more hunters were active in the mountains, close to find-bearing snow patches, during the melting season. Given the local awareness of the possibility for snow patch discoveries that existed at the time, it seems likely that more finds would have been recovered from snow patches if they had appeared, or if suitable conditions for find recovery had presented themselves during Phase 2.

Conclusion

The question at hand has been whether the record of archaeological finds made around local snow patches is best viewed as a disjointed series of finds in similar locations, or whether the collection is rather a cohesive long-term record of melting alpine snow patches. An initial mapping of the temporal distribution of finds highlighted an uneven development, with two distinct phases characterized by large numbers of recovered artifacts. These phases were separated by nearly 60 years during which few new finds or sites were discovered. There is evidence of fluctuations in the intensity and regularity with which mountain snow patches were surveyed. But the analysis has also shown that there is much to indicate that the perceived pattern is in fact real. This evidence includes the continuity of the local collector tradition in Oppdal, important direct links between the pioneer group and today's collectors, records from local weather data, and evidence from the history of local reindeer hunting in the area. All these data lead to the conclusion that the pattern of temporal distribution demonstrated in Figure 4 is not a product of varying survey activity. And thus, the snow patch collection from central Norway can be confidently viewed as a cohesive, long-term product and record of melting alpine snow patches in the region in the period 1914 – 2011.

Other Snow Patch Archaeology Issues

This review of aspects of the snow patch collection from central Norway raises a number of issues that might be relevant to similar collections or applied studies in the future. These issues include specific questions that have already been raised, such as the "discovery effect" and the role of surveying intensity in creating patterns of temporal distribution. Other issues are important to highlight because they seem fundamental to the nature of snow patch archaeology and to the kind of data we create. In the future, these and similar perspectives might temper and inform the demands we make of the data we possess, especially within the context of linking snow patch discoveries to climate variation and change.

Visual inspection, as commonly employed in snow patch surveys, is a method with obvious inherent weaknesses. Even when sites have been carefully surveyed, there is no guarantee that an artifact has not been over- looked or that finds will not appear later within the same melt season. Many anecdotes of finds being recovered in locations carefully surveyed just minutes before underline this weakness. In central Norway, we are fortunate that iron was used in the past to produce arrowheads. Metal detectors are therefore a great aid in increasing the reliability and effectiveness of visual surveys for recovering material from these periods. But the potential for error remains, and at present there appear to be no methodological parallels to traditional surveying techniques, such as test pitting and trenching, by which we can create reliable negative data from alpine snow patches.

A related issue is the importance of well-documented negative data. Until quite recently, it was not the norm in central Norway to record details of surveys that did not result in finds. And as we have seen, this omission can cause difficulties when trying to assess the validity of periods during which few finds were recovered. However, it is becoming increasingly clear that the ablation of many archaeological snow patches is a long-term, non-linear process, in which patches might often increase in size or melt in unexpected ways during any given season. In the future, it may be useful to be able to make year-to-year comparisons when trying to identify the causal factors behind long-term snow patch development. From this perspective, documenting the extent and conditions of surveys that do not produce finds may produce valuable data too. Obviously this perspective will have implications for how and over what time spans snow patch surveys might be designed.

Finally, more attention should be given to the proposed differentiation between primary and secondary melting events in relation to individual artifacts. As shown in Table 3.2, the degree to which artifacts are preserved on snow patches varies considerably, which may be partly explained by the effects of multiple melting episodes after the artifact's initial deposition. We should therefore probably be wary of presuming that the date of recovery for an individual artifact automatically marks the season or period during which it emerged from the snow and ice for the first time (primary melt). On the contrary, the release of artifacts from snow patches is probably more often than not a process that is repeated over time, rather than a singular event. With this in mind, if we wish to draw closer causal links between the appearance of ancient objects on alpine snow patches and developments in present-day weather and climate patterns, greater account needs to be taken of this issue.

Having such an old snow patch collection has its own particular possibilities and problems. Establishing the back- ground and true nature of this collection is an important step forward with a view to future studies. Having confirmed the long-term nature of this snow patch collection, it is now possible to start looking for the long-term causal factors and drivers that lie behind these patterns. This is a complex and multidisciplinary challenge that will have to account not only for recent finds recovered since 2001, but also for the considerable number of finds recovered during the 1930s. Another challenge relates to finding a way to integrate the sizeable group of artifacts found by metal detectors with this larger group. And last but not least, there is the question of what the future will bring and how this archaeological record will continue to develop in the years and decades to come.

Chapter 4 - Methodological Discussion

4.1 Introduction

In the chapters that follow, the snow patch collection is examined according to three main analytical categories: **A**. Chronology- the antiquity of selected individual artefacts **B**. History of artefact recovery- when the artefacts were recovered. **C**. Distribution-how the artefacts are distributed across sites in the region. The history of artefact recovery has already been discussed in detail in chapter three, where a three-phase structure was put in place. It was also established that the collection as whole represents a cohesive record of melting events between 1914 and 2011. This chapter is a description of the methods and analytical principles applied in the rest of this study.

4.2 Dating prehistoric arrows- Typological and Radiocarbon Dating

Determining the age of the arrowheads, shafts, bows and other objects that have been collected from snow patches is one of the primary goals of this thesis. Two dating methods have been employed: typological dating and radiocarbon dating.

Typological dating

A number of factors influence the precision of typological age estimates. The first is the class of artefact under investigation, as some types of finds are more easily dated than others. Arrowheads are the class of finds more readily dated. Wooden arrow shafts are the second class of finds in terms of dating. Bow sections and fragments are more difficult to date typologically than shafts. Lastly, it is generally not possible to typologically date other wooden objects such as staffs, poles and snares even if they are found in a good condition. The ranking of artefact classes in this regard is governed by the extent of our previous knowledge on a specific artefact class. Reference finds from other sites or contexts give fixed temporal points against which new finds can be compared. For example arrowheads belong to a ubiquitous artefact class that is well researched. Therefore, no matter the form or raw material used for arrowheads, a parallel of some kind can be found in the existing record. At the other end of the scale, although a number of wooden bow fragments have been found in Norway, these have not been systemised chronologically. Date estimates for this class are therefore usually very coarse, if at all possible. A third example is the snare holder (T17695B) discovered at Brattfonna (Farbregd 1972. fig 10). This object is very well preserved and its function is tentatively interpreted. But it is not possible to suggest a typological date for this object as no other dated examples exist that could be used for reference.

Within the class arrowheads, another factor that appears to influence the precision of typological dates is the raw material used to produce the arrowhead. Generally speaking, typological dates on iron arrowheads tend to be more precise than those made from stone, bone or antler. Partly, this is due to the level of existing knowledge of the different raw material classes. But past practices also appear to influence the precision of typological dates within the class arrowheads. This is due to the fact that morphological variation is greater in arrowheads of stone and antler than among those in iron. Take for example slate arrowheads that are common in central Norway. Nonetheless, as a wide range of different forms exist within this class, it is usually difficult to suggest precise typological dates for these finds (Ramstad 1999b). One might suggest that increased morphological variation in arrowheads of stone and bone is related to how they were produced. Readily available materials such as stone, bone and antler appear to be more subject to morphological variation. On the other hand, the form of iron arrowheads tends to be relatively more standardised within given time periods. Perhaps this is in part due to the fact that iron requires a certain level of craftsmanship in order to be worked into functional objects?

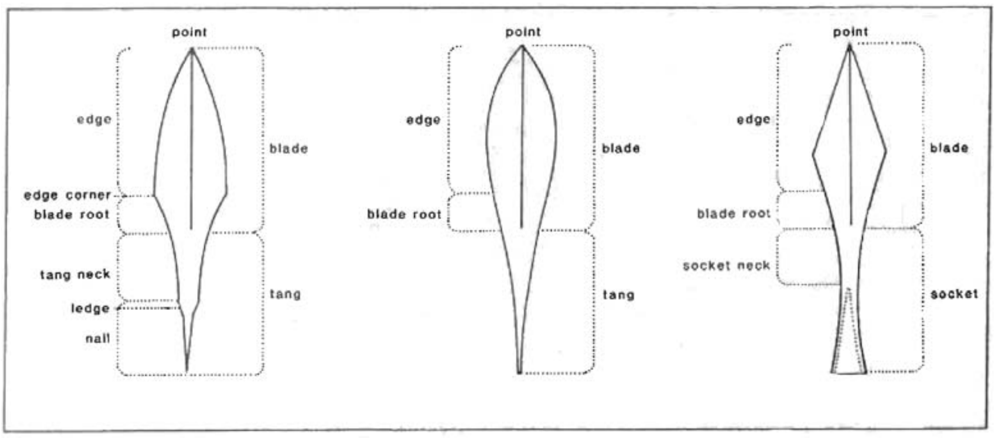


Figure 4.1 Variations in the form and composition of the tang section of iron points are the most temporally sensitive part of this class of artefacts. After Sognnes 1988:fig. 1.

Another important influence on the precision of typological dates is the general state of preservation of individual artefacts. This is true of both organic finds such as arrowshafts, as well as inorganic finds such as iron or stone arrow heads. On iron arrowheads, the most temporally diagnostic traits are found on the tangs (Farbregd 2009:160). Usually it is possible to judge which period the projectile belongs to by examining the form and section of the tang. But in some cases, the arrowheads have been exposed from snow patches over a period of time and reduced by rust. In these instances, the tang can be difficult to interpret chronologically although even in the worst cases, rough estimates are usually possible. In the case of wooden arrowshafts, the diagnostic traits include the form of the shafting and nock ends as well as the diameter and length of the shaft (Farbregd 2009: fig. 9). The precision of a typological date on a shaft depends on the extent to which these traits have been preserved, either individually or in combination with each other. Even the smallest shaft fragment can sometimes be dated if the nock end is still in place. But sometimes an artefact is so degraded or fragmentary that no typological estimate, however coarse, is possible.

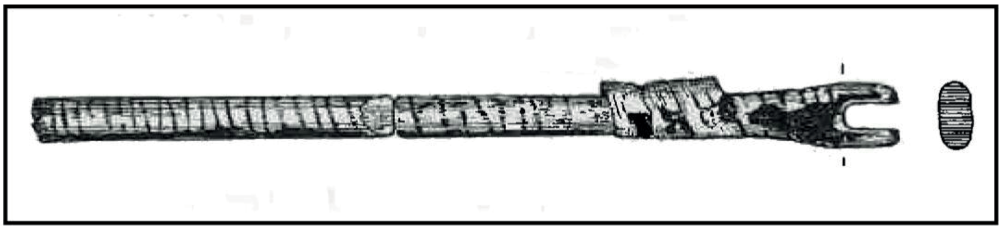


Figure 4.2 (T17697 d). 15cm long shaft section recovered in three pieces. Despite the partial and fragmentary condition, the preservation of the diagnostic proximal notch means that this piece can be dated to between AD1200-1700. Farbregd 1972: pl.8).

One of the characteristics of snow patch projectiles is the fact that organic and inorganic elements are often recovered in association with each other. Finds in combination provide detailed insights that are of great value when individual elements recovered alone need to be interpreted.

Finds discovered during phases 1 and 2, were analysed and systematised in previous work by way of the same typological approach as described here (*i.e.* Farbregd 1972, 1983, 1991 & 2009). The typological framework that springs from previous work covers the period AD400-1700 (fig. 4.3). This framework is the mainstay of chronological analyses in this thesis.

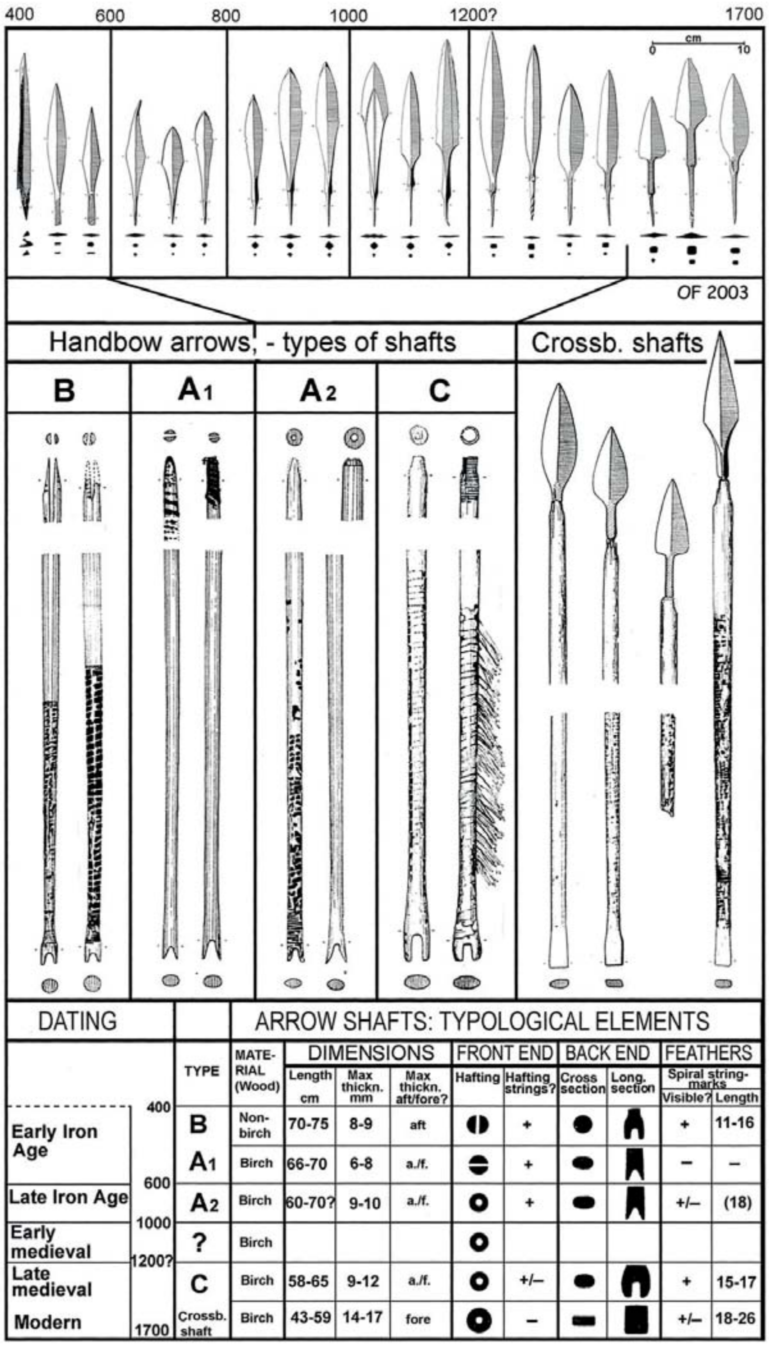


Figure 4.3 Chronological framework for arrowheads and shafts from between AD400-AD1700. (Farbregd 2009: fig 9).

Although the framework in fig. 4.3 describes the arrowheads and shafts in use during the timeframe AD400-1700, our knowledge of temporally diagnostic traits of finds is not uniform across the whole timeframe. Rather it varies from period to period. It is useful therefore to view the typology as a series of fixed points that mark the appearance or disappearance of particular technical traits that are well established temporally. The following is a discussion of these fixed points.

Iron points and wooden shafts from the period AD400-600 are quite distinctive (*e.g.* chap. 2 fig.2). The arrowheads have a flat tang and are associated with two shaft variants that are readily identified (Farbregd 2009:161 & fig.9). Finds from this period can usually be dated with a precision of within 200 calendar years. Points and shafts from the Late Iron Age (AD600-1000) usually have a similarly precise date, although the technical traits have changed (see fig. 4.3).

During the medieval and historical periods (*c.* AD1000-1700) the typological resolution for both points and shafts becomes coarser. This is due to the fact that as Christianity began to spread, grave goods such as arrowheads are no longer buried with the dead. Therefore as the artefacts get younger, it becomes increasingly difficult to confidently date arrow and crossbow projectiles. For this reason, there are many instances in which the closest estimate that can be suggested for medieval artefacts is AD1200-1700. This gives us a precision range of as much as 500 years.

Sometimes, enough technical information is preserved to allow a confident *post/ante* dating proposal in relation to one of the fixed points already established in the local typology (*e.g. post/ante* 600AD or *post/ante* 1000AD). Occasionally, individual finds exhibit traits that indicate it may in fact be from one period or another. However, if the age determination is uncertain, the tradition is to err on the side of caution and instead refer to the nearest certain fixed point, while at the same time noting the suspected date (*e.g. post* 600AD (AD1200-1700?)). There are a number of different find variations that fall within this group, but the same principles are followed across the board. The precision range for this group therefore varies between 500 and1100 years.

The precision ranges for typological dates as applied in this thesis are summarized in table 4.1.

Artefact group/period	Precision range (calendar years)
Arrowheads &well-preserved shafts, sections and fragments from the period *c.* AD300-AD1200 (excluding AD600-800)	200 years
Arrowheads &well-preserved shafts, sections and fragments from the period c. AD1200-AD1700	500 years
Poorly preserved shafts, fragments and sections. *Ante* AD1000 (Iron Age)	700 years
Individual variants (*e.g.*AD600-800)	500-1100 years
Poorly preserved shafts, sections and fragments *Ante c.* AD1 (Iron, Bronze & Stone Age)	Up to 4000 years
Small, poorly preserved sections and fragments. Unidentifiable period.	N.D.

Table 4.1 Precision ranges for typological dates for different classes of arrowheads and shafts.

Radiocarbon dating snow patch artefacts

We can now turn our attention to radiocarbon dating and how it has been applied in this study. Between 1972 and 2008 just five artefacts from central Norway were radiocarbon dated. This stands in contrast to the approach taken in other snow patch regions where radiocarbon dating played a major analytical role (*e.g.* Andrews *et* al 2012, Hare *et al* 2012 & VanderHoek *et al* 2012). There are a number of reasons why little of the material from central Norway has been radiocarbon dated previously.

The first is related to the long history of snow patch archaeology in central Norway. The arrowheads and shafts from the mountains around Oppdal were studied and ordered chronologically before the general introduction of ^{14}C dating as a method in archaeology. That said, the first ^{14}C dates from snow patch artefacts were carried out as early as 1968 (see sample no's T-774 & T-775 in appendix 3).

The cost of radiocarbon dating is also part of the reason why their use has not been more widespread. Even today radiocarbon dates are still too expensive to be carried out on all artefacts that are brought to regional museums. The usual praxis is that ^{14}C dates are financed and carried out in conjunction with research or larger cultural heritage management projects.

The chronological profile of finds recovered between 1914 and 2001 has also influenced the way they were dated. Until 2003 all shafts and arrowheads from snow patches originated from the timeframe *c.* AD300-1700. Previous archaeological research provided a sufficiently accurate reference material for most of this timeframe. As long as the finds belonged to a time period that had good archaeological coverage, the dates offered by typological interpretation more than sufficed for the construction of local relative chronologies.

Typological dating is still the primary dating method today, and all new finds are analysed and dated typologically first. However in recent years, finds with unfamiliar technical traits have started to appear on snow patches and the local archaeological record includes little reference material against which some of the new finds can be compared. This is especially true of disassociated arrow shafts from before the Iron Age and Medieval period. In some cases the typological age estimates of these artefacts are coarse estimates with precision ranges of up to 4000 years (table 4.1). In order to get a more precise date on the actual age of these artefacts and of their relative chronology, radiocarbon dating is necessary. The typological analysis however, ensures that the limited number of radiocarbon dates available is applied in an efficient and effective manner.

The samples used for dating are all high quality wood samples taken from individual artefacts. Samples are taken under lab conditions with little danger of contamination. All samples from this project were dated by accelerator mass spectrometry dating. The ^{14}C method gives independent absolute dates. But because we are dating artefacts from over a long time period (*i.e.* 3447BC-AD618) the precision ranges of the calibrated ages of artefacts vary greatly, according to where the measured ages intersect the calibration curve (Banning 2002:268-270). Among the 18 radiocarbon dates carried out during this study, the probability ranges at 2Σ or 95.2% vary from between 89 years (TRa 1052/T24140) to 357 years (Beta-308922/T25675). Despite this variation, the precision ranges are still generally superior to those associated with typological dates.

When submitting samples to radiocarbon labs, age estimates are also sent in. If we compare the estimates submitted with the measured results, this might tell us something about the relationship between typological interpretations and 14C determinations. Table 4.2 gives an indication of the accuracy with which these artefacts were dated typologically. The age estimates vary. Sometimes only coarse ‘guess-timates’ of a few thousand years have been suggested. On other occasions the estimate points toward concrete archaeological periods (*i.e.* Bronze Age 3500-2440BP). Alternatively a *termius post quem* is suggested with reference to known technological fixed points as described above (*i.e. Ante* 1500BP). On some occasions, fixed chronological points such as 3000BP are proposed.

Sample no.	Typological estimate	14C Result
T-775	250-750BP	390±50BP
T-774	250-950BP	650±60BP
TRa-1052	*Ante* 1400BP	1440±30BP
TRa-1051	*Ante* 1500BP	1705±30BP
TRa-2769	2440-3500BP	2350±30BP
TRa-2768	2440-3500BP	2455±30BP
TRa-2766	2500-4500BP	2710±40BP
TRa-1050	*Ante* 1500BP	2935±30BP
TRa-2767	2440-3500BP	3030±30BP
TRa-1047	3000-6000BP	3275±30BP
TRa-1048	2000-6000BP	3290±35BP
TRa-1049	3000-6000BP	3295±30BP
Beta-308925	*c.* 3500BP	3340±30BP
Beta- 319547	*c.* 3400BP	3370±30BP
TRa-2771	*Ante* 1500BP	3445±35BP
Beta-308924	*c.* 3000BP	3490±30BP
TRa-2770	2500-4500BP	3670±30BP
Beta-308923	*c.* 4000BP	4530±30BP
Beta-308921	*c.* 4000BP	4650±30BP
Beta-308922	*c.* 4000BP	4690±30BP

Table 4.2 Comparison of typological date estimates and measured radiocarbon results for 20 samples submitted from central Norwegian snow patch artefacts. The ages cited here are all uncalibrated radiocarbon years.

The comparison demonstrates that on the whole, the typological determinations are relatively accurate. There are no glaring outliers where the typological estimate misses the mark entirely. The comparison in fig. 4.5 shows no systematic tendency in relation to typological estimates. Estimates are both too high and too low with no clear pattern in either direction. The accuracy of the typological estimates is reassuring, especially since these are the arrow shafts about which we have least prior knowledge. By following the order of the sample numbers, one can see that the typological estimates become gradually more accurate. The development from coarse *ante/post* estimates to rough period estimates (*i.e. Bronze Age*) to concrete benchmarks. This is a further reflection of the interplay between typological and radiocarbon dates. As radiocarbon results are received, concrete technological traits start to become fixed chronologically. The fact that this is a relatively limited material of the same technological class aids the speed of this process.

4.3 ^{14}C Dates Used for Control and Reference

The main aim of the radiocarbon dates undertaken during this study is to identify and date the oldest elements in the snow patch collection. These finds cannot be dated by reference or comparison to previous finds, and therefore radiocarbon dates are used. Radiocarbon dates have also served a control function during the study. The aim here was to control the veracity of specific typological fixed points established in earlier research in light of the new information coming in. The following is a short description of the background for these control dates.

Until now four osseous points have been recovered from snow patches in central Norway. Two of these were bone points recovered in the 1930's. The age estimate for these points of between AD300-600 was based on a typological and comparative analysis (Farbregd 1972: 15, 118-119 & pl.1). In recent years, two antler points were also discovered in the region and both were selected for radiocarbon dating (Chap 5. figs. 6 & 7). Both these artefacts returned Bronze Age dates and were therefore considerably older than the osseous points recovered previously. This opened the possibility that the use of bone/antler projectiles in prehistoric hunting archery was perhaps more ancient than previously believed. If this was the case, the bone projectiles collected in the 1930's could in fact be older than AD300-600. Therefore it was decided to radiocarbon date the one bone point that had been found together with a wooden shaft and from which a sample could be taken (T17698,f & T 17694/17698,e). The result of this date at 2 sigma was AD255-408 with a median of AD341 (see sample no. TRa-1051 in Appendix 3). In this instance, the control date both confirmed the earlier typological determination and the duration of the osseous point tradition in local hunting archery.

The second control date was taken on a wooden shaft discovered at Storbreen in September 2008 (T24140). The shaft initially appeared to be of Iron Age origin, with a narrow, long hafting split as for tanged iron arrowheads. However, the shaft was also unusually thin and lacked traces of rust around the haft as is often the case. At the same time, it was becoming increasingly clear that narrow, long hafting splits were also a feature of Neolithic shaft traditions. It was therefore possible that this 'typical' Iron Age shaft was in fact much older. Perhaps it had been hafted with a lithic or osseous tanged point instead of an iron point? A sample taken from this shaft returned a median calibrated date of AD618 (see TRa-1052 in appendix 3). The date confirmed that this shaft was of Iron Age origin.

The aim of the third and final control date was to help clear up doubts that arose in conjunction with the discovery of a fragmented arrow shaft at Løpesfonna, Oppdal in September 2010. A total of five shaft fragments were discovered on the rocky forefield below the melting snow patch. The discovery was very well documented in the field with photographs. In the museum's lab, three of the fragments were refitted to form a shaft section with a straight nock in one end and with a 3.5 cm long bevel in the other. This shaft section measured 63.7 cm in length (T25286.1). The bevelled end could easily be interpreted as the distal (hafting) end. At 63.7 cm, the length of the three fragments lay well within the metric parameters we would expect for complete shafts in the region. Under other circumstances, the three conjoined fragments could easily have been interpreted as a complete shaft.

Figure 4.4 Radiocarbon dates played an important role in deciphering the fragmented arrow shaft discovered at Løpesfonna, Oppdal. 12th September 2010. Photo: Rune Pedersen.

The two remaining fragments formed a 22.5cm long section that also had a 3.5cm long bevel in one end and a break in the other (T25286.2). Again the bevelled end could be interpreted as distal end of an arrow shaft. This would mean that the two conjoined fragments were the remains of a second arrow found in close association to the first. Or were they rather all part of one segmented arrow shaft, with a bevelled scarf joint towards the incomplete distal end? Although the bevelled ends fit well together, there were still reasons to be uncertain whether or not this was the correct interpretation. Although segmented joints have been shown to be a feature of projectile armatures elsewhere (Hare *et al* 2012:123-124), these are not yet recognised as a regular feature of inventories in Norway. Another concern was that when all five fragments were refitted, the total length was just over 86cm, and the arrow was still not complete as the distal end was missing when refitted in this configuration. An arrowshaft of this length would far exceed what one would expect from a wooden shaft from this period. In sum, there were serious doubts as how to best interpret these arrow fragments. Therefore samples from both shaft sections were sent in for dating in the hope that they might cast further light on the question.

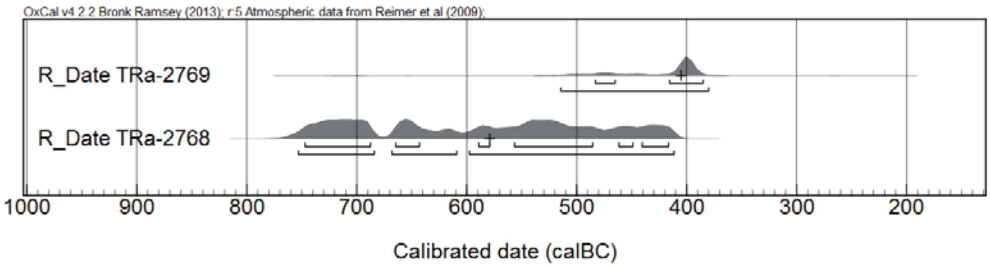


Figure 4.5 Comparison of the calibration curves for the two bevelled arrows found at Løpesfonna in 2010.

The presumed complete shaft (T25286.1) returned a result that unluckily intersected with the calibration curve in a number of places giving a very imprecise calibrated result (TRa-2768). The other fragment, thought to be a second bevelled distal end (T25286.2) did indeed appear to be slightly younger based on the conventional radiocarbon age. However the two determinations still overlapped when calibrated (see fig. 4.7). Therefore, while the length of the five-fragment alternative exceeds the norms for shaft length, radiocarbon dating shows this to be the most likely alternative.

One non-snow patch artefact was also radiocarbon dated as part of this project. This artefact was selected for dating in order to explore the broader technological relations between archery-related finds at the broader regional scale. There are few well-preserved prehistoric shafts in the region from outside the snow patch collection. The arrow in question (T16056) consists of a flint projectile hafted onto a wooden shaft section. This arrow was recovered from a bog site in 1955 and had not yet been radiocarbon dated (See chap. 6, table 1 & fig.10).

These examples illustrate how during this study, radiocarbon dating has also been applied in control and reference functions that go beyond simply pinpointing the oldest finds recovered in recent years. Again it is clear that the reasoning that guides the application of control and reference dates builds on an initial typological analysis and interpretation.

4.4 Geographical Analysis- Four snow patch zones of Central Norway

The most important question with respect to analyzing geographical distribution is at what scale the analysis should take place? Finds can be either mapped at the individual artefact level, site level or zone level of scale depending on what the level of detail is required for the analysis at hand.

In previous research on the central Norwegian collection, the main focus has been on the site and zone level (*e.g.* Farbregd 1983: figs 1 &2; 2009: fig. 4). The same approach has been taken in other recent analyses and overviews (*e.g.* Andrews *et al* 2012: fig. 1, Hare *et al* 2012: fig. 1). The reason for choosing this level of scale may be related to the physical characteristics of snow patches, when viewed as archaeological contexts.

As natural structures, snow patches have an important temporal aspect that affects the way we approach them archaeologically. This temporal aspect is a result of the melting of surface snow throughout the late summer. In the case of most other archaeological sites, such as a burial cairns, temples or even Stone Age lithic scatters, it is possible to observe a site's boundaries and formally define its extent. In other words, both the site and the artefacts found in association with the site have fixed geographical positions that can be related to one another afterwards. This is not the case with respect to snow patches. The extent and size of any given snow patch changes from year to year, but also throughout any given year. Therefore, while the position of an individual find may be recorded and in that way become fixed in space, the extent of the site itself is constantly changing and fluid. Because snow patches as archaeological localities are emerging and reemerging from year to year in new configurations, it is perhaps useful to view snow patches more as locations within the landscape that contain many finds spots, rather than a bordered site in the traditional sense.

The temporal aspect poses no serious problems for site surveying and find collection, as the focus is usually on the edge of the patch and any newly uncovered surfaces. But it does pose certain problems for detailed mapping of finds at the artefact-level over many years.

The positional data that is available at the artefact level is in many cases very detailed. It may consist of a text description or a GPS coordinate. For example the collector can report that a shaft was recovered "2 meters below the edge of the southern end of the patch on the 7th September".While this does give us important contextual information, it is still impossible to map the find accurately unless we know where the edge of the patch was on the 7th September.

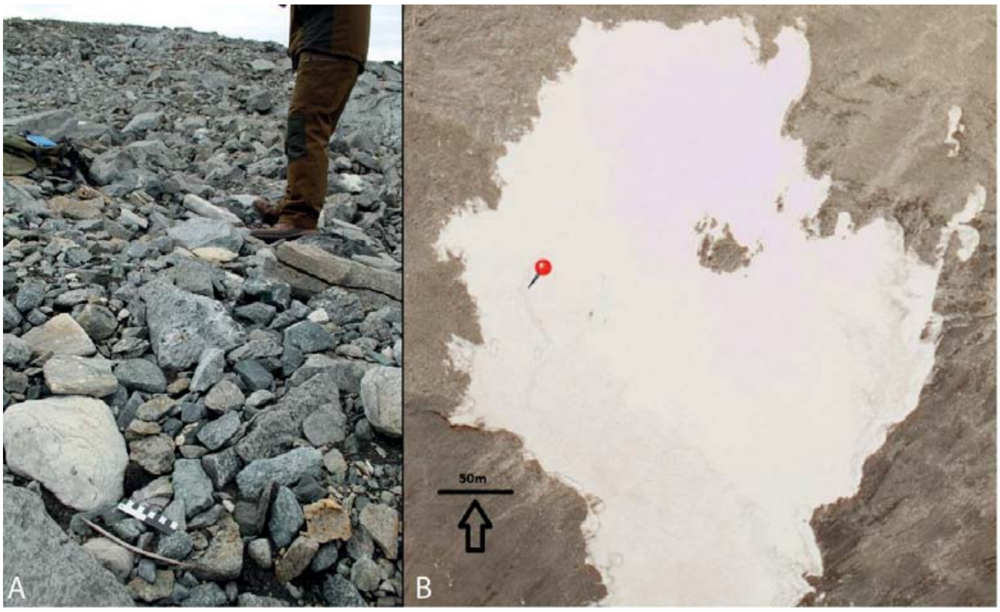


Figure 4.6 Illustration of problems related to detailed mapping of snow patch artefacts. In fig. A we look towards the west at the antler point (T25167) and the conditions around it on 21st August 2010. In fig. B. we see the result when the coordinates are inserted on a recent satellite image that dated 14th September 2009. The area to the west of the find is still clearly covered with snow and ice. Mapping finds in this way would misrepresent their find conditions and context.

Ideally one would also document the entire extent of the patch at the time of discovery as well as the artefact itself. Although this has been done on a couple of occasions internationally (VanderHoek *et al* 2007a:75; Hafner 2012: fig. 4), it is usually not feasible to map the extent of snow patches on a regular basis, as they are often very large. Instead one has to rely on existing maps and satelitte images of snow patches in order to map finds at the artefact level. Figure 4.6 demonstrates the result if one attempts to map an individual find on an already existing image or map taken at a different time. The result gives a misleading picture of the conditions under which the artefact was recovered and could well be confusing. Site maps of this kind are useful in other situations; for example when trying to identify concentrations or hot spots on sites. But for the current analysis, where the aim is to map chronological patterns at the site or regional scale, the level of detail on these site maps is probably too fine. Consequently, in the geographical analyses in chapter seven, I have chosen to analyse the snow patch finds in central Norway at the site and zone levels of scale. The 28 archaeological snow patches in the region have already been described in Chapter three. This description includes their position and the number of finds they have produced.

In chapter seven, these sites are divided into four distinct geographical zones (fig 4.9). The sites and zones are the main spatial categories used during the analysis in chapter seven.

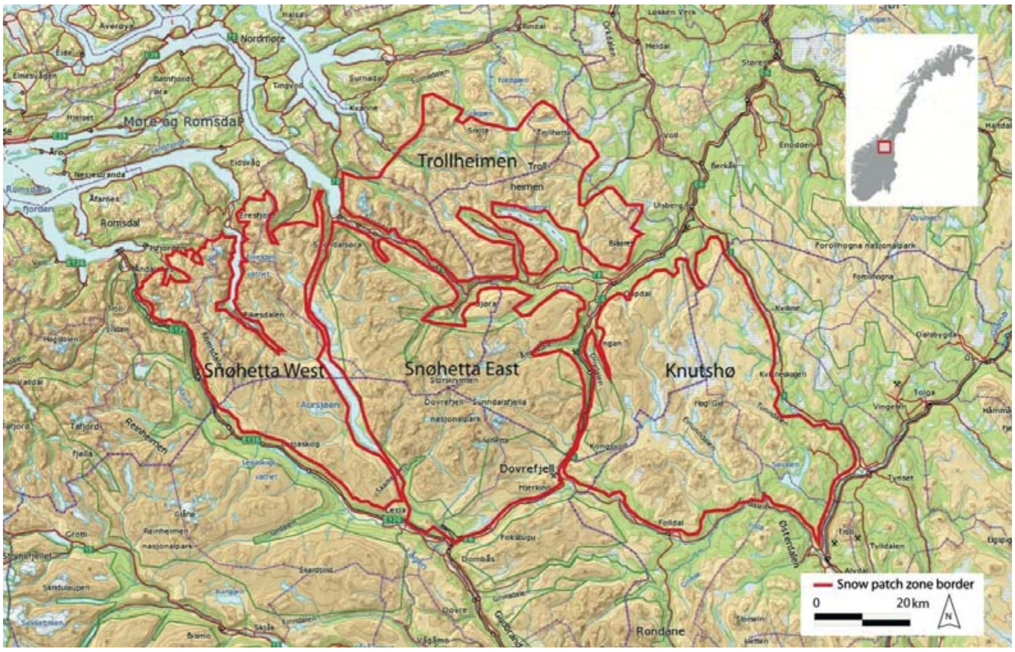


Figure 4.7 Finds and snow patch sites from central Norway are divided into four geographical zones for the purpose of this analysis. See appendix 1-3.

4.5 Other methods employed during the project

Besides dating and mapping the finds, other methods have also been employed.

There is a large archive related to snow patch finds at the NTNU-Museum of Natural History and Archaeology at Trondheim, Norway. The project began by focusing on this vast material. The archive covers many of the finds discovered during the period 1914-2011 in the form of photos, letters, notes and reports. All information relevant to individual finds and the timing and circumstances of their discovery were gathered in a dedicated database. Local collectors were consulted for supplementary information relating to their finds from 2001 and onwards where this was necessary

All 234 snow patch finds in the collection have been examined. Of particular interest were the 147 artefacts recovered between 2001 and 2011. The composition and metrics of all finds have been measured and studied. In a few cases it has been possible to refit disassociated fragments of finds based either on their find location, or on observation of metric of technical details.

Because many of the snow patch finds still have their organic component preserved, a number of other analyses aimed at identifying raw materials were also arranged during this project. Colleagues with the necessary expertise carried out these analyses. Helge Irgens Høeg and Helene Løvstrand Svarva (NTNU) carried out wood species analysis of 66 artefacts on different occasions. Gordon Turner Walker (National Yunlin University of Science and Technology) analysed and identified the antler and bone points in the collection. A DNA analysis of 4 bone and antler artefacts with the aim of identifying the species was carried out by Jørgen Rosvold (NTNU) in 2011 as part of a pilot cooperation between NTNU-Museum of Natural History and Archaeology and Prof. Knut H. Røed of the Norwegian School of Veterinary Science. The results of these analyses have been important for interpreting the cultural historical and technical background for newly dated arrows as will be seen in the following chapters.

4.6 Suitability for the current analysis?

The final question to be examined in this chapter is whether or not these methods are suitable given the current material and questions at hand?

The 234 artefacts were recovered from 28 sites over a period of 97 years. A critical review in chapter three of how the artefacts have been collected through the years indicates that the collection can be viewed as a long-term cohesive record. The size and distribution of the material appears large enough to produce chronological and geographical patterns that are both representative and meaningful (Farbregd 1991:7).

The goal of this study is to identify the age of the oldest artefacts as well as the general chronological and geographical developments on the snow patch sites in the region. A combination of typological analysis and radiocarbon dating has been used to carry out the chronological part of this study. A review of the precision of typological dating shows that these are within acceptable ranges (*e.g.* Fig. 4.5). Radiocarbon dates have been used when the estimate ranges are too broad. Ideally a larger portion of this total data set should be radiocarbon dated, as this would increase the precision and resolution of the analysis considerably. However, the economic resources required for this are beyond the frames of the present study.

We can also ask if the methods are suitable for the analysis with respect to coverage. For example what portion of the total collection can be dated? And what portion can be analysed spatially? Table 4.3 shows how the different dating techniques have been applied across the collection. Here we see that it was possible to date 85% of the total snow patch collection. This is a very high rate of coverage and tells us something about the suitability and effectiveness of the methods, but also about the levels of preservation on snow patch sites.

Dates Types	**Number of Artefacts** (n=234)
Typological dates	177 (75.6%)
Radiocarbon dates	22 (9.4%)
No datum	35 (14.96%)

Table 4.3 Distribution of types of dates applied to snow patch collection.

With respect to geographical mapping and coverage, all artefacts can be mapped to the zone level. Chapter 3, table 1 shows that only 14 of the 234 artefacts could not be mapped to a specific snow patch. Instead these are mapped to a small area within the Knutshø zone (See Appendix 1: Zone 2 Knutshø). Again the coverage levels here are very high. To summarise, the methods chosen for this analysis appear to be sufficiently accurate in order to describe the general temporal and geographical tendencies within the material at hand.

4.7 The Remaining Chapters

This chapter completes the review of the data and methods employed in this study. The results of the radiocarbon dating program are presented in chapters 5 and 6. In chapter 7, the results are combined with the typological results in a series of temporal and geographical overviews. Chapter 8 is a discussion of what the future holds for snow patch archaeology both locally and globally.

Chapter 5 -Melting snow patches reveal Neolithic archery

Introduction

Snow patches are perennial accumulations of snow and ice, found in the mountains of Norway and other regions of the world at high altitude or latitude. Continually exposed to the varying effects of weather and climate, they are dynamic contexts, prone to constant change and development. On hot summer days, animals such as reindeer, sheep and birds often seek out high-lying snow patches to get some relief from both the heat and from parasitic insects. In the past, this behavior attracted the attention of hunters who used snow patches as summer hunting grounds. Objects lost or discarded by these hunters are often very well preserved and are discovered when patches melt sufficiently. This chain of events forms the background for snow patch archaeology and the finds described here.

In this paper, a number of Neolithic (4000–1800 BC) artefacts recently discovered from snow patches in central Norway are reported. In 2010 and 2011 fragments of five Neolithic arrows and a Neolithic bow were discovered at two mountain sites. Despite a long tradition of artefact collection from snow patches in the region, these are the oldest snow patch artefacts that have yet been recovered in Scandinavia. The finds are significant for two reasons. First, they offer a rare glimpse into the archery technology of the Neolithic period in Scandinavia. Second, the repeated recovery of organic artefacts from melting snow patches serves as a warning to us of changes that are currently taking place in the alpine landscapes of central Scandinavia.

Background/setting

The snow patch region in question lies in the mountainous south-western corner of central Norway between 62° and 63° N. Here, the mountain complexes of Trollheimen and Dovre meet across a series of valleys converging on the town of Oppdal (Figure 5.1).

The geology of this area is complex, lying in a contact zone between Cambrosilurian and Precambrian bedrocks to the west and east respectively. The overlying landscape was heavily modified during the last ice age, especially in the west. Furthermore, the area has the character of a borderland with regard to climate. Maritime conditions in the west give way to mildly continental conditions in the east. Vegetation in the area follows elevation gradients from middle boreal vegetation in the valleys up to 700m asl. There follows a belt of sub-alpine birch forest up to *c*. 1100m asl. Archaeological snow patches are generally found at elevations above 1400m asl within middle and high alpine vegetation zones.

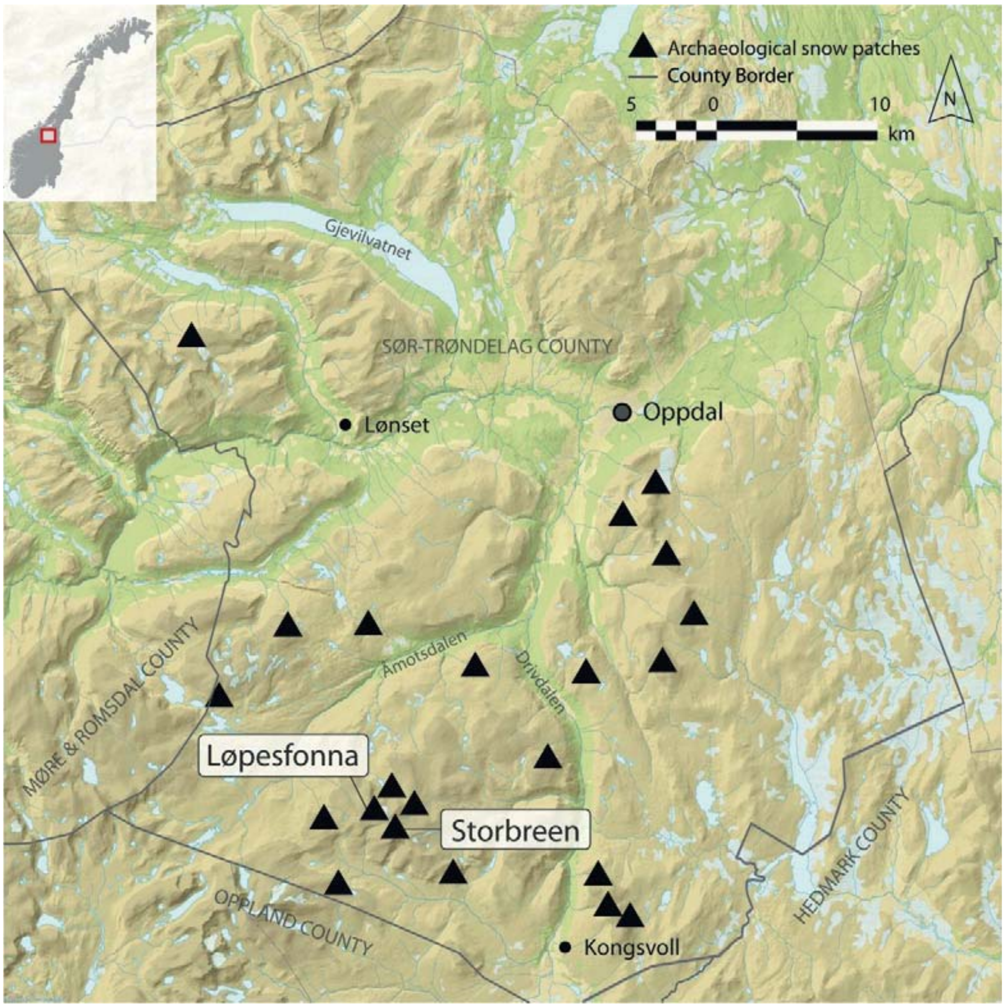


Figure 5.1 Archaeological snow patches identified in the Oppdal Mountains, central Norway. The sites mentioned in this article, Løpesfonna and Storbreen are highlighted.

Scattered communities of lichen and mosses between areas of bare bedrock and scree are found around the highest-lying snow patches (Moen 1987: 217). The fauna of the region includes herbivores such as reindeer and musk ox as well as carnivores such as wolverine, polar fox, gyrfalcon, rough-legged buzzard and golden eagle.

There is a long-standing tradition of artefact surveying among a group of local volunteer collectors in Oppdal. Regular surveying is carried out on foot and often involves long treks in demanding terrain, frequently in difficult weather conditions. Nonetheless, no fewer than 234 artefacts have been collected in the region from 27 different snow patches in the period 1914–2011 (Callanan 2012a; Figure 2).

Figure 5.2 Examples of different contexts from which collectors discover objects around local snow patches. Few objects have been recovered directly from the ice itself (A). Artefacts are usually found on stony surfaces close to the edges of the snow patch (B &C).

The material collected comprises arrowheads, shafts and bow fragments as well as other items associated with hunting activities (Farbregd 2009; Callanan 2012a). Since 2006, snow patch discoveries have also been made in other parts of Norway, most notably in Oppland County in the inner mountains of southern Norway, where a series of complex sites, mostly from the Iron Age and medieval periods (*c.* 500 BC–AD 1500) have been identified and surveyed. Moreover, a few Bronze Age artefacts (1800–500 BC) have been recovered, most notably a shoe, a birch bark quiver and more recently a complete bow dated to *c.* 1300 BC (Finstad & Vedeler 2008; Mímisbrunnr n.d.).

Beyond Norway, archaeological snow patches have been identified in a number of high altitude/latitude environments around the globe. In many instances objects related to projectile/hunting technology have been found, as in the Yukon and Northwest Territories in Canada (Farnell *et al.* 2004; Andrews *et al*. 2012), and in Alaska (Dixon *et al*. 2005; VanderHoek *et al.* 2007) and the Rocky Mountains in the United States (Lee 2012). A more varied group of snow patch finds have been recovered from the Schnidejoch site in Switzerland (Suter *et al.* 2005). In each region, finds from snow patches offer researchers important chronological and technical information on human movements and on the utilisation of peripheral environments through prehistory. Snow patch archaeology also forms part of a global complex of finds and sites, associated with frozen contexts such as glaciers, permafrost and alpine sites where an increasing number of prehistoric and historic sites and materials are being exposed, often as a result of rising temperatures and changing climates.

Previous snow patch research in central Norway

Chronological patterns have been an important theme for research on the material recovered from the central Norwegian snow patches. Particular attention has been paid to determining the antiquity of recovered artefacts. By monitoring the age of the oldest finds, researchers are able to formulate and update theories regarding the chronology of the use, formation and development of snow patches in the past (Farbregd 1972, 1983, 2009; Fig. 3).

Figure 5.3 Snow patches melt and reduce in size during the summer. Once dirty surfaces with ice begin to appear, the possibility of finding ancient artefacts increases. A) Løpesfonna, Oppdal, Norway seen from the east. 20 August 2010. (B). Storbreen, Oppdal, Norway.

Until recently it was thought from the evidence available that the dearth of finds older than AD 200 was probably due to a large-scale melting of snow patches during the warm Roman Iron Age (0–AD 400) (Fægri 1938; Farbregd, 1972: 95, 1983: 33, 2009: 167). In this scenario, a complete melt-out of snow patches would have exposed artefacts older than AD 200 to the elements, causing them to deteriorate and disappear. However, developments since 2001 make it necessary to revisit this issue. Since then, the assemblage of material from the region's snow patches has increased by 183 per cent as new finds have been recovered (Callanan 2012a: 186–87). Further, in 2006, adhesive on a slate point discovered close to a snow patch was ^{14}C dated to 2480–2340 cal BC and an atypical wooden arrow shaft was also dated to 1740–1600 cal BC (Åstveit 2007: 15–17). In short, we now have a much larger snow patch assemblage available for analysis and there are indications that local snow patches contain artefacts considerably older than the proposed AD 200 boundary. Previous questions hence arise anew. What is the age of the oldest material now appearing at local snow patches? Are the few old finds recovered hitherto simply the result of fortuitous preservation? Or have older finds continued to appear at the snow patches in recent times (Åstveit 2007: 20; Farbregd 2009: 167)? The aim of the research reported here was to analyse systematically and date a selection of recent snow patch finds in order to gain a clearer view of the chronological developments currently taking place at local snow patches.

Method

Snow patches follow a natural annual cycle of growth during the winter months and decline during the summer. Recent investigations with ground penetrating radar (GPR) demonstrate the internal structure of snow patches consisting of a layer of recent snow superimposed on a core of ice (Callanan & Barton 2010). Geomorphic features registered around snow patches show that their size and extent fluctuated during the Holocene. But hunting probably took place on individual snow patches that were similar to those found in the landscape today, even during the coldest periods. Artefacts initially lost in the surface snow layer have probably, over time, become integrated within the ice core. They are subsequently released as the surface snow melts and the ice core reduces in size under warm and unstable weather conditions (Figure 5.4).

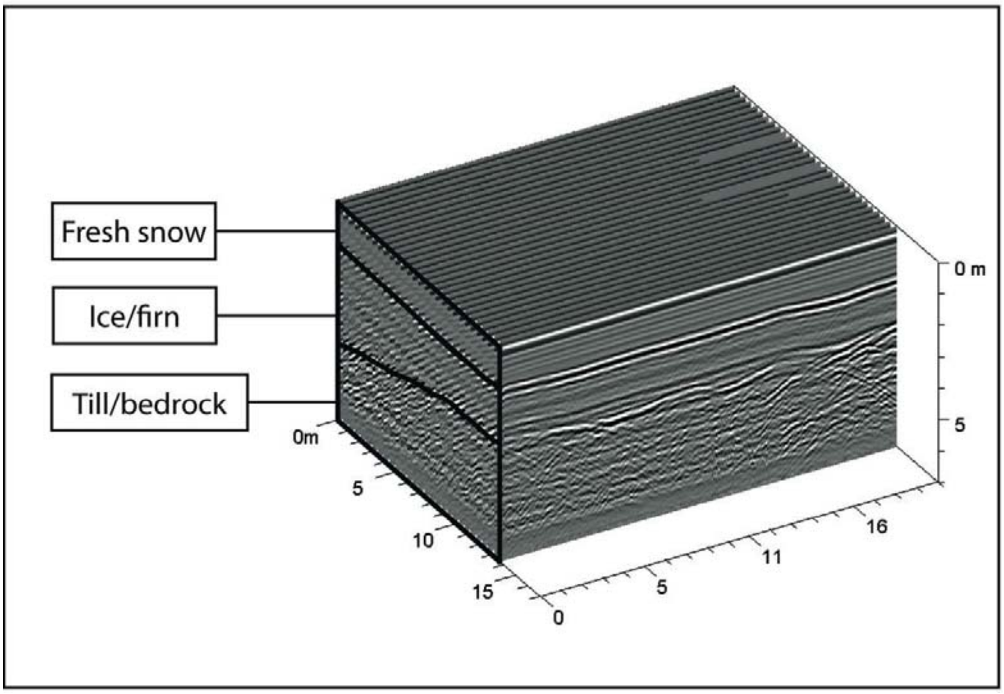


Figure 5.4 Ground penetrating radar profile gathered in 2008 from the northern end of Storbreen, Oppdal that shows the internal structure of a snow patch. In this profile, recent snow has formed a layer over the core of ice and/or firn, where ancient objects are probably situated. In years of advanced melting, the upper snow layer melts and the core becomes exposed. Under these conditions ancient objects can be found, often at the foot of the snow patch.

Artefacts are normally recovered from the edges of alpine snow patches towards the end of the summer, when the previous year's snow has melted sufficiently. Objects are often found lying on rocks and gravels surrounding the melting snow patch.

Following conservation, the artefacts were analysed with a particular focus on typological and morphological features. Farbregd has previously shown that certain arrow shaft elements are prone to change through time and are therefore typologically significant. These are the nock and hafting ends, as well as the length and width of the arrow shaft itself (Farbregd 2009: 161–63). Until 2006 the vast majority of the collection in Trondheim was dated typologically to the Iron Age and medieval periods (*c.* 500 BC–AD 1500). For the present study, a selection of recent finds displaying nock ends, hafting ends or metric dimensions unlike examples previously analysed were submitted for radiometric dating. The following is a description of the Neolithic finds identified using this approach.

Artefact ID	Museum No.	Snowpatch	Type	Lab. No.	Radiocarbon Age ^{14}C yr BP	1Σ	2Σ	Median Cal.	^{13}C
A	T25675	Storbreen	arrowshaft	Beta-308922	4690± 30	3519-3376BC	3628-3371BC	3447BC	-23,5
B	T25674	Storbreen	arrowshaft	Beta-308921	4650± 30	3499-3368BC	3518-3362BC	3456BC	-25,4
C	T25676	Storbreen	arrowshaft	Beta-308923	4530± 30	3356-3118BC	3361-3102BC	3206BC	-23,8
D	T25170	Storbreen	arrowshaft	TRa-2770	3670± 30	2132-1980BC	2139-1956BC	2056BC	-30,2
E	T25287	Løpesfonna	arrowshaft	TRa-2771	3445±35	1871-1691BC	1883-1682BC	1759BC	-27,5
F	T25677	Storbreen	bow frag.	Beta-308924	3490± 30	1878-1840BC	1894-1700BC	1816BC	-23,7

Table 5.1 Radiocarbon determinations of Neolithic artefacts presented in this paper.

Results

Artefact A (T25675) (Tables 5.1 & 5.2; Figure 5.5) is an almost complete arrow shaft that is dated to between 3628–3371 cal BC. The shaft, identified as *Pinus,* is preserved as six contiguous fragments giving a total length of 420mm. The hafting split is V-shaped. With an internal width of 1–3mm, it was probably intended for a tanged point of bone, antler or lithic material. The nock end is missing, but the imprint of lashings is clearly visible between 25–35mm from the extant proximal end. (In the descriptions that follow, the nock end, closest to the archer when being fired, will be described as the 'proximal' end and the tip will be described as the 'distal' end.) A red-brown colouring can also be seen on the proximal end. This coloured area continues for some 150mm along either side of the shaft in two uniform 2–3mm-wide lines. The coloured material has not been identified but is probably decoration.

Figure 5.5 Artefact A (T25675)- An almost complete arrowshaft of *pinus* discovered at Storbreen on 28 August & 13 September 2011. Dated to between 3628-3371 cal BC. Pigment traces and lashing imprints are clearly visible on the proximal end of the shaft. Photo: Åge Hojem/NTNU-Museum of Natural History and Archaeology. Layout: Martin Callanan.

A volunteer collector recovered fragments of the shaft on two separate occasions from the southern end of Storbreen, Oppdal. During the first survey, four fragments were recovered at the foot of the snow patch. On a later visit, two more fragments were recovered on the surface of the snow patch itself, only 8m from the initial find. The six fragments were subsequently refitted during conservation. The manner in which the fragments were recovered, together with the clean, almost fresh nature of the breaks, appears to indicate that the shaft was released from the snow patch only recently.

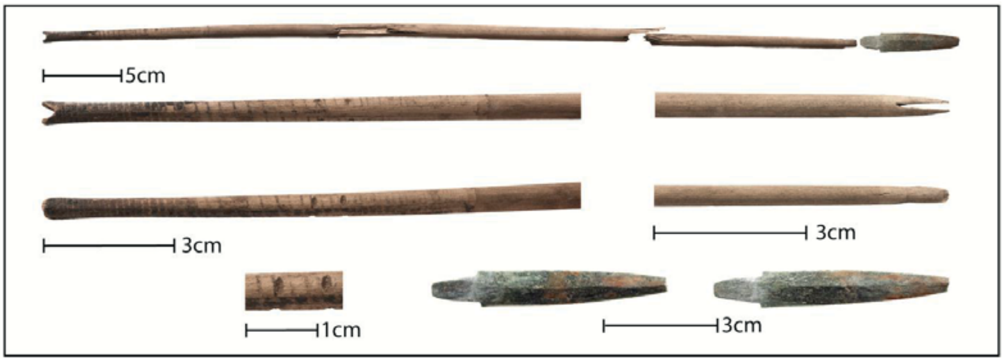


Figure 5.6 Artefact B (T25674)- Arrowshaft of *salix* with accompanying slate point found on 28 August 2011at Storbreen. Dated to between 3518-3362 cal BC. Photo: Åge Hojem/NTNU-Museum of Natural History and Archaeology. Layout: Martin Callanan.

Artefact B (T25674) (Tables 5.1 & 5.2; Figure 5.6) consists of a fragmented arrowshaft of *Salix,* with a small slate point, found together at the southern end of Storbreen, Oppdal. A sample from the shaft was dated to 3518–3362 cal BC. The shaft was recovered in three fragments, of which two are contiguous to a length of 372mm. The third fragment is 137mm long, but could not be definitively conjoined with the rest of the shaft, giving the shaft a minimum length of 509mm. The proximal end of the shaft is straight and ends in a wide, V-formed nock. Remains of a black adhesive associated with the spiral imprint of sinew lashings are clearly visible along the proximal end to a length of 105mm. Distinct markings are visible around 60mm from the proximal end, each consisting of three clear indentations, evenly distributed around the shaft at approximately 120° intervals. There are two sets of indentations close to one another. These are probably production marks, as they were covered by adhesive, sinew and vanes once the arrow was completed. Markings of this kind have not previously been observed on other shafts in the snow patch collection. However, similar markings are visible on other later finds, for example at the Nydam bog site in southern Denmark (Engelhardt 1865: pl. XIII).

At the distal end, the shaft narrows slightly to a rounded hafting split that measures 1–2mm internally. Here too, lashing imprints and faint remains of black adhesive can clearly be seen, concentrated in a 5mm wide area at the base of the split. In all respects, this shaft is a particularly well-fashioned and finished piece.

A small stone point was found together with the shaft. It is in a green-grey slate with red inclusions and has parallel to converging edges with a straight base and flat tang. The point is 65mm long and 9mm broad at the base of the blade.

Artefact C (T25676) (Tables 5.1 & 5.2; Figure 5.7) consists of a slate point together with a 70mm long shaft fragment of *Pinus* from Storbreen, Oppdal. Also preserved is the adhesive used to join the point and shaft. The grey slate point is 105mm long and 19mm wide at the base and is slightly asymmetrical, possibly as a result of re-sharpening. The V-formed hafting split is around 22mm deep and between 1–7 mm wide. From the features preserved, we can see that both the tang and shaft have been covered with adhesive before hafting. Moreover, the adhesive imprints show that the joint was subsequently strengthened by lashings that covered both shaft end and slate tang. A sample taken from the shaft was dated to between 3361–3102 cal BC. Although slate points are a common feature of the Neolithic of northern Scandinavia, this is a rare example of a hafted slate point.

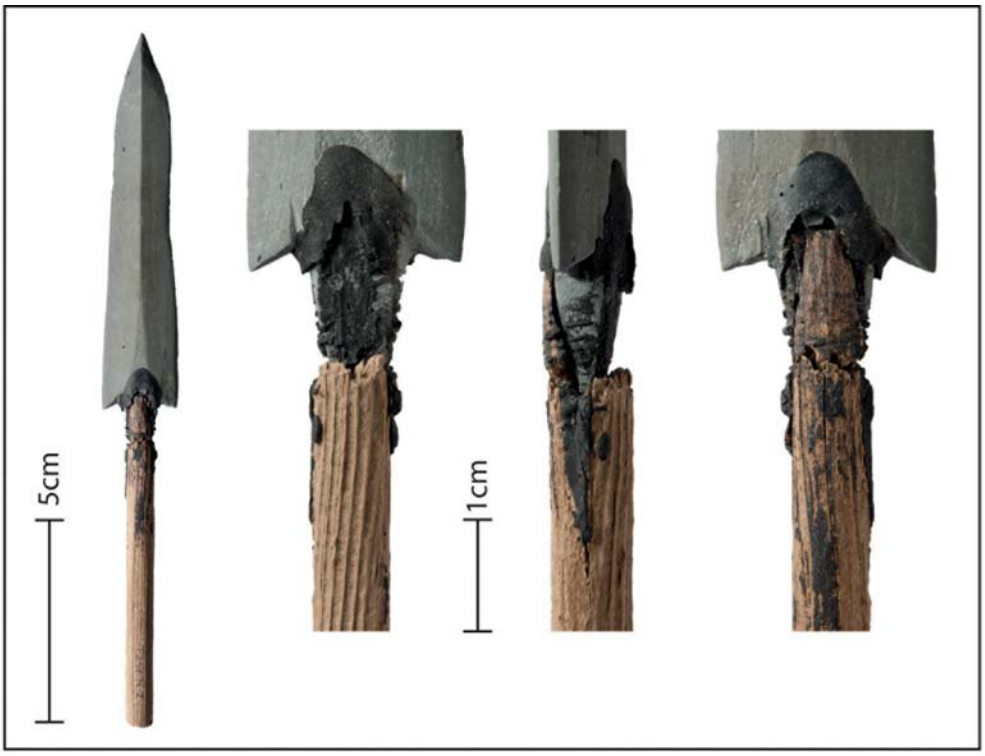


Figure 5.7 Artefact C (T25676)- Details of a slate point, hafted on a shaft fragment of pinus discovered 29 August 2011 at Storbreen, dated to between 3361-3102 cal BC. Photo: Åge Hojem/NTNU-Museum of Natural History and Archaeology. Layout: Martin Callanan.

Artefact D (T25170) (Tables 5.1 & 5.2; Figure 5.2c) consists of an incomplete shaft in two fragments, preserved to a total length of 420mm. Neither the haft nor the notch is preserved. The shaft was discovered on gravels below the center of Storbreen, Oppdal, and is dated to between 2139–1956 cal BC. The arrow is formed from a narrow sapling of *Betula*. This is only the second prehistoric arrow in the collection that was produced from a sapling, the other example being dated to the Bronze Age (Åstveit 2007: 15–17). This contrasts with the extensive use of shafts fashioned from staves split from solid tree trunks during the Iron Age and medieval periods. Artefact E (T25287) (Tables 5.1 & 5.2; Figures 5.2a & 5.8) from Løpesfonna, Oppdal, is one of the few artefacts recovered directly from within a snow patch. The arrow consists of a shaft of *Betula* preserved to a length of 794mm, with two small rings of sinew thread still attached. Lashing imprints are visible over *c.* 300mm adjacent to the split at one end. The split is 8mm deep × 4mm at its widest and has subsequently cracked along the arrow shaft. The other end is pointed and slightly askew. The shaft has been dated to between 1883–1682 BC and as such represents an arrow find from a transitional phase between the local Neolithic and Bronze Age.

Museum ID	Wood Type	# Frags	Description
T25675	*Pinus*	6	Distal+5 medial. Contiguous
Location	**mm**	**Location**	**mm**
0cm/ Break	6mm	**25cm**	7mm
5cm	6mm	**30cm**	6mm
10cm	7mm	**35cm**	6mm
15cm	7mm	**40cm**	5mm
20cm	7mm	**42cm/Haft**	4mm

Museum ID	Wood Type	# Frags	Description
25674	*Salix*	3	Proximal, medial & distal (discontiguous)
Location	**mm**	**Location**	**mm**
0cm/ Break?	5mm	**35cm**	7mm
5cm	5mm	**37.2cm /break**	7mm
10cm	6mm	**0cm**	6mm
15cm	6mm	**5cm**	5mm
20cm	6mm	**10cm**	5mm
25cm	7mm	**13.7cm/haft**	3mm
30cm	6mm	**Point weight**	2,4g

Museum ID	Wood Type	# Frags	Description
T 25676	*Pinus*	1	Distal
Location	**mm**	**Location**	**mm**
0cm	7mm		
5cm	6mm		
7cm/Haft	6mm	**Point weight**	13,8g

Museum ID	Wood Type	# Frags	Description
T 25170	*Betula*	1	Medial
Location	**mm**	**Location**	**mm**
0cm/ Break	3.5mm	**25cm**	5mm
5cm	5mm	**30cm**	5mm
10cm	6mm	**35cm**	4mm
15cm	5mm	**39.4cm break**	4mm
20cm	6mm		

Museum ID	Wood Type	# Frags	Description
T25677	*Ulmus*	6 +(4)	Bow arm & frags. Leather strips.
cm	**Location**	**Width**	**Bredth**
2cm	nock	9mm	15mm
5cm		14mm	15mm
10cm		15mm	14mm
15cm	frag. in place	14mm	16mm
20cm	frag. in place	16mm	17mm
25cm	frag. in place	16mm	17mm
29cm	frag. in place	18mm	19mm
30cm	damaged	-	-
31cm		16mm	22mm
35cm		11mm	29mm
38.5	break	-	-

Museum ID	Wood Type	# Frags	Description
25287	*Betula*	2	whole saft
Location	**mm**	**Location**	**mm**
0cm	5mm	**40cm**	8mm
5cm	5mm	**45cm**	8mm
10cm	6mm	**50cm**	8mm
15cm	7mm	**55cm**	8mm
20cm	7mm	**60cm**	8mm
25cm	8mm	**65cm**	7mm
30cm	8mm	**70cm**	7mm
35cm	8mm	**75cm**	6mm
		79.4cm/Haft	0mm

Table 5.2 Technical data on the five arrow shafts and bow limb presented in this paper. The diameter of each arrow is measured at 55mm intervals along the shaft, starting from the proximal end.

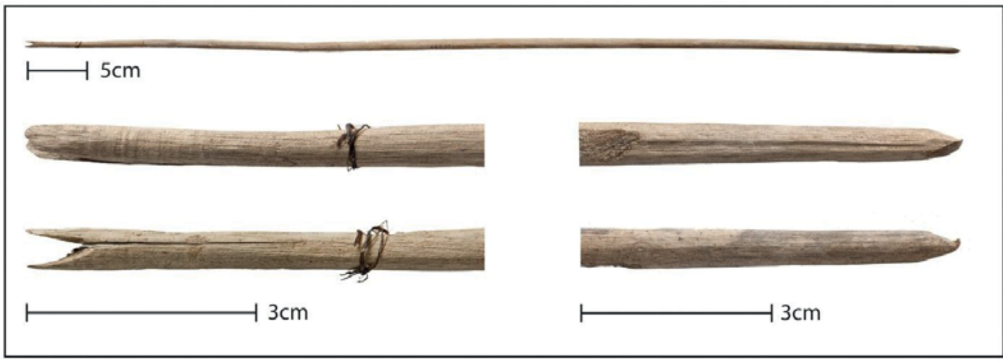


Figure 5.8 Artefact E (T25287)- Discovered at Løpesfonna on 21 August 2010. This complete shaft of betula is dated between 1883-1682 cal BC. Photo: Åge Hojem/NTNU-Museum of Natural History and Archaeology. Layout: Martin Callanan.

This arrow is something of a conundrum as it is impossible to identify positively the function of the preserved split. This may be a self-pointed arrow (*e.g.* Waguespack *et al.* 2009), in which case the split would represent the proximal end. That seems unlikely, however, given the crude nature of the split, since nock ends are usually particularly well finished. Alternatively, we might interpret the split as the distal end. However, this would imply that the arrow, if used in its current form, had a pointed proximal end. Again this seems unlikely as it would have damaged the valuable bow-string. Perhaps some nock component such as a bone or antler blunt, used to hunt birds or furred animals, is missing from the distal end? The arrow might also be an anomaly. Perhaps, for example, a hunter was forced to improvise and use an unfinished arrow such as those found with the Neolithic Iceman at Similaun in the Tyrolean Alps or more recently at Schnidejoch, in the Bernese Alps (Egg 1992; Suter *et al.* 2005).

Artefact F (T25677) (Table 5.1; Figure 5.9) is a bow fragment that was discovered lying exposed on stones and gravels by the upper edge of Storbreen, Oppdal. The find consists of a 385mm long bow limb that begins with a well-formed plano-convex to oval nock, continuing to a *c*. 14–15mm rounded square section before widening out to a width of around 38mm at the break. Also recovered were four 2–4mm wide hide lashings, found in direct association with the bow limb. Context photographs and imprints on the bow show that the lashings were attached to the limb between 255mm and 292mm from the nock end and may have formed a contiguous band. Given the short length and form of the extant limb, the lashings probably functioned as reinforcement. No other imprints have been located along the limb.

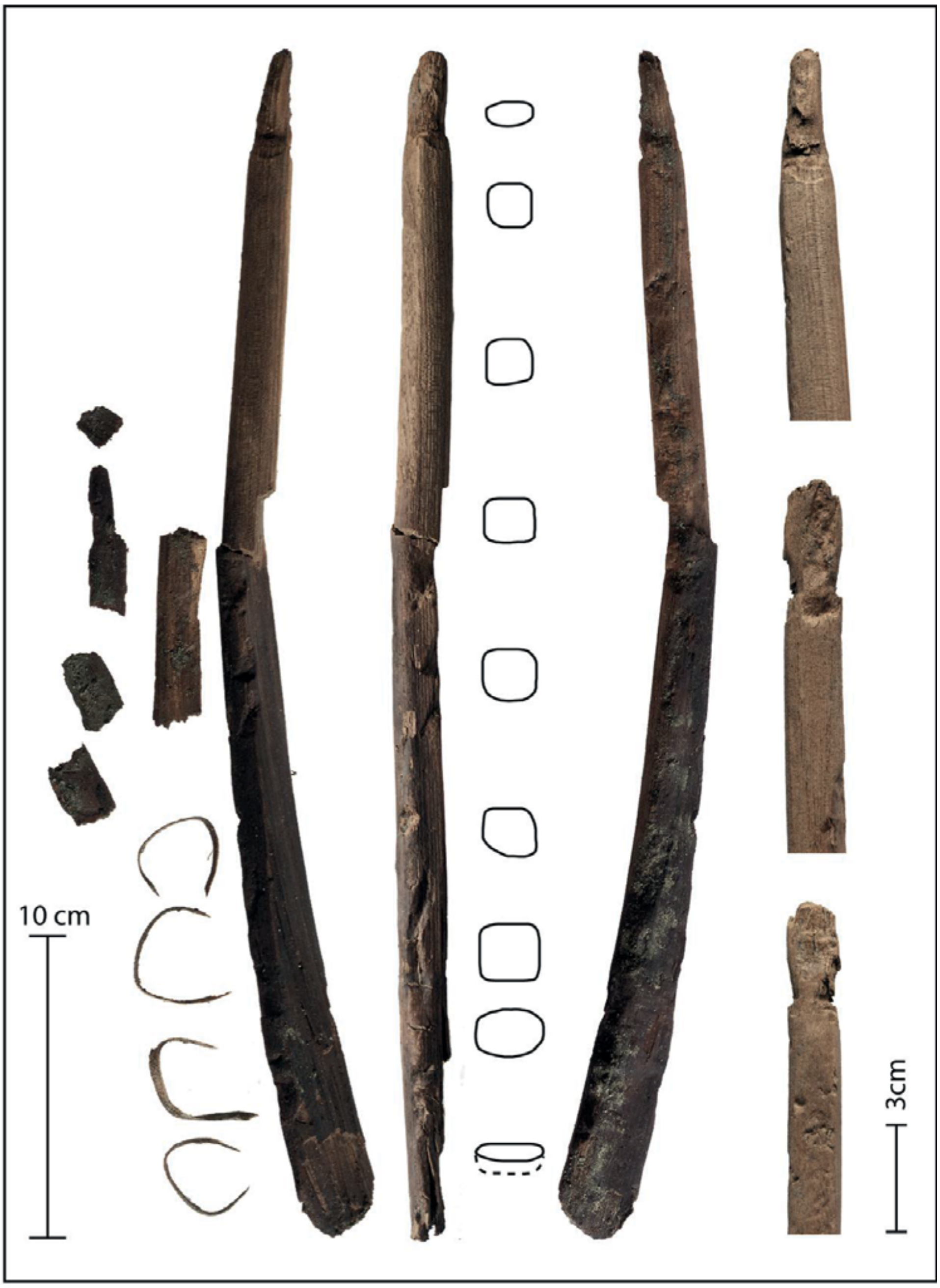


Figure 5.9 Artefact F (T25677)- Neolithic bow limb from Storbreen, Oppdal. Photo: Ole Bjørn Pedersen/NTNU-Museum of Natural History and Archaeology. Layout: Martin Callanan.

The bow is made from *Ulmus,* a raw material often chosen by northern bow makers in the past (Clark 1963: 51; Bergman 1993: 101; Junkmanns 2010). The site at Storbreen lies within the current northern border of European elm distribution, where the local upper limit is around 500masl (Nedkvitne & Gjerdåker 1995: 18, 28). *Ulmus* appears in a mountain pollen diagram at Ølstadsetri (820masl), some 25km to the south of the snow patch at Storbreen, at around 6000 BC, but the levels decline again as the post-glacial climatic optimum draws to a close around 5000 BC (Gunnarsdóttir & Høeg 2000: 39). The bow must therefore be of lowland origin.

Discussion: Neolithic archery

Slate points are signature artefacts of the Neolithic period in Scandinavia and are found throughout the region. The bow and arrows reported here span the whole period and were lost or discarded by groups or individuals on hunting expeditions. These early snow patch hunters probably originated from small, semi-sedentary, hunter-fisher communities based either in coastal areas to the West or further inland to the North or South (Alsaker 2005; Olsen 2009). Indicators of animal husbandry and cereal cultivation are clearly present in the region from around 2500 BC (Hjelle *et al*. 2006). However, the use of inland and mountain resources, a recurring feature of prehistory in western Norway, remained an important part of the economy throughout the Neolithic and subsequent periods.

These finds from melting snow patches in central Norway offer, for the first time, insights into the organic component of Neolithic bow and arrow technology in central Scandinavia. In the following, these discoveries are discussed in relation to other European finds that are relevant from a morphological or typological perspective.

In Europe between 140 and 150 Neolithic bow finds are known, a large proportion of them coming from lacustrine settlement sites in central Europe. In a recent analysis, Junkmanns (2010) organised these bows into two main groups based on their morphology. Bows in the propeller group (*e.g.* Rotten Bottom, southern Scotland, and Meare Heath, southern England) have broad, flat limbs with a narrowing at the grip. Bows in the staff group (*e.g.* Similian, Ashcott Heath) are more regular along the length of the bow (Junkmanns 2010: 55–65). The Storbreen bow belongs to the staff group. Viewed diachronically, the preserved nock end closely resembles Bow 2 from Agerød V, southern Sweden, dated to *c*. 5500 cal BC (Larsson 1983). The oval/square section is reminiscent of Bow 1 from La Draga in northern Spain that is dated to between 5440 and 5045 cal BC (Junkmanns 2010: 61). These few scattered parallels indicate that the Storbreen bow was anchored within a broader European technical template. Locally, there are few bow finds to which the Storbreen bow can be compared. A complete, 1.31m-long bow, dated to *c.* 1300 cal BC, was recently discovered at Lendbreen, Oppland (Mímisbrunnr n.d.). The Lendbreen bow also belongs to the staff group, but has a triangular profile, similar to the older bow from Koldingen, northern Germany (Beckhoff 1977; Junkmanns 2010: 490–93). A few bow fragments have been found at local snow patches through the years, but these belong to later periods and a different, laminated bow tradition (Farbregd 2009: 162–65, fig. 10).

As regards the Neolithic arrows, the degree of variability demonstrated by the finds is striking. There is considerable variation in the choice of shaft wood as well as in the size and morphology of shafts and points. However the sample of Neolithic finds recovered from snow patches is very small when compared with the 1600-year time period they span. The variability might be the first emerging sign of older archery traditions in the region. On the other hand, it might be the result of a production mode based on individual manufacture and technological choices.

It is interesting to compare the length of the Neolithic arrow shafts with the few Mesolithic shafts found in Europe. As a group, Mesolithic shafts are rather long, varying between *c.* 650mm and 1200mm in length (*e.g.* Junkmanns 2010: 54). Arrows of this period were probably hafted with small, light points of flint or similar lithic materials.

The Neolithic shafts presented here appear shorter than their Mesolithic counterparts. The incomplete shaft A which was probably tipped with a stone point is at present 420mm long. From vane lengths measured on later Iron Age arrows, the missing proximal fragment was probably no longer than 100–200mm (see Farbregd 2009: 163). This brings the total length of shaft A to between 500 and 600mm. The same is also true of shaft B, to which a small 2.4g slate point was hafted. The shaft has a complicated medial fracture, but the whole shaft has been recovered and its total length comes to 510mm.

Shaft E is the only complete shaft recovered in this group and with a total length of 794mm is within the Mesolithic range quoted above. There are, however, considerable problems in interpreting this shaft. Furthermore, it is dated to the Neolithic/Bronze Age transition, a period when the use of slate projectiles had ceased, to be replaced by either bifacial stone or antler and bone points. In conclusion, this shaft is probably not typical of Neolithic shafts, especially those used in conjunction with slate projectiles.

One of the characteristic traits of slate point technology is the large variation in both morphology and size of the point. The four slate points found at snow patch sites in central Norway, for example, weigh 2.4g, 7g, 10.5g and 13.8g (Åstveit 2007; Table 2). Slate points are generally larger and heavier than the lithic points used earlier, such as microliths, tanged points and transverse points. As the total weight (point plus shaft) is one of the technical parameters important for a well-functioning arrow, the Neolithic bowyer probably had to take varying slate point weights into account when fashioning individual shafts (Kooi 1983: 28, 164–65). Seen in this light, one might suggest that the Neolithic shafts were shorter in order to compensate for the heavy weight of the slate points. Of course the weight of the bow would also be an important variable in the total equation, but for the time being we are limited to posing hypotheses based solely on the arrows. Should this hypothesis prove correct, however, the same technical dynamic may also be visible in other arrow configurations. We might expect, for instance, that lighter arrowheads of antler and bone were fitted to relatively long shafts in order to increase the total weight. As yet, however, the sample of Neolithic arrows is very small and these questions have to remain open. But if current trends at local snow patches continue, we can expect more clarity on this and related issues in the near future.

Melting snow patches

In recent years we have seen repeated instances of advanced melting at local sites. This has led to a number of record-breaking seasons with increasingly large numbers of finds being recovered on classic sites. Many finds have been also been discovered at new sites in new areas (Callanan 2012a). Since snow patches are natural, dynamic formations, it is logical to view these developments in the light of ongoing weather and climate processes. The message from the foregoing is thus unequivocal: something is afoot in the mountains of central Norway. Ancient alpine ice is melting and yielding large numbers of organic artefacts. And the number and antiquity of some of these artefacts is unprecedented in the almost century-long history of snow patch surveying in the region.

These discoveries can also be viewed alongside the results of studies from other disciplines in the same region. Those studies map recent developments in the natural environment which, like the ablating snow patches, are presumed to be linked to unstable or extreme weather conditions and rising temperatures. Recent investigations at Snøhetta, close to Storbreen, have shown that alpine permafrost is retreating and becoming shallower (Isaksen *et al.* 2007). Other research maps early evidence for altitudinal creep in sub-alpine and alpine flora, as lower-lying plants begin to appear at increasingly high altitudes (Michelsen *et al.* 2011). Local fauna are also being affected, as can be seen by a recent outbreak of deadly pneumonia in the local musk ox herd during a particularly warm and humid summer (Ytrehus *et al.* 2008). Taken together, these studies paint a troubling picture of the episodic and systemic changes currently taking place in the sub-alpine and alpine environments of central Norway.

The relationship between current climate change and archaeology in its various intellectual, ethical and practical aspects is a theme that has been the focus of a number of recent contributions (*e.g.* Mitchell 2008; Brook 2009; Rowland 2010). Snow patch archaeology is situated at the frontline of this issue. As new objects continue to appear at melting snow patches, all efforts are focused on recovering as much as possible. Not only the finds but their contexts too are important as fragile sources of information that are disappearing before us. This is a demanding rescue mode that requires both being in the right place at the right time and asking the right questions before it is too late. The institutional challenge is to provide the reliable funding and flexible routines that permit effective field responses in the face of changing conditions.

For local collectors, snow patch archaeologists and managers, climate change has an immediacy of its own. On the one hand, there is the possibility of recovering unique ancient objects that will occupy and inform us for many years to come. At the same time, as the climate continues to heat up and the snows melt away, one wonders what long-term price there will be to pay for these precious glimpses of the frozen past.

Chapter 6 -Bronze Age Arrows from Norwegian Alpine Snow Patches

Introduction

Alpine snow patches in central Norway have produced large numbers of archaeological finds over many years (*e.g.* Farbregd 2009 & Callanan 2012a). The material recovered from these sites consists mainly of personal equipment such as bows and arrows, knives and snares that were used in the past during hunting expeditions in the mountains. Due to the frozen conditions on alpine snow patches many of these implements are found today in relatively good condition. Well-preserved snow patch artefacts offer us rare glimpses of the archery technology of the past, as the organic portions of bows and arrows are usually missing from lowland sites. This article is a presentation of a group of eight Bronze-Age (1800-500 BC) shafts and projectiles from melting snow patches in the Oppdal region that were recovered by local collectors during the period 2003-2011.

The presentation begins with a description of where and how these discoveries were made. A detailed description is also given of eight Bronze Age arrows identified as part of a recent study. This is followed by a discussion of the implications these finds have for our understanding of archery technology in the region during the period *c.* 1800-500 BC. Finally, some issues specific to snow patches as archaeological sites are highlighted and discussed.

Background and Method

The term 'central Norway' refers to the region between 62°-63° N on the western side of the Scandinavian Peninsula. Archaeological snow patches are found in alpine zones, usually at altitudes above *c.* 1400masl. The majority of snow patches in the region with archaeological finds are located inland, in the alpine areas towards the southwest. (See Callanan 2012a: 181-183 and 2013:729-730 for a more detailed description of the snow patches and their natural setting). Perennial snow patches are discreet but important structures within the broader ecological landscape and serve as vital cold niches for a number of local species such as reindeer, arctic fox and grouse during the warmest summer days. Periodic congregations of animals on snow patches provided the region's populations with a good hunting opportunity that made the long, uphill hikes to these sites worthwhile. Over time, this led to an accumulation of ancient artefacts on sites where objects were lost or discarded during late summer hunting events.

Archaeological artefacts emerge from alpine snow patches under special conditions. Ancient arrows and bows can usually only be recovered from around these sites during particularly warm summers, once the snow and ice has melted back sufficiently. In central Norway, the main period of recovery falls at the end of the summer, between the middle of August and the middle of September, when snow patches have reached their minimum extent (Callanan 2012a: fig.6). The majority of the region's snow patch finds have been discovered and rescued by different generations of local collectors, who voluntarily survey these remote sites when conditions are suitable. Through their efforts, during the period 1914-2011, a total of 234 individual artefacts have been recovered from 28 different sites in the region (Fig. 6.1). This forms the background for the finds reported in this paper, all of which were discovered by local volunteer collectors.

The arrowheads, shafts and bow fragments recovered from snow patches in central Norway have been studied for many years (*e.g.* Farbregd 1972, 2009 and see Callanan 2010:47 for an overview). Particular attention has been paid to documenting and analysing long-term technical changes in archery technology through time. Farbregd has identified a number of key technical elements on bow and crossbow arrows that are sensitive to gradual change. These include metric and morphological traits such as the length and width of the shafts, the form of both the nock and haft ends and the wood material chosen to form the shafts (2009:fig.9). These studies give a relatively clear overview of the most important forms and developments through the period *c.* AD200-AD1700. And until quite recently snow patch hunting was an activity mainly associated with the local Iron Age and Medieval periods. However during the last decade there has been a large increase in the number of finds recovered from local snow patches. And several new sites have been discovered. (Callanan 2012a: 185-186). These new discoveries raise new questions and perspectives. For example, in 2007 it was shown that at least three of the new artefacts where significantly older than the Iron Age (Åstveit 2007). Among the artefacts was an arrow shaft (T23069) discovered in 2004 that was dated to the Early Bronze Age (Åstveit 2007: 16-17). The results presented in 2007 mark the starting point for the current study.

Were the Neolithic and Bronze Age artefacts identified by Åstveit in 2007 stray finds on otherwise predominantly Iron Age and Medieval sites? Or were older finds now appearing regularly on snow patches in the region? The aim of the current study was to answer these questions by investigating whether or not significant numbers of Neolithic or Bronze Age artefacts were among the large number of artefacts being recovered from snow patches.

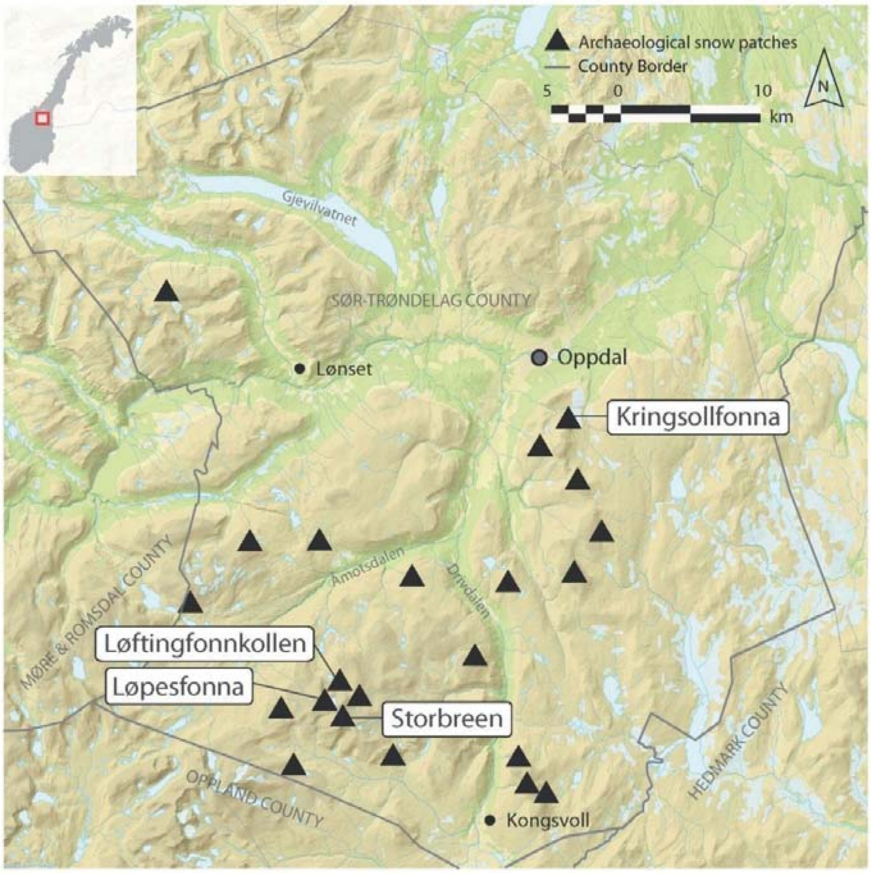


Figure 6.1 Overview of snow patches sites with archaeological finds in central Norway. Sites mentioned in the text are labeled.

To this end, all recent shaft and points where carefully examined and analysed in terms of their metric and morphological traits. A selection of artefacts that could not be related to existing Iron Age or Medieval typologies was subsequently submitted for ^{14}C dating. The study has already revealed a significant number of Neolithic hunting artefacts from snow patches (*e.g.* Callanan 2013). The Bronze Age artefacts presented in detail in this paper are a further result of the same study.

Museum #	Snow Patch	Description	Shaft Material	Year of Discovery	Lab Number	Measured age	Calibrated age 2σ	Delta 13	Note
T25172	Løpesfonna	shell point & arrow shaft	*Betula*	2010	Beta-319547	3370±30 BP	1745-1538BC	-25.1	
T23069	Kringsollfonna	arrow shaft fragment	*Corylus*	2004	TUa 5293	3365±45 BP	1753-1526BC	-27.0	Previously published in Åstveit 2007.
T25684	Løpesfonna	shell point & shaft fragments	*Betula*	2011	Beta-308925	3340±30 BP	1728-1529BC	-25.5	
T23411	Storbreen	arrow shaft fragments	*Betula*	2006	TRa-1049	3295±30 BP	1663-1499BC	-24.1	
T24981 & T25284	Storbreen	arrow shaft fragments	*Betula*	2009	TRa- 1048	3290±35 BP	1669-1494BC	-26.7	
T24138	Løftingfonnkollen	arrow shaft fragments	*Betula*	2008	TRa-1047	3275±30 BP	1626-1461BC	-28.4	
T25167	Storbreen	antler point & shaft fragments	*Betula*	2010	TRa- 2767	3030±30 BP	1396-1135BC	-27.3	
T24367 & T24982	Løpesfonna	antler point & arrow shaft	*Betula*	2008	TRa- 1050	2935±30 BP	1261-1041BC	-24.3	
T16056	Frøya (Non-snow patch)	flint point & shaft fragment	*Pinus*	1941?	TRa 2766	2710±40 BP	968-801BC	-26.1	Non-snow patch find. Dated as reference.
T25286.1	Løpesfonna	arrow shaft fragments	*Betula*	2010	TRa-2768	2455±30 BP	754-412BC	-25.4	
T25286.2	Løpesfonna	arrow shaft fragments	*Betula*	2010	TRa-2769	2350±30BP	484-386BC	-26.0	
T17698f & T17694/ T17698e	Storbreen	Bone point & shaft fragments	*Pinus*	1937	TRa-1051	1705±30BP	AD255-409	-25.0	Older snow patch find. Dated as control.

Table 6.1 Calibrated radiocarbon dates for the artefacts discussed in this article. Calibration was carried out using OxCAL 4.1 and the IntCal 09 curve (Bronk Ramsey 2009).

Results

Eight new Bronze Age arrows were identified during this analysis. When the shaft fragment (T23069) dated in 2007 is included, the current total number of Bronze Age arrows found on the region's snow patches is now nine. The radiocarbon dates for these nine artefacts are included in table 6.1.

Two other artefacts were also radiocarbon dated as part of this analysis. The purpose of these dates was either to cross-reference with other possible Bronze Age finds from the region. These are an arrow with a flint point (T16056) from a coastal site on the island of Frøya, Sør Trøndelag that was suspected to be of Bronze Age origin. Also dated was an arrow with a bone point (T17698& T17694/T17698e) found at Storbreen in 1937. These dates are also presented in table 6.1 and are both discussed in a later section.

The following is a detailed description of the Bronze Age arrows newly identified and dated. The arrows are arranged into separate groups, according to their material composition or condition. These groups are shell arrows, antler arrows, plain shafts and refitted shafts.

Shell arrows (T25172 & T25684)

Two of the arrows have projectiles of a material never before discovered in Scandinavia. The arrows consist of shell points with associated fragmented shafts (Fig. 6.2). The shell points were compared to a modern study collection and have been visually identified as the freshwater pearl mussel *Margaritifera margaritifera*. In both instances, portions of the periostracum and calcareus ostracum are preserved and the shells have been worked to clear point-like forms analogous to those found in lithic inventories of the period (Prescott 1986: 29-32).

Both arrows were discovered at Løpesfonna, only 8m from each other during separate surveys in 2010 and 2011. In the case of T25172, the arrow was discovered in 2010 below the snow patch with the shell point still attached to the shaft. The shaft is incomplete with a section from the proximal end missing. The remaining fragments were conjoined to a length of 67.9cm. The width of the shaft varies gradually giving it a straight appearance. The widest point of 7.2mm is found at the base of the haft (Table 6.2). The point has the form of an elongate triangle with a concave to straight base. The point was originally attached to the shaft by way of a layer of black adhesive that covers the shell point and continues down

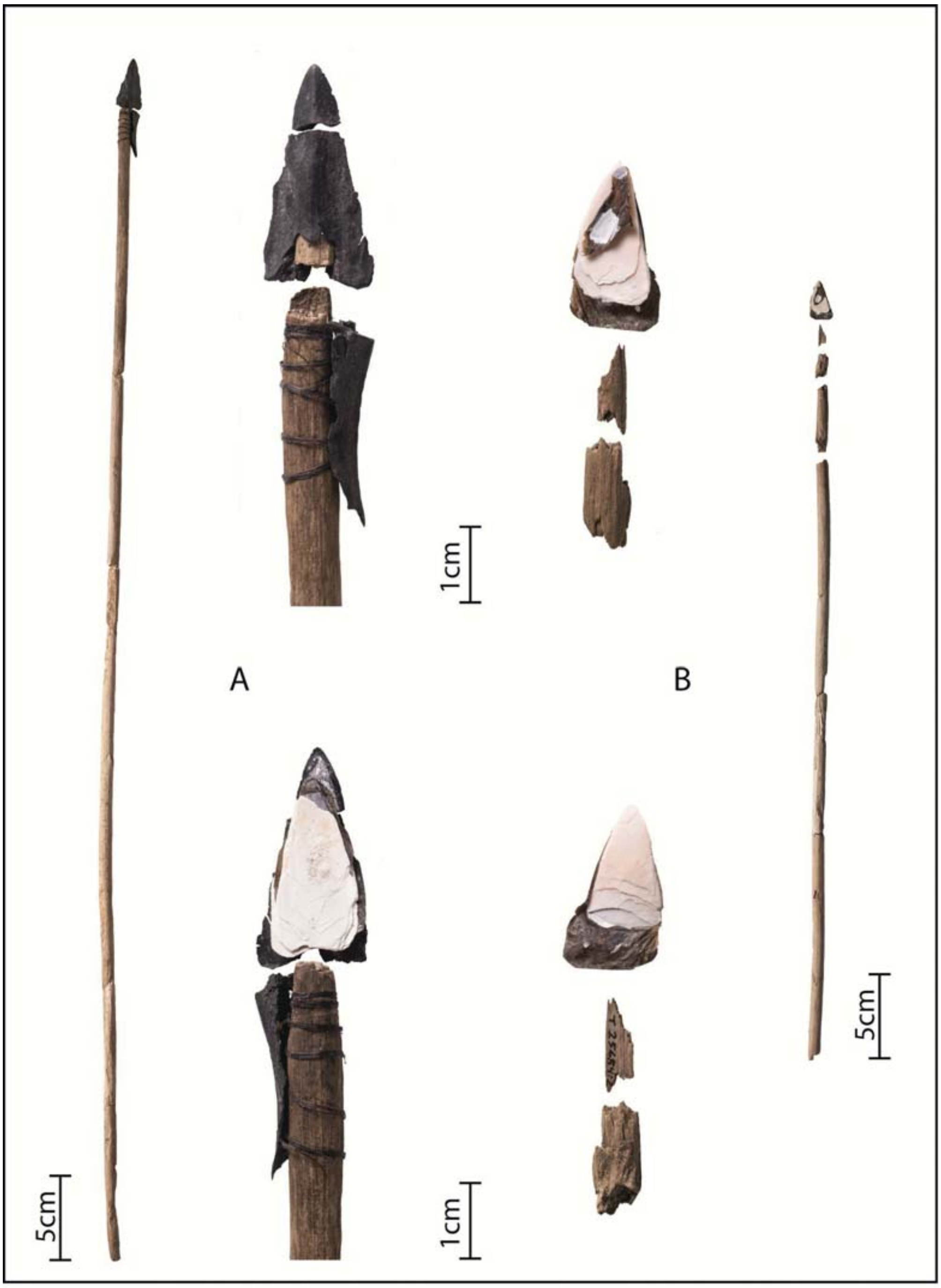


Figure 6.2 Arrows with shell points recovered from the Løpesfonna snow patch. (a)T25172; (b)T25684. Photo: Åge Hojem/NTNU-Museum of Natural History and Archaeology. Layout Martin Callanan.

along one side of the shaft. Other recovered fragments of adhesive show that a similar, presumably symmetrical adhesive fixture was originally in place on the other side of the shaft too. The distal end of the shaft has an open U-shape although both hafting arms broken off. One hafting arm was discovered encased in the adhesive together with the shell point. Refitting shows that the hafting arms were unusually long, extending almost the length of the shell point. Also preserved are several rounds of lashing, of an unknown plant material at the distal end. The imprint of the lashings can also be clearly seen on the inside of the adhesive that runs along the shaft. This demonstrates that the distal end was tightened with lashings before the adhesive was applied. Figure 6.3 is a reconstruction suggesting how the main components might have been combined to complete the shell arrow at the time of production.

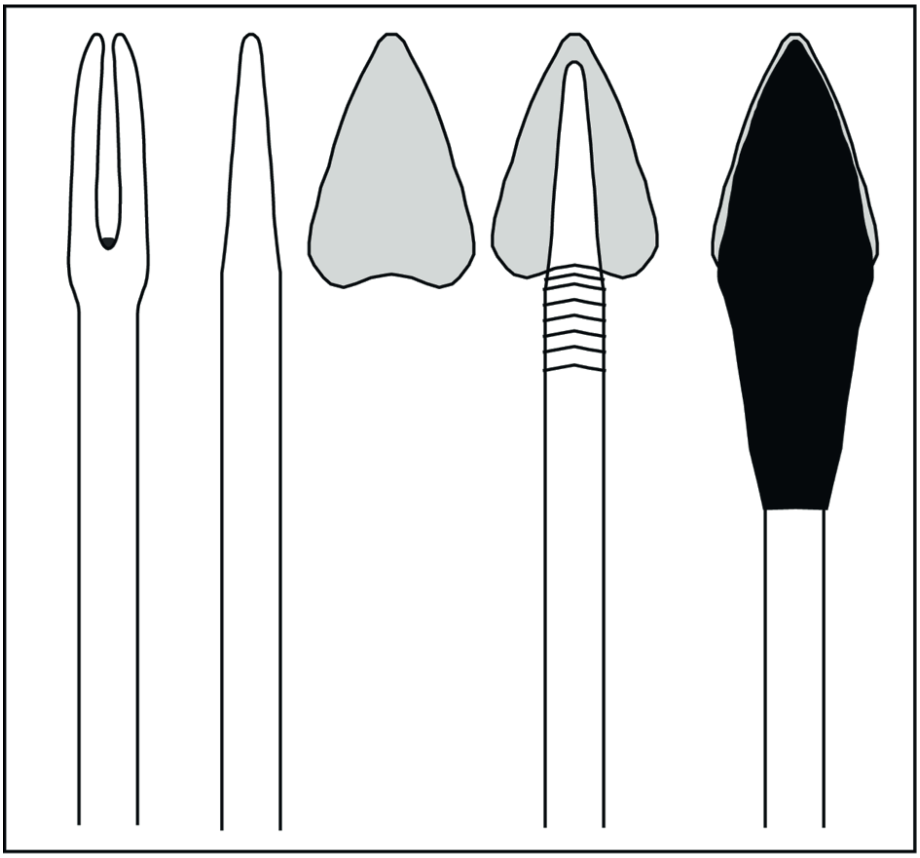


Figure 6.3 Suggested reconstruction of the Bronze Age shell arrows. The form and dimension of each technical element is based closely on the two arrows discovered at Løpesfonna.

The second shell arrow (T25684) was discovered in 2011, in close proximity to the previous year's find location. The second shell arrow lay slightly closer to the edge of the snow patch than the first and might not have been exposed at the time of the 2010 survey (Fig. 6.4). The second shell arrow is not as well preserved as the first, with few technical elements visible. But the shaft appears to have had a relatively straight overall shape. The width values measured on individual fragments (6.5-7mm) are all within the range of the first shell arrow (Table 6.2). Comparison of the two shell arrowheads shows that they differ in both size and form. This rules out any possibility that they could be two fragments of the same arrowhead.

Both shafts are made from *Betula*. Wood analysis shows that both shafts have been fashioned from staves rather than branches and both exhibit a similar cross-section that runs slightly diagonally to the grain of the wood.

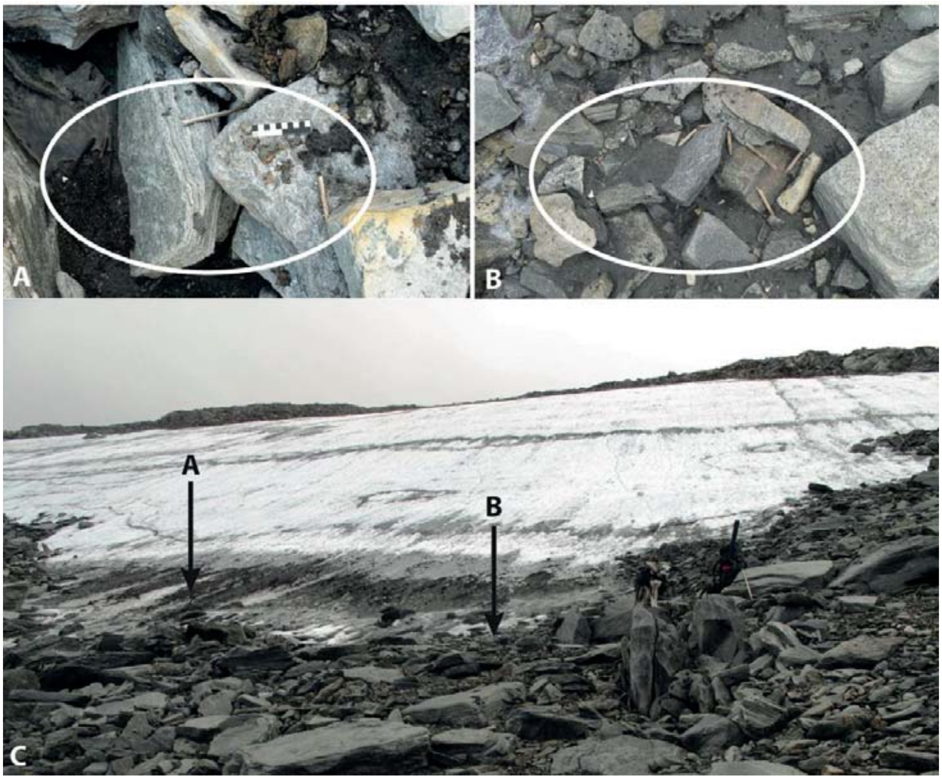


Figure 6.4 Discovery of the shell arrows at Løpesfonna. (a) T25172. 21st Aug. 2010. (b) T25684. 2nd Sept. 2011. (c) Shows the distance between both find locations. Photo: Martin Callanan (a) & Tord Bretten (b & c).

The radiocarbon dates returned on the samples from these two shafts are for all intents and purposes identical and overlap completely at 2σ (see Table 6.1). When one considers how similar these arrows are, together with the fact that they were found at the same location and have returned the same radiocarbon dates, it appears likely that the shell arrows were lost during a single hunting episode, perhaps by the same hunter.

Antler arrows (T25167 & T24367/24982)

Osseous materials also played an important role in the archery technology of the Bronze Age period. A pair of arrows with antler points discovered in recent years illustrates this fact. Both are dated towards the end of the Early Bronze Age (1800-1200BC).

The older arrow (T25167) was discovered at Storbreen, Oppdal in August 2010, lying spread out among rocks and earth at the northern end of this site (Fig. 6.5). The find spot lay above the upper portions of the patch. At the time of discovery the micro-context was completely dry, as snow in the immediate vicinity of the find spot had already melted. Archived photographs show that the snow patch usually covers this location. However the area is also documented as having been exposed during extreme melting events, as was the case in 2006.

This arrow consists of an osseous point together with a number of shaft fragments. The point is 18.5cm long and has a slender lanceolate form with a sharp tip at one end and a beveled tang at the other. The point reaches its maximum width of 11 mm at roughly the midpoint of the blade and it's broadest of 4mm just before the bevel begins. Microscopic examination shows that the point is made from antler. A DNA sample taken from the point shows that the antler was from reindeer (*rangifer tarandus*). The point was recovered together with nine shaft fragments of *Betula* that are heavily weathered, shrunken and generally poorly preserved. Despite this, several of the pieces could be refitted and some technical details noted. By adding the preserved fragments' length, we find the minimum length of the shaft comes to 64.8cm. Due to the condition of the shaft, the diameter values measured probably do not reflect the true dimensions at the time of production and use. A beveled hafting end is preserved on one of the shrunken shaft fragments and corresponds closely to the bevel on the antler point. A sample taken from the shaft returned a date of between 1396-1135 cal. BC, placing the arrow at the transition (1200 BC) between the Early and Late Bronze age in relation to the regional chronology.

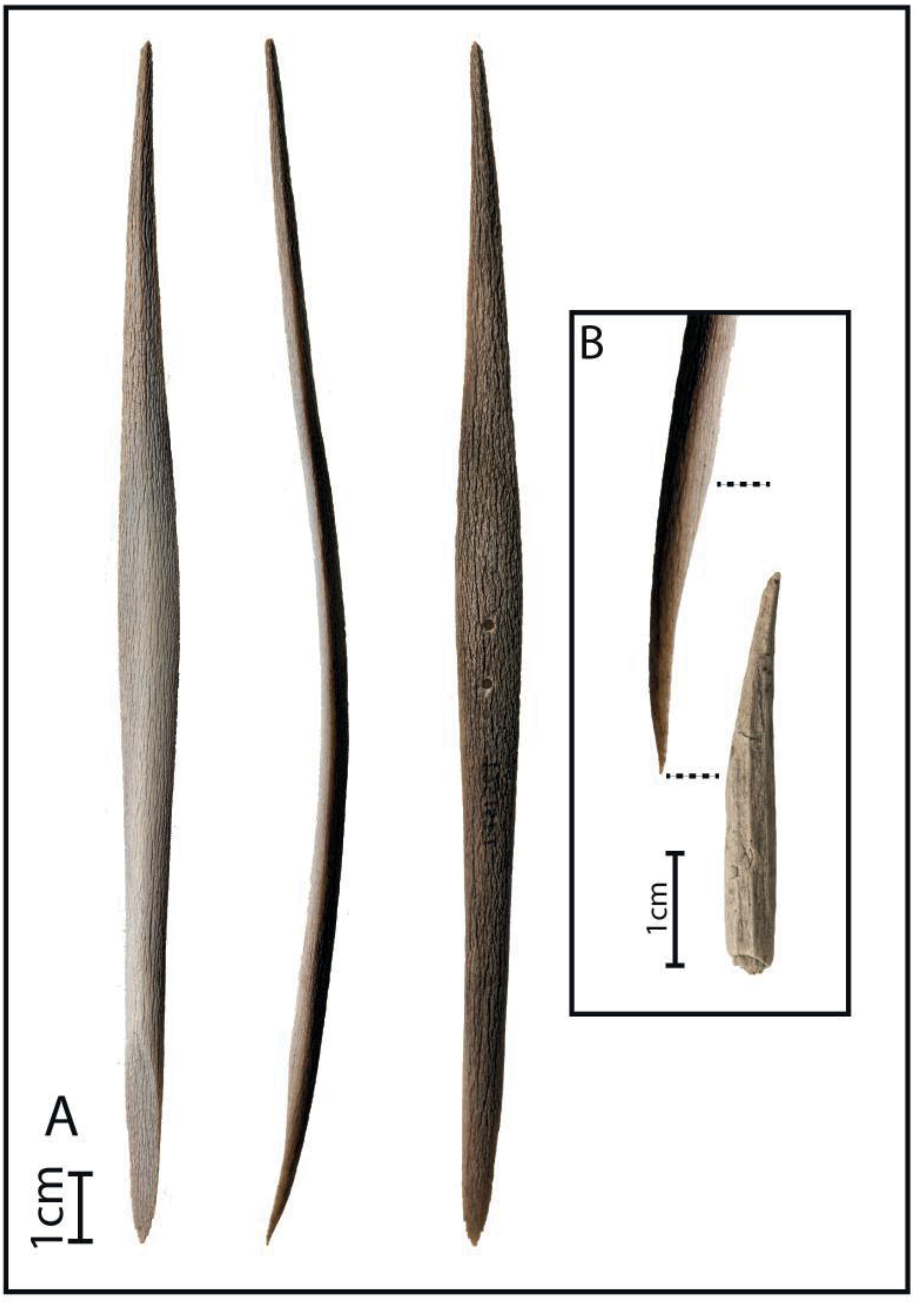


Figure 6.5 (a) The antler point (T25167) from Storbreen. (b) Close-up comparison of the beveled ends of both point and shaft in section. Photo: Åge Hojem/NTNU-Museum of Natural History and Archaeology. Layout Martin Callanan.

The second antler arrow (T24367/T24982) consists of an osseous point with a complete shaft, discovered along the lower slope of Løpesfonna, Oppdal (Fig. 6.6). The two components were discovered by the same collector on two separate occasions in 2008 and 2009. The shaft was discovered first and is a complete 55.3cm long shaft of *Betula.* It was recovered a couple of meters below the edge of the snow patch lying among stones and boulders. The diameter of the shaft varies from between 3-6.5mm. The shaft is clearly barrel-formed, while the distal section is generally thicker than the proximal. The proximal end has a V-formed nock. The distal end has a 2.5cm long bevel, which is marked by a number of light cuts across the face of the bevel, presumably to ensure better purchase between the shaft and point. The inside bevel face of the shaft has a dark discoloration which indicates that some sort of adhesive was used to join the elements together. A number of individual lashing imprints *c.* 3mm apart and a clear dark discoloration can also be seen along the distal end over *c.* 3cm.

In 2009, the point (T24982) was discovered at the same location as the shaft the year before. It was found lying on a small, dry patch of earth below the snow patch. The point is 12cm long and has a lanceolate form similar to the other antler point but is broader and generally more robust. The point has a beveled tang over 2,4cm that also has a dark discoloration. The beveled end of the point exhibits discrete rifts or ridges, but these may be chatter marks rather than notching. The beveled ends of both point and shaft form a perfect match with respect to angle and length. The point has a varied oval to round cross-section that measures 12mm at the midpoint. The thickest point of 4mm is located just before the bevel. Microscopic visual inspection indicates that the point is fashioned from antler. A DNA sample taken shows the material to be *rangifer* also. The shaft returned a ^{14}C date of 1261-1041 cal. BC which corresponds to the start of the Late Bronze Age (1200-500 BC).

Figure 6.6 The antler point (T24982) and shaft (T24367) from Løpesfonna. Note the precision of the beveled ends. Photo: Åge Hojem/NTNU-Museum of Natural History and Archaeology. Layout Martin Callanan.

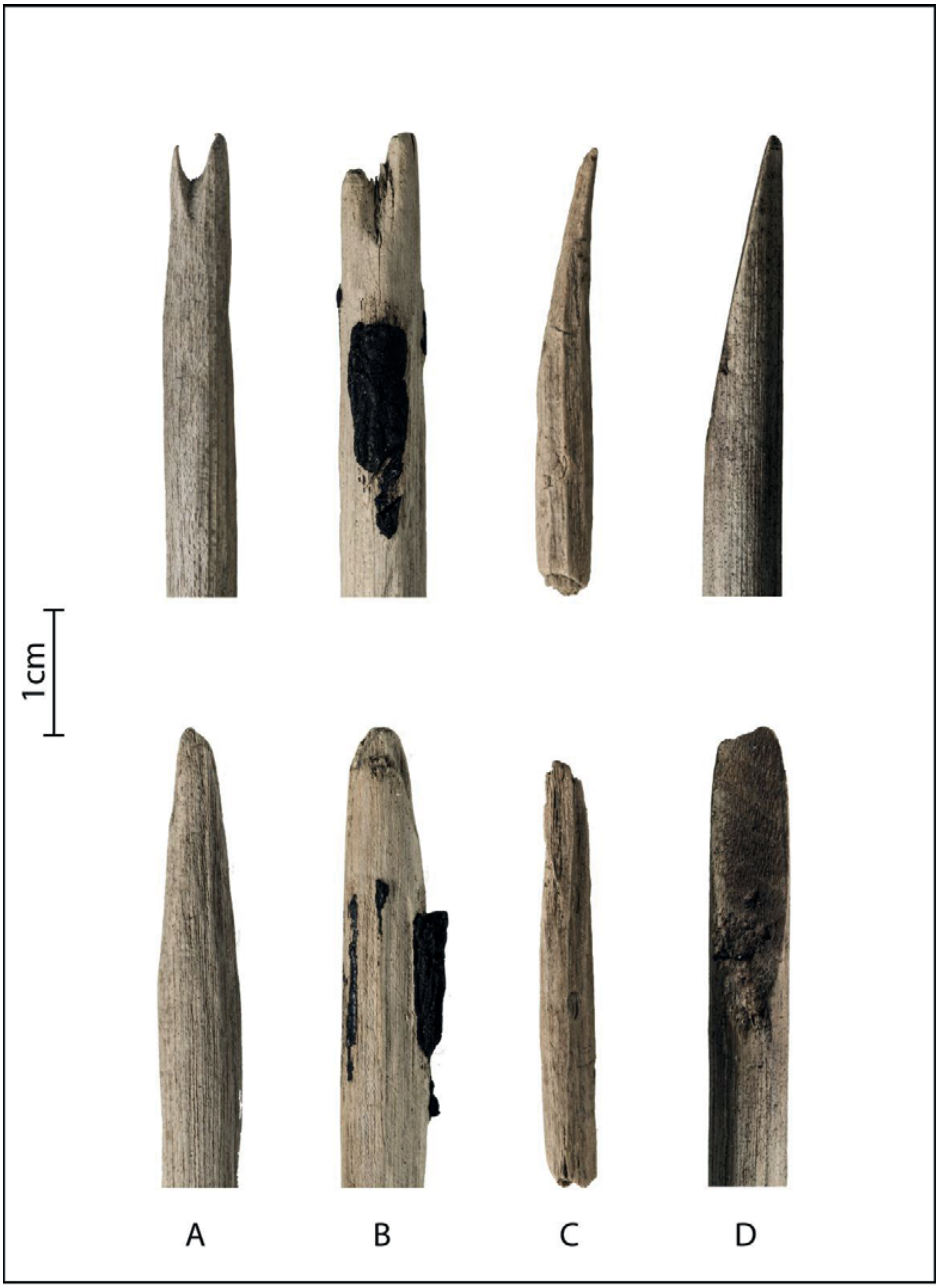


Figure 6.7 Bronze Age haft ends presented in this study. (a)T23411; (b)T24138; (c)T25167; (d)T24367. Photo: Åge Hojem/NTNU-Museum of Natural History and Archaeology. Layout Martin Callanan.

Plain Shafts (T23411 & T24138)

Bifacially reduced points of flint, quartz or quartzite that are usually associated with the Bronze Age period have not been found on snow patches in Norway. But the use of stone points on hunting arrows might be deduced from the hafting end of two plain shafts recently recovered and identified.

The first shaft (T23411) is a 43.6 cm long distal shaft fragment made from *Betula.* The shaft was recovered in three contiguous fragments in September 2006, close to the upper edge of the northern patch at Storbreen. The shaft tapers gradually from its widest of 6mm in the distal end to a diameter of 3.5mm at the break. The haft is V-shaped. It is *c*. 6mm deep and measures 2-3mm across at the widest. The hafting arms are asymmetrical, with one of the arms thicker and longer than the other. The shaft is dated to between 1663-1499 cal. BC, placing it firmly within the Early Bronze Age.

The second shaft (T24138) measures 48.3cm long. It is comprised of a distal and medial fragment of a *betula* shaft that ends in a break that has splintered over *c*. 13cm along the shaft towards the proximal end. This may be one end of an intentional beveled joint. At the distal end is a hafting split that is 4mm deep and 3 mm across at the widest. Here too, one of the hafting arms is slightly thicker and longer than the other. Traces of a black adhesive are visible along the shaft's distal end. The adhesive lies in two groups, perpendicular to the hafting split on both sides of the shaft. On one side, the adhesive appears as a small 1.6 x 4mm clump. On the other side it forms two distinct stripes *c*. 1.4mm long. These traces are undoubtedly the remains of an adhesive covering, probably similar to that used on the shell arrows. The positioning of the adhesive, at right angles to the haft fits well with other observations as to how these arrows might have been constructed. The shaft was discovered in September 2009, close to another wooden artefact below the eastern end of the snow patch at Løftingfonnkollen.

Refitted shafts (T24981/T25284 & T25286:1/T25286:2)

Another heavily fragmented Bronze Age arrow shaft (T24981/T25284) was recovered on two different occasions at Storbreen in 2009 and 2010. In September 2009, eight shaft fragments were discovered lying close to the lower edge of the northern section of the site under difficult conditions following a fresh fall of snow. A year later, in September 2010, four more fragments were discovered close to the initial find location. During conservation in the lab, a number of fragments from both shafts were found to belong together, although not all fragments could be refitted.

Figure 6.8 Bronze Age nock ends. (a) T24367. (b)T25286.1. Photo: Åge Hojem/NTNU-Museum of Natural History and Archaeology. Layout Martin Callanan.

In its present state, the *Betula* shaft is still heavily fragmented and neither the proximal nor distal ends are preserved. The shaft fragments measure between 6-7mm. However due to the condition of the arrow it was impossible to deduce anything more regarding the general form of the shaft. Nonetheless, due to the find circumstances, metric dimensions and general condition of the shaft it was selected for radiocarbon dating. The date returned was 1669-1494 cal. BC, indicating that the shaft was deposited on the site during the Early Bronze Age (1800BC-1200BC).

In September 2010, five shaft fragments were discovered lying close together at the eastern end of the snow patch at Løpesfonna. The fragments lay among rocks and boulders roughly 3m below the lower edge of the patch. Following conservation and analysis, the recovered fragments were subsequently refitted to form an extremely long but incomplete arrow shaft comprising of three proximal fragments with a total length of 63.7cm (T25286:1) and 2 distal fragments that are 18.6 cm long (T25286:2). Both sections end in 3.5cm long bevels that join snugly together.

The arrow shaft is made from *betula* and although incomplete, at 82.3 cm it is still the longest arrows in the central Norwegian snow patch collection. The shafts width varies from 5.5 mm at the proximal end to 9.5 mm along the medial sections. The distal end is missing and the diameter at the distal break is 8.5 mm. Therefore it is likely that this shaft was barrel-formed when complete. The proximal nock has a simple v-form with straight sides. No traces lashing or adhesive remains are visible on the proximal end. Matching discolourations and patterns on both beveled ends indicate that some form of adhesive was used in making the joint.

Both the proximal and distal portions of the arrow were ^{14}C dated. The proximal section returned a date of 754-412BC, while the distal fragments were dated to 484-386BC. At 2σ the calibrated dates overlap at the younger end of the probability ranges and therefore indicate that the shaft probably belongs to the transition between the Late Bronze Age (1200BC-500BC) and subsequent Early Iron Age (500BC- AD570).

This concludes the detailed presentation of recent Bronze Age artefacts from snow patches in central Norway. We can now summarize and discuss different aspects of these discoveries in relation to relevant local and European finds.

Bronze Age Archery

General discussion

Bows and arrows from the Bronze Age are quite rare even at a European level. The paucity of finds led Clark to suggest a possible decline in the use of the bow during the Bronze Age (Clark 1963:84). According to Junkmanns, around 10 bows and 19 arrow fragments are known from Western Europe at present excluding the snow patch finds (2010:74). Besides direct evidence for archery in the form of bows and arrows, the other main source of knowledge on projectile technologies in the Bronze Age comes from loose metal and lithic points, which in some regions can be quite numerous. In Norway, metal points are very few in number and play no major role in discussions of archery technology of the period. Lithic points are found either on excavated sites or as loose finds. Earlier research in Norway has focused on constructing a chronology for Bronze-Age lithic points on the basis of a limited number of excavated sites (*e.g.* Prescott 1986). Points are one of the few formal types found among the lithics of the period and often come from small sites with low artefact densities (Prescott 1991:43). The most important point types for the period are various forms of pressure flaked unifaces and bifaces of flint, quartz or quartzite with fluted, straight, concave or convex bases (Prescott 1986: 153-166). The chronology for Bronze Age points is relatively coarse. However, lithic points from the Norwegian Bronze Age clearly demonstrate that bow and arrows were in use throughout the period, but can tell us little more in terms of archery technology.

There are some notable individual exceptions to this general picture, some of which are relevant for the current material. A hafted flint biface was discovered in a bog on the island of Frøya, Trøndelag in 1941. The arrow consists of a flint point on a 41cm long distal shaft fragment of *Pinus* (pine) (Table 6.1 and Fig. 6.12). The shaft measures between 9-11mm in diameter and is relatively straight, except for a marked narrowing around the haft. The stone point is inserted in the shaft that has medium long hafting arms. The haft is completed with black adhesive and serveral strands of sinew. Previously the arrow could not be dated more closely than 'the end of the Late Stone Age to Bronze Age' (Ramstad 1999:22). As part of the present study a wood sample from the shaft was radiocarbon dated and returned a result of 968-801 Cal BC, which corresponds to the Late Bronze Age date in the local chronology.

In Sweden, the situation is largely similar to Norway with a general paucity of finds that can illustrate fundamental aspects of Bronze Age archery technology. Few organic remains have been recovered and the main source of knowledge on the topic remains lithic points. However an interesting find from an island off the southwest coast of Sweden reminds us of the role bone and antler points played in archery technology in the region during the Bronze Age. In 1963, at least eight bone points were discovered in a stone barrow at Stora Vikars, Gotland as part of a cremation grave. The burnt points were heavily fragmented but were reconstructed to demonstrate that the projectile industry of the period included a variety of forms both with and without tangs and barbs. The bone points were dated to the Early/Late Bronze Age tradition at around 1200 BC (Rydh 1968: 160-162).

Morphological and technical aspects of newly dated Bronze Age Arrows

Snow patch arrows dated to the Bronze Age allow us to look at a number of key technical traits relating to the archery technology of the period. The following is a summary of a number of important technical elements found on the new finds.

Haft ends

With respect to hafting techniques found among the current material, there appear to be three types of hafts. These are long- and short- armed hafts and beveled hafts (Fig. 6.7).

Long armed hafts are found on both the shell points and the flint arrow from Frøya (Table 6.1, Table 6.2 & Fig. 6.10). The flint point has a tang that is inserted into the hafting arms and fixed with adhesive and lashings. The hafting arm on the shell point is quite distinctive and runs almost the whole length of the point. This is the first time an arrow shaft with extended hafting arms like this has been discovered in Scandinavia. The closest European parallel is the flint arrow found at Fyvie, Aberdeenshire, Scotland during the late 19th century, which may be from around the same time period (Anderson 1876). Anderson also highlights an interesting parallel between the shape of these extended wooden hafting arms and the medial ridges often found on casted bronze points (1876:508-509) (*e.g.* Fig. 6.9). This is striking example of distinct echoes that resonate between different raw materials during the period, where technical details are mirrored back and forth across different media and between different regions (*e.g.* Johansen 2000: 31-44).

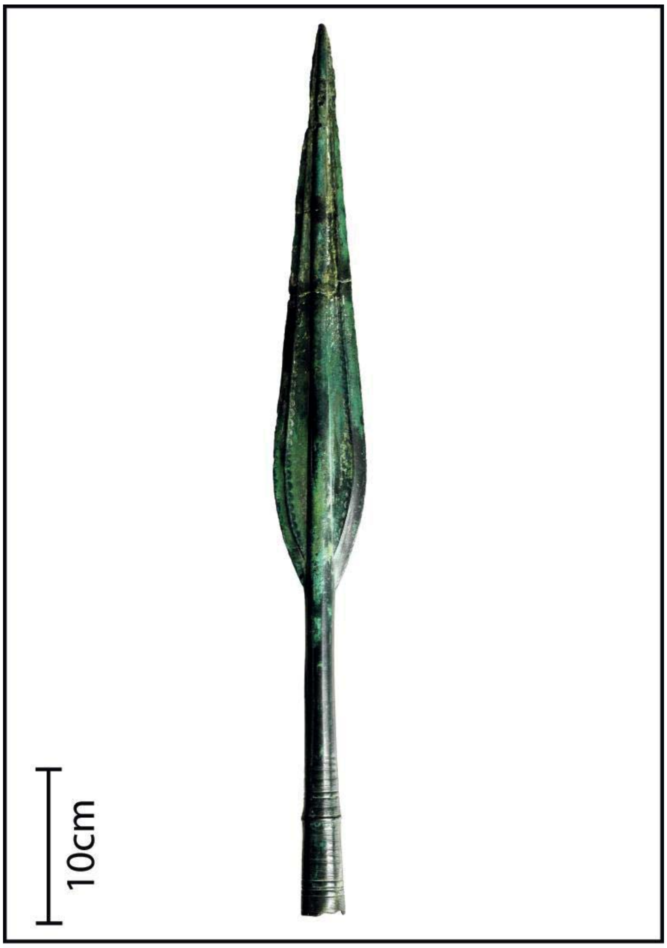


Figure 6.9 (T12452) A 58cm long bronze spear from Hoddøy, Namsos, Nord Trøndelag (c. 900-700BC). Functional details such as the hafting arm and lashings familiar from arrows, have become stylized into décor in the new raw material. Photo: Per Fredriksen Fredriksen /NTNU-Museum of Natural History and Archaeology. Layout Martin Callanan.

The use of long hafting arms in the Bronze Age shows continuity from the Neolithic where we have three complete distal ends, all with long hafting arms. Two of these are found together with tanged slate points. (Callanan 2013: Figs. 5, 6 & 7). The use of long hafting arms is also the dominant hafting technique for tanged iron points into the Early Iron Age although in this period the hafting splits are decidedly narrower.

This hafting-technique appears to fall out of use at somewhere around AD 500-600 (Farbregd 2009:160). Unfortunately neither of the two arrows with short-armed hafts was found in association with points. At first glance, one might easily mistake the hafting ends of these two arrows for proximal string nocks given their form. However other details such as the slight narrowing of the haft arms, the presence of adhesive and the edged form of the inside of the hafting cleft all clearly indicate that these are both hafting ends. One of the regular traits of prehistoric archery is the care and attention given to forming a smooth proximal nock end in order to avoid damage to the bowstring (*e.g.* Fig 6.8).

The points used with these shafts may have had either fluted, straight, concave or convex bases all of which are common for the period (Prescott 1986: 29-30). Mounting stone points on *c*. 4-9mm wide shafts with short-armed hafts was probably a difficult task. For this reason it was likely that the hafts were carefully strengthened by the generous use of adhesive and lashing as is evident from the haft end of the arrow from Løpesfonna (T24138)(Fig 6.7b).

At present, we have three dated examples of beveled hafts (T25167, T24367/T24982 & T25286.1). The beveled joint appears as a hafting technique for the first time around the Early/Late Bronze Age transition at c. 1200 B.C. and is limited to use with osseous points. Details preserved on the distal ends show that the beveled joints were secured with adhesive and sinew lashings. Beveled ends were also used as technique for joining arrow segments as can be seen on T25286.1. At this stage it is unclear if this was a simple repair or part of a more common practice for making shafts as appears to be the case in other regions (*e.g.* Hare *et al* 2012: 123-124). The beveled hafting technique continues until at least the Early Iron Age, where it also appears as a method for joining segmented shafts (Hougen 1937: fig. 5, Farbregd 1972:46).

In summary, there is considerable variation in the hafting techniques used on hunting arrows during the Bronze Age in Central Norway. This is probably due to the variety of projectile raw materials in use at the time. Although lithic points with distinct tangs were being used, producers were also experimenting with a number of other solutions to the problem of how to affix points to arrow shafts. It is not until the Early Iron Age though that tanged iron points and narrow hafting splits begin to dominate.

Proximal/nock end

Only two nock ends are preserved among the Bronze Age shafts (Fig. 6.8). Both are straight forms without knobs. This parallels with the one extant Neolithic nock end preserved in the collection that also has a straight, simple nock end (Callanan 2013: Fig.6). This technique continues into the later Early Iron Age when another tradition associated with distinct knob-like nock ends begins to appear on snow patches (Farbregd 2009:161 & Fig. 9). The nock ends on the Neolithic and Bronze Age arrows appear to confirm an earlier hypothesis that the straight, simple nock end is part of an older Scandinavian technical tradition (Farbregd 1972: 17-21).

Period/artefact ID	Nock	Haft	Point	Shaft	Shaft Width mm	Shaft Length cm
Early Bronze Age (1800-1200 BC)						
T25172	x		Shell	Betula	5.2-7.2	(67.9)
T25684	x	x	Shell	Betula	6.5-7	(-)
T23411	x		X	Betula	3.5-6	(43)
T24981/T25284	x	x	X	Betula	6-7	(-)
T24138	x		X	Betula	5.5-7	(48.3)
T25167	x		Antler	Betula	(3-4)	(-)
Late Bronze Age (1200-500 BC)						
T24367/T24982			Antler	Betula	3-6.5	55.3
T16056	x		Flint	Pinus	9-11	(41)
T25286.1&2		X	X	Betula	5.5-9.5	(82.3)

Table 6.2 Overview of the key technical and metric details of archery-related Bronze Age artefacts. The artefacts are arranged in chronological order. Metric values that either due to shrinkage or fragmentation are somewhat uncertain are in brackets.

None of the Bronze Age arrows show traces of adhesive at the nock end. Nor are any lashing imprints preserved. It is therefore difficult to link the way vanes were attached to the arrows with earlier or later periods- if indeed fletching was used? If we look to the Neolithic material recovered in recent years we see evidence for the use of adhesive and lashings along the proximal end in at least two instances (Callanan 2013: Figs. 5 & 6). Later, in the Early Iron Age there are two traditions with respect to the fixing of vanes. Arrows belonging to Type A usually have imprints from rounds of lashings with no indication that adhesive has been used. The other arrow group (Type B) usually has traces of both adhesive and lashings in the proximal end (Farbregd 2009: 160-161). Adhesive has been preserved on three of the eight Bronze Age arrows, perhaps indicating that the lack of adhesive on the proximal ends is real rather than simply a function of bad preservation? It appears that in the Bronze Age vanes were fixed to the shafts with rounds of lashings only, perhaps in line with the later A-Type from the Early Iron Age?

Adhesive

The Bronze Age finds show that a black adhesive has been used as a construction element in producing the arrows. As yet this material has not been identified chemically but is probably birch or pine tar (*e.g.* Pollard & Heron 2008: 241-257). Among the Bronze Age arrows traces of adhesive are found on the distal ends where it is evident either as a dark discoloured area (*e.g.* Fig. 6.6) or where remnants of the black material are still present (Fig. 6.2a & 6.7). There are also faint traces of adhesive on the bevelled joint on the segmented arrow T25286:1.

The clearest example of how the adhesive could be employed for fixing points to shafts is found in the case of the shell arrow (T25172) (Fig. 6.2a). Here an elongated wing of adhesive runs along the haft and shaft probably to stabilize the flat or round based point (*e.g.* Fig 6.3). The use of tar to affix points to shafts in this way is a technique documented elsewhere in the archaeological record in Europe. A number of examples recovered from the lacustrine lakeside dwellings sites in Switzerland, show the technique was also applied to lithic points (Müller-Beck 1965: 74a). A recent Bronze Age find on an underwater site in northeastern Germany that consists of a flint arrowhead with a distal shaft fragment covered in tar, illustrates how the edge of the projectile point was left to protrude from the pitch covering (Krüger et al 2012: Fig.5). This is similar to how the shell arrows probably appeared in their original condition. Another Bronze Age example of the same technique from Fiavé-Carera, Lago di Carera, Italy also includes a bone barb that protrudes backwards from the pitch at the base of the point (Junkmanns 2010: 527-528).

Adhesive was used widely on hafts during the Neolithic, Iron Age and Medieval periods too. In these periods and in contrast with the Bronze Age arrows, adhesive was used on both the proximal and distal ends.

Projectile raw-material variety 1- Shell Points

One of the most striking insights into Bronze Age archery gained from the recent snow patch discoveries is the variety of raw materials used for projectiles on arrows. This is related to the preservation conditions associated with snow patches. Osseous points have of course been found on other sites with favourable preservation conditions such as in caves. But the discovery of points in association with their wooden shafts makes these snow patch finds particularly informative. We begin by looking more closely at aspects of shell as projectile raw material.

Margaritifera margaritifera is a freshwater mussel that is currently a threatened species in a number of European countries including Norway. It has lowland, mainly costal distribution along most of the Norwegian coast. The highest documented population is found at 472 masl, which is considerably lower than the altitudes associated with snow patches (Dolmen & Kleiven 2008: 4-7). There are no parallels with these shell arrowheads in the archaeological record of Norway or Scandinavia. The use of shells as ornaments and tools has been documented in a number of regions of the world throughout prehistory (*e.g.* Douka 2012, Przywolnik 2003, Stiner 1999, Szabó *et al* 2007). Some examples of the use of shells for projectile and harpoon points are known from the Northwest coast of America (Stewart 1996). Solana and Zugasti also cite other examples from North and South America (2011:84). The arrowheads from Løpesfonna appear to be the first evidence of use of *margaritifera margaritifera* for either projectiles or toolmaking.

How effective is laminated mussel shell as a raw material for hunting projectiles? In their current state, the points appear weak and brittle and thoroughly unsuitable especially when compared to more common materials such as lithics, bone or antler. However, an examination of modern examples of *margaritifera margaritifera* shows that in a fresh state the shell material is both hard and stiff while at the same time suitably elastic. Individual valves have portions that are flat and from which reasonably sized points could be fashioned. The calcareus section of broken modern valves shows a substantial, homogenous layer of material that could easily lend itself to polishing or grinding. In summary, a simple visual consideration of these mussel shells as raw materials indicate that recently gathered shells would have been a fully functional and workable raw material. The worked shell points together with the extended hafting arms and pitch adhesive covering could be readily combined to make the shell arrows into lethal hunting tools.

As can been seen from the arrows from Løpesfonna the producers of these arrowheads succeeded in forming a flat portion of the shell into a point-like form that is easily recognizable. Examination of the second arrowhead indicates that the edges have probably been ground or polished, presumably in order to produce a sharp edge. Shell arrowheads were very light in weight and in this regard the use of shell is reminiscent of other light, lithic points such as transverse arrowheads and microliths that were in use during the Stone Age. In these instances the main role of the point was to provide a sharp cutting edge to the projectile rather than any significant weight contribution to the projectile as a whole.

The question of representativity raises itself once we attempt to assess the significance of these finds in relation to Bronze Age archery in general. Do these finds indicate that shell was a material commonly used by hunters in the Bronze Age? Perhaps this was simply a personal preference on the part of one particular hunter? Perhaps it was a one-off, never repeated experiment that happens to have been preserved in the archaeological record? In short, how representative of the general range of past behaviors in this period are these particular snow patch finds?

The use of shell as a projectile raw material is probably not as unusual as it first appears. For use as a projectile the hard, stiff shell does not appear to have had any serious technical major flaws that would exclude it from being used in this way. The points' form appears to correspond to morphologies known from the period. The manner in which they were hafted has parallels with over-regional traditions known from the time. And the arrows were recovered from within a small mountain area where most of the Bronze Age arrows have been recovered. In sum, the shell arrows have appeared in a manner and context that places them within some of the existing practices and norms of the time.

Marine shellfish were harvested and consumed through thousands of years along the coast of Norway, although few physical remains of their use remain today (*e.g.* Bjerck 2007). If marine or freshwater shells were commonly used in past tool production, why have no other shell artefacts been discovered elsewhere before now? Some of the answer may lie in the physical characteristics of shell as raw material in general. It is generally difficult to demonstrate anthropogenic modification of shells, as identifiable traces of modification are either hard to reconise or a quickly erased by exposure. (Przywolnik 2003: 16). Our mental templates with regard to appropriate tool materials may also be part of the answer. In short if we don't expect to find shell tools, we simply don't see them. In the case of the two shell arrows, it is highly unlikely that they would have been recognized as projectiles points if not for the fact that they were recovered together with wooden shafts at the foot of a known archaeological snow patch. As a result of this discovery, a process has begun where we now recognize that freshwater shells were in fact used as projectile points in the Bronze Age. This recognition transforms our mental templates and makes us better able to recognize shell tools in the future, provided they are there and are preserved. In this way the circumstances around the discovery and identification of the shell points found at Løpesfonna mirror the same processes of recognition and identification that actually apply to all classes of archaeological finds, from thunder stones to Dolmens. And as often as not, once an individual specimen is recognized to be of archaeological significance other examples of the same subsequently appear. In summary then, the shell arrows from Løpesfonna represent a single instance of a technical practice that does indeed belong to the past, more specifically the Bronze Age of central Norway. But as to the question of how widespread this practice really was, only time and subsequent recognizable archaeological discoveries will tell.

Projectile raw-material variety 2- Antler Points

We can now turn our attention to the antler points. Both are relatively simple forms, with beveled ends (Figs. 6.5 & 6.6). These Bronze Age antler points are the earliest dated example of osseous points we have from snow patches until now. Similar osseous point forms are known from coastal sites, although their precise age is unclear (Nummedal 1920: Fig. 15 &

Bøe 1934: Figs. 35 & 36). As the use of bronze as a projectile raw material was never in widespread in Norway, there has been longstanding discussion as to what projectile raw materials dominated in the time between the disappearance of slate and the emergence of iron (*e.g.* Brøgger 1925, Gjessing 1945 & Shetelig 1922). Bone and antler points are thought to have played a significant role in Bronze Age archery technology, but we know little about how they were used. For this reason the antler points presented here are of particular interest.

These are not the first osseous points found on snow patches in central Norway. Two bone points were discovered in the region during the 1930's (Farbregd 1972: 118-119; pl.1 nrs.1 & 2). Based on their morphological similarity with finds from Southern Scandinavia, these points were at the time typologically dated towards the second half of the Early Iron Age (*c.* AD300-600) (Farbregd 1972: 15). As part of the present study, one of the 1930's bone points was radiocarbon dated, in order to determine whether it might be older than previously thought. A sample taken from the shaft (T17694/ T17698e) found in direct association with the bone point (T17698f) was dated to AD255-409 (See Table 6.1). Analysis of the point shows it to have been made from reindeer bone. The radiocarbon dating confirms the previous typological interpretation and date. The new dates also demonstrate continuity of use, where osseous points were in use on hunting arrows during both the Bronze Age and Early Iron Age.

Bone and antler points have been found on snow patches in other regions of Norway too. One of the first reported snow patch finds in Norway was an 88cm long shaft of *Betula* (birch) found in 1937 together with a 10.5cm long bone point, at Storhøi, Lesja *c.* 45 km west of Løpesfonna. This arrow has a beveled tang and is dated typologically to the Early Iron Age (0-600AD) (Hougen 1937: 197-200). The majority of snow patch arrows dated to the Early Iron age in both southern and central Norway have iron arrowheads with flattened tangs (Farbregd 2009: 162-163). This indicates that the use of wooden shafts with beveled ends continued into the Early Iron Age, where they we used parallel with slotted distal ends (see Farbregd 2009: fig. 9).

Wood choices for shafts

The type of wood chosen for making the Bronze-age shafts shows another interesting pattern. Although the sample available for this period is still small (n=9), it is clear that during the Bronze Age *Betula* was the main wood type used for shafts (*e.g.* table 2). This contrasts with the situation in the preceding Neolithic where the few finds show a greater variety with pine and willow also in use (Callanan 2013). In addition, two of the Bronze Age shafts were produced on staves while in the Neolithic saplings were also used.

The reason for this development is unclear. It is difficult to a find convincing link between these technical shifts and changes in the composition of local forests at the end of the Neolithic period. Pollen diagrams from inland sites *c.* 35 km to the south of the central Norwegian snow patches do indicate a resurgence of *Betula* at around 2000cal BC (Gunnarsdóttir & Høeg 2000).

However, it is unlikely that this in itself is enough to explain the shift to *Betula*, as this tree was available even during the preceding warm period. It seems more plausible that these shifts are the result of changes related to shaft production. Here we are not suggesting specialized production of any kind. A look at the morphological variation on all elements of the recovered shafts shows that the standardization visible in later periods is still a long way off. Rather, with the move to *Betula* as the dominant raw material for shafts, we may here be witnessing the establishment of an archery related technical norm during the Bronze Age –that the proper wood material for arrow shafts was birch staves.

This completes the detailed presentation of snow patch artefacts from central Norway dated to the Bronze Age. Eight arrow shafts is insufficient material to form a chronological framework or typology and these finds should not be viewed in this manner. But both in detail and in general, the arrows do contribute greatly to our knowledge of the archery technology of the period. The most striking general impression one gets from this material is that of a surprising variety. This applies both to the morphology of the hafts and to the projectile raw materials utilized. This variation stands in contrast to the general impression one gets from lithic point chronologies for the period, where only slight variations on some very general themes are for the most part visible.

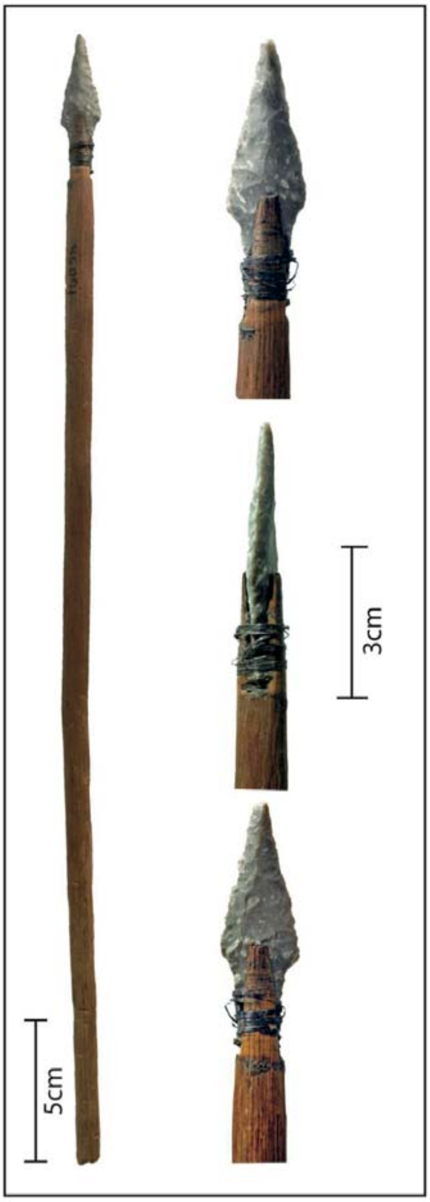


Figure 6.10 (T16056)-The arrow discovered during bog-cutting on the Island of Frøya, Sør Trøndelag during the 1940s. This arrow returned a Late Bronze Age date. Photo: Åge Hojem/NTNU-Museum of Natural History and Archaeology. Layout Martin Callanan.

Other General Snow patch issues

We now turn our attention to the contextual conditions surrounding some of the Bronze Age artefacts presented here. These are observations specific to snow patch archaeology that may be of value in other snow patch regions.

Favourable Micro-contexts on Snow Patches

The finds presented here were recovered by volunteer collectors in circumstances familiar from earlier discoveries- the shafts and arrowheads lay exposed on the foreground below snow patches that had melted sufficiently. However a couple of interesting circumstances can be further underlined.

The first relates to the snow patch at Løftingfonnkollen, where one of the plain shafts (T24138) was recovered in 2008. The snow patch here is extremely steep and runs downhill into a small pond surrounded by a rough, rocky forefield. An iron arrowhead typologically dated to between AD600-800 was discovered below the patch at some date prior to the 1950's (Farbregd 1972:125).

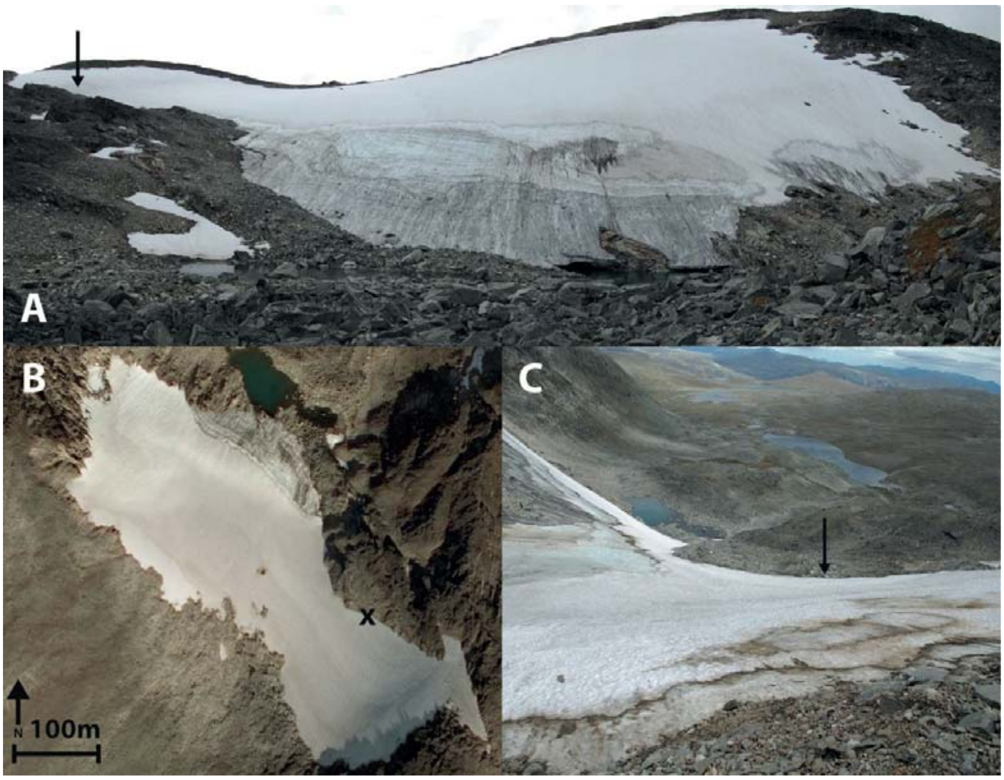


Figure 6.11 The snow patch at Løftingsfonnkollen on (a) 14th Sept. 2008. (b) 17th Sept. 2008. (c) 21.Aug. 2010. The find location of the Bronze Age shaft (T24138) is marked. Photo: Geovekst, Statens kartverk, Norkart AS (b) & Martin Callanan (a & c).

Nevertheless it was considered unlikely that this snow patch would produce organic artefacts. The snow patch appears to be very active and it was felt the rapid turnover of ice and snow along the steep slope would destroy any organic artefacts the patch might contain. It was therefore a surprise when in 2008 a local collector recovered two wooden artefacts from the site. The question was 'how did a 3500 year old wooden object manage to survive in such an environment?'

Individual snow patches are sometimes described as steep or flat, high or extended. On some snow patches however it is difficult to apply one simple description that expresses the character or nature of the snow patch as a whole. Small variations and nuances along individual patches' extent can create micro-topographies or contexts that might impact greatly on artefact preservation. Løftingfonnkollen is a case in point. Aside from the steep, active main bod, the patch has a section to the south east that is blocked by a rocky ridge. The ridge prevents this side of the snow patch from running down the full face of the slope. The organic artefacts were recovered along the base of this ridge where it appears the movement of the ice has either been halted or deflected. There must have been relativity little movement of the ice and snow in order for the shaft to have survived in its present condition. Therefore while this snow patch appears too dynamic for organic artefact preservation at the macro-level, small differences in the surrounding topography have created favorable micro-level circumstances from which well-preserved organic artefacts have been recovered. The fact that hunting implements are recovered from flat, more stable parts of alpine snow patches is likely also linked to the fact that these were more attractive sites for animals to stand on than rather than other steeper sections. It is probably on flatter sections like this that hunting episodes took place on otherwise steep sites. The important point is that some apparently unpromising sites appear to have micro-features or sections that create conditions favorable for artefact recovery and preservation. Flat or otherwise enclosed sections of snow patches appear to have a higher potential for finds than steep, active slopes. This observation may prove useful to others when carrying out field surveys with the aim of visually identifying new snow patches with the potential for archaeological finds.

Surveying Disappearing Snow Patches

The second issue relates to artefact recovery from patches in the final stages of degradation. This is the case on a number of snow patches in the region, where during extreme melting events only flat sheets of ice survive (*e.g.* Farbregd 2009: Fig.1). These are the last remains of the patches' ice cores that once covered much larger areas. Two of the finds (T25167 & T23411) reported here were discovered under such circumstances above the upper edge of the flat northern section of the snow patch at Storbreen in 2010. It seems that these finds were not released from the ice in the usual manner by either being exposed or released onto the forefield below the face. Rather they appear to simply have become exposed once the ice above or around them had melted. In itself, it is an interesting observation that 1600-year-old finds are recovered from the upper portions of a melting snow patch - Especially in light of questions regarding whether or not there are significant throughputs of snow and ice associated with patches. However, the observation may have implications for snow patch surveying strategies too.

When surveying snow patches, there is often a tendency to follow the current edge whilst looking for exposed artefacts. As productive snow patches continue to decline and reduce in size, the two 'upper' finds highlighted here remind us of the importance of surveying the entire area, both above and below the base of the snow patch and not just the forefield. Surveying in this manner is familiar from field walking and is probably significantly more time consuming than simply controlling along the snow patches' edges. But at the same time, the potential for recovering artefacts missed on previous occasions once the basal remnants of productive snow patches melt appears to be high.

Implications of Degradation on Wooden Shaft Metrics-A Cautionary Tale

The third issue these new finds raise is related to changes in the dimensions of artefacts following their discovery. Well-preserved arrows from snow patches are rare and crucial to our understanding of past projectile technologies. The metric dimensions of prehistoric points and particularly shafts are regularly measured and collated in the search for chronological and or regional patterns that are potentially significant (*e.g.* Farbregd 2009: Fig. 9; Junkmanns 2010 & Callanan 2013: Table.2). At present, wooden snow patch artefacts usually receive no active conservation. Once they have been stabilized in the conservation laboratory they are allowed to dry under controlled conditions and at a controlled rate. However, while analyzing this material in the time between the discoveries until 2013 we have noticed that some of the artefacts have slowly decreased in size. This is especially obvious in relation to shaft diameters on some of the artefacts reported here. In figure 5b we see that although the bevels on the antler point and wooden shaft were the same size at the time of use, the wood of the shaft's distal end has shrunk considerably. Figure 6.7 also provides a comparative example of the condition of different distal ends of similar age. Researchers in other regions have noted the same phenomenon too (*e.g.* VanderHoek *et al* 2007:197-198). It is difficult to know what can be done to avoid this potential problem until information on post-depositional processes pertaining to ancient wooden objects under frozen conditions has been gathered systematically. Beginning with the season of 2013, we are hoping to monitor this process by measuring the metrics of shafts as soon as possible following discovery. Measurements can then be repeated at regular intervals in order to get firmer data on the nature and extent of this potential problem.

At present when reporting the dimensions of recovered finds, one has to rely on a subjective consideration of the degree of degradation on individual artefacts. If there is a suspicion that individual artefacts have changed significantly following discovery, it is important that these are instances are flagged or excluded as has been done here (Table 6.2). And until we know more about material degradation and post-recovery changes that wooden shafts go through in general it might be wise to view the metric values from snow patch artefacts as minimum values in terms of past archery technological parameters.

Conclusion

The eight archery related artefacts presented in this paper confirm that archaeological materials from the Bronze Age have been appearing regularly on alpine snow patches during the period 2003-2011. The points and arrows are of great value in extending our knowledge about how and when snow patch sites were used in the region. The findings are also a further confirmation of earlier work that has demonstrated the emergence of significant numbers of Neolithic materials on the same sites during the same time frame (*e.g.* Callanan 2013). Seen together, these results demonstrate that as snow patches continue to melt and degrade, the archaeological materials recovered are getting successively older. Several of the sites that have produced Bronze Age and Neolithic artefacts, still have large ice cores that remain intact. This means that we can expect more exciting Neolithic and Bronze Age discoveries on snow patches in the region in the years to come.

Chapter 7 – Synthesizing Chronological and Geographical Patterns 1914-2011

Introduction

Chapters five and six focused on individual objects from the Neolithic and Bronze Ages that were identified and dated during this project. In this chapter, these artefacts are reintegrated with the rest of the snow patch collection in a series of broader analyses. The different analyses chart the main chronological and geographical trends in the central Norwegian snow patch region between 1914 and 2011. All 234 artefacts found on the region's 28 sites were examined. Of these 199 were found to be dateable. These finds are examined in relation to their archaeological age, the find date and the location of their discovery. The main aim of the analysis is to map temporal patterns in the record of prehistoric snow patch hunting in the region. Tracking the organic and inorganic composition and timing the recovery of individual finds will highlight any significant temporal patterns produced by melting events over time.

Portions of this material has been analysed previously in different formats by Farbregd (1972, 1983: Fig. 2, 2009: Fig. 4). These studies highlighted interesting chronological and geographical patterns among parts of the collection (see Chapt. 2: 43-44). The present analysis differs from earlier presentations in three ways. First, the finds are ordered according to their material composition (*i.e.* organic or inorganic). Second, in each analysis the artefacts are ordered according to the recovery phase during which they were discovered. Finally, the analysis in this chapter is the first follow-up on earlier questions to include the large number of finds recovered since 2001.

Chronological analysis

Recovery Phase 1-1914-1943

The first phase of discovery is characterised by a large number of finds recovered in a relatively short period of time (see Chap. 3: 184-185 for a detailed description). Sixty-eight of the finds were dateable. There are three radiocarbon determinations from this recovery phase, the remaining dates have been estimated typologically. An overview of the chronological profile of finds from this phase is presented in table 7.1.

Chronological distribution of snow patch finds from central Norway during **Phase 1 (1914-1943)**

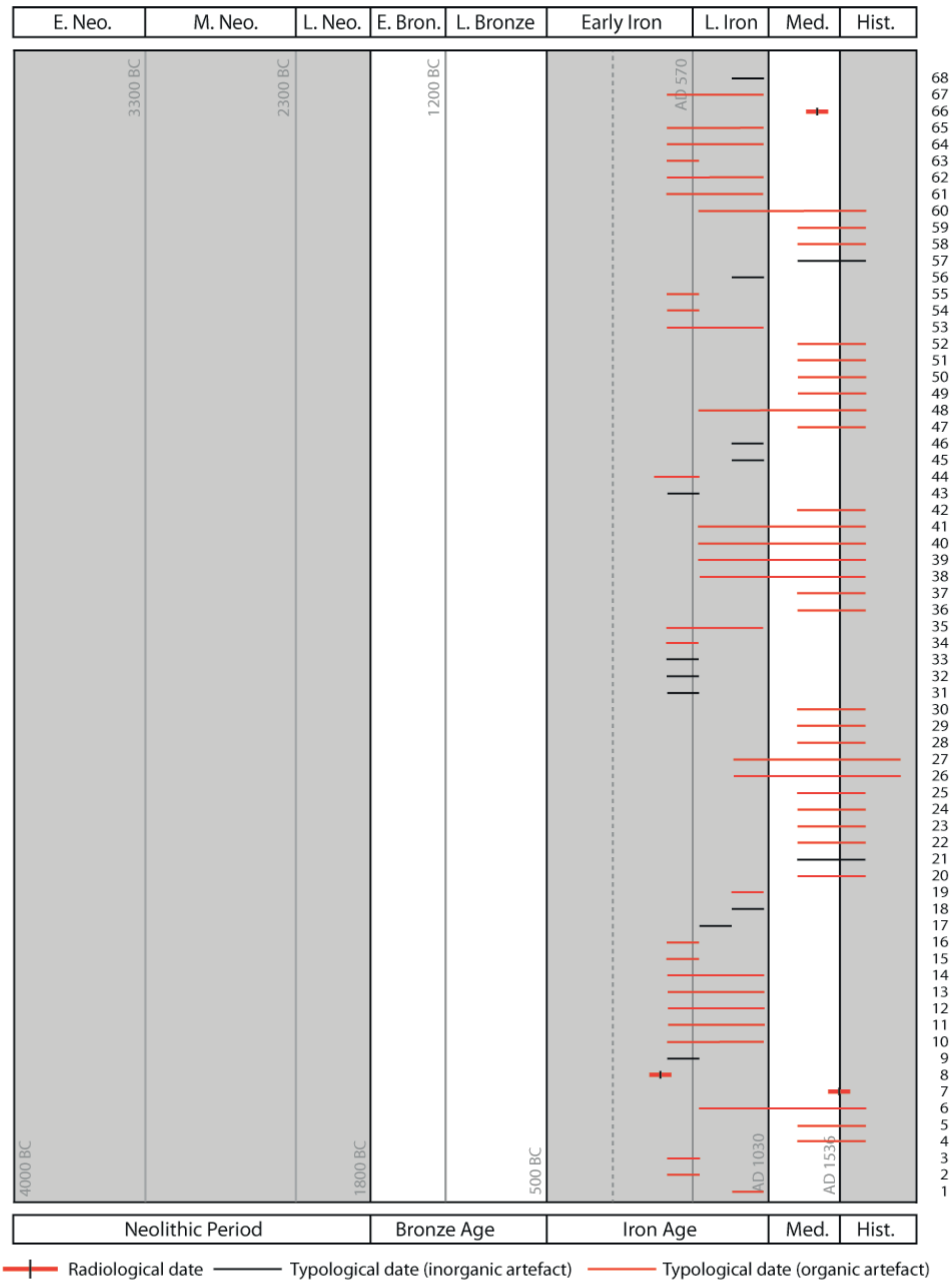


Table 7.1 Chronological overview over finds from central Norway during phase 1 (1914-1943).

Many of the finds were in good condition with elements such as sinew lashings and birch bark wrappings recovered on a number of arrows (Farbregd 1972: pl 1-13). This is reflected in table. 7.1 where artefacts with preserved organic components clearly dominate. This further underlines the dramatic nature of the melting events during the 1930's where many well-preserved finds emerged from snow patches.

Clear temporal clusters are visible in the overview over phase one. Finds from two periods dominate the material during this phase: the Migration period (AD400-600) and Early to Late Medieval Period (AD1200-1700) (Farbregd 1972 & 1983). The chronological patterning in the material from this phase is particularly neat, without any significant outliers. The chronological development is stable with no obvious changes in the age of the finds as they were recovered year after year.

In the phase one overview (Table 7.1), we see for the first time how the broad dating ranges associated with certain periods affects the chronological resolution. In particular there are 22 finds that belong to the dating groups '*post* AD600' and '*ante* AD1000'. Only one artefact from phase one was radiocarbon dated as part of this project (see chap 4.4.3). The ^{14}C date confirmed the prior typological estimate, while also reducing the temporal resolution from *c.* 300 to 150 years

Recovery Phase 2 (1944-2000)

This is the longest of the three recovery phases, but is also the phase during which fewest finds were produced. During this 60 year period 12 new artefacts were discovered, all of which were dated typologically (see Chap.3). The main chronological characteristics observed during phase 1 are repeated in recovery phase 2. Again the finds range in age from AD400 to 1700. The relationship between organic and inorganic finds remains balanced. Only one complete arrow was recovered during this phase. The others have all been damaged or fragmented in some way. Overall phase 2 is something of a hiatus, during which few finds were extirpated from snow patches even during hot summers when the ice cores on a number of sites were exposed (*e.g.* Farbregd 1983).

There is also a small group of finds for which the date of discovery has been lost. It was therefore not possible to assign these to a specific phase. However, the finds were all entered into the museums catalogue in 1955. Therefore they belong to either recovery phase 1 or 2. These finds are included in Appendix 2 in a separate section. The chronological profile of this group is mapped in table 7.2, where the finds are arranged according to their museum number. There is nothing in the composition or age distribution in this group that has the potential to disturb the tendencies already noted for recovery phases 1 and 2.

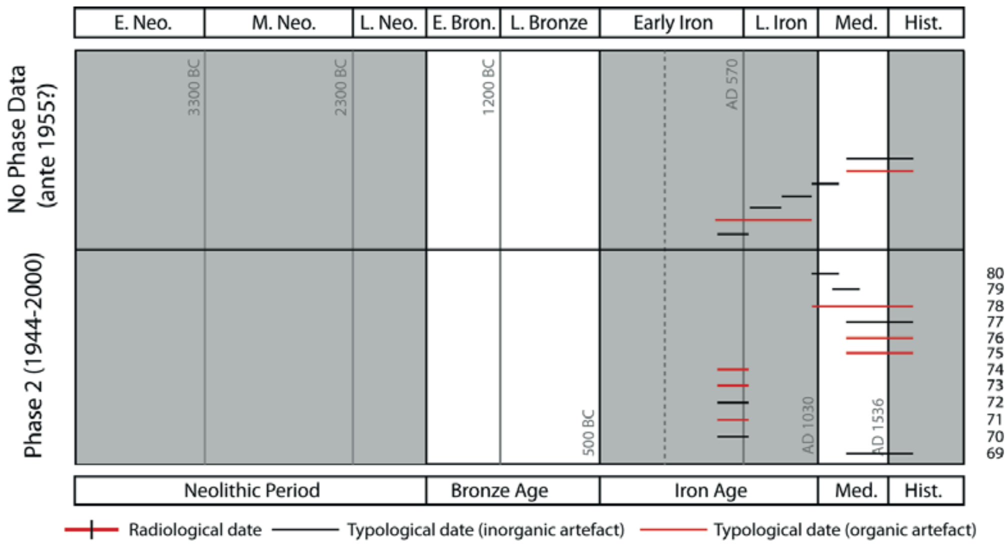


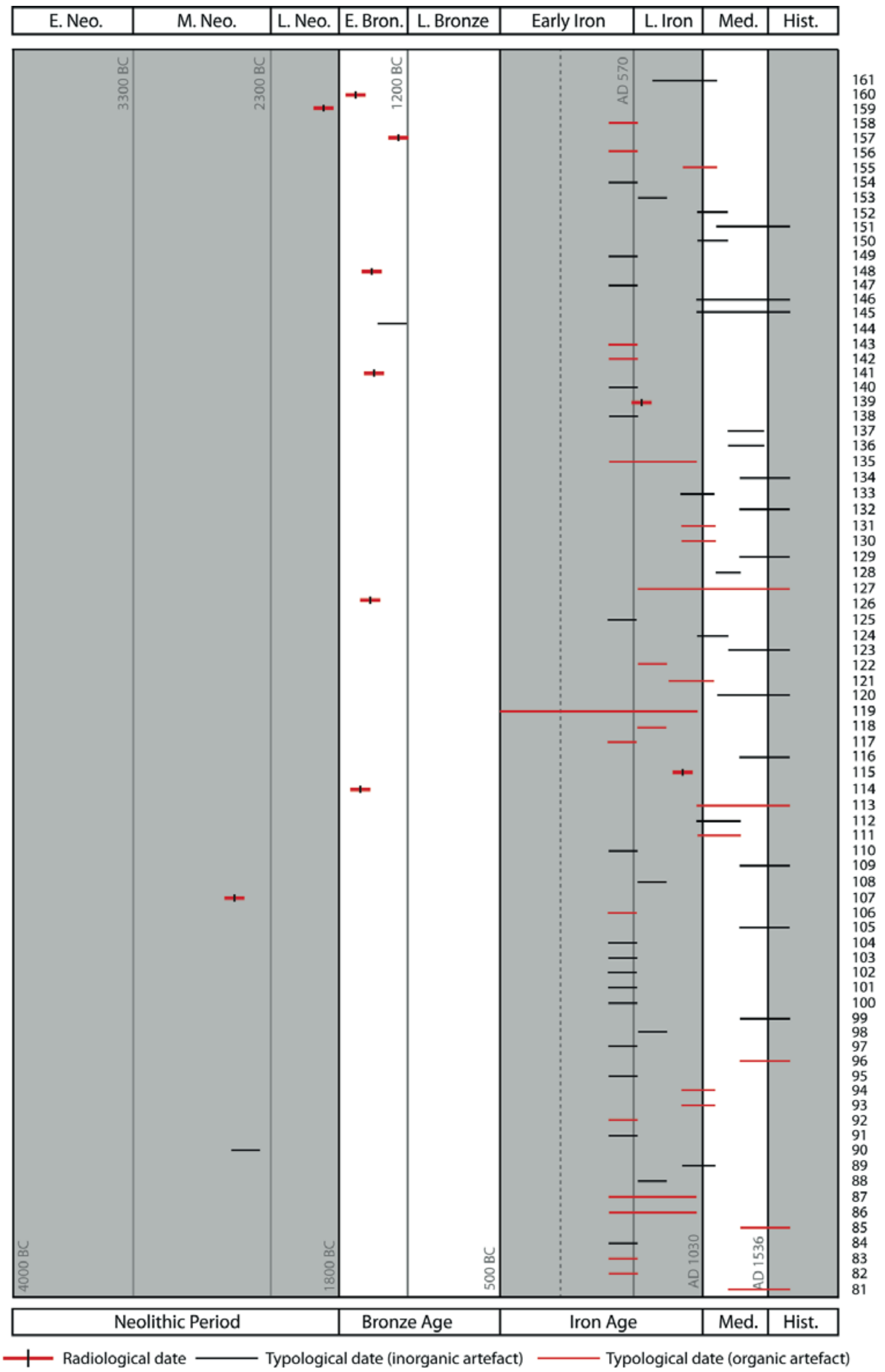
Table 7.2 Chronological distribution of snow patch finds from central Norway from 1944-2000 (Phase 2). Also included are seven artefacts could not be assigned to a specific phase.

Recovery Phase 3 (2001-2011)

The situation changes once we enter the recovery phase between 2001 and 2011. During this period, 145 artefacts were recovered from sites in the region. 112 of these were dated using both typological and radiocarbon methods (see Fig. 4.10). Table 7.3 is a presentation of all dateable artefacts recovered during this third phase. Several developments that stand in contrast to the situation during phases 1 and 2 are visible in this table. The numbers of finds recovered has risen significantly. The age of the oldest finds has increased from c. AD300 to 3400BC. It is still possible to see clusters on the periods AD400-600 and AD 1200-1700, at least during the first half of phase 3. But in general the chronological distribution is now more muddled and spread out than before. Inorganic finds appear to now dominate the finds being recovered.

However, the overview presented in table 7.3 is distorted as it contains elements that are not fully commensurable with finds in the overviews from phases 1 and 2. A large number of artefacts recovered during phase 3 were discovered using metal detectors. Finds recovered in this way have the potential to distort the true picture of the natural appearance and extirpation of artefacts from the snow patches as they melt. As a result the overview for recovery phase 3 needs to be adjusted. Before we can adjust the dataset for phase 3, we need to first examine the profile of artefacts recovered with metal detectors during the last ten years.

Chronological distribution of snow patch finds from central Norway during **Phase 3 (2001-2011)**



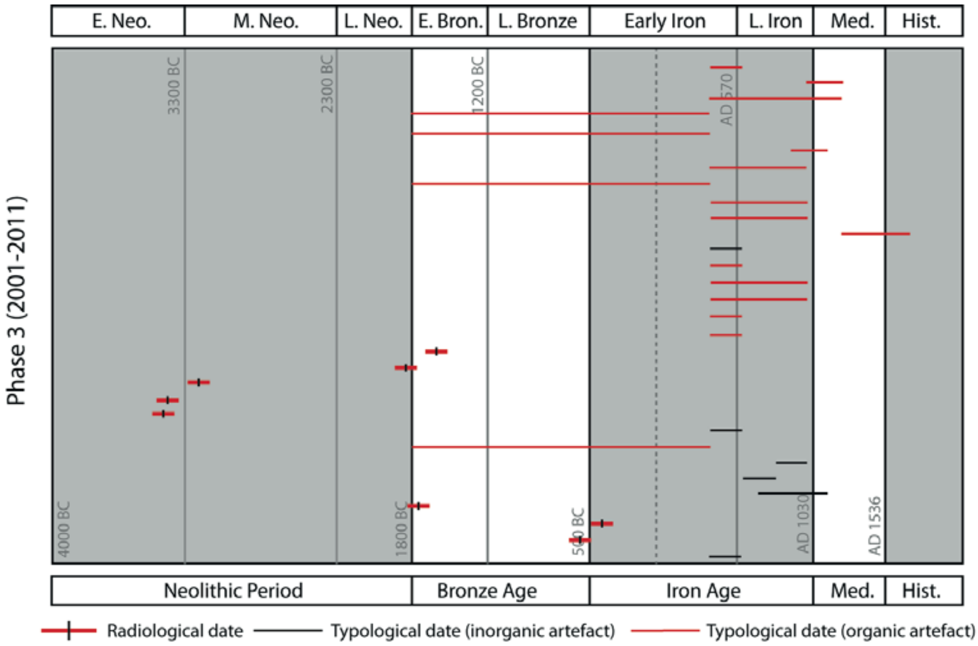


Table 7.3 Overview of all dateable snow patch finds from central Norway during Phase 3 (2001-2011).

The 'Problem' with Metal Detector Finds

The introduction of metal detectors during snow patch surveys is an important development that has contributed greatly to the number of finds recovered. Methodological aspects of this development have already been discussed in Chapter 3. Between 1914 and 2000 collectors did not use metal detectors. The finds from this period were all surface finds that were visible either on the ground or on the surface of snow patches. And as we have seen, phase 1 was characterised by a large number of organic finds. From this we can conclude that the finds recovered during phases 1 and 2 were either exposed or extirpated from their patches at a point in time relatively close to the moment they were discovered. Otherwise they would most likely have been damaged either by exposure or erosion. Researchers in other snow patch regions have made similar conclusions based on field discoveries and observations-that the period of time between exposure and discovery of surface finds on snow patches must be relatively short. This is especially true with respect to organic finds or components (Lee *et al* 2006: 38; Grosjean *et al* 2007:206; VanderHoek 2007(b):197; Hafner 2012:193).

Metal detector finds have a different background. These artefacts are not usually visible on the surface as they have been covered by mud and gravels or have become otherwise lost in the rocky fields that surround most patches. The environment around snow patches is very dynamic, which makes it difficult to estimate the rates of solifluction and the time scales involved in artefacts becoming covered in gravel and mud once they have emerged from the snow patch. However, it seems clear that the metal detector finds are artefacts that melted out of the snow patches at earlier dates. Because they were not discovered within a reasonable period of time, the organic component is now lost.

Because of these differences, comparing the metal detector finds from recovery phase 3 with surface finds from the earlier phases could be problematic, depending on the line of questioning we are following. If we are simply interested in the artefacts' age and location, the metal detector finds can be combined with the other surface finds from phase 3 with no further ado. However, if the aim of analysing chronological developments is to get a better view of the nature and frequency of melting events on snow patches, the metal detector finds should be removed from the dataset.

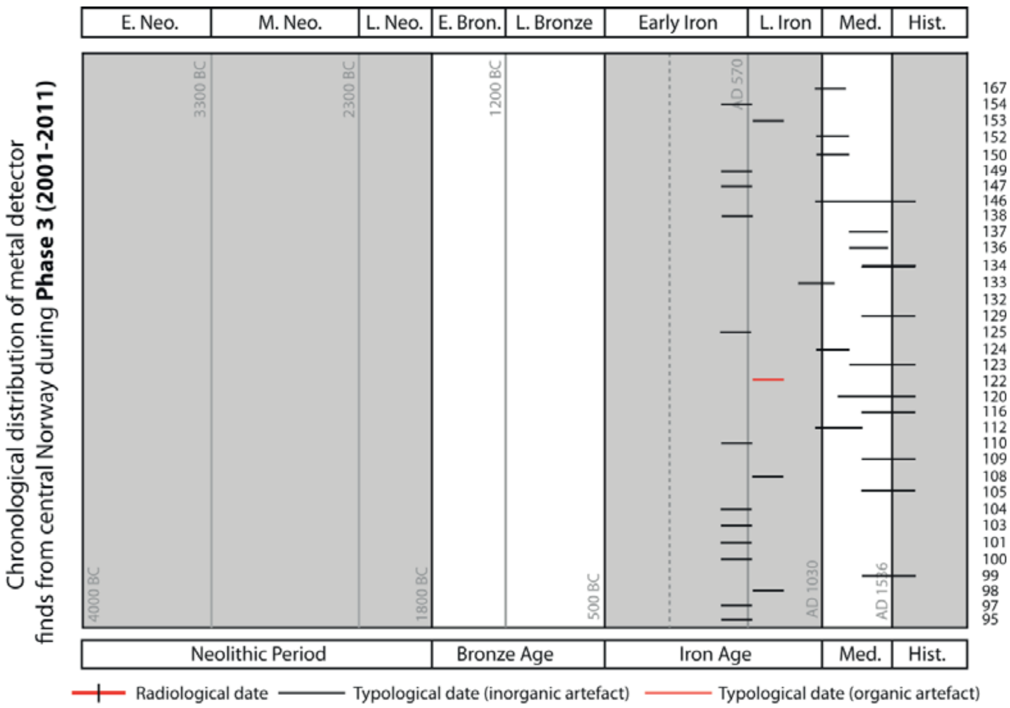


Table 7.4 Chronological distribution of artefacts discovered with metal detectors during the period 2001-2011.

This is because they are not a product of recent melting events, but rather they emerged during previous melts and have only been recovered due to the application of a new method. Including metal detector finds in the overview of phase 3 inflates the find numbers, giving the impression that more finds have melted out of the ice during the last 10 years than is actually the case. Their inclusion also has the effect of distorting the numerical relationship between organic and inorganic finds. This is due to the fact that the method specifically targets iron components of finds that for the most part have already lost their organic components. For these reasons, it is necessary to remove artefacts that have been recovered by way of metal detectors from the overview of finds from phase 3. Table 7.4 gives an overview of the chronological profile of the 34 metal detector finds discovered during recovery phase 3.

Predictably, inorganic iron arrowheads dominate this group of finds. Other interesting chronological tendencies are also evident. As a whole the finds range from c. AD400 to 1700 as is the case in both phases 1 and 2. This is not surprising, as we have yet to find iron arrowheads on snow patches prior to this date (Farbregd 2009: fig.9). Within this general distribution, two clusters are visible. These are during the periods *c*. AD400-600 and *c*. AD 1200-1700. Again this repeats the general pattern demonstrated in recovery phases 1 and 2.

Another interesting feature of this group of finds is that it includes five arrowheads that date to the period AD600-800. The lack of finds from this period is one of the characteristics of recovery phases 1 and 2. Between 1914 and 2000, only one iron arrowhead from this period was discovered, although at least some of the disassociated shafts found during these periods are likely to originate from this phase too. Previously, it has been suggested that the lack of finds from between AD600 -800 might be the result of subsequent melting events, during which the arrows were extirpated from the snow patches and lost (Farbregd 2009:161). The five arrowheads recovered with metal detectors appear to confirm this suggestion. If we are correct in presuming that metal detector finds recovered from under sludge and gravels originate from melting events prior to the early 1900s, then the metal detector finds give an insight to the chronological profile of finds that were lost before regular site surveys began. In a way they represent a hypothetical Phase 0 prior to 1914. If this interpretation is correct than the metal detector finds complement the picture we have of recovery phase 1 to a certain degree. However, it is at present impossible to give a precise estimate as to when they initially melted out of the snow patch based on an archaeological analysis alone. This question requires specialist studies that would need to look at solifluction rates in peri-glacial and permafrost environments as well as at the condition of the artefacts. The position of these finds might also play an important future role in reconstructions of snow patches past extent, as they might potentially give an indication of how large or small snow patches were when the artefacts melted out in the past.

Figure 7.1 Iron arrowheads dated to between AD600-800. These were recovered between 2003 and 2011 from around snow patches using metal detectors. (L-R: T23063, T22982, T25671, T25419 and T23400:1. Photo: Åge Hojem. Layout: Martin Callanan.

Reassessing the Recovery Phase 3 Chronology

With the metal detector finds now reviewed and isolated, we can return to the remaining phase 3 artefacts and reassess the chronological distribution of finds that emerged during this recovery phase. The revised overview of dateable artefact discovered between 2001 and 2011 is presented in table 7.5.

The first noticeable feature of the revised distribution is that artefacts with organic components once again dominate the overview of the period. The fact that so many 'fresh' organic finds are again appearing on sites after the 60 year long hiatus of period 2, demonstrates that during this period snow patches have in a sense reawoken, having been subject to a series of hard melts in recent years.

In terms of the chronological distribution, a number of points can be highlighted. The revised overview confirms the general impression that finds emerging from local snow patches are now significantly older than they were in earlier periods. The age of the oldest artefacts discovered has increased dramatically during recovery phase 3. At the turn of the millennium, the oldest finds recovered from snow patches were dated to *c.* AD300 (T15886). At the end of 2011 the oldest finds can be dated to *c.*3400BC. This is a significant new development on sites that, over time, have shown themselves to be relatively stable, producing finds from within clearly defined chronological parameters.

The overview from recovery phase 3 provides clear evidence that this development is not simply based on one or two outlying finds. Rather the trend towards increasingly older finds has unfolded throughout phase 3 and includes both Bronze Age and Neolithic artefacts.

The number of finds from the Medieval Period (*i.e.* AD1200-1700) shows a marked reduction. It is also noteworthy that the few organic finds that can be dated to this period are all damaged in some way or another and only recovered as fragments or sections. This stands in contrast to the situation during phase 1, when a large number of whole, well preserved medieval shafts were recovered (Farbregd 1972).

Arrowheads and shafts from the Late Iron Age (AD800-1030) are still being recovered in significant numbers, although the coarseness of typological dates after this period may be distorting the picture somewhat.

The Migration period (AD400-600) is still well represented in the finds from recovery phase 3. This includes both organic and inorganic finds.

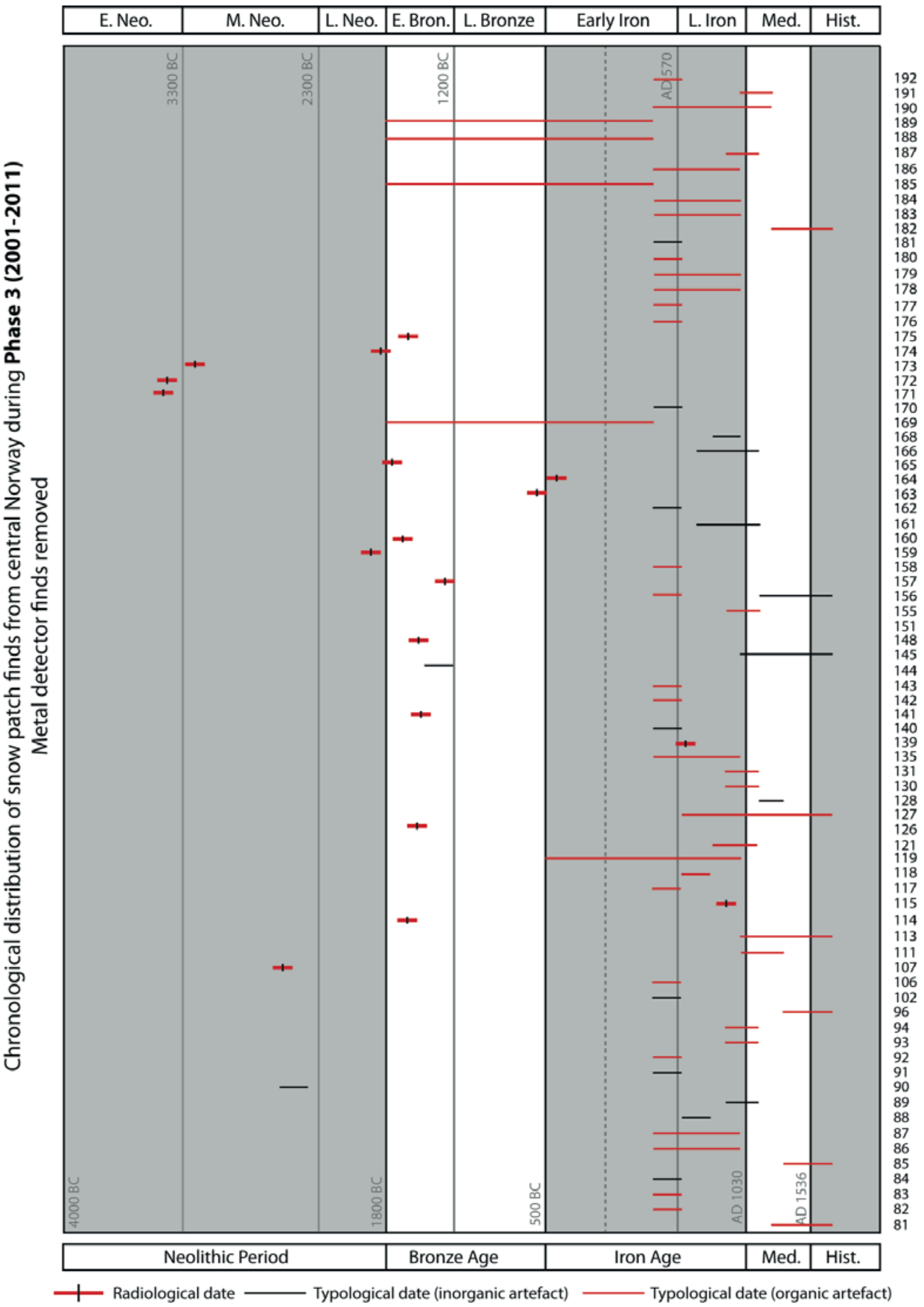


Table 7.5 Chronological distribution of snow patch finds from central Norway between 2001 and 2011 once metal detector finds are removed.

During recovery phase 3, it is also noticeable that finds from the period c. 1300-400BC are absent from the sample. This gap in the snow patch chronology has only become visible since the discovery and dating of the older Bronze Age and Neolithic artefacts. This corresponds to the Late Bronze and start of the Early Iron Age locally. The overview shows four shafts that may belong to this period, but this is as yet still uncertain.

Finds from the Bronze Age are markedly weighted towards the Early Bronze Age (1800-1200BC). It is also noteworthy that these finds have been recovered regularly throughout phase 3. Again there is a degree of uncertainty regarding at least four undated shafts that may belong to this period. But should they subsequently show themselves to be from the Early Bronze age too, this will only reinforce the tendencies noted here.

Until now six finds can be attributed to the Neolithic period. The three oldest finds cluster at around *c.* 3300BC. These were all discovered during the 2011 season which stands out as by far the single most productive snow patch season to date (See figure 3.5). The clustering of Neolithic finds appears to be a result of one single, hard melting event rather than the regular melt patterns seen up to this point. But perhaps this is an early notice as to the kind of finds that may appear on these sites in the future?

Geographical analysis

Introduction

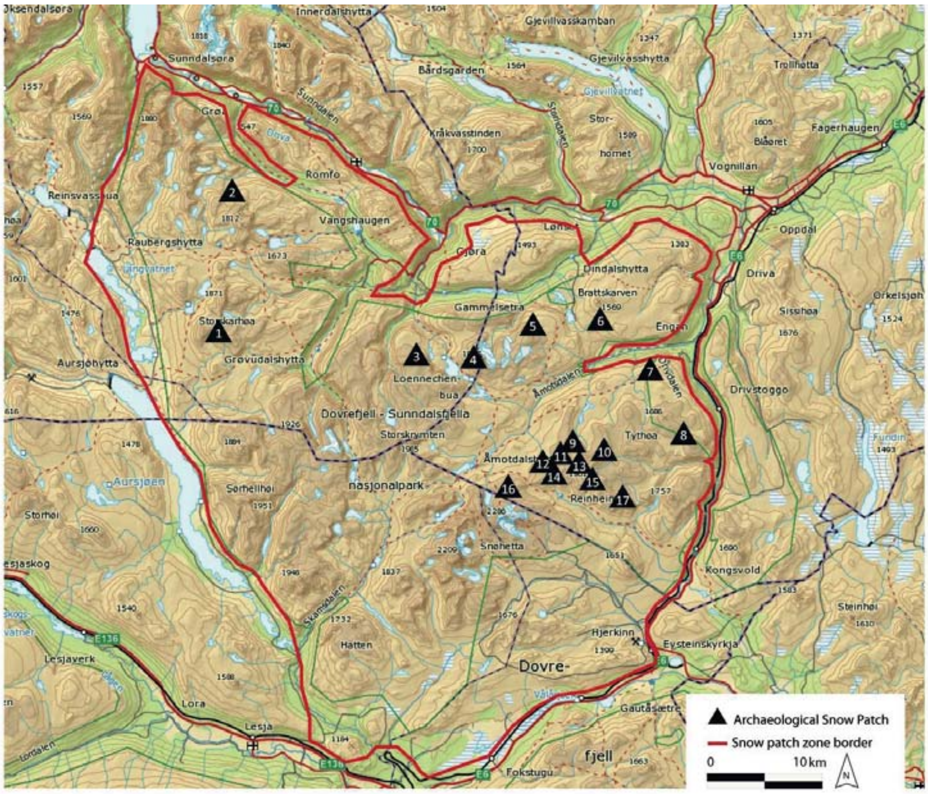
With the chronological layer now in place, we can dig deeper into the material by looking at how chronological patterns vary according to the geographical zone in which finds were made.

The region's 28 snow patch sites have been divided into four geographical zones (see chap. 4). The zones Snøhetta East and Knutshø account for the majority (99%) of finds in the collection. The number of finds in Trollheimen and Snøhetta West is still too low to impact on the overall geographical distribution. Therefore only Snøhetta East and Knutshø are analysed geographically here.

As before, we must alternate presentations of the distribution of finds in each zone where metal detector finds are either included or excluded. When metal detector finds are included, the resultant pattern represents past hunting activities as they have been preserved on patches. Once the metal detector finds are removed we get a more precise picture of how melting has progressed in the two zones during recovery phase 3.

Snow patch zone- Snøhetta East

The 17 snow patches in the Snøhetta zone have produced a total of 91 archaeological artefacts (Fig. 7.2). Table 7.6 shows how finds have appeared on sites in this zone through the three phases of discovery. The large and productive snow patch Storbreen dominates the zone numerically.



Snøhetta East- Archaeological Snow Patches (n= 17)

1. N. Svarthammaren. 2. Råstu. 3. Skirådalskardet. 4. Skiråtangen. 5. Svartdalskardet. 6. Tverrfjellet. 7. Gravbekkfonna. 8. Hesthågåhøa. 9. Løftingfonnkollen. 10. Namnlauskollen. 11. Løpesfonna. 12. Vegskardet. 13. Storbreen. 14. Håråkollen. 15. Kinnin. 16. Snøhetta. 17.Kaldvellkinn

Figure 7.2 Location of the archaeological snow patches within the Snøhetta East zone.

However, Løpesfonna and Løftingfonnkollen also have produced important finds in recent years (See chap. 5 & 6). Despite the fact that surveys have been carried out on both

Storbreen and Løpesfonna, none of the artefacts from the Snøhetta East zone were recovered using metal detectors. (Jostein Mellem, Oppdal. pers. com. 2014).

In table 7.7 we see the chronological distribution of finds from sites in the Snøhetta East zone between 1914 and 2011. Six archaeological snow patches, producing 24 finds were identified in the Snøhetta East zone during phases 1 & 2. During these phases the majority of finds discovered on sites in the zone dated to the Iron Age. There were few finds from the Medieval and historical periods, especially when compared with snow patch zone at Knutsø (Farbregd 1983:10-12).

	Phase 1	***Phase 2***	***Phase 3***	***Data lost***	***Total***
Storbreen	16	2	28	2	48
Løpesfonna	1	1	16		18
Løftingfonnkollen			2	1	3
Tverrfjellet		1	2		3
Vegskardet		1	3		4
Hesthågåhøa	1				1
Snøhetta		1			1
Kaldvellkinn			3		3
Skiråtangan, Sunndal			1		1
Råstu, Sunndal			1		1
N. Svarthammaren, Sunndal			1		1
Gravbekkfonna			1		1
Namnlauskollen			1		1
Kinnin			1	1	2
Skirådalskardet			1		1
Svartdalskardet			1		1
Håråkollen			1		1
Totals	**18**	**6**	**63**	**4**	**91**

Table 7.6 Distribution of finds through time on sites in the Snøhetta East Zone

Since 2001, a number of important developments have taken place in this zone. A total of 12 new sites have been discovered and 63 new finds have been recovered. As before, Storbreen plays a leading role in these developments, contributing almost half of the total number of finds. No new large, productive sites have been discovered in this area during phase 3, despite considerable surveying activity. Another important development is the discovery of productive sites in the west of the zone, along the mountain border between

Oppdal and Sunndal municipalities (Fig 7.2). Until now survey activity has been sporadic in this western area, despite having promising topography and rich history of reindeer hunting.

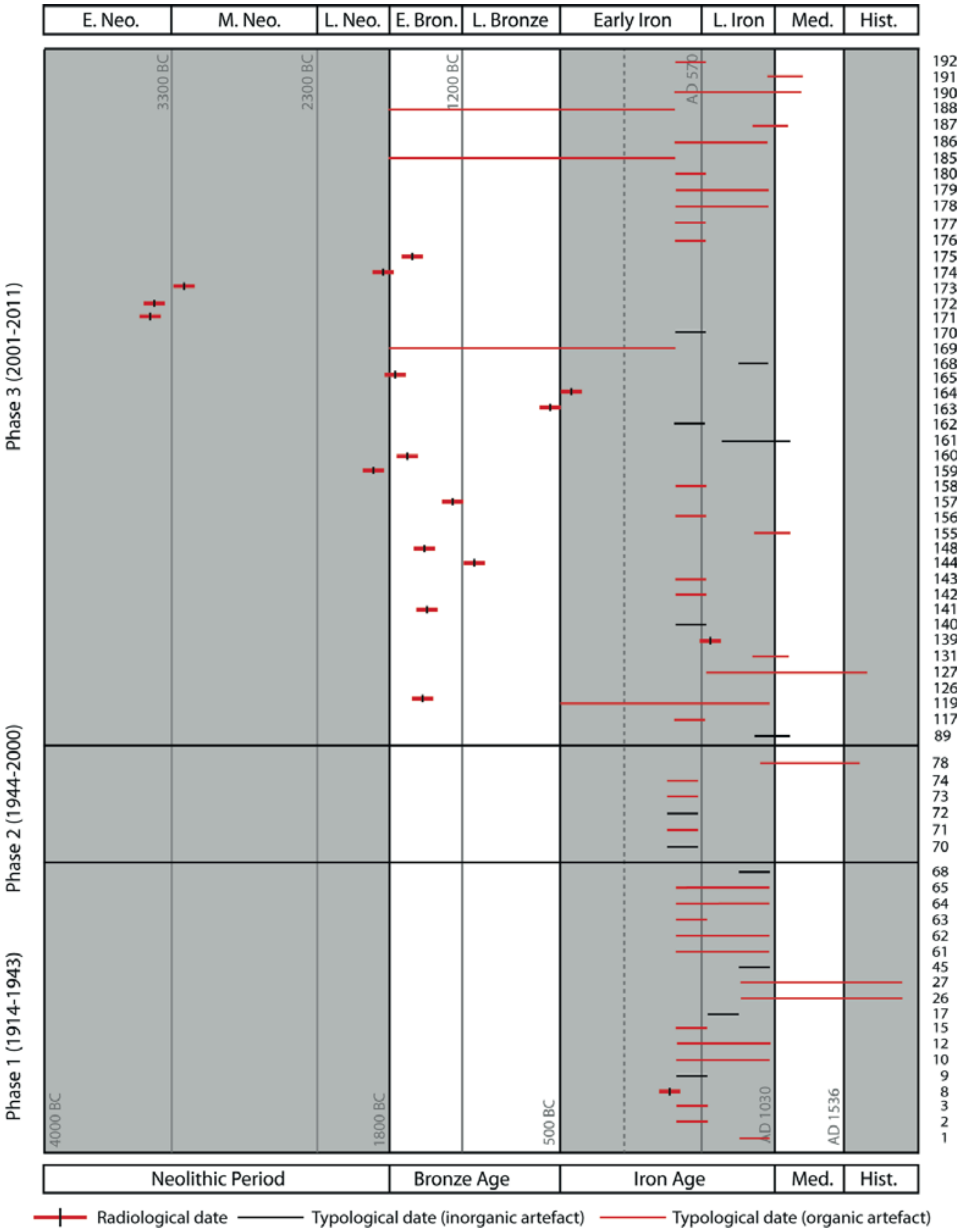


Table 7.7 Overview of the age of all finds from the Snøhetta East zone during all three phases of discovery (1914-2011).

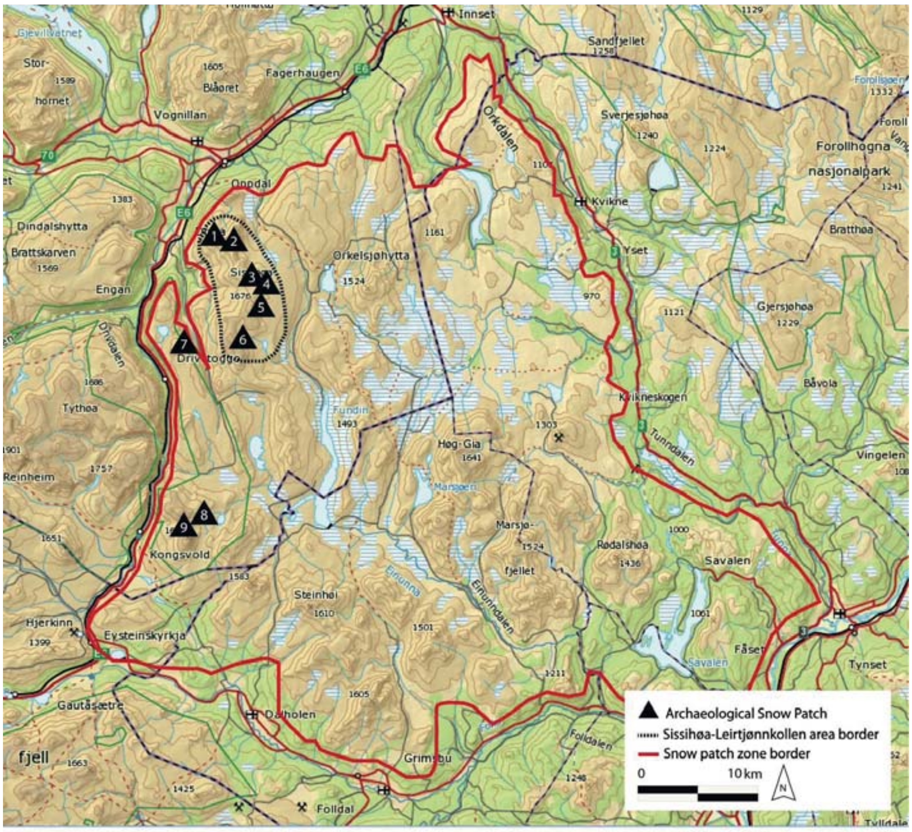
With respect to the chronological distribution, a number of developments can be highlighted within this zone at the close of recovery phase 3. To start with, the movement towards increasingly older finds is most clear in the Snøhetta East zone (*e.g.* Fig 7.7).

Most of the Neolithic and Bronze Age artefacts have come from this area. At the same time, Iron Age finds continue to appear on sites in significant numbers, while the number of medieval and historical finds is still low. This means that the tendency towards increasingly older objects that was notable at the regional level is also present when we examine the Snøhetta East zone in isolation. There are no signs of a breakdown of the chronological structure in Snøhetta East. Rather we are seeing an extension of existing temporal patterns, with Neolithic and Bronze Age elements being added to the zone's overriding chronological profile.

Snow patch zone- Knutshø

Further to the east lies the Knutshø zone. Here the archaeological snow patches are divided between two highland areas. The majority of sites in the Knutshø zone are found along a series of N-S mountain ridges centred on Sissihøa.

Further to the south, productive patches have also been discovered in the northeastern faces of mountain peaks at Knutshø. Overall, the snow patches in the Knutshø zone lie at lower elevations than those in the Snøhetta zone. They are also closer to the modern-day town of Oppdal and the historical centres of Lønset, Vang and Rise (Fig. 7.3). Much of the early surveying activity in recovery phase 1 was concentrated to the Knutshø zone, especially on the three sites Krinsgollfonna, Brattfonna and Leirtjønnkollen that dominated in the early material from the zone. By the end of recovery phase 2 in the year 2000, five sites had been identified in the Knutshø zone. This included sites in the northern group at Sissihøa and in the southern group above Kongsvold.



Knutshø- Archaeological snow patches (n=9)

1. Bekkfonnhøa. 2. Sissihøa. 3. Kringsollfonna. 4. Kringsollfonna +.
5. Brattfonna. 6. Leirtjønnkollen. 7. Langfonnskarven. 8. N. Knutshø.
9. M. Knutshø.

Figure 7.3 Location of the archaeological snow patches within the Knutshø zone.

	Phase 1	Phase 2	Phase 3	Data lost	Total
Leirtjønnkollen	13	5	17 (12)		35
Kringsollfonna	15		28(6)		43
Brattfonna	7	1	22(11)	2	32
N. Knutshø	1		7(4)		8
Bekkfonnhøa	1		2		3
Kringsollfonna+			1		1
M. Knutshø			1(1)		1
Langfonnskarven			2		2
Sissihøa			1		1
Sissihøa-Leirtjønnkollen	13			1	14
	50	6	81(34)	3	140

Table 7.8 Distribution of finds through time on sites in the Knutshø Zone. Number of metal detector finds in brackets.

Some organic finds have been recovered at Leirtjønnkollen in recent years. However, most finds from the site recovered during phase 3 were recovered using a metal detector. Eventually the ice core will disappear completely. Once the surface organic materials have been collected and any residual iron arrowheads located, that will be the end of the story of a snow patch that produced many wonderful prehistoric finds for almost a century.

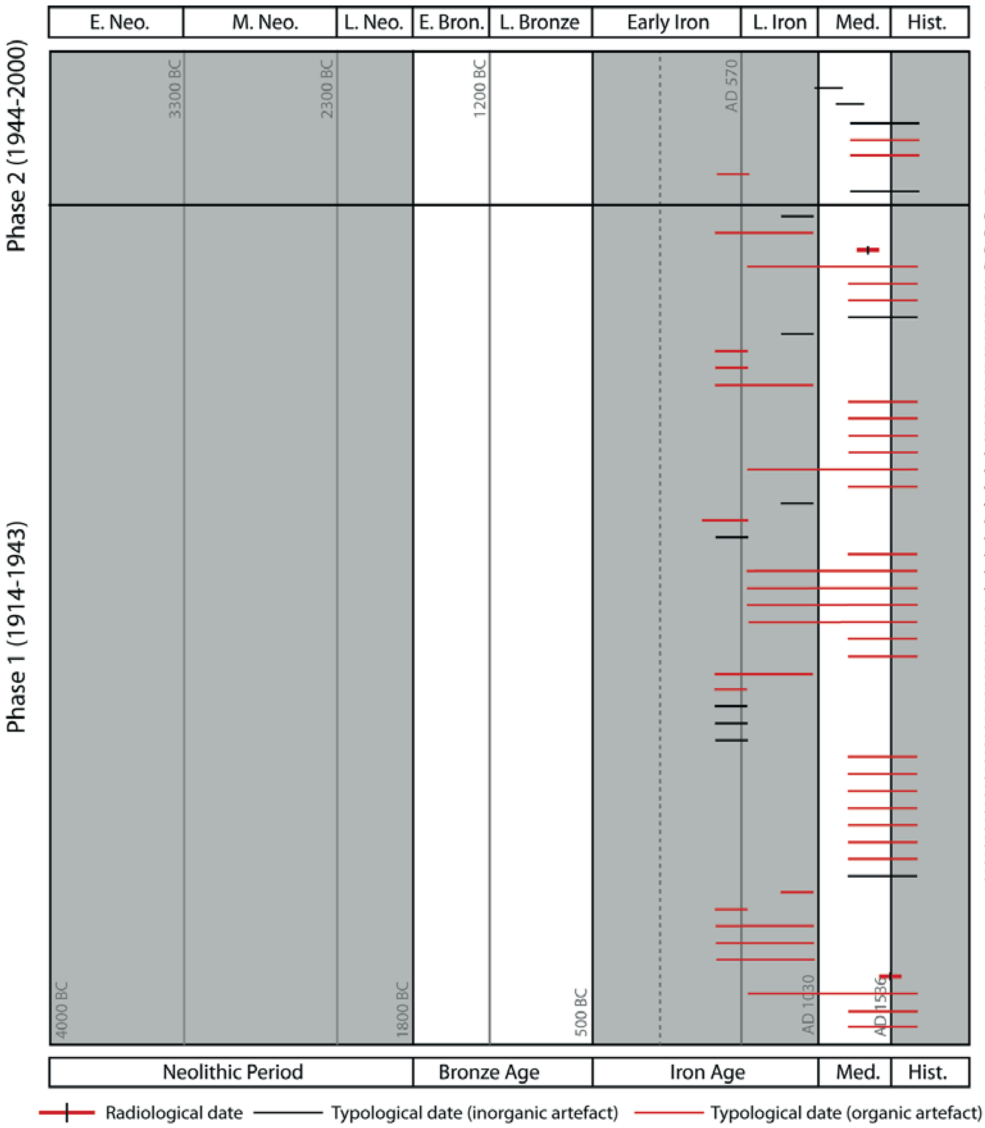


Table 7.9 Overview of the age of all dateble finds from Knutshø during phases 1 and 2.

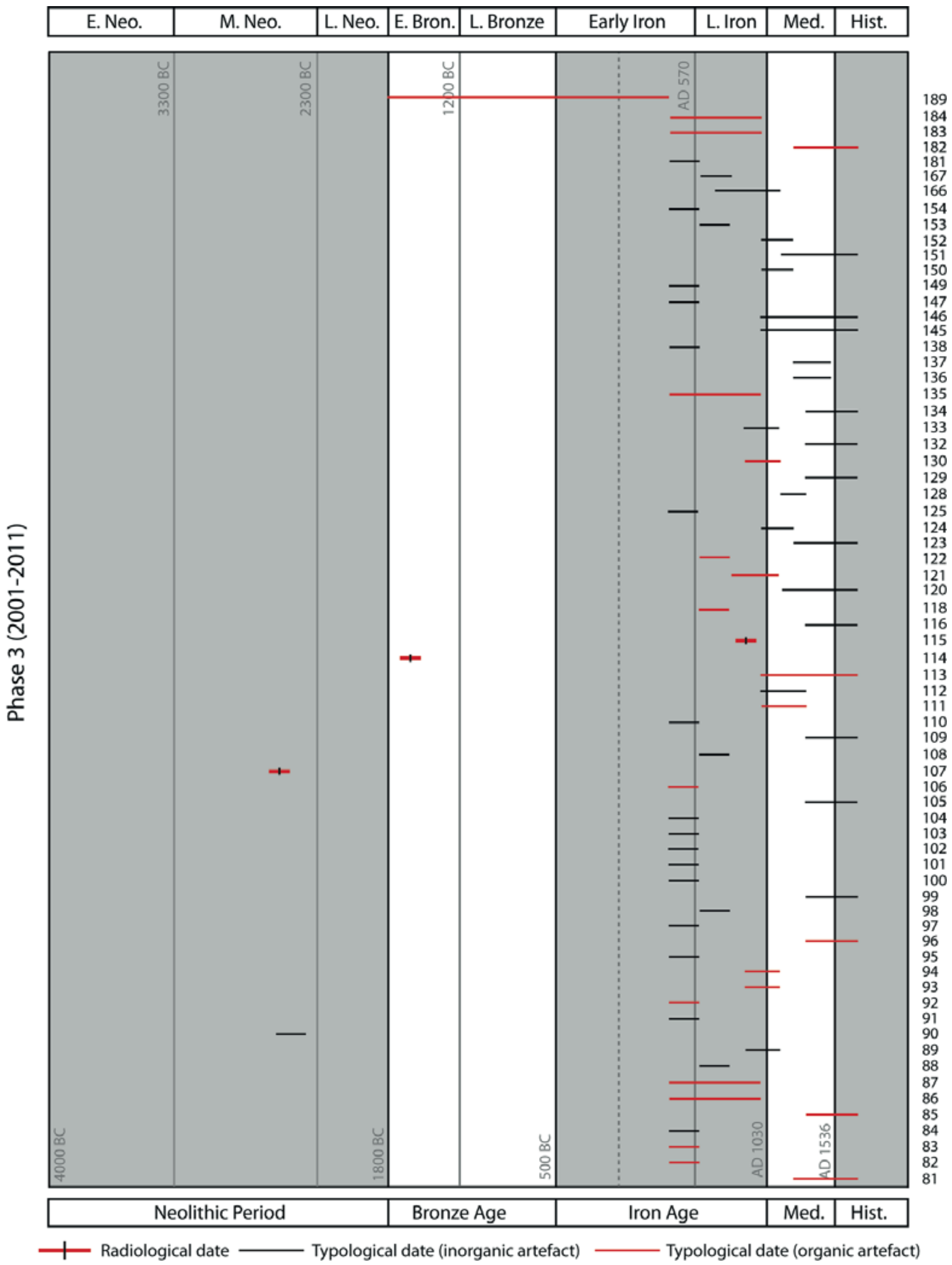


Table 7.10 Overview of the chronology of all dateable finds from the Knutshø zone during Phase 3.

Nevertheless, the number of new artefacts retrieved from sites in the Knutshø zone has risen sharply since 2001 with 81 new finds coming from this zone. Metal detector finds have contributed significantly to this increase with 34 finds from five different sites (Table. 7.4).

The chronological profile of Knutshø during phases 1 and 2 is dominated by finds from the medieval and historical periods (Table 7.9). Although there are a number of finds with wide chronological ranges, it is also possible to see a clear temporal structure in the finds from sites in this zone. During recovery phases 1 and 2, Iron Age artefacts are from the Migration Period (AD400-600) and Viking Age (ADAD800-1030). Finds from the Late Medieval and historical periods are more numerous in Knutshø during phases 1 and 2. Organic finds dominate the overall picture during these two phases. It is interesting to compare the chronological profiles of Snøhetta East and Knutsø during phases 1 and 2. (*i.e.* Tables 7.7 and 7.9). Two points emerge immediately from this comparison. One is that the Knutshø region produced far more finds during the years 1914-2001 than the patches in Snøhetta East. A second point is that by comparing the two figures, we can clearly see the chronological differences between the two zones: Medieval and historical finds play a much more significant role in the Knutshø profile than in Snøhetta West. Are these trends continued during phase 3?

As before we must view the chronological profile of the Knutshø zone during recovery phase 3 in two different versions because of the many metal detector finds recovered there. In table 7.10, we see all artefacts recovered in the zone between 2001 and 2011. This overview shows all evidence of past hunting activity in the zone. Meanwhile in table 7.11, the metal detector finds have been removed. In this chart we get a clear picture of the material that has emerged during phase 3 as a result of recent melts. Both these figures can be compared with table 7.9 in order to get a fuller picture of developments in the zone.

In general terms, the overall chronological profile of Knutshø during phase 3 remains largely the same as in phases 1 and 2 (Table 7.10). While a small number of Neolithic and Bronze Age artefacts have also been recovered in Knutshø in recent years, they are sporadic and fewer in number. These finds are also on the whole more fragmented and not as well preserved than those from Snøhetta East.

We can compare developments in the two different zones during recovery phase 3 by comparing tables 7.7 and 7.11. Here we can see how Snøhetta East has now become the most productive snow patch zone in the region. The comparison also shows that the tendency

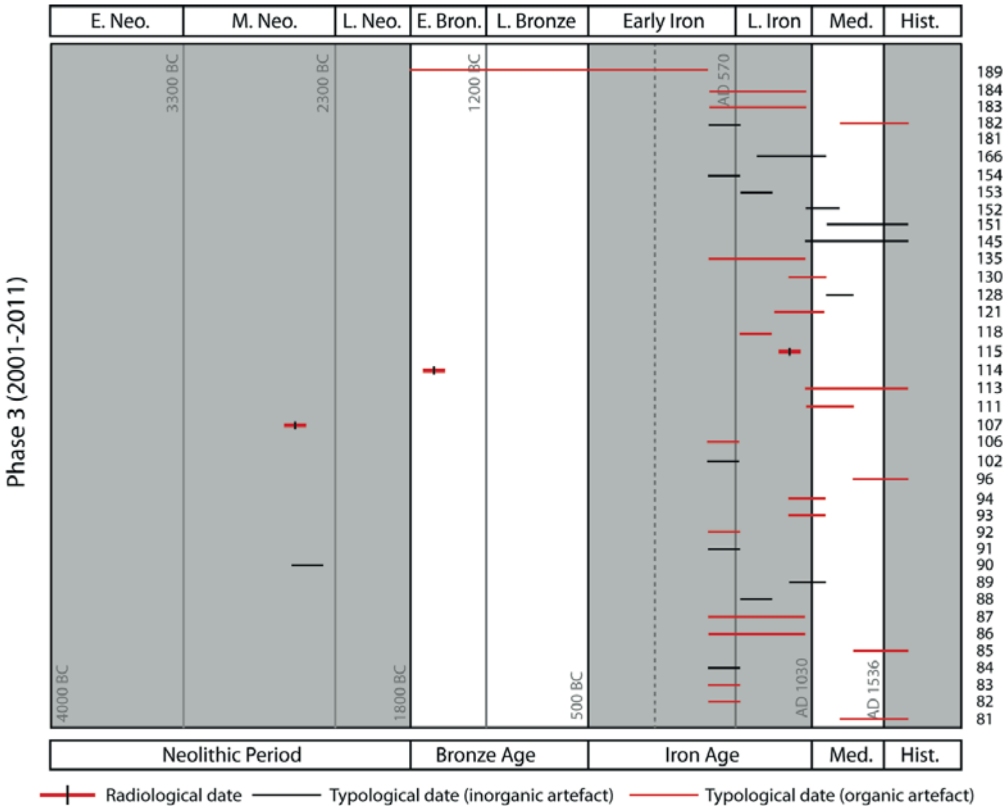


Table 7.11 Chronological distribution of snow patch finds from the Knutshø zone during phase 3 once metal detector finds have been removed.

towards older finds is far more pronounced in Snøhetta East than in Knutshø. The Iron Age components from both regions are similar during period three.

While the chronological structure visible during phases 1 and 2 is largely maintained through recovery phase 3, it is at the same time not as clearly defined as in the earlier phases (Table 7.10). This is in part due to the fact that arrowheads from the Late Iron Age are now appearing. At the same time fewer shafts from the late Medieval and historical periods are being recovered. The cumulative effects of these two tendencies are giving the zone's overall chronological profile a more cluttered appearance than during phases 1 and 2.

Removing the metal detector finds as in table 7.11 reduces this impression to a certain degree. In this analysis we see that organic artefacts again play a prominent role, but the number of artefacts recovered as the result of melting events has reduced significantly. However, the most striking feature to emerge from table 7.11 is the clear reduction in the number of Medieval and Historical objects from patches in the Knutshø zone. The analysis in figure 7.11 clearly shows that the general find picture during recovery phase 3 in the Knutshø zone is now dominated by organic finds from the Iron Age.

Before summarising the results of this analysis, we shall take a look at the remaining two snow patch zones. Although there are few finds in these zones, they complement the picture of the prehistoric snow patch hunting in the past and give an indication that there are probably other productive snow patches in the region outside the Snøhetta East and Knutshø zones.

Snow patch zone- Trollheimen

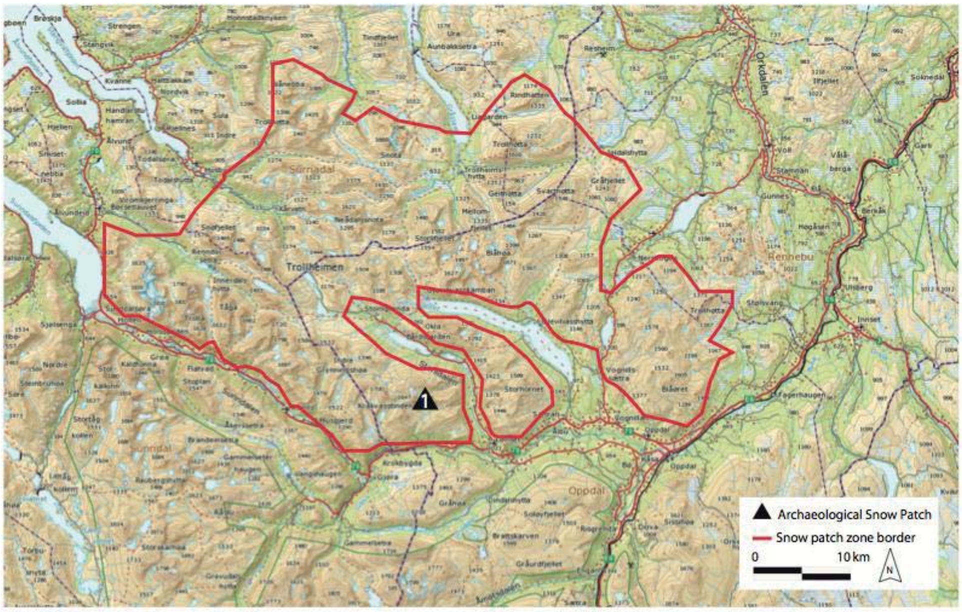
Only one productive snow patch has been identified in Trollheimen. Two arrow finds from a large snow patch in the southern part of the zone show that snow patch hunting also took place in the mountains to the North of Oppdal. Both finds were recovered during the summer of 1937, which was a particularly rich find season (see fig. 2.5).

	Phase 1	Phase 2	Phase 3	Total
Sandåfjellet/Svorundkammen	2			2

Table 7.12 Distribution of finds through time in the Trollheimen zone.

The discoveries consist of an iron point (TT15861) and a complete arrow with iron point (T15860 & T 17698d). These are dated to the Late Iron Age and Medieval to Historical periods respectively.

The fact that so few finds have been discovered in Trollheimen is something of a surprise if we consider the physical, natural and cultural historical factors present in the area. Trollheimen is a complex mountain area with many peaks and ridges well above 1400 masl. The satellite imagery for the zone shows there to be many large bodies of snow that appear to have permanent ice cores. Satellite images from the right time periods show that dirty surfaces are also evident on a number of snow patches at high elevations (G. Vatne. pers. comm. 2013).



Trollheimen- Archaeological snow patches (n=1)
1. Sandåfjellet/Svorundkammen

Figure 7.4 Location of the archaeological snow patches within the Trollheimen zone.

The archaeological record shows that Trollheimen area has been utilised throughout prehistory. Many of these sites and structures were directly connected with reindeer hunting and trapping (*e.g.* Gustafson 1988; Sanden 2013). Wild reindeer were probably exterminated from the zone at some stage in the early 1900's (Mølmen 1995; Røv 2002). In historical times, Sami tame reindeer herders used the zone. Recent archaeological surveys show that the herding tradition has its roots at least into medieval times, if not earlier (*e.g.* Hellqvist 2012). In summary, all the physical, natural and cultural indicators usually found in mountain areas with a high potential for snow patch discoveries are present in Trollheimen. This makes it surprising that until now only one site has been discovered in the zone.

The reason for the low number of finds is a result of limited surveying activity in this promising snow patch zone. In chapter 3, we saw how wild reindeer hunting in the Knutshø and Snøhetta zones was an important factor that drew local contemporary collectors to the vicinity of snow patches during the early autumn when snow patches were reduced in size. Since wild reindeer have become extinct from Trollheimen, hunters do not frequent the area in the same way during the melt season. As a result, we do not have the same network of collectors and accumulated body of knowledge about good sites in the region as we do in the zones directly to the south and southeast. However, everything about this zone appears to indicate that it has as much potential as Snøhetta East and Knutshø have shown. The question is how the challenge and promise that this zone offers best can be addressed?

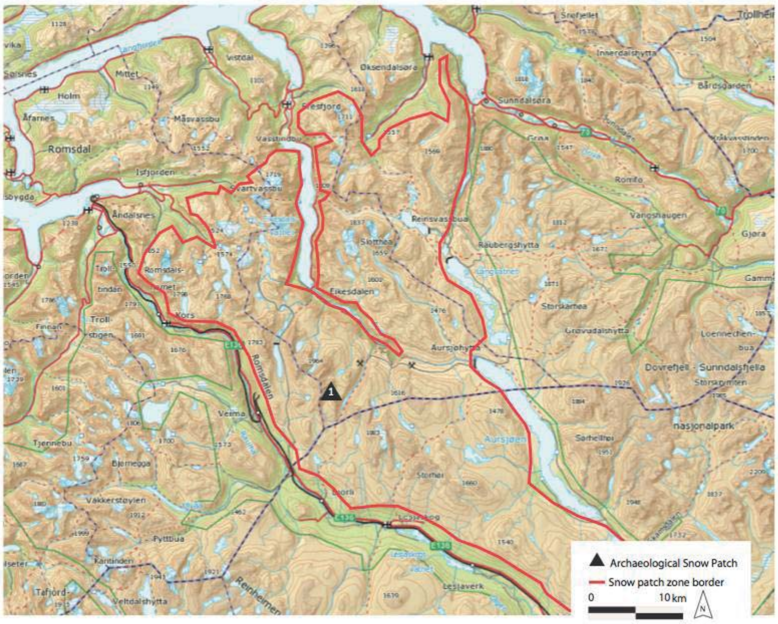
Snow patch zone- Snøhetta West

We meet a similar situation in the Snøhetta West zone. One productive snow patch has been discovered in this zone.

	Phase 1	Phase 2	Phase 3	Total
Grovåbotn, Nesset			1	1

Table 7.13 Distribution of finds through time in the Snøhetta West zone.

The one object discovered on this patch is a *c.* 185cm long staff. Both the age and function of the staff are uncertain. The circumstances surrounding the discovery and recovery of this staff are interesting. It was first discovered on a snow patch in Gråvåbotn early in the 1980s. The finder returned to the site in 2006 and re-found the staff in the same spot despite the fact that 20 years had passed since it was first discovered, and that the snow patch there is now significantly smaller than it was in the 1980s (Marit-Solveig Finset, pers. comm. 2006).



Snøhetta West- Archaeological snow patches (n=1)
1. Grovåbotn, Nesset.

Figure 7.5 Location of the archaeological snow patches within the Snøhetta West zone.

Snøhetta west is another zone that, on paper at least, has great potential for archaeological discoveries on snow patches. Wild reindeer still populate the area. But prior to the disturbances caused by modern developments, this westerly part of the Snøhetta zone was a summer pastureland. This is precisely the time of year one would expect reindeer to draw up to snow patches. There is also a rich archaeological record of human activity in this area, in the high mountains between Romsdal and Eikedal (Fig. 7.5) (*e.g.* Hofseth 1980; Vike, Ringstad & Strand 2004). Interestingly, many of these finds and structures are located in the high alpine zone, and are directly related to reindeer hunting. Nevertheless, despite the potential, no large and productive sites have until now been located in this zone. This may be the result of little targeted surveying. It may also be related to the zones slightly more maritime climate that is thought to be less conducive to favourable preservation conditions than continental conditions are, with colder temperatures and relatively less snowfall than in coastal areas. But the Grovåbotn find demonstrates that good conditions for preservation do exist even on large dynamic sites in this maritime zone.

Summary of temporal and geographical developments 1914-2011

The following is a summary of the results of the chronological and geographical analysis of sites and finds from central Norway between 1914 and 2011.

At the outset, the research questions for this project were:

- What is the age of the oldest artefacts recovered from snow patches in central Norway in recent years?
- What other chronological or geographical patterns can be documented in the current snow patch collection?
- Are new developments limited to single finds and sites or are they systematic across the whole region?
- What do these finds tell us about possible developments on these sites and the potentials for snow patch archaeology in the future?

The chronological and spatial analysis carried out during this study was based on 192 dateable objects, recovered from snow patches in central Norway during the period 1914-2011. The finds were analysed in relation to three variables; the age of the artefact, when they were discovered, and where they were discovered. Typological and radiometric dating techniques were applied. The artefacts were sorted into three recovery phases according to when they were discovered, and into four distinct geographical zones according to where they were recovered. Only two of the geographical zones were large enough to be analysed in great detail. The analyses produced the following results:

- The oldest artefacts in the collection date back *c.* 5400 years to the Early Neolithic period. A total of 14 hunting artefacts from the Neolithic and Bronze Ages finds recovered from sites in the region during the last decade were identified as part of this study. These artefacts have given us new, valuable information and perspectives on long term developments in hunting archery technology. They also cast new light on nature and antiquity of hunting related activities in the mountains of central Norway in prehistory.
- The number of snow patch finds discovered in central Norway has increased dramatically since 2001. The large classic sites are all producing significant quantities of both organic and inorganic artefacts.

Figure 7.6 A selection of projectiles that represent over 5000 years of hunting on the snow patches of central Norway. (L-R: T 25674, T25167, T15886, T25686, T23403, T25165, T23230, lead musketball and modern rifle casing date stamped 1919-all recovered from snow patches by collectors during the last 100 years. Photo: Åge Hojem/NTNU-Museum of Natural History and Archaeology. Layout Martin Callanan.

- The number of sites producing archaeological snow patches has also increased. No new large sites producing significant numbers of finds have been identified since 2001. Instead new sites are generally characterised by being small in size and only producing low quantities of finds. A small number of finds in outlying snow patch zones (Snøhetta West and Trollheimen) underline the fact that there are other potentially productive areas in the region where finds are probably appearing on sites. Snow patches in these zones are currently not being surveyed.

- The analyses have demonstrated that archaeological snow patches in central Norway are in the midst of a dramatic, active period that looks set to continue for the foreseeable future. Melting events from 2001 until 2011 have been regular, but sporadic. Survey seasons that produce no new finds are followed the next year by a season with wholesale melting and record-breaking numbers across the region. Short-term weather patterns in the region during the same period have similarly been erratic (Martinsen 2012. Fig. 5). The short response times associated with snow patches makes developments unpredictable from year to year. Analyses of discoveries during the last decade indicate that the region's snow patches are now riding on a kind of tipping point. The ice cores on several sites are greatly reduced. The cores are also more regularly exposed when compared with earlier phases. In this context, relatively minor annual weather variations are producing large numbers of finds.
- Alongside the Neolithic and Bronze Age artefacts that have been recovered and identified from the region, finds from the Iron Age and Medieval period continue to be discovered too although the distribution of these finds is shifting somewhat. A detailed assessment of this shift remains difficult however, as the ranges of uncertainty associated with finds from the Medieval period are large. Therefore discreet temporal shifts that may be occurring within the material from this period may be being masked. A new find lacuna has emerged during the current chronological analysis. The overviews indicate that few finds from the period *c.* 1300-400BC have been recovered from sites in the region during recovery phase 3. As before, it is uncertain whether this reflects changes in past activities or is the result of snow patch processes. It may also be the case that the material is already present in the collection but it has not been identified yet.
- The overall tendency towards increasingly older finds is not limited to a few stray discoveries, but appears to be a broader scale development. However, the geographical analysis uncovered some interesting details behind these general trends. In particular, the overall tendency towards older finds at the regional level that was observed appears to be a composite of developments taking place at the zone level.

    - Since 2001, Snøhetta East has emerged as the most productive snow patch zone in the region. It is also producing the oldest finds in a regular fashion.
    - During the same period, there has been a marked decrease in the number of finds from the late medieval and early historical periods in the Knutshø zone.
- The introduction of metal detectors during snow patch surveys has been an important and productive new development since 2003. This method has produced a large number of iron arrowheads that provide new information about how sites were used in the past. The metal detector finds include a number of arrowheads from the period AD600-800. Finds from this period were largely absent from the collection in previous analyses, and it was unclear if this was due to changed hunting patterns in the past or rather the result of sorting processes within snow patches in the time since the artefacts were deposited. The discovery of iron arrowheads from this period close to snow patches appears to confirm that the patches in Knutshø were indeed being used between AD600-800. The fact that relatively low numbers of finds from this period were recovered during earlier phases is most likely the result of sorting processes associated with snow patches. This means that arrows from this period melted out of the snow patches on previous occasions and the organic component rotted away without being recovered. This is a important observation with possible implications for future investigations and discussions. These might include issues such as the representativity of present-day snow patch inventories in relation to past hunting activity. It might also be possible to examine subsoil archaeological artefacts as possible markers of snow patch dynamics in the past.

The analyses have also brought to the fore other issues relating to the analysis and interpretation of artefacts from local alpine snow patches.

- Typological dating is more than adequate for many archaeological objectives such as the construction of relative chronologies and technological overviews over finds from certain periods. However, it would not have been possible to identify many of the Neolithic and Bronze Age arrows described in this study without the use of radiometric dating. The ^{14}C dates in this project have not only given us new and valuable information about hunting and archery in the past, they have also given important information about ongoing developments on sites. This has allowed us to focus the available surveying resources on sites where ancient finds have been appearing. In addition, given the fact that many of the remaining objects from snow patches in the collection have associated organic components, there is also great potential for applying this method to a larger portion of the collection than has been the case until now. This has been the approach in other regions where archaeological snow patches have been discovered in recent years (*e.g.* Andrews *et* al 2012; Hafner 2012; Hare *et* al 2012; VanderHoek *et al* 2012). Through the results of these projects, we can see how in modern projects, serial radiometric dating has become the first fundamental step towards transforming prehistoric and historical organics recovered from snow patches into valuable datasets for archaeology as well as other disciplines. Radiometric dating is expensive, but this method should not be limited to research projects only. Instead it should be an integrated tool available for the day-to-day analysis and management of archaeological snow patch artefacts and sites generally. This will make it possible to monitor developments on sites in an effective manner. It will also allow for the construction of data set, potentially of considerable scientific value.

- The different analyses also highlight the need for more focused studies of the degradation processes that affect snow patch artefacts post-depositionally. This will involve specialist studies that can tell us something about the agents and time frames involved in the degradation of complicated organic artefacts. This is vital if we are to understand the patterns of artefact loss visible in the collection (*e.g.* the 1300-400 BC lacuna). It will also allow us to differentiate between primary and secondary melting events in relation to recovered artefacts. This would be an important step towards identifying the true climatic significance of certain archaeological artefacts that emerge out of the ice.
- Constantly in the background, is the promise that snow patch artefacts might serve as independent or proxy climate indicators. This has already been attempted with some success under a special set of circumstances (*e.g.* Grosjean *et al* 2007; Hafner 2012). However, in other settings converting snow patch artefacts into convincing climatic data is still proving to be somewhat of a challenge (*e.g.* Nesje *et al* 2012;

Reckin 2013). The root cause of these difficulties lies in the fact that our understanding of both alpine snow patches as structures and of the ablation and accumulation processes associated with them is still rudimentary. A number of recent contributions have already highlighted the complexity of these structures and processes and demonstrated some of the archaeological challenges this raises (Farbregd 1983: Fig. 3; Callanan *et al* 2010; Meulendyk *et al* 2012; Martinsen 2012). The lack of models that adequately describe processes associated with snow patches specifically is problematic for archaeologists attempting to interpret finds. This is particularly acute in the case of collections that have been collected up over many years and/or have been deposited over long periods of time, as is doubly the case in central Norway. We need better models of the mechanics of modern melting and growth events for the simple reason that this may help us better understand past events that have disrupted the archaeological record as it is preserved in snow patches today. It is also important for archaeology to have more detailed and fact-based prognoses of the rate at which snow patches will ablate and ultimately disintegrate in the future. This is crucial for both field archaeologists and local and national authorities in their efforts to plan and execute effective surveys rescue campaigns. Ultimately, these questions can only be resolved by way of focused, specialist studies of snow patches as cryptospheric structures in their own right. There is every reason to be optimistic in relation to this crucial issue. With new discoveries constantly being made and new projects coming on line, it will not take long before some of the important pieces of the snow patch puzzle begin to fall into place.

That concludes the summary of this project's main results. In the next and final chapter, the last of the research questions is addressed as we look at what future developments we might expect on snow patches and other frozen sites around the world.

Chapter 8 - Looking Forward

Introduction

The analyses in this thesis end with the 2011 season, but the melting of archaeological snow patches and the appearance of ancient artefacts on alpine sites are on-going processes. The picture presented in this study is therefore only the latest chapter in a story that will continue to unfold before us in the future.

With that perspective in mind, we turn and examine what snow patch archaeology might bring both locally and internationally in the future. We examine what kind of discoveries we can expect and in what areas. We list some of the challenges that snow patch archaeology poses to heritage management as a whole. Finally, we point to some of the promise that archaeological snow patches might hold for future multidisciplinary study.

New Discoveries?

Archaeology always fascinates with the promise of the unknown and the unexpected. During the long winter and spring months it is easy to find oneself wondering what objects still lie out there in the mountain snow and ice, waiting to melt out and be discovered.

Figure 8.1 In winter mountains wondering. Looking south over Skarvatnet, Oppdal. 31st Dec. 2011. Photo: Martin Callanan.

In the case of archaeological snow patches, is a feeling of fascination mixed with worry, because we need to be there when the objects emerge out of the ice.
Looking at the potential for future finds at the broadest level, the possibilities are boundless. The Neolithic Man of Hauslabjoch is a stunning icon of archaeological serendipity, a one-off that may never be repeated. But there are still many exciting frozen discoveries waiting to be made in different regions of the world.
Humans have used frozen zones and regions in many different ways through the ages and the material culture they left behind is varied and complex. More and more of these remains will melt and become exposed as global temperatures rise in the future. As a result important archaeological and historical finds of any kind can occur in either high altitude or high latitude contexts wherever humans have deposited cultural remains in the past.

Looking more specifically at snow patch archaeology, the same prognoses apply whether one looks at the question globally, regionally or locally. The snow patches in central Norway, and the north of Canada have all produced many interesting finds through the years. The finds from these regions all represent a specific technological profile of projectiles and other hunting equipment. As snow patch hunting is now understood as past adaptation that appeared over a wide area, we should expect new finds from the projectile group in the future.
However, other recent discoveries illustrate the breadth of material culture that might be discovered on snow patch sites in the future (*e.g.* Åstveit 2010, Finstad & Pilø 2010, Vedeler & Jørgensen 2013). These sites appear to have a different functional background than the hunting sites from central Norway. This is in large part due to their geographical and topographical setting where they were used as travel corridors or campsites. The artefacts already recovered from these kinds of sites illustrate the great variety of material culture that may be lying in snow patches with the right topographical setting. As alpine ice continues to melt, more transport and encampment sites of this kind may be discovered, in which case there is really no limit to what segments of the material past may appear from the ice and snow.

It is very common for snow patch archaeologists to be asked at the end of interviews or presentations something like ‘and when will you find an Ötzi’ or ‘what are the chances of finding an Iceman in these parts?’ The simple answer is that there is always a possibility of chance in any region where people have been active in areas that are covered in snow and ice. In terms of space, this is a potentially very large area indeed. The Similaun man ended his life as a result of specific circumstances and was preserved under very specific topographical and physical conditions. But subsequent frozen mummies in other regions demonstrate that other contexts of preservation also allow for the preservation of human remains (Dickson 2012). While Ötzi is and will probably always remain a unique discovery in many ways, archaeologists in snow patch regions should consider the possibility for the discovery of frozen human remains in their district and prepare in some way for that eventually (*e.g.* Rerolle 2008, Callanan 2012b).

Figure 8.2 Charlotte Rerolle testing portable excavation equipment designed for complex frozen finds at Storbreen, Oppdal in 2009. Photo: Martin Callanan.

With respect to snow patches in central Norway, the question remains if current trends will continue and for how long? Georadar surveys of the find bearing portions of Storbreen and Kringsollfonna show that thick ice cores remain on these two prolific sites (Geir Vatne pers. comm. 2013). Therefore it appears likely that archaeological material will continue appearing on sites in the region for the foreseeable future. It is also likely archery and hunting related artefacts will continue to dominate the recovered material in the future, at least on central Norwegian snow patches

There is also the question of past activities and resulting material deposits of which we still know nothing. Future melting of permafrost, glaciers and snow patches will surely produce surprises in the future. While it is difficult to guess what these surprises will be, locally at least, it is possible to point to a few areas that we know are missing from the snow patch record until now. Perhaps they will appear sometime in the future?

Until now no evidence of reindeer herding activities has been discovered on snow patches in Norway or Sweden, or indeed anywhere in the world. This is surprising given what we know about the important role snow patches and glaciers played in reindeer husbandry activities in the past in the region (*e.g.* Meløe 1990, Ryd 2007). One of the important questions to ask in this regard is what sort of material culture can we expect to recover? Perhaps specific activities associated with reindeer herding and husbandry do not result in large amounts of material culture being left behind on snow patches. Perhaps we should instead be looking for other structures in or around the ice itself? Perhaps there are still chemical traces of these activities preserved within the snow patches themselves? We know that this activity took place. It is a matter of trying to find out how the material record will appear on sites today. Local informants and tradition bearers have an important role to play in this work in the future.

Another interesting question is related to the hybrid hunting-trapping sites recovered in Jotunheimen in Southern Norway (Finstad & Pilø 2010). This large body of material has yet to be published in detail, and conclusions must remain open in relation to a number of central questions such as the chronology, functional interpretation of these sites. One of these questions relates to the distribution of this hunting/trapping technique in other regions, if indeed the preliminary interpretations prove to be correct. Until the present, there are no indications that this technique was applied in the past beyond the few sites in Jotunheimen where Iron Age sewels have been recovered in large numbers. It is interesting to ask why sewels haven't been found in adjacent snow patch areas too. Is the preliminary interpretation of these sites correct? Was it simply a local adaptation or tradition? Will similar remains appear in other regions in the future? These are all interesting questions to be addressed once these sites and materials have been presented in detail.

New Regions-Old Regions?

The question 'what will we find?' is closely related to asking 'where should we look?'

In this thesis, the focus has been squarely on reindeer hunting sites. Therefore, the presence of reindeer within a region is seen as a necessary perquisite for the presence of hunting artefacts (*e.g.* fig. 2.4). But this is only true of sites directly linked to reindeer or caribou hunting. If we ask 'where should we look?' at a broader level, the necessary prerequisites are reduced to the prevalence of frozen conditions and past human activity that produced some or other form of material culture. Based on earlier finds, snow patches and permafrost contexts are the most productive contexts. But mountain tops where frozen conditions prevail are also very promising contexts even as one moves away from the high latitudes (*e.g.* Ceruti 2004, Lee 2010). In general however, any context where any human activity has taken place in connection with snow, ice or permafrost has the potential to produce exciting archaeological and historical discoveries. It is easy to focus primarily on Northern or alpine regions, but in reality the potential for finds might be present in any high altitude region where permanent or semi-permanent exists. From a broad European perspective, other regions where the potential for frozen heritage appears to exist include The Pyrenees, the Carpathian mountains and the many upland areas in the Balkans. Cultural remains on snow patches in these regions may not necessarily be very ancient, but they may contain interesting evidence of human activities in alpine areas from the Medieval and historical periods that will be of considerable interest. Consider for example the following passage from Washington Irving, written during his travels in Southern Spain in 1829 (Irving 1994:107-108)

> *"But what lights are those, Mateo, which I see twinkling along the Sierra Nevada, just below the snowy region, and which might be taken for stars, only that they are ruddy, and against the dark side of the mountain?"..."Those, senor, are fires, made by the men who gather snow and ice for the supply of Granada. They go up every afternoon with mules and asses, and take turns, some to rest and warm themselves by the fires, while others fill the panniers with ice. They then set off down the mountains, so as to reach the gates of Granada before sunrise. That Sierra Nevada, senor, is a lump of ice in the middle of Andalusia, to keep it all cool in summer." (A Ramble Among the Hills).*

Although taken from a literary source, this passage describes an unexpected yet exciting example of a confluence between regular human activity and a context suitable for the preservation of archaeological or historical materials. We don’t know if this activity resulted in any the deposition of cultural material or construction of sites or structures. The city of Granada has a long and varied history. How far back does this practice go? Are there any other sources of information about this activity in the Sierra Nevada? And where else was this practice carried out?

As glaciers, snow patches and permafrost melt and degrade in the future it will be important to develop a nose for these kinds of potential sites, even in areas far from the North.

Returning specifically to snow patches, a number of regions yet to be surveyed may contain productive archaeological sites. In terms of snow patch discoveries; there is a wide, empty space between the sites discovered in Scandinavia and those in North America. The vast region between these two outer markers has seen a wide range of human/reindeer interactions over long time periods. However, there are only a limited number of high altitude zones in the Eurasian North where perennial snow patches might exist today. Some of these may contain exciting new discoveries. For example; how did hunters and herders in the past use snow patches in the Urals, or the Verkhoyansk Range? And what material traces remain there today? By applying the lessons learned in other snow patch regions it should be possible to approach these vast ‘new’ landscapes in a targeted and effective manner.

Closer to home in Scandinavia, there are still large mountain areas containing snow patches that remain to be assessed and surveyed systematically. In Northern Sweden the recent discovery of prehistoric arrows on alpine snow patches show how planning, patience and a bit of luck produce exciting results over time (thelocal 2013). A recent review of archery related finds from relevant landscapes in the north of Norway demonstrates that there is great potential on this side of the border also at lower altitudes than in southern and central Norway (Sommerseth 2013). As we have already discussed in this chapter, there is a strong likelihood that snow patches in Northern Scandinavia have preserved physical remains from reindeer herding activities. The area where finds with this background might be discovered is vast.

Within the established snow patch regions in central Norway, it is unlikely that many new large productive sites have gone unnoticed. The exception to this will probably be the Trollheimen zone where there is most potential for discovering new important sites, as surveying activity has been sporadic in this area in the past. The fact that finds have been discovered on small snow patches means that the number of sites discovered in the region might increase greatly in the future. But these will probably be concentrated to the main snow patch zones that we recognise today.

New Management?

The promise of frozen archaeological finds in the future brings with it a number of challenges to existing heritage management structures and routines. As we have seen, snow patch and glacial sites often produce high-value and delicate cultural remains. The appearance of finds on sites is unpredictable and sporadic, meaning that many sites ideally require long-term monitoring and supervision. New discoveries, whether it be new sites or individual artefacts often require immediate action. This is an especially challenging proposition for a sector accustomed to procedures that allow time to consider, plan and prioritise future actions and interventions. What is more, glacial and snow patch sites tend to lie in remote areas or in difficult landscapes. This means that both long term and rapid-response logistics can at times be costly and complicated. In short, archaeological snow patches pose a number of difficult questions with respect to the management of valuable cultural remains.

The response to these challenges in different regions has varied. In terms of format, the most common approach is the short to medium project. These are dedicated research or management projects that last from between 3 to 5 years. Sometimes the aim of these projects is to investigate whether or not frozen heritage might be present in a particular region that appears promising. The project format is probably effective for initial investigations and surveys but what should be done once productive sites are located? The central Norwegian case clearly demonstrates that the degradation of archaeological snow patches and the appearance of valuable artefacts on sites are long term processes. Many glacial and snow patch sites cannot be contained within the format of the short-term project. As often as not, once the project period ends so too does the financing along with the surveying and monitoring activities. The question then is how should we organise and fund the long-term management of productive alpine sites? Are we interested in long-term management? Perhaps we are more content with limited, reactive responses to individual discoveries? If we wait and see, perhaps the whole thing will go away?

Also, how do we deal with situations, such as is the case at present in Norway, where numerous districts with great potential have not been accessed or surveyed at all? Is it best to establish and build up small local projects in each district, or does effective snow patch archaeology demand a specialist approach? Perhaps in the future, we will need to prioritise and focus funds and energies. Are all sites and districts of equal importance? Should central authorities channel all management funding to one find-rich district at the exclusion of other productive regions? Is this approach equitable or sustainable in the future?

In the future, these difficult questions will only become more pressing as alpine ice and snow continues to recede and more sites are discovered. We need a more open and explicit discussion about frozen heritage management if we are to reach effective solutions that are institutionally, economically and environmentally sustainable.

New Science?

The scientific potential of alpine snow patches is not limited to archaeology or to glaciological and climate investigations as discussed at the end of the previous chapter. From a wider scientific perspective, snow patches have great potential as environmental archives too. Despite the fact that they lie in remote and desolate landscapes, snow patches are rich biological niches (Barry & Gan 2011). Snow patches have captured and stored a wide range of environmental materials deposited either by water or wind processes or from animals that expire in the vicinity of the snow patch. Recent investigations in central Norway have shown that snow patches contain a variety of environmental material in the form of pollen, insects and floral and faunal remains (Solem 2013).

Figure 8.3 Snow patches contain a variety of environmental information that is probably of great scientific value. Here we see a large stratified snow patches at Snøfjellkollan. What information do these ancient layers contain? What could this material tell us about local environmental and ecological conditions in the past? Photo: Stuedal 2006.

As can been seen from the archaeological discoveries, some snow patches have probably been amassing this material for thousands of years. Although the depositional and contextual conditions surrounding specimens are complex, the environmental material within snow patches is likely to be well preserved. Samples of ancient local environmental material are proving to be of great scientific value to disciplines interested in chemical and genetic samples from the past as demonstrated in a number of recent studies (*e.g.* Helwig *et al* 2008; Kuhn *et al* 2010; Galloway *et al* 2012; Letts *et al* 2012; Helwig *et al* 2014; Røed *et al* 2014). These sites and contexts will not be available forever and need to be tested and evaluated while they still exist. Archaeology cannot initiate studies of this kind independently. However we could do well to advertise the broader scientific potential to colleagues whenever opportune. There are important synergies to be gained from a broader scientific focus on these ancient alpine sites. In summary, the future facing snow patches and other glacial archaeological sites appears to hold a wealth of archaeological and scientific promise both locally and globally.

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Åstveit, L. I. 2010. *Iron Age snow patch find from Vik, western Norway.* Poster presented at "Frozen Pasts," The 2nd International Glacial Archaeology Symposium, 5 – 7th October 2010, Trondheim, Norway.

Appendices

Note to appendices

The following is a short description of the definitions, sources and references that appear in the appendices.

Appendix 1

Appendix 1 contains a series of overview maps showing the different snow patch regions and the location of sites within the individual regions.

Appendix 2

Appendix 2 contains data on all 234 individual snow patch artefacts collected between 1914-2011. It includes both tables and chronological overviews. In both the tables and overviews, artefacts have been ordered according to when they were discovered, starting with the oldest finds. The tables are organised in three groups that correspond to the phase during which they were discovered. Numbered chronological overviews for each phase are also provided.

Museum's no.

The museum number (*e.g.*Txxxxx) is the unique identifier for artefacts at NTNU-Museum of Natural History and Archaeology, Trondheim. Refitted artefacts retain all original identifiers. For this reason, a number of arrows that have been co-joined through the years have multiple museums numbers attached.

Dating and Date Class

Two dating techniques have been applied in this study: typological dating and radiological dates. Typological dates (Typo) range from ±100 years to ± 250 years. In some instances it is has been possible to suggest *terminus post quem* (TPQ) or *terminus ante quem* (TAQ) dates for individual artefacts based on technical details (*e.g. ante* AD1000, *post* AD600). In some cases no date (N.D.) can be suggested. For radiological dates (C14) the median value is cited in the table.

Metal Detector Finds

Finds that were recovered using metal detectors during Phase 3 are marked in this field.

Snow Patch Zone

Snow patch sites have been grouped into 4 snow patch zones. The reference in this field shows which snow patch zone the artifact belongs to.

Snow Patch Zone	Reference
Trollheimen	T
Knutshø	K
Snøhetta East	SE
Snøhetta West	SW

Codes used in appendix 2 to denote snow patch zone

Geographical Coordinates (North and East)

The coordinates listed in appendix 2 are North and East grid references to Euref89 UTM32.

Position

The field 'position' describes the quality of the geographical information associated with individual find. The information available for each artefact varies from vague descriptions of the area a find came from, to precise GPS measurements of the find's position. The following terms are used in this field:

"Position"	Meaning
'N.D.'	No contextual data available.
'Estimated'	The position and coordinates from this find have been estimated from text-based descriptions.
'GPS'	The finds position was recorded in situ with a handheld GPS unit.
'Site'	The find site is known, but no further estimates could be made.
'Zone'	The mountain area where the find was discovered is known, but no closer estimate could be made.

Overview of definitions used to classify the contextual information available for individual artefacts.

Literature references

These are reference to images of individual arrows and artefacts published previously. In appendix 2, shorthand references are used to refer to specific texts and illustrations. In some cases the reference is by a followed page, figure or find number. *e.g.* "OF72:13" refers to page 13, "OF72 pl. 13" refers to plate 13 and "OF72 nr. 13" refers to find no. 13 in Farbregd 1972.

Shorthand reference	Longhand reference
OF72	Farbregd 1972
OF83	Farbregd 1983
OF91	Farbregd 1991
F&B00	Farbregd & Beverfjord 2000
OF09	Farbregd 2009
LIÅ07	Åstveit 2007
OF09	Farbregd 2009
MC10	Callanan 2010
MC12	Callanan 2012
MC13	Callanan 2013
MCxx	Callanan in press
TB03	Bretten 2003
B&R04	Bretten & Røtvei 2004
F&B03 (These seven finds are numbered from left to right)	Fredriksen & Beverfjord 2003

Explanation of shorthand literature references used in the appendices.

Figure No.

Chapter 7 includes a series of chronological and geographical overviews of the dateable artefacts. Numbered versions of these overviews are included in appendix 2. The numbers in the overview corresponds to the numbers in the artifact tables.

Appendix 3 Radiocarbon Dates

Appendix 3 is an overview of all radiological dates from snow patch artefacts from Central Norway. The ^{14}C dates are arranged from youngest to oldest dates. This includes both published and unpublished ^{14}C dates. In each case, the original measured radiocarbon age has been calibrated using OxCal v4.2.2. The plots include the artefact ID, lab ID, the measured age and the calibrated age values (1Σ & 2Σ). References to previous publications and relevant chapters in the present work are also provided.

Appendix 4 Published publications

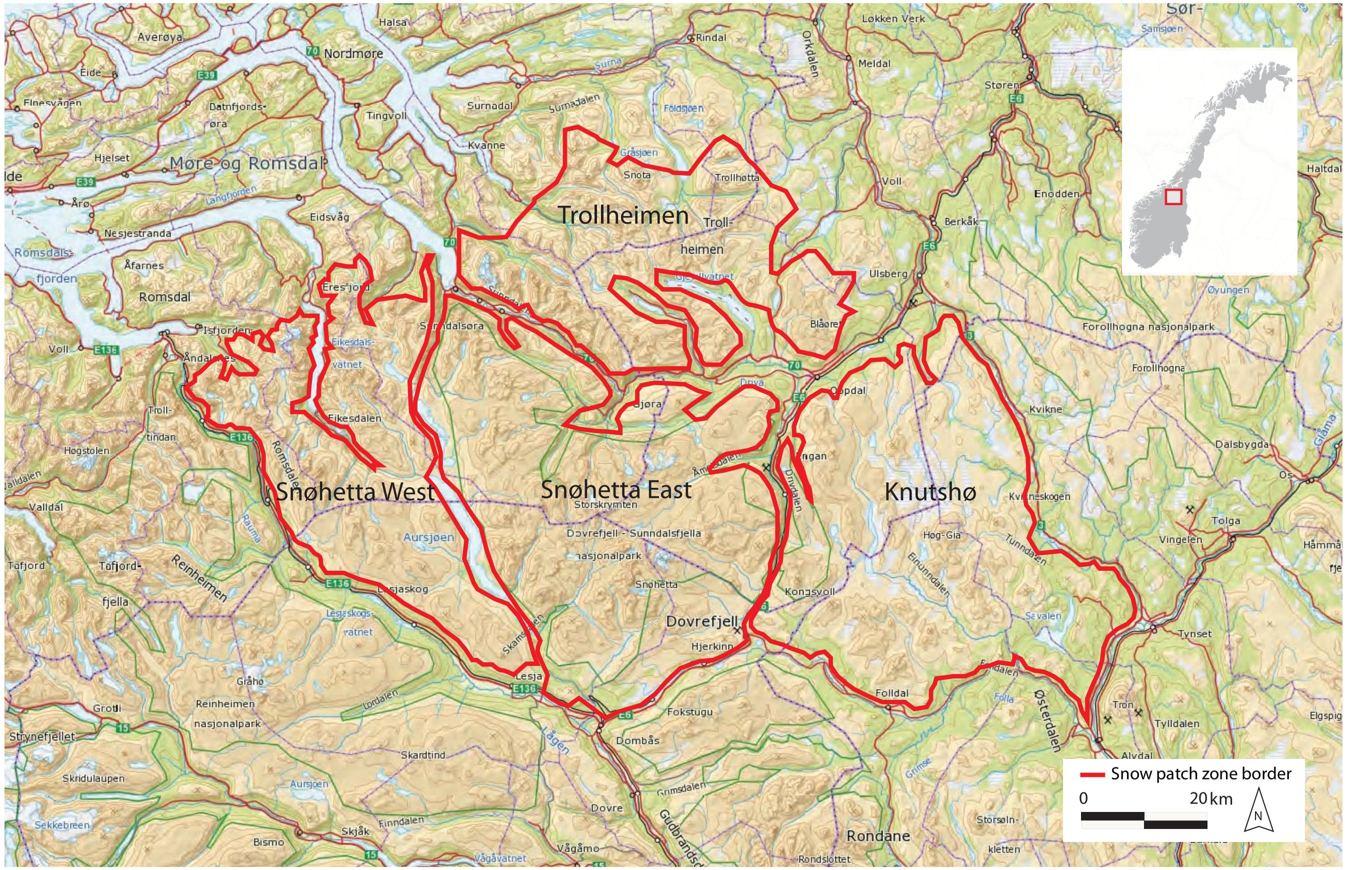
Appendix 4 contains original copies of the published articles included in this thesis. These are:

Callanan, M.2010. Northern Snow Patch Archaeology. In Westerdahl, C. (ed.), *A Circumpolar Reappraisal: The Legacy of Gutorm Gjessing (1906-1979)*. BAR International Series 2154. Archaeopress. Oxford. 43-54.

Callanan, M. 2012. Central Norwegian Snow Patch Archaeology. Patterns Past and Present. *Arctic*. Vol. 65. Suppl. 1. The Arctic Institute of North America. 179-189.

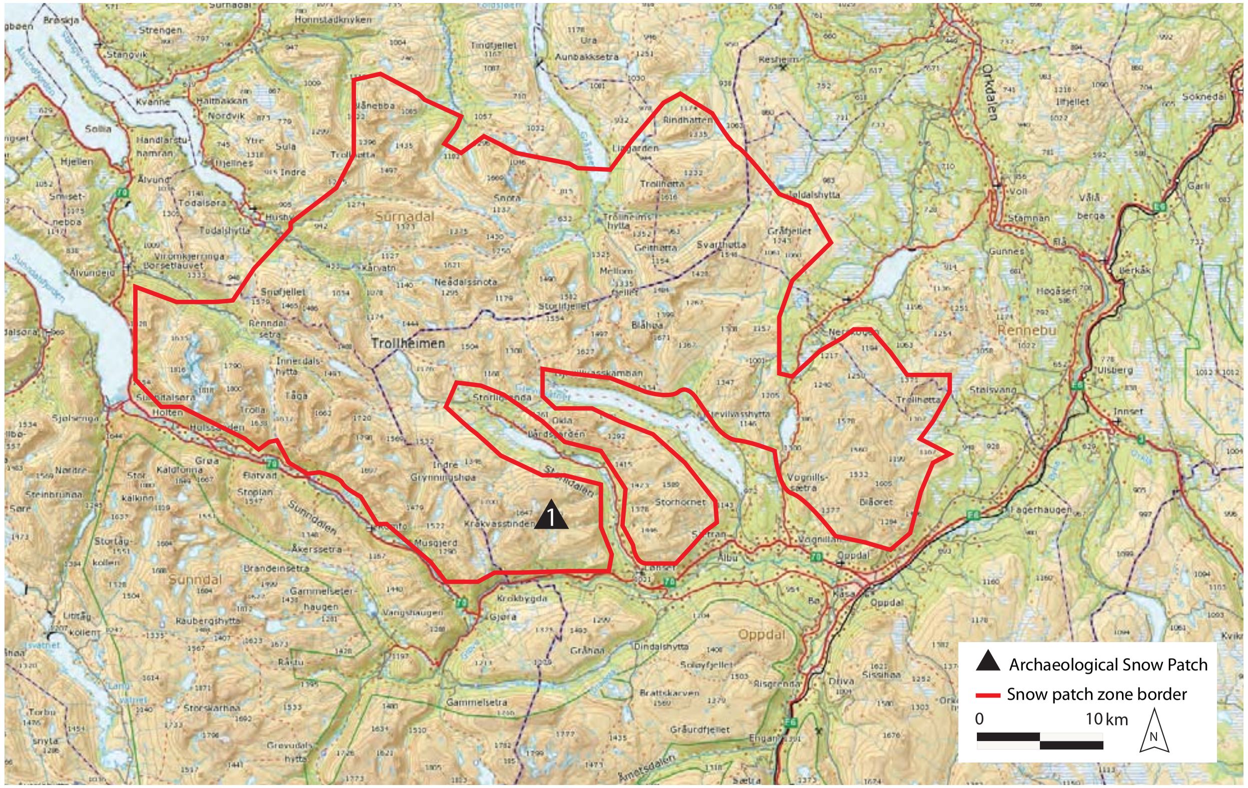
Callanan, M. 2013. Melting snow patches reveal Neolithic archery. *Antiquity* Vol. 87.887. 728-745.

Appendix 1: Overview Maps



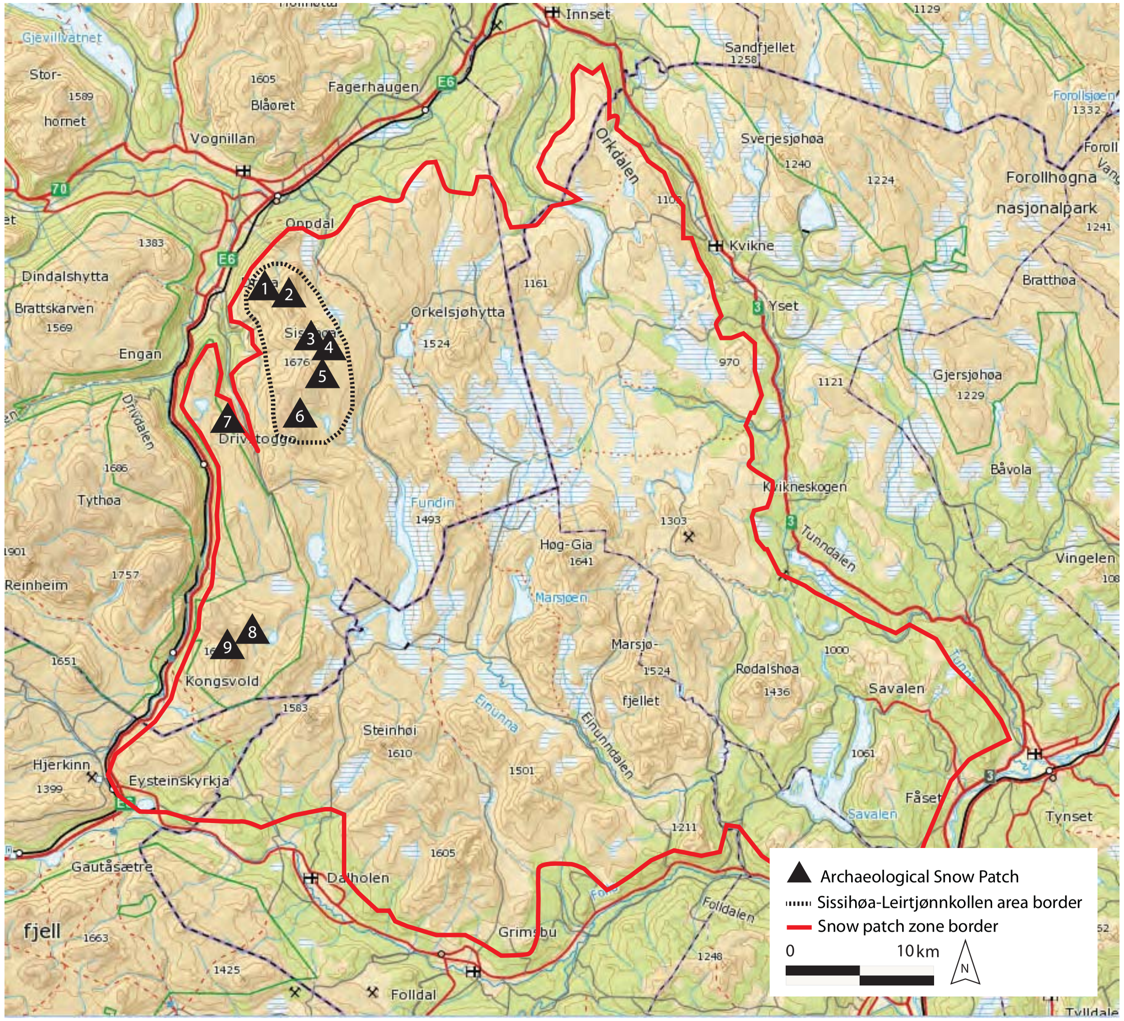
4 snow patch zones of central Norway

Zone 1-Trollheimen



Trollheimen- Archaeological snow patches (n=1)
1. Sandåfjellet/Svorundkammen

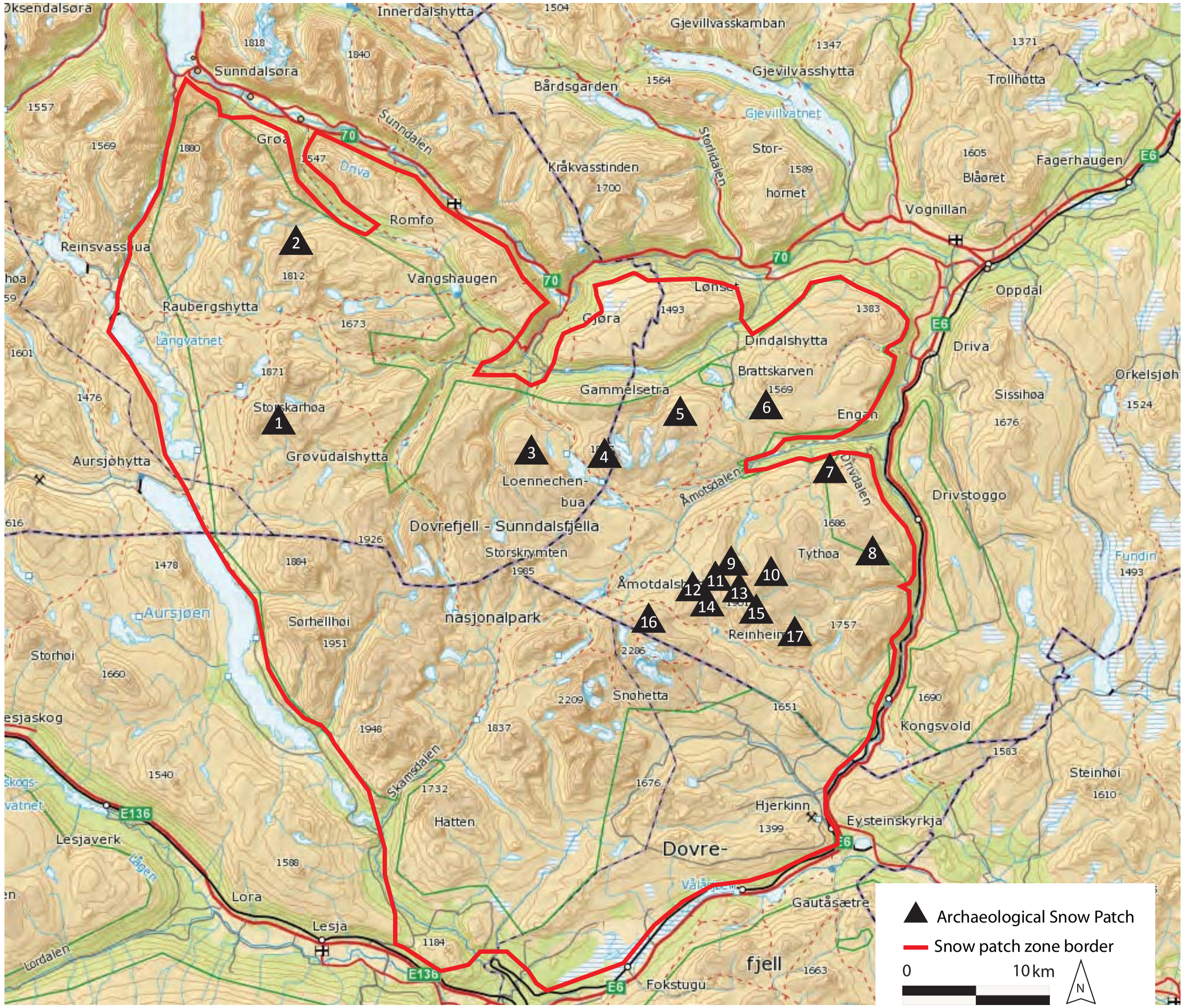
Zone2-Knutshø



Knutshø- Archaeological snow patches (n=9)

1. Bekkfonnhøa. 2. Sissihøa. 3. Kringsollfonna. 4. Kringsollfonna +. 5. Brattfonna. 6. Leirtjønnkollen. 7. Langfonnskarven. 8. N. Knutshø. 9. M. Knutshø.

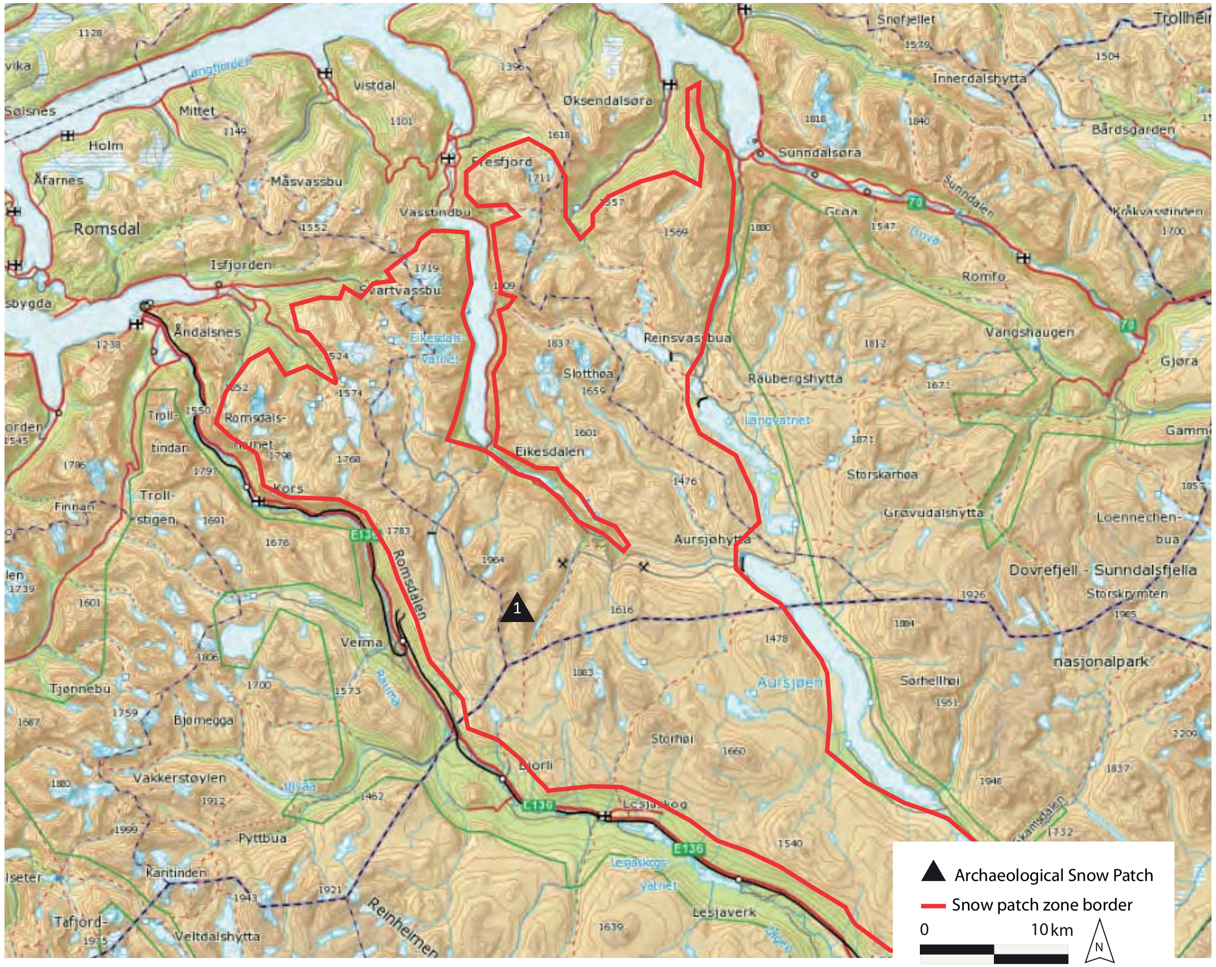
Zone 3-Snøhetta East



Snøhetta East- Archaeological Snow Patches (n= 17)

1. N. Svarthammaren. 2. Råstu. 3. Skirådalskardet. 4. Skiråtangen. 5. Svartdalskardet. 6. Tverrfjellet. 7. Gravbekkfonna. 8. Hesthågåhøa. 9. Løftingfonnkollen. 10. Namnlauskollen. 11. Løpesfonna. 12. Vegskardet. 13. Storbreen. 14. Håråkollen. 15. Kinnin. 16. Snøhetta. 17.Kaldvellkinn

Zone 4-Snøhetta West



Snøhetta West- Archaeological snow patches (n=1)

1. Grovåbotn, Nesset.

Appendix 2: Artefact Tables and Chronological Overviews

Appendix 2: Artefacts from Central Norwegian Snow patches

Museum no.	Find Description	Dating	Date Class	Year Found	Found By	Snow Patch/ Location	Zone	North	East	Position	Literature ref.	Figure No.
T 11190	Shaft of *Betula* and iron point	AD800-1000	Typo	1914	Ingebrikt Ivareng	Løpesfonna	SE	6915369	519157	Estimated	OF72/45 & 72/58	1
T 15272	Shaft of *Betula*	AD400-600	Typo	1936	Gudbjørn Havdal & Hallvard Håker	Storbreen	SE	6914638	521298	Estimated	OF72/16	2
T 15272	Shaft of *Betula*	AD400-600	Typo	1936	Gudbjørn Havdal & Hallvard Håker	Storbreen	SE	6914638	521298	Estimated	OF72/17	3
T 17687,a & T 17697,a	Shaft fragment of Betula and iron point	AD1200-1700	Typo	1936	Martin H. Loe	Leirtjønnkollen	K	6925307	538365	Estimated	OF72/67 & OF72/79	4
T 17697,d	Shaft of *Betula*	AD1200-1700	Typo	1936	Martin H. Loe	Leirtjønnkollen	K	6925307	538365	Estimated	OF72/82	5
T 17695 A	Shaft section of *Betula*	*post* AD600 (AD1200-1700?)	Typo	1936	Martin H. Loe	Brattfonna	K	6927571	539889	Estimated	OF72/88	6
T 17697,b	Shaft section of *Betula* and iron point	Median AD1512	C14	1936	Martin H. Loe	Leirtjønnkollen	K	6925307	538365	Estimated	OF72/104 & OF72/113	7
T 17695 B	Wooden snare of *Juniperus*	N.D.	N.D.	1936	Martin H. Loe	Brattfonna	K	6927571	539889	Estimated	OF72:89.	x
T 17698,f & T 17694/17698e	Shaft fragment of *Betula* with bone point	Median AD341	C14	1937	Hallvard Håker	Storbreen	SE	6914638	521298	Estimated	OF72/2 & OF72/19	8
T 17698,c	Iron point	AD400-600	Typo	1937	Hallvard Håker	Storbreen	SE	6914638	521129	Estimated	OF72/4	9
T 17698,b	Shaft fragment of *Betula*	*ante* AD1000 (AD400-600?)	Typo	1937	Hallvard Håker	Storbreen	SE	6914638	521298	Estimated	OF72/20	10
T 17699,b	Shaft section of *Betula*	*ante* AD1000 (AD400-600?)	Typo	1937	Martin H. Loe	Kringsollfonna	K	538281	538281	Estimated	OF72/21	11
T 17698,b	Shaft section of *Betula*	*ante* AD1000 (AD400-600?)	Typo	1937	Hallvard Håker	Storbreen	SE	6914638	521298	Estimated	OF72/25	12
T 17697,g	Shaft fragment of *Betula*	*ante* AD1000 (AD400-600?)	Typo	1937	Martin H. Loe & Johs. Petersen	Leirtjønnkollen	K	6925307	538365	Estimated	OF72/27	13
T 17697,g	Shaft fragment of *Betula*	*ante* AD1000 (AD400-600?)	Typo	1937	Martin H. Loe & Johs. Petersen	Leirtjønnkollen	K	6925307	538365	Estimated	OF72/28	14
T 17698,d	Shaft of *Betula*	AD400-600	Typo	1937	Hallvard Håker	Storbreen	SE	6914638	521298	Estimated	OF72/31	15
T 17699,a	Shaft of *Pinus*	AD400-600	Typo	1937	Martin H. Loe	Kringsollfonna	K	6931605	538281	Estimated	OF72/32	16

Find Catalogue for Phase 1 (1914-1943)

Museum no.	Find Description	Dating	Date Class	Year Found	Found By	Snow Patch/ Location	Zone	North	East	Position	Literature ref.	Figure No.
T 17698,h	Iron point	AD600-800	Typo	1937	Hallvard Håker	Storbreen	SE	6914638	521298	Estimated	OF72/36 & OF72/61	17
T 15861	Iron point	AD800-1000	Typo	1937	Arne Apefjell	Sandåfjellet/ Svorundkammen	T	6944271	509379	Estimated	OF72/38 & OF72/59	18
T 17696	Shaft section of *Betula* and iron point	AD800-1000	Typo	1937	Martin H. Loe & Johs. Petersen	Brattfonna	K	6927571	539889	Estimated	OF72/42	19
T 15860 & T 17698,d	Shaft of *Betula* and iron point	AD1200-1700	Typo	1937	Arne Apefjell	Sandåfjellet/ Svorundkammen	T	6944271	509379	Estimated	OF72/52 & 72/86	20
T 17697,h	Iron point	AD1200-1700	Typo	1937	Martin H. Loe & Johs. Petersen	Leirtjønnkollen	K	6925307	538365	Estimated	OF72/62	21
T 17697,c	Shaft section of *Pinus* and iron point	AD1200-1700	Typo	1937	Martin H. Loe & Johs. Petersen	Leirtjønnkollen	K	6925307	538365	Estimated	OF72/63 & OF72/91	22
T 17697,f	Shaft fragment of *Betula* and iron point	AD1200-1700	Typo	1937	Martin H. Loe & Johs. Petersen	Leirtjønnkollen	K	6925307	538365	Estimated	OF72/65 & OF72/87	23
T 17697,e	Shaft of *Betula* and iron point	AD1200-1700	Typo	1937	Martin H. Loe	Leirtjønnkollen	K	6925307	538365	Estimated	OF72/68 & OF72/78	24
T 17701,d & T 17700,a,T 17701,i	Shaft of *Betula* and iron point	AD1200-1700	Typo	1937	Erik S. Lo	Kringsollfonna	K	6931605	538281	Estimated	OF72/74 & OF72/75	25
T 17698,a	Shaft fragment of *Betula*	*post* AD600 (AD1200-1700?)	Typo	1937	Hallvard Håker	Storbreen	SE	6914638	521298	Estimated	OF72/85	26
T 17698,g	Shaft fragment of *Pinus*	*post* AD600 (AD1200-1700?)	Typo	1937	Hallvard Håker	Storbreen	SE	6914638	521298	Estimated	OF72/96	27
T 17700,b & T 17701,c	Shaft of *Betula* and iron point	AD1200-1700	Typo	1937	Erik S. Lo	Kringsollfonna	K	6931605	538281	Estimated	OF72/103 & OF72/118	28
T 17702,a & T 17702,b	Shaft section of *Betula* and iron point	AD1200-1700	Typo	1937	Erik S. Lo	Brattfonna	K	6927571	539889	Estimated	OF72/106 & OF72/112	29

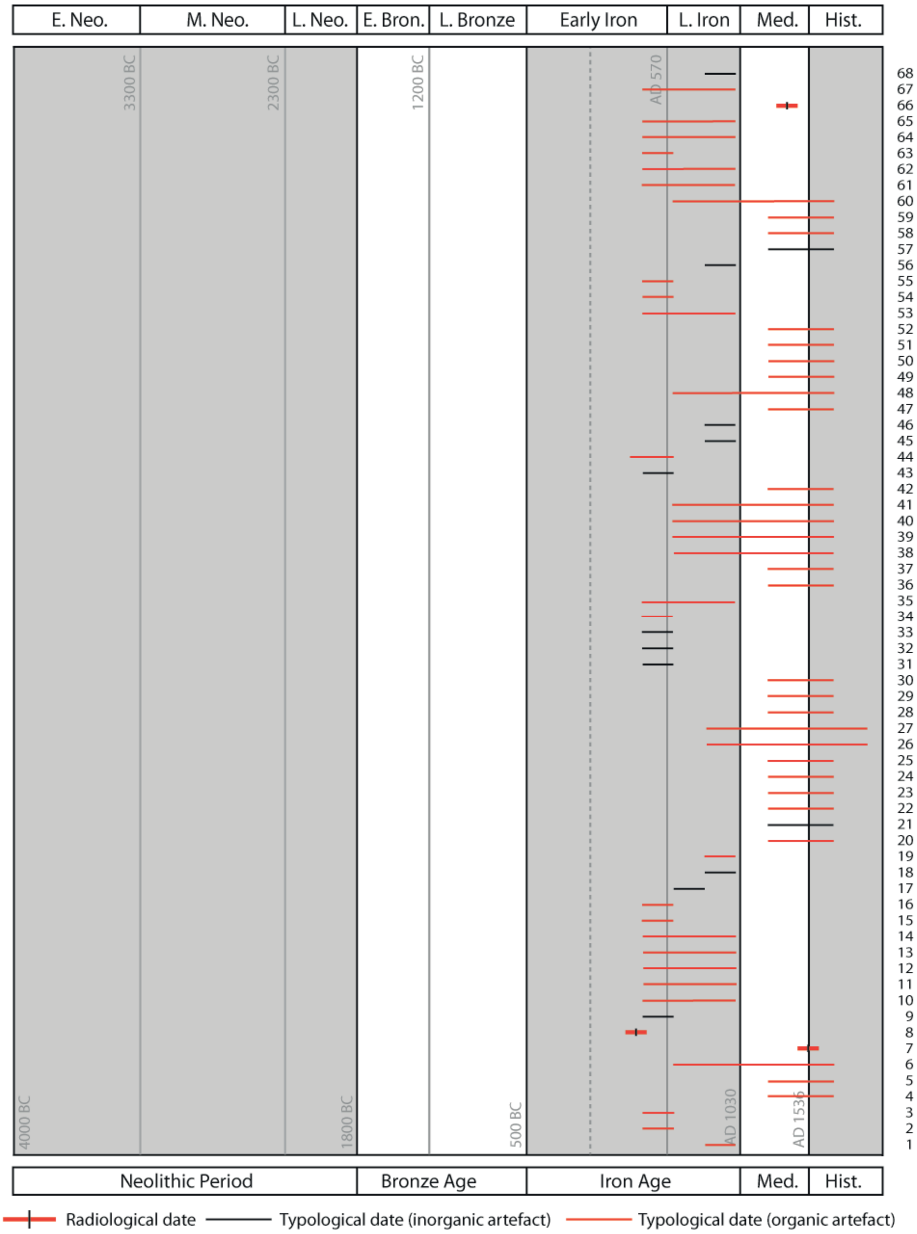
Find Catalogue for Phase 1 (1914-1943)

Appendix 2: Artefacts from Central Norwegian Snow patches

Museum no.	Find Description	Dating	Date Class	Year Found	Found By	Snow Patch/ Location	Zone	North	East	Position	Literature ref.	Figure No.
T 17697,g,/17701h	Shaft fragment of *Betula*	AD1200-1700	Typo	1937	Martin H. Loe & Johs. Petersen	Leirtjønnkollen	K	6925307	538365	Estimated	OF72/107	30
T 17701,a	Iron point	AD400-600	Typo	1936-1937	Martin H. Loe	Sissihøa-Leirtjønnkollen	K	N.D.	N.D.	Zone	OF72/5	31
T 17701,a	Iron point	AD400-600	Typo	1936-1937	Martin H. Loe	Sissihøa-Leirtjønnkollen	K	N.D.	N.D.	Zone	OF72/9	32
T 17701,f	Iron point	AD400-600	Typo	1936-1937	Martin H. Loe	Sissihøa-Leirtjønnkollen	K	N.D.	N.D.	Zone	OF72/12	33
T 17701,g	Shaft of *Pinus*	AD400-600	Typo	1936-1937	Martin H. Loe	Sissihøa-Leirtjønnkollen	K	N.D.	N.D.	Zone	OF72/29	34
T 17701,h	Shaft fragment of *Betula*	*ante* AD1000 (AD400-600?)	Typo	1936-1937	Martin H. Loe	Sissihøa-Leirtjønnkollen	K	N.D.	N.D.	Zone	OF72/34	35
T 17701,e	Iron point and sinew	AD1200-1700	Typo	1936-1937	Martin H. Loe	Sissihøa-Leirtjønnkollen	K	N.D.	N.D.	Zone	OF72/69	36
T 17701,g	Shaft fragment of *Betula*	AD1200-1700	Typo	1936-1937	?	Sissihøa-Leirtjønnkollen	K			Zone	OF72/83	37
T 17701,h	Shaft fragment of *Betula*	*post* AD600 (AD1200-1700?)	Typo	1936-1937	?	Sissihøa-Leirtjønnkollen	K	N.D.	N.D.	Zone	OF72/92	38
T 17701,h	Shaft fragment of *Betula*	*post* AD600 (AD1200-1700?)	Typo	1936-1937	?	Sissihøa-Leirtjønnkollen	K	N.D.	N.D.	Zone	OF72/93	39
T 17701,h	Shaft fragment of *Betula*	*post* AD600 (AD1200-1700?)	Typo	1936-1937	?	Sissihøa-Leirtjønnkollen	K	N.D.	N.D.	Zone	OF72/94	40
T 17701,h	Shaft fragment of *Betula*	*post* AD600 (AD1200-1700?)	Typo	1936-1937	?	Sissihøa-Leirtjønnkollen	K	N.D.	N.D.	Zone	OF72/95	41
T 17701,b	Shaft of *Betula* and iron point	AD1200-1700	Typo	1936-1937	?	Sissihøa-Leirtjønnkollen	K	N.D.	N.D.	Zone	OF72/105 & OF72/115	42
T 17701 a	Iron point	AD400-600	Typo	1936-1937	Martin H. Loe	Sissihøa-Leirtjønnkollen	K	N.D.	N.D.	Zone	OF72/10	43
T 15886	Bone point	AD300-600	Typo	1938	Martin H. Loe	Kringsollfonna	K	6931605	538281	Estimated	OF72/1	44

Find Catalogue for Phase 1 (1914-1943)

Chronological distribution of snow patch finds from central Norway during **Phase 1 (1914-1943)**



Appendix 2: Artefacts from Central Norwegian Snow patches

Museum no.	Find Description	Dating	Date Class	Year Found	Found By	Snow Patch/ Location	Zone	North	East	Position	Literature ref.	Figure No.
T 15634	Iron point	AD800-1000	Typo	1938	Gunnar Wollum	Hesthågåhøa	SE	6918786	530553	Estimated	OF72/40	45
T 15856	Iron point	AD800-1000	Typo	1938	Martin H. Loe	Brattfonna	K	6927571	539889	Estimated	OF72/44	46
T 15858	Shaft of *Betula* and iron point	AD1200-1700	Typo	1938	Martin H. Loe	Kringsollfonna	K	6931605	538281	Estimated	OF72/70 & OF72/76	47
T 18761	Shaft fragment of *Betula*	*post* AD600 (AD1200-1700?)	Typo	1938	Steingrim Lie	Brattfonna	K	6927571	539889	Estimated	OF72/90	48
T 15857	Shaft of *Betula* and iron point	AD1200-1700	Typo	1938	Martin H. Loe	Kringsollfonna	K	6931605	538281	Estimated	OF72/102 & OF72/120	49
T 15854	Club-headed arrow of *Betula*	AD1200-1700	Typo	1938	Hans Bø	Kringsollfonna	K	6931605	538281	Estimated	OF72/108	50
T 15853	Club-headed arrow of *Betula*	AD1200-1700	Typo	1938	Martin H. Loe	Bekkfonnhøa	K	6934051	535652	Estimated	OF72/109	51
T 15855	Club-headed arrow of *Betula*	AD1200-1700	Typo	1938	Erik S, Lo	Kringsollfonna	K	6931610	539406	Estimated	OF72/110	52
T 15845,b	Shaft section of *Betula*	*ante* AD1000 (AD400-600?)	Typo	1939	Erik S. Lo	Kringsollfonna	K	6931605	538281	Estimated	OF72/14	53
T 15845,a	Shaft of *Pinus*	AD400-600	Typo	1939	Erik S. Lo	Kringsollfonna	K	6931605	538281	Estimated	OF72/30	54
T 15845,b	Shaft of *Fraxinus*	AD400-600	Typo	1939	Erik S. Lo	Kringsollfonna	K	6931605	538281	Estimated	OF72/33	55
T 15845,b	Shaft fragment of *Betula*	AD800-1000	Typo	1939	Erik S. Lo	Kringsollfonna	K	6931605	538281	Estimated	OF72/60	56
T 15844,a	Iron point	AD1200-1700	Typo	1939	Jon I. Riise	Leirtjønnkollen	K	6925307	538365	Estimated	OF72/64	57
T 15844,b & T 15844,a	Shaft fragment of *Betula* and iron point	AD1200-1700	Typo	1939	Martin H. Loe & Johs. Petersen	Leirtjønnkollen	K	6925307	538365	Estimated	OF72/66 & OF72/89	58
T 15844,c	Shaft fragment of *Betula*	AD1200-1700	Typo	1939	Jon I. Riise	Leirtjønnkollen	K	6925307	538365	Estimated	OF72/81	59
T 15845,b	Shaft fragment of *Betula*	*post* AD600 (AD1200-1700?)	Typo	1939	Erik S. Lo	Kringsollfonna	K	6931605	538281	Estimated	OF72/100	60
T 16077,c	Shaft section of *Betula*	*ante* AD1000 (AD400-600?)	Typo	1941	Hallvard Håker	Storbreen	SE	6914638	521298	Estimated	OF72/13	61
T 16077,d	Shaft section of *Betula*	*ante* AD1000 (AD400-600?)	Typo	1941	Hallvard Håker	Storbreen	SE	6914638	521298	Estimated	OF72/15	62

Find Catalogue for Phase 1 (1914-1943)

Appendix 2: Artefacts from Central Norwegian Snow patches

Museum no.	Find Description	Dating	Date Class	Year Found	Found By	Snow Patch/ Location	Zone	North	East	Position	Literature ref.	Figure No.
T 16077,b	Shaft of *Betula*	AD400-600	Typo	1941	Hallvard Håker	Storbreen	SE	6914638	521298	Estimated	OF72/18	63
T 16077,d	Shaft section of *Betula*	*ante* AD1000 (AD400-600?)	Typo	1941	Hallvard Håker	Storbreen	SE	6914638	521298	Estimated	OF72/22	64
T 16077,d	Shaft section of *Betula*	*ante* AD1000 (AD400-600?)	Typo	1941	Hallvard Håker	Storbreen	SE	6914638	521298	Estimated	OF72/26	65
T 16055	Shaft of *Betula* and iron point	Median AD1340	C14	1941	Ola Nerlo	Brattfonna	K	6927571	539889	Estimated	OF72/73 & OF72/84	66
T 16077	Bow fragment of *Pinus*	N.D.	N.D.	1941	Hallvard Håker	Storbreen	SE	6914638	521298	Estimated	OF72/111	x
T 16243	Shaft section of *Betula*	*ante* AD1000 (AD400-600?)	Typo	1943	Erik S. Lo	Kringsollfonna	K	6931605	538281	Estimated	OF72/24	67
T 14658	Iron point	AD800-1000	Typo	?	Erik Nestavold	N. Knutshø	K	6910609	534922	Estimated	OF72/47	68

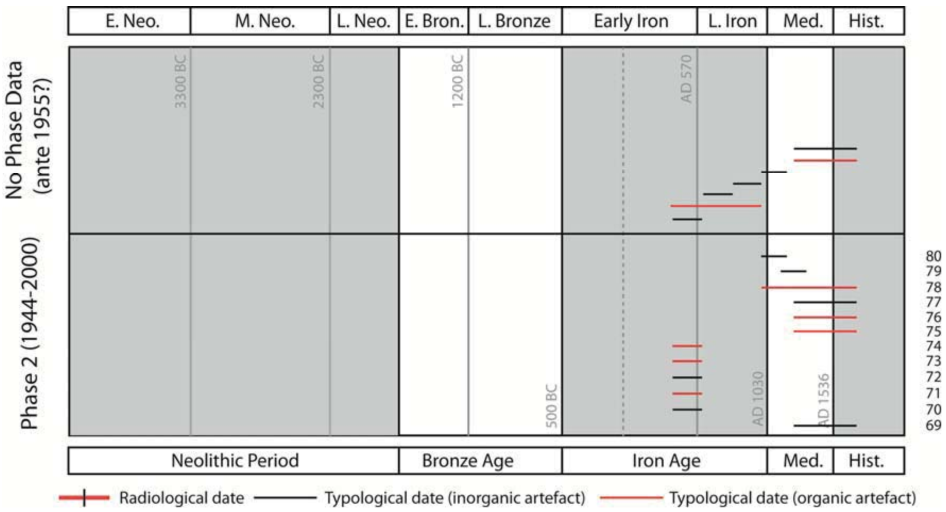
Find Catalogue for Phase 1 (1914-1943)

Museum no.	Find Description	Dating	Date Class	Year found	Found by	Snow patch/ Location	Zone	North	East	Position	Literature ref.	Figure No.
T 16540	Iron point	AD1200-1700	Typo	1947	Ola H. Mjøen	Brattfonna	K	6927571	539889	Estimated	OF72/116	69
T 18936	Iron point	AD400-600	Typo	1950	Audun Håvimb	Storbreen	SE	6914638	521298	Estimated	OF72/7	70
T 24761	Shaft fragments of *Betula* and iron point	AD400-600	Typo	1955	Oddvar Hoel	Storbreen	SE	6914279	521169	Estimated		71
T 19277	Iron point	AD400-600	Typo	1973	Per Johansen	Snøhetta	SE	6909717	515388	Estimated	OF83/fig.17	72
T 20101,a	Shaft of *Betula* and iron point	AD400-600	Typo	1980	Oddmunn Farbregd	Løpesfonna	K	6915369	519157	Estimated	OF83/fig.11	73
T 20102	Shaft section of *Betula*	AD400-600	Typo	1980	Oddmunn Farbregd	Vegskardet	SE	6914433	517321	Estimated	OF83/fig.11	74
T 20103	Shaft section of *Betula*	AD1200-1700	Typo	1980	John Reidar Ekrann, Jon I. Rise & Oddmunn Farbregd	Leirtjønnkollen	K	6925307	538365	Estimated	OF83/fig.11	75
T 20104	Shaft fragments of *Quercus*	AD1200-1700	Typo	1980	Jon Reidar Ekrann, Jon I. Rise & Oddmunn Farbregd	Leirtjønnkollen	K	6925307	538365	Estimated	OF83/fig.11	76
T 20105	Iron point	AD1200-1700	Typo	1980	Harald Lo	Leirtjønnkollen	K	6925307	538365	Estimated		77
T 22285	Bow fragments of *Betula*	AD1000-1700	Typo	c. 1980	Oddleif Myrvan	Tverrfjellet	SE	6927265	520056	Estimated		78
T 23012	Iron point	AD1100-1300	Typo	c. 1980	Asgeir Norheim	Leirtjønnkollen	K	6925307	538365	Estimated		79
T 21735	Iron point	AD1000-1200	Typo	1993	Knut Tore Ekrann	Leirtjønnkollen	K	6925307	538365	Estimated		80

Appendix 2: Artefacts from central Norwegian Snow Patches

Museum No.	Find Description	Dating	Date Class	Year Found	Found by	Snow patch/ Location	North	East	Position	Literature Ref.
T 17687	Iron point	AD400-600	Typo	?	Henry O. Klett	Storbreen	6914638	521298	Estimated	72/11
T 17686	Shaft section of *Betula*	*ante* AD1000	Typo	?	Peder Fossheim	Storbreen	6914638	521298	Estimated	72/23
T 17675	Iron point	AD600-800	Typo	?	Gunnar Wesche	Løftingfonnkollen	6916048	520033	Estimated	72/35
T 17688	Iron point	AD800-1000	Typo	?	Alf Klett	Kinnin	6913992	522496	Estimated	72/49
T 17690	Iron point	AD1000-1200	Typo	?	Hans Bøe	Brattfonna	6927571	539889	Estimated	72/54
T 17689	Iron Point & whole shaft of *Betula*	AD1200-1700	Typo	?	Gustav Hevle	Sissihøa-Brattfonna	6927571	539889	Estimated	72/71 & 72/80
T 18700	Iron point	AD1200-1700	Typo	?	John P. Mjøen	Brattfonna	6927571	539889	Estimated	72/117

Find catalogue for finds with no find date (ante 1955?)



E. Neo.
M. Neo.
L. Neo.
E. Bron.
L. Bronze
Early Iron
L. Iron
Med.
Hist.
No Phase Data (ante 1955?)
Phase 2 (1944-2000)
3300 BC
2300 BC
1200 BC
500 BC
AD 570
AD 1030
AD 1536
80
79
78
77
76
75
74
73
72
71
70
69
Neolithic Period
Bronze Age
Iron Age
Med.
Hist.
Radiological date
Typological date (inorganic artefact)
Typological date (organic artefact)

Museum no.	Find Description	Dating	Date Class	Year found	Found by	Snow Patch/ Location	North	East	Position	Literature ref.	Figure no
T 22640	Bow fragments of *Betula*	N.D	N.D.	2001	Sturla Sæther	Tverrfjellet	6927265	520056	Estimated	F&B00:51 OF09 fig.10	X
T 22834	Shaft sections of *Betula*	AD1200-1700	Typo	2002	Geir Arild Espenes	Bekkfonnhøa	6934051	535652	Estimated		81
T 22928	Shaft fragments of *Betula*	N.D.	N.D.	2003	Tord Bretten	Leirtjønnkollen	6925050	538500	GPS		X
T 22929	Shaft of *Quercus* and iron point	AD400-600	Typo	2003	Tord Bretten	Brattfonna	6927125	539989	GPS	B&R04:46	82
T 22924	Whole shaft of *Pinus* with feathers	AD400-600	Typo	2003	Tord Bretten & Ingolf Røtvei	Nær Kringsollfonna	6931639	539390	GPS	TB03:13 OF09 fig.7&8	83
T 22930	Iron point	AD400-600	Typo	2003	Tord Bretten	Brattfonna	6927144	539912	GPS	F&B03:2	84
T 22931	Shaft section of *Betula* and iron point	AD1300-1700	Typo	2003	Ingolf Røtvei	Leirtjønnkollen	6925307	538365	Estimated	F&B03:6	85
T 22932	Shaft fragments of *Betula*	ante AD1000	Typo	2003	Tord Bretten	Kringsollfonna	6931432	538558	GPS		86
T 22933	Wood fragments of *Prunus*	N.D.	N.D.	2003	Tord Bretten	Kringsollfonna	69311678	538157	GPS		X
T 22934	Shaft fragment of *Betula*	ante AD1000	Typo	2003	Tord Bretten	Brattfonna	6927115	540029	GPS		87
T 22935	Iron knife blade	AD600-800	Typo	2003	Ingolf Røtvei	Kringsollfonna	6931437	538521	GPS	OF09 fig.12	88
T 22984	Iron point	AD900-1100	Typo	2003	Asbjørn Iveland	Skiråtangan (Sunndal)	6924032	504776	GPS		89
T 22939	Slate point	(ante 1500 BC) (2480-2340BC?)	Typo	2003	Bodil & Ola Munkvold	Brattfonna	6928639	539691	Estimated	LIÅ07 fig.5	90
T 22940	Iron point	AD400-600	Typo	2003	Bodil & Ola Munkvold	Brattfonna	6928639	539691	Estimated		91
T 22936	Shaft fragment of *Betula* and iron point	AD400-600	Typo	2003	Ingolf Røtvei	Kringsollfonna	6931595	538150	GPS		92
T 22937	Shaft of *Betula*	AD900-1100	Typo	2003	Tord Bretten	N. Knutshø	6910947	534119	GPS		93
T 22938	Shaft fragments of *Betula* and iron point	AD900-1100	Typo	2003	Tord Bretten	N. Knutshø	6910609	534922	Estimated	F&B03:3	94

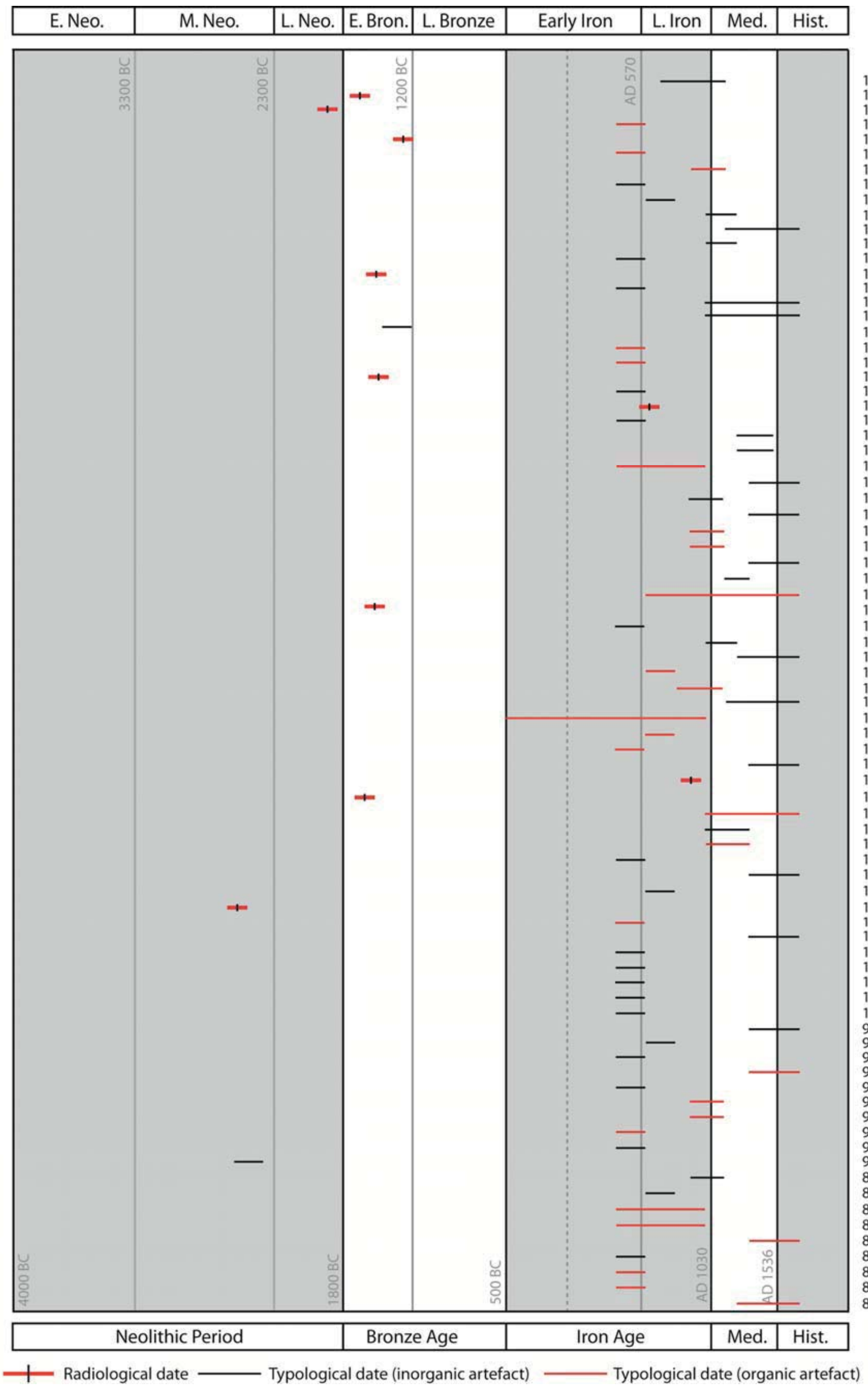
Museum no.	Find Description	Dating	Date Class	Year found	Found by	Snow Patch/ Location	North	East	Position	Literature ref.	Figure no
T 22979	Iron point	AD400-600	Typo	2003	Ingolf Røtvei & Tord Bretten	Kringsollfonna	6931580	538445	GPS	F&B03:4	95
T 22980	Shaft fragment of *Betula*	AD1300-1700	Typo	2003	Ingolf Røtvei & Tord Bretten.	Kringsollfonna	6931712	538087	GPS		96
T 22981	Iron point	AD400-600	Typo	2003	Jostein Mellem	Kringsollfonna	6931605	538281	Estimated	F&B03:7	97
T 22982	Iron point	AD600-800	Typo	2003	Jostein Mellem	Kringsollfonna	6931605	538281	Estimated	F&B03:5	98
T 22983	Iron point	AD1300-1700	Typo	2003	Jostein Mellem	Leirtjønnkollen	6925307	538365	Estimated		99
T 23013	Wooden object of *Betula* (Snare?)	N.D.	N.D.	2003	Sturla Sæther	Tverrfjellet	6927265	520056	Estimated		X
T 23050	Iron point	AD400-600	Typo	2004	Jostein Mellem	Brattfonna	6928639	539691	Estimated		100
T 23051	Iron point	AD400-600	Typo	2004	Stig Innerdal & Jostein Mellem	Brattfonna	6928639	539691	Estimated		101
T 23058	Iron point	AD400-600	Typo	2004	Randi Røtvei	Kringsollfonna	69316119	538222	GPS		102
T 23059	Wooden object	N.D.	N.D.	2004	Ingolf Røtvei	Kringsollfonna	6931619	538222	GPS		X
T 23060	Shaft fragment of *Betula*	N.D.	N.D.	2004	Ingolf Røtvei	Kringsollfonna	6931621	538356	GPS		X
T 23061	Wooden object of *Pinus*	N.D.	N.D.	2004	Ingolf Røtvei	Kringsollfonna	6931621	538356	GPS		X
T 23052	Iron point	AD400-600	Typo	2004	Jostein Mellem	Brattfonna	6927571	539889	Estimated		103
T 23053	Iron point	AD400-600	Typo	2004	Jostein Mellem	Brattfonna	6927571	539889	Estimated		104
T 23054	**Beslag til slagpil (armb)**	AD1300-1700	Typo	2004	Jostein Mellem	Brattfonna	6927571	539889	Estimated		105
T 23055	Shaft fragments of *Betula*	AD400-600	Typo	2004	Jostein Mellem	Brattfonna	6927571	539889	Estimated		106
T 23062	Slate point	Median 2410BC.	C14	2004	Jostein Mellem	Kringsollfonna	6931605	538281	Estimated	LIÅ07 fig.5	107
T 23063	Iron point	AD600-800	Typo	2004	Jostein Mellem	Kringsollfonna	6931605	538281	Estimated		108
T 23064	Iron point	AD1300-1700	Typo	2004	Jostein Mellem	Leirtjønnkollen	6925307	538365	Estimated		109
T 23065	Iron point	AD400-600	Typo	2004	Jostein Mellem	Brattfonna	6927571	539889	Estimated		110
T 23066	Shaft fragment of *Betula* and iron point	AD1000-1300	Typo	2004	Jostein Mellem	Kringsollfonna	6931605	538281	Estimated		111
T 23067	Iron point fragment	AD1000-1300	Typo	2004	Jostein Mellem	Kringsollfonna	6931605	538281	Estimated		112
T 23068	Shaft section of *Betula*	AD1000-1700	Typo	2004	Jostein Mellem	Kringsollfonna	6931605	538281	Estimated		113

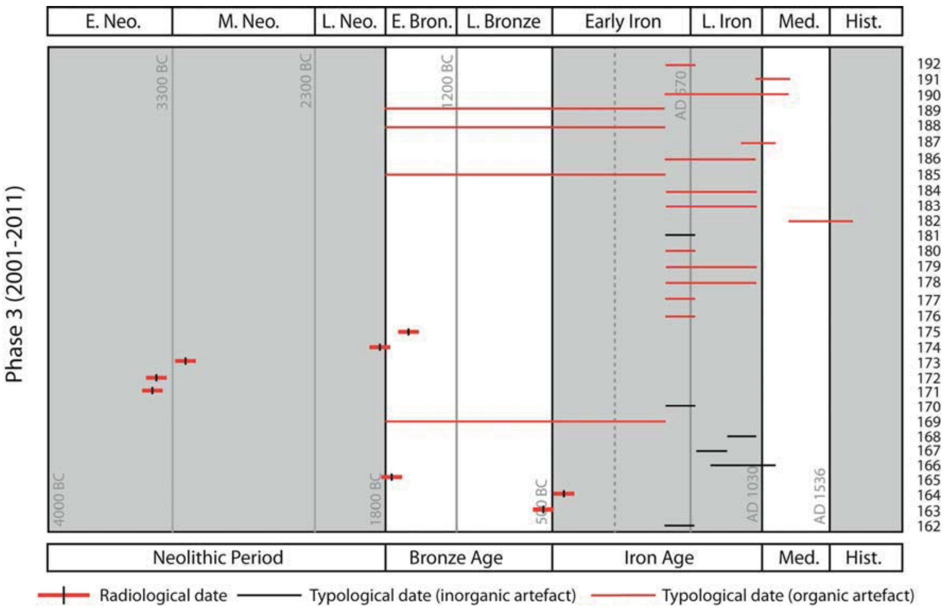
Appendix 2: Artefacts from Central Norwegian Snow patches

Museum no.	Find Description	Dating	Date Class	Year found	Found by	Snow Patch/ Location	North	East	Position	Literature ref.	Figure no
T 23069	Shaft section of *Corylus*	Median 1656BC	C14	2004	Jostein Mellem	Kringsollfonna	6931605	538281	Estimated	LIÅ07 fig.7	114
T 23070	Shaft fragment of *Betula*	Median AD900	C14	2004	Jostein Mellem	Kringsollfonna	6931605	538281	Estimated		115
T 23230	Iron point	AD1300-1700	Typo	2005	Jostein Mellem	Leirtjønnkollen	6925307	538365	Estimated		116
T 23396	Shaft section of *Betula*	AD400-600	Typo	2006	Ingolf Røtvei	Løpesfonna	6915402	519143	GPS	OF09 fig.14	117
T 26452	Wood fragments of *Pinus*	N.D.	N.D.	2006	Tor Helge Gravem & Morten Rye	N. Svarthammaren	6924023	487491	GPS		X
T 23398	Shaft section of *Betula* and iron point	AD600-800	Typo	2006	Ingolf Røtvei	Leirtjønnkollen	6925295	538401	GPS		118
T 23402	Shaft section of *Betula*	ca. 500BC-AD1000?	Typo	2006	Tord Bretten	Vegskardet	6914742	516785	GPS		119
T 23399	Wooden object of *Pinus* (poles?)	N.D.	N.D.	2006	Ingolf Røtvei	Langfonnskarven	6924512	533527	GPS		X
T 23401	Iron point	AD1100-1700	Typo	2006	Leif Inge Åstveit	Brattfonna	6927515	539819	GPS		120
T 23403	Shaft fragments of *Betula* and iron point	AD800-1000	Typo	2006	Tord Bretten	N. Knutshø	6910932	534208	GPS		121
T 23400	Shaft fragment of *Betula* and iron point	AD600-800	Typo	2006	Leif Inge Åstveit	Leirtjønnkollen	6925291	538409	GPS	LIÅ07 fig.2	122
T 23404	Iron point	AD1200-1700	Typo	2006	Jostein Mellem	Leirtjønnkollen	6925153	538499	GPS	OF09 fig.13	123
T 23405	Iron point	AD1000-1200	Typo	2006	Jostein Mellem	Leirtjønnkollen	6925084	538504	GPS		124
T 23406	Iron point	AD400-600	Typo	2006	Jostein Mellem	Leirtjønnkollen	6925307	538365	Estimated		125
T 23411	Shaft fragments of *Betula*	Median 1571BC	C14	2006	Rune Pedersen	Storbreen	6914638	521298	Estimated	OF09 fig.15 MCxx fig.7a	126
T 23412	Shaft fragments of *Betula*	AD600-?	Typo	2006	Rune Pedersen	Storbreen	6914638	521298	Estimated		127
T26453	Wooden object of *Pinus* (staff?)	N.D.	N.D.	2006	Mary Finset	Grovåbotn, Nesset kommune	6915200	459391	Estimated		X
T 23416	Iron point	AD1100-1300	Typo	2006	Arne I. Holen	Brattfonna	6927571	539889	Estimated		128

Museum no.	Find Description	Dating	Date Class	Year found	Found by	Snow Patch/ Location	North	East	Position	Literature ref.	Figure no
T 23430	Iron point	AD1300-1700	Typo	2006	Jostein Mellem	Leirtjønnkollen	6925307	538365	Estimated		129
T 23417	Shaft fragments of *Betula* and point of iron	AD900-1100	Typo	2006	Ingolf Røtvei	Brattfonna	6927318	539963	GPS		130
T 23431	Shaft section of *Betula* and iron point	AD900-1100	Typo	2006	Joar Løvsletten	Råstu, Sunndal	6932321	489211	GPS		131
T 24130	Iron point	AD1300-1700	Typo	2008	Jostein Mellem	Leirtjønnkollen	6925168	538480	GPS		132
T 24131	Iron point	AD900-1100	Typo	2008	Jostein Mellem	Leirtjønnkollen	6925109	538509	GPS		133
T 24132	Iron point	AD1300-1700	Typo	2008	Jostein Mellem	Brattfonna	6927135	539987	GPS		134
T 24133	Shaft fragments of *Alnus/Betula?*	ante AD1000	Typo	2008	Jostein Mellem	Brattfonna	6927102	540006	GPS		135
T 24134	Iron point	AD1200-1500	Typo	2008	Jostein Mellem	M. Knutshø	6909076	535269	GPS		136
T 24135	Iron point	AD1200-1500	Typo	2008	Jostein Mellem	N. Knutshø	6910560	534950	GPS		137
T 24136	Iron point	AD400-600	Typo	2008	Jostein Mellem	N. Knutshø	6910819	534701	GPS		138
T 24140	Shaft of *Betula*	Median AD618	C14	2008	Martin Callanan	Storbreen	6915007	521102	GPS		139
T 24137	Iron point	AD400-600	Typo	2008	Ingolf Røtvei	Storbreen	6914997	521090	GPS		140
T 24138	Shaft section of *Betula*	Median 1556BC	C14	2008	Ingolf Røtvei	Løftingfonnkollen	6915957	520190	GPS	OF09 fig.16	141
T 24139	Wooden object of *Pinus*	N.D.	N.D.	2008	Ingolf Røtvei	Løftingfonnkollen	6915954	520204	GPS		X
T 24141	Shaft fragments of *Betula* and point of iron	AD400-600	Typo	2008	Martin Callanan	Storbreen	6914735	521179	GPS	MC10 fig.2	142
T 24366	Shaft of *Betula*	N.D.	N.D.	2008	Rune Pedersen	Løpesfonna	6915299	519258	GPS		X
T 24982 & T 24367	Shaft of *Betula* & antler point	Median 1150BC	C14	2008	Rune Pedersen	Løpesfonna	6915310	519258	GPS	MCxx fig.6, fig.7d, fig.8	143
T 24992	Iron point	AD1000-1700	Typo	2009	Jostein Mellem	Leirtjønnkollen	6925368	538261	GPS		144
T 24993	Iron point	AD1000-1700	Typo	2009	Jostein Mellem	Leirtjønnkollen	6925374	538189	GPS		145
T 24994	Iron point	AD400-600	Typo	2009	Jostein Mellem	Leirtjønnkollen	6925384	538186	GPS		146
T 24981	Shaft fragments of *Betula*	Median 1569BC	C14	2009	Rune Pedersen	Storbreen	6914943	521233	GPS		147
T 24995	Iron point	AD400-600	Typo	2009	Jostein Mellem	N. Knutshø	6910585	534916	GPS		148
T 24996	Iron point	AD1000-1200	Typo	2009	Jostein Mellem	N. Knutshø	6910820	534715	GPS		149

Chronological distribution of snow patch finds from central Norway during **Phase 3 (2001-2011)**




E. Neo.
M. Neo.
L. Neo.
E. Bron.
L. Bronze
Early Iron
L. Iron
Med.
Hist.
Phase 3 (2001-2011)
4000 BC
3300 BC
2300 BC
1800 BC
1200 BC
500 BC
AD 570
AD 1030
AD 1536
192
191
190
189
188
187
186
185
184
183
182
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167
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165
164
163
162
Neolithic Period
Bronze Age
Iron Age
Med.
Hist.
Radiological date
Typological date (inorganic artefact)
Typological date (organic artefact)

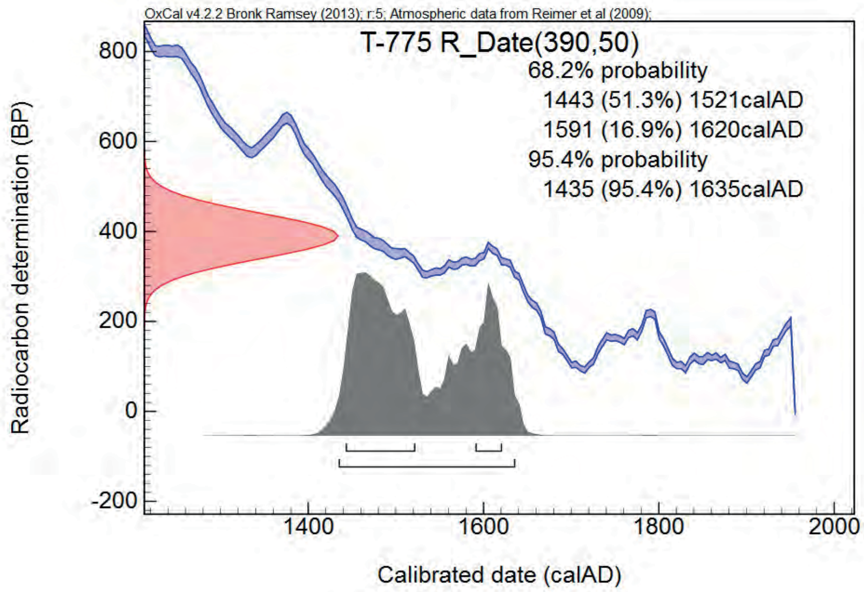
Museum no.	Find Description	Dating	Date Class	Year found	Found by	Snow Patch/ Location	North	East	Position	Literature ref.	Figure no
T 25417	Iron point	ca. AD1100-?	Typo	2010	Jostein Mellem	Leirtjønnkollen	6925359	538464	GPS		150
T 25418	Iron point	AD1000-1200	Typo	2010	Jostein Mellem	Brattfonnhøa	6927767	539688	GPS		151
T 25419	Iron point	AD600-800	Typo	2010	Jostein Mellem	Brattfonnhøa	6926890	540326	GPS		152
T 25420	Iron point	AD400-600	Typo	2010	Jostein Mellem	Brattfonnhøa	6929970	540320	GPS		153
T 25165	Shaft of *Betula* and iron point	AD900-1100	Typo	2010	Ingolf Røtvei	Storbreen	6914597	521375	GPS		154
T 25166	Shaft of *Pinus* and iron point	AD400-600	Typo	2010	Ingolf Røtvei	Storbreen	6914600	521384	GPS		155
T 25421	Wooden object of *Pinus*	N.D.	N.D.	2010	Jostein Mellem	Gravbekkfonna	6924718	525803	GPS		X
T 25167	Shaft of *Betula* and antler point	Median 1301BC	C14	2010	Tord Bretten	Storbreen	6914975	520959	GPS	MCxx fig.5a&b, fig7c	156
T 25168	Shaft of *Betula* and iron point	AD400-600	Typo	2010	Tord Bretten	Storbreen	6914811	521086	GPS	MC12 fig.2	
T 25169	Shaft fragments of *Betula*	N.D.	N.D.	2010	Tord Bretten	Storbreen	6914563	521433	GPS		X
T 25170	Shaft fragment of *Betula*	Median 2056BC	C14	2010	Tord Bretten	Storbreen	6914771	521097	GPS		157
T 25171	Shaft fragments of *Betula*	N.D.	N.D.	2010	Tord Bretten	Løpesfonna	6915384	519158	GPS		X
T 25172	Shaft of *Betula* and shell point	Median 1664BC	C14	2010	Tord Bretten	Løpesfonna	6915398	519149	GPS	MCxx fig.2a	158
T 25173	Wooden object of *Betula* (staff?)	N.D.	N.D.	2010	Julian Martinsen	Storbreen	6914564	521426	GPS		X
T 25284	Shaft fragments of *Betula*	N.D.	N.D.	2010	Rune Pedersen	Storbreen	6914943	521232	GPS		X
T 25175	Shaft section of *Betula*	N.D.	N.D	2010	Arne Johs. Mortensen	Kaldvellkinn	6911796	524361	GPS		X
T 25174	Iron point	AD700-1100	Typo	2010	Arne Johs. Mortensen	Kaldvellkinn	6911796	524361	GPS		159
T 25289	Wooden object of *Quercus* (flat)	N.D.	N.D.	2010	Ingolf Røtvei	Sissihøa	6933946	536791	GPS		X
T 25283	Bone fragment	N.D.	N.D.	2010	Rune Pedersen	Løpesfonna	6915224	519436	GPS		X

Museum no.	Find Description	Dating	Date Class	Year found	Found by	Snow Patch/ Location	North	East	Position	Literature ref.	Figure no
T 25285	Iron point	AD400-600	Typo	2010	Rune Pedersen	Storbreen	6914761	521161	GPS		160
T 25286.1	Shaft sections of *Betula*	Median 580BC	C14	2010	Rune Pedersen	Løpesfonna	6915231	519384	GPS	MCxx fig.7b, fig.8b	161
T 25286.2	Shaft section of *Betula*	Median 406BC	C14	2010	Rune Pedersen	Løpesfonna	6915231	519384	GPS		162
T 25287	Shaft of *Betula*	Median 1759BC	C14	2010	Rune Pedersen	Løpesfonna	6915382	519153	GPS	MC13 fig.8	163
T 25288	Wooden object of *Betula* (pointed)	N.D.	N.D.	2010	Tord Bretten	Storbreen	6914733	521078	GPS		X
T 25282	Iron point	AD700-1100	Typo	2010	Ivar Berthling	Kringsollfonna	6931565	538468	GPS		164
T 25671	Iron point	AD600-800	Typo	2011	Jostein Mellem	Kringsollfonna	6910820	534714	GPS		165
T 25672	Shaft fragment of *Betula*	AD800-1000	Typo	2011	Jostein Mellem	Storbreen	6915064	521108	GPS		166
T 25678	Shaft section of *Betula*	ca. 1800BC-AD400	Typo	2011	Ingolf Røtvei	Løpesfonna	6915229	519357	GPS		167
T 25679	Wooden object of *Betula*	N.D.	N.D.	2011	Ingolf Røtvei	Løpesfonna	6915229	519357	GPS		X
T 25681	Iron point	AD400-600	Typo	2011	Håvard Rønning	Kaldvellkinn	6911770	524358	GPS		168
T 25673	Bow fragments of *Pinus*	N.D	N.D.	2011	Tord Bretten & Line Bretten Aukrust	Storbreen	6915014	521153	GPS		X
T 25674	Shaft of *Salix* and slate point	Median 3456BC	C14	2011	Tord Bretten & Line Bretten Aukrust	Storbreen	6914548	521432	GPS	MC13 fig.6	169
T 25675	Shaft fragments of *Pinus*	Median 3447BC	C14	2011	Line Bretten Aukrust & Tord Bretten	Storbreen	6914465	521496	GPS	MC13 fig.5	170
T 25676	Shaft fragments of *Pinus* and slate point	Median3206BC	C14	2011	Line Bretten Aukrust & Tord Bretten	Storbreen	6914254	521198	GPS	MC13 fig.7	171
T 25677	Bow fragments of Ulmus	Median1816BC	C14	2011	Line Bretten Aukrust & Tord Bretten	Storbreen	6914547	521287	GPS	MC13 fig.9	172

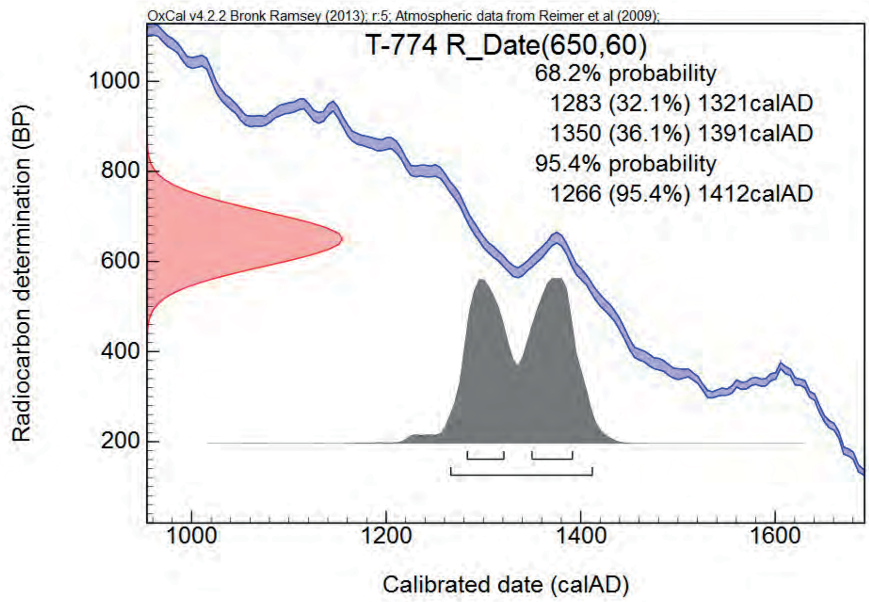
Museum no.	Find Description	Dating	Date Class	Year found	Found by	Snow Patch/ Location	North	East	Position	Literature ref.	Figure no
T 25683	Wood fragment of *Betula*	N.D.	N.D.	2011	Tord Bretten	Løpesfonna	6915385	519159	GPS		X
T 25684	Shaft section of *Betula* and shell point	Median 1628BC	C14	2011	Tord Bretten	Løpesfonna	6915390	519148	GPS	MCxx fig.2b	173
T 25698	Wood fragment of *Pinus*	N.D.	N.D.	2011	Ingolf Røtvei	Brattfonna	6927215	539853	GPS		X
T 25699	Wood fragment of *Pinus*	N.D.	N.D.	2011	Ingolf Røtvei	Langfonnskarven	6924505	533526	Estimated		X
T 25685	Shaft fragments of *Betula*	N.D.	N.D.	2011	Tord Bretten	Vegskardet	6914728	516852	GPS		X
T 25686	Shaft of *Betula* and iron point	AD400-600	Typo	2011	Tord Bretten	Løpesfonna	6915236	519276	GPS		174
T 25687	Shaft of *Betula* and iron point	AD400-600	Typo	2011	Tord Bretten	Storbreen	6915003	520979	GPS		175
T 25688	Shaft fragments of *Betula*	ante AD1000	Typo	2011	Tord Bretten	Storbreen	6915007	521015	GPS		176
T 25689	Shaft fragment of *Betula*	ante AD1000	Typo	2011	Tord Bretten	Storbreen	6914536	521449	GPS		177
T 25690	Shaft section of *Betula* and iron point	AD400-600	Typo	2011	Tord Bretten	Storbreen	6914441	521500	GPS		178
T 25692	Iron point	AD400-600	Typo	2011	Marita Danielsen,	Kringsollfonna	6931619	538352	GPS		179
T 25693	Shaft fragments of *Betula*	N.D.	N.D.	2011	Ivar Berthling	Kringsollfonna	6931662	538243	GPS		X
T 25694	Bark fragment (unidentified)	N.D.	N.D.	2011	Ivar Berthling	Kringsollfonna	6931605	538281	Estimated		X
T 25700	Shaft section of *Betula* and iron point	AD1200-1700	Typo	2011	Line Bretten Aukrust et al	Kringsollfonna	6931657	538352	GPS		180
T 25701	Wooden fragments of *Betula*	N.D.	N.D.	2011	Line Bretten Aukrust et al	Kringsollfonna	6931629	538426	GPS		X
T 25732	Shaft fragments	ante AD1000	Typo	2011	Jostein Mellem	Kringsollfonna	6931777	538018	Estimated		181
T 25733	Shaft fragments	ante AD1000	Typo	2011	Jostein Mellem	Kringsollfonna	6931655	538254	GPS		182
T 25702	Wooden fragment of *Betula*	N.D.	N.D.	2011	Liv B. Flå	Løpesfonna	6915389	518977	GPS		X

Museum no.	Find Description	Dating	Date Class	Year found	Found by	Snow Patch/ Location	North	East	Position	Literature ref.	Figure no
T 25703	Shaft fragments of *Betula*	ca. 1800BC-AD400	Typo	2011	Håvard Rønning	Løpesfonna	6915231	519357	GPS		183
T 25704	Shaft fragments of *Betula*	ante AD1000	Typo	2011	Hårvard Rønning	Storbreen	6914537	521449	GPS		184
T 25707	Wood fragments of *Pinus*	N.D.	N.D.	2011	Tord Bretten	Vegskardet	6914326	517794	GPS		X
T 25709	Shaft of *Betula* and iron point	AD900-1100	Typo	2011	Tord Bretten	Namnlauskollen	6915883	521864	GPS		185
T 25715	Shaft fragments of *Betula*	1800BC-AD400?	Typo	2011	Ola E. Bolme	Skirådalskardet	6923644	510398	GPS		186
T 25716	Shaft section of *Betula*	1800BC-AD400?	Typo	2011	Ingolf Røtvei	Brattfonna	6927110	539888	GPS		187
T 25710	Wooden fragments of *Betula*	N.D.	N.D.	2011	Tord Bretten	Storbreen	6915024	521148	GPS		X
T 25712	Shaft of *Betula*	ante AD1200	Typo	2011	Tord Bretten	Kinnin	6913996	522506	GPS		188
T 25713	Small wooden fragments of *Tilia*	N.D.	N.D.	2011	Line Bretten Aukrust	Kringsollfonna	6931442	538557	GPS		X
T 25714	Modified feathers (Unidentified)	N.D.	N.D.	2011	Line Bretten Aukrust	Bekkfonnhøa	6934459	536211	GPS		X
T 25717	Shaft of *Betula* and iron point	AD1000-1200	Typo	2011	Ingolf Røtvei	Svartdalskardet	6927085	514824	GPS		189
T 25734	Shaft fragments and iron point	AD400-600	Typo	2011	Jostein Mellem	Håråkollen	6914959	518416	Estimated		190

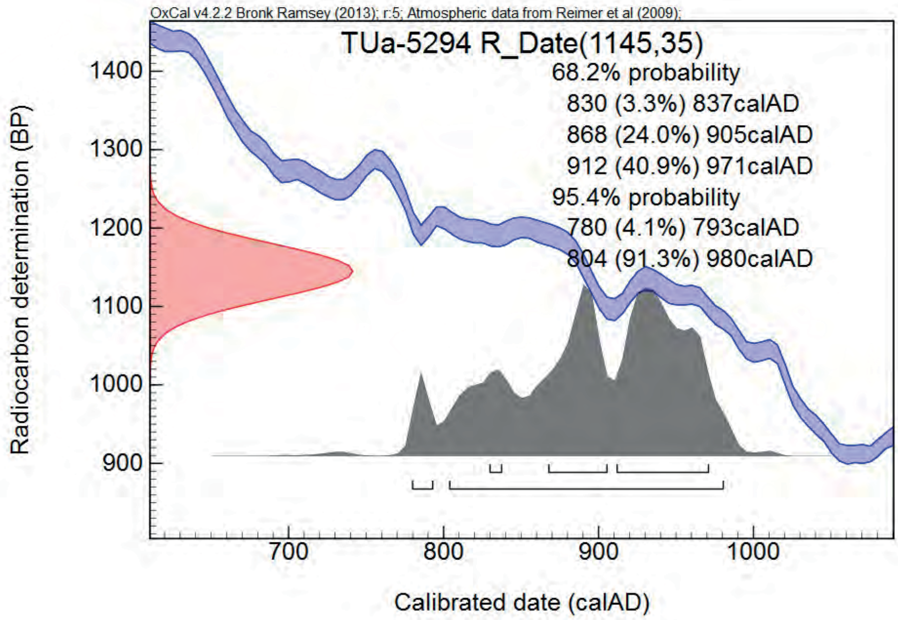
Appendix 3: Radiocarbon dates from Artefacts from Central Norwegian Snow Patches



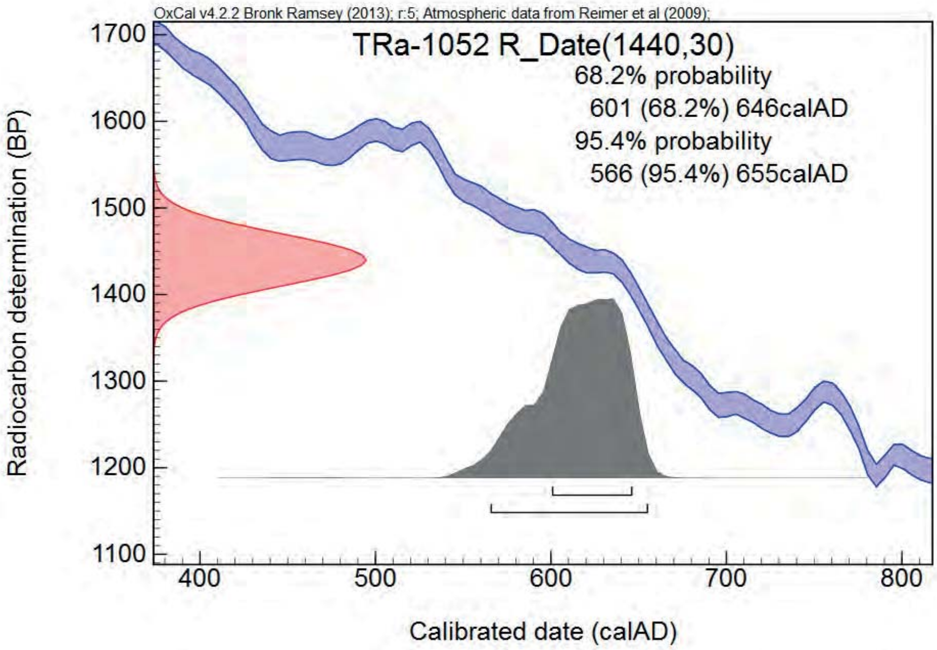
T-775: ^{14}C result for artefact ID T 17697,b. See OF 72/104 & 72/113.



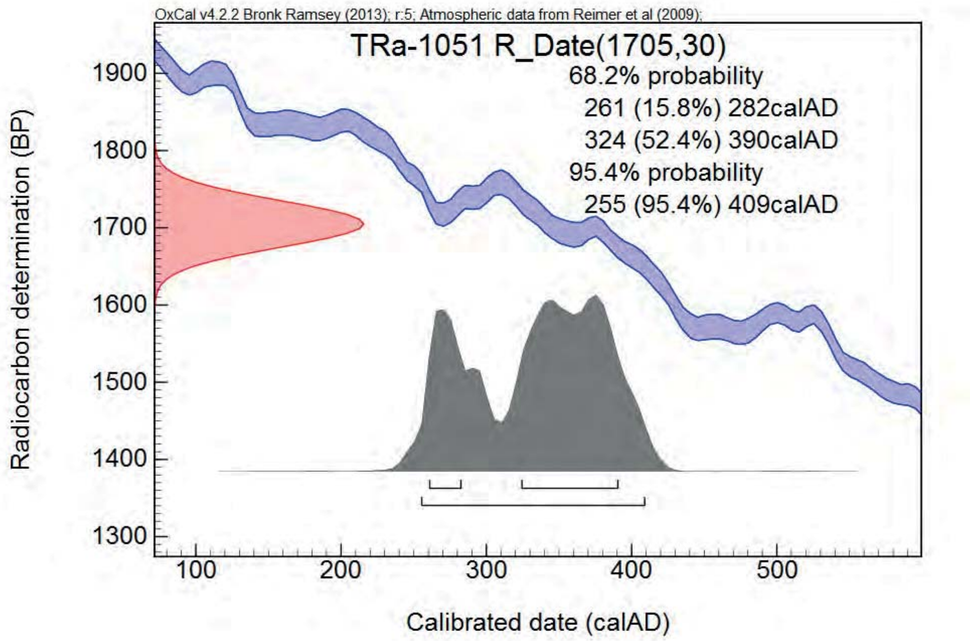
T-774: ^{14}C result for artefact ID T 16055. See OF 72/73 & 72/84.



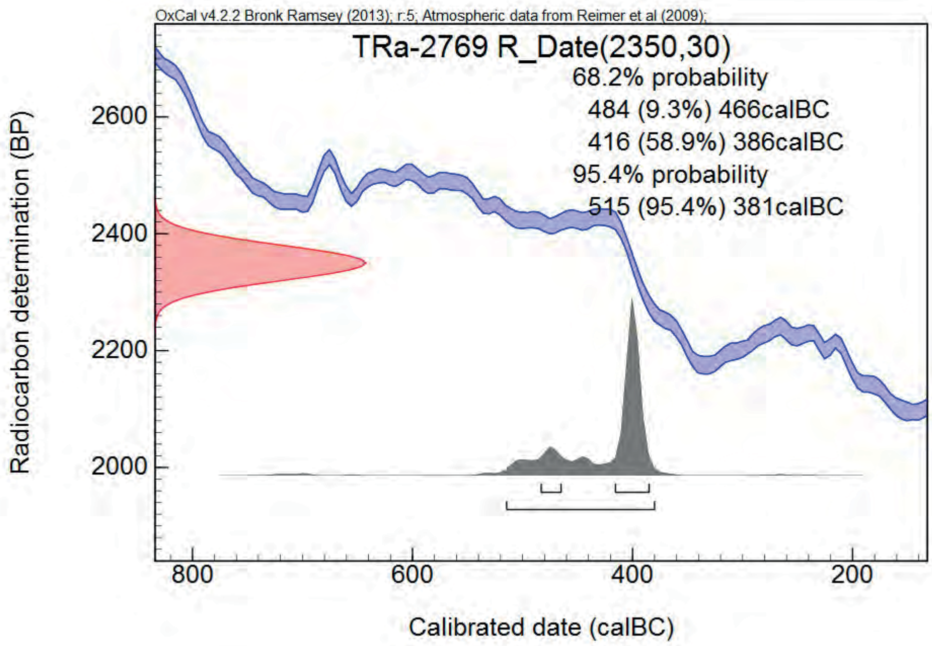
TUa 5294: ^{14}C result for artefact ID T 23070. Previously unpublished.



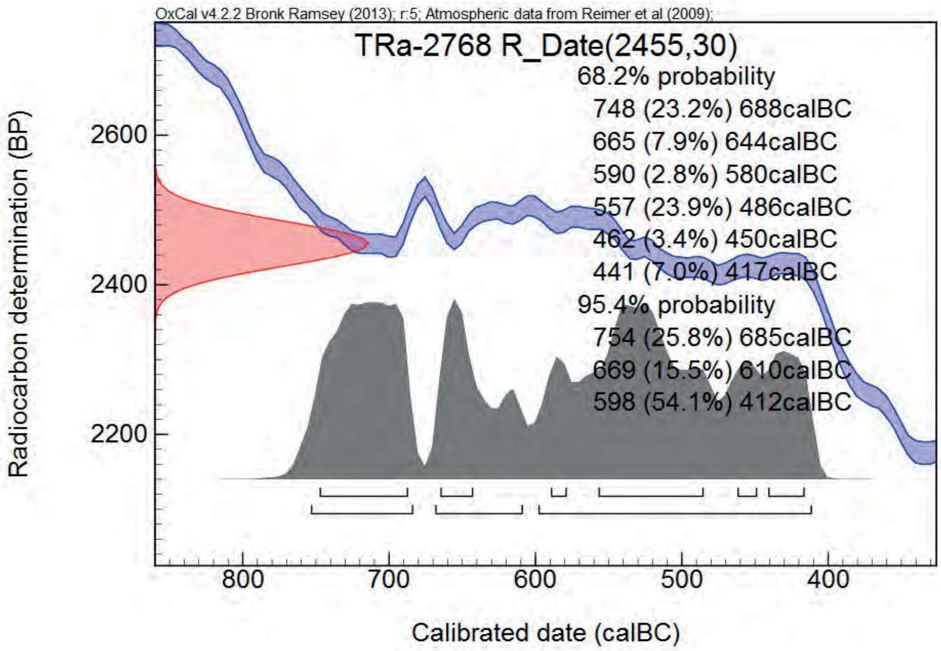
TRa-1052: ^{14}C result for artefact ID T 24140. See Chap. 4.



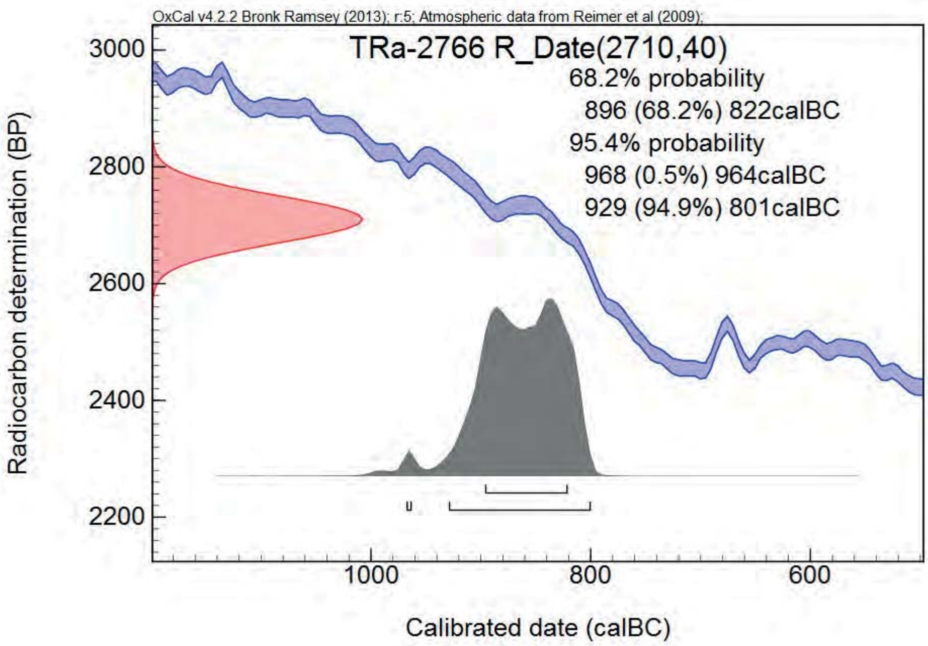
TRa-1051: ^{14}C result for artefact ID T 17698,f & T 17694/17698e. See OF 72/2 & OF 72/19.



TRa-2769: ^{14}C result for artefact ID T25286.2. See Chap. 6.



TRa-2768: ^{14}C result for artefact ID T 25286.1. See Chap. 6.



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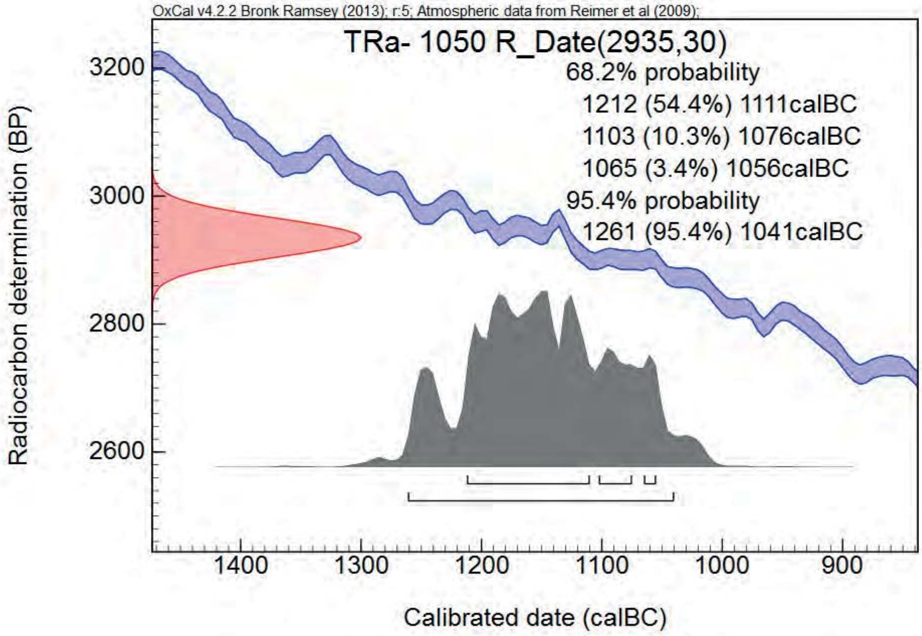

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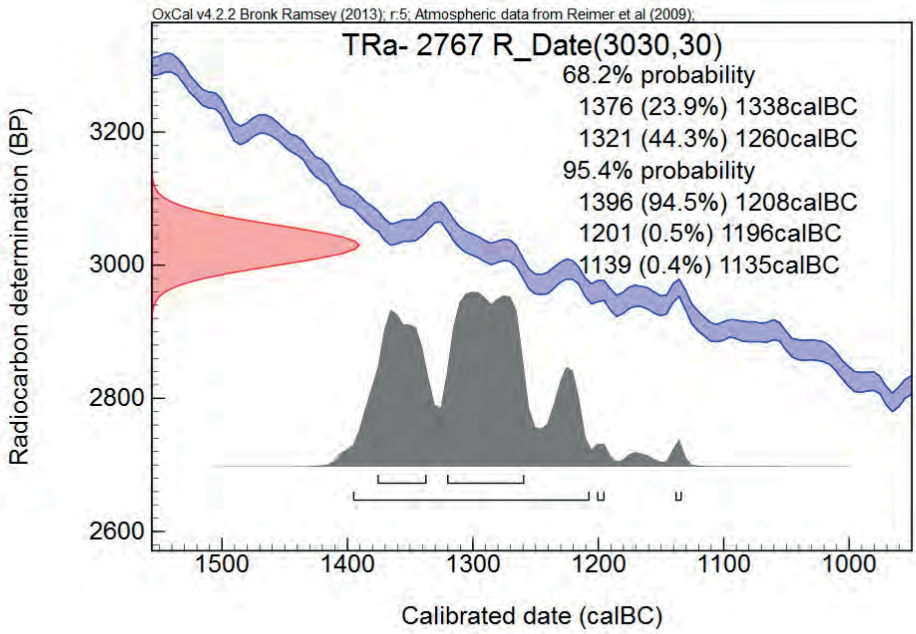

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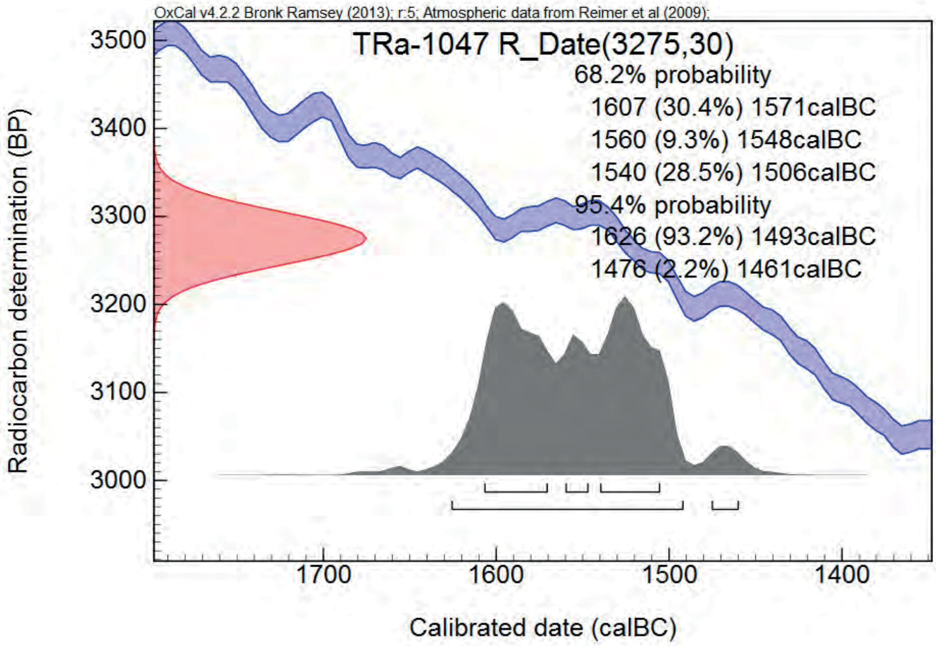

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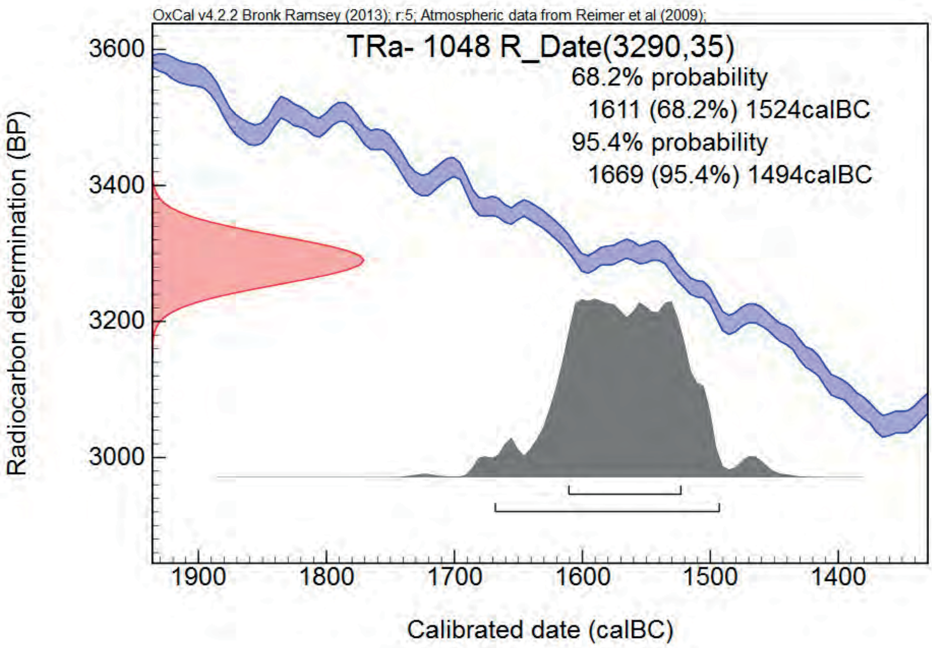

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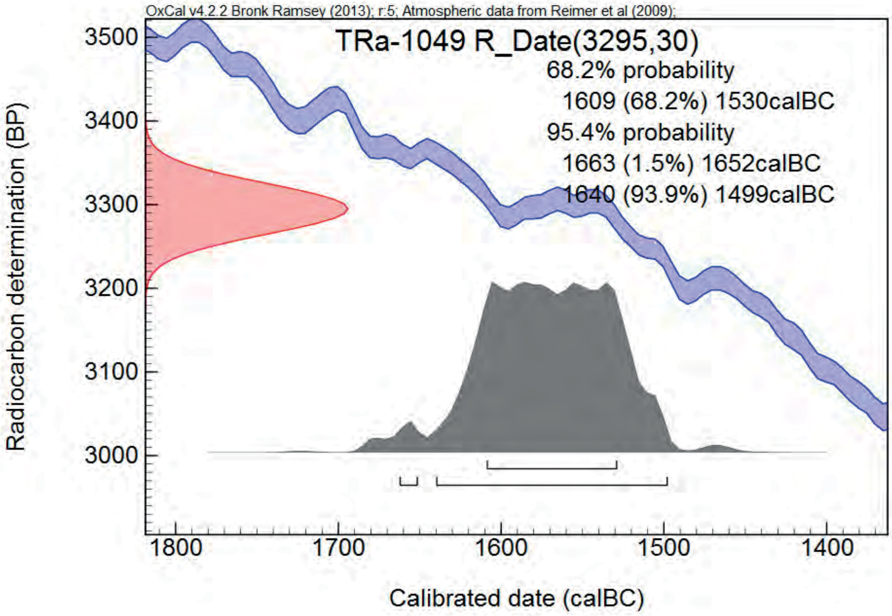

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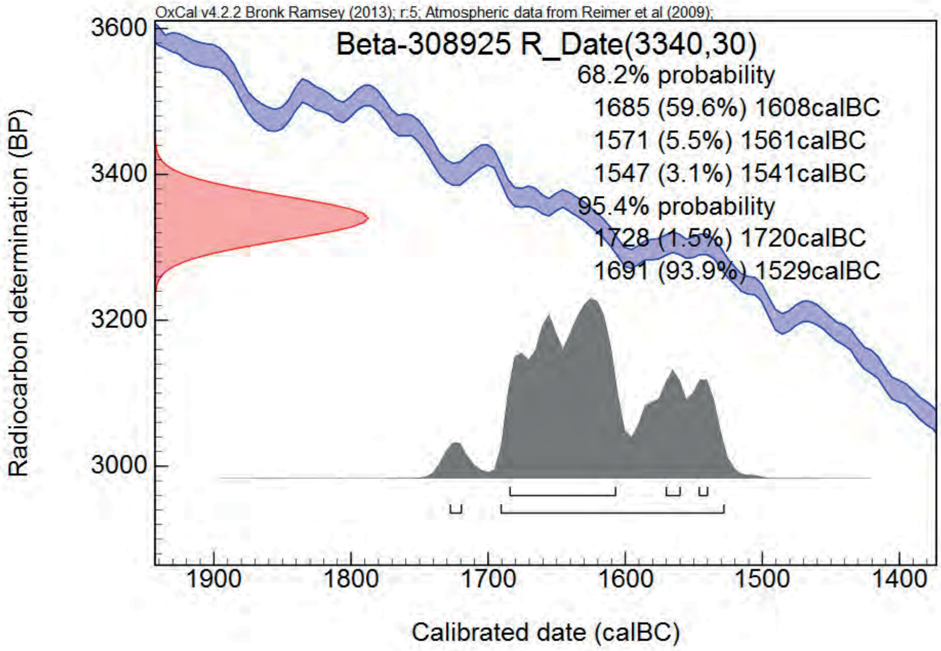

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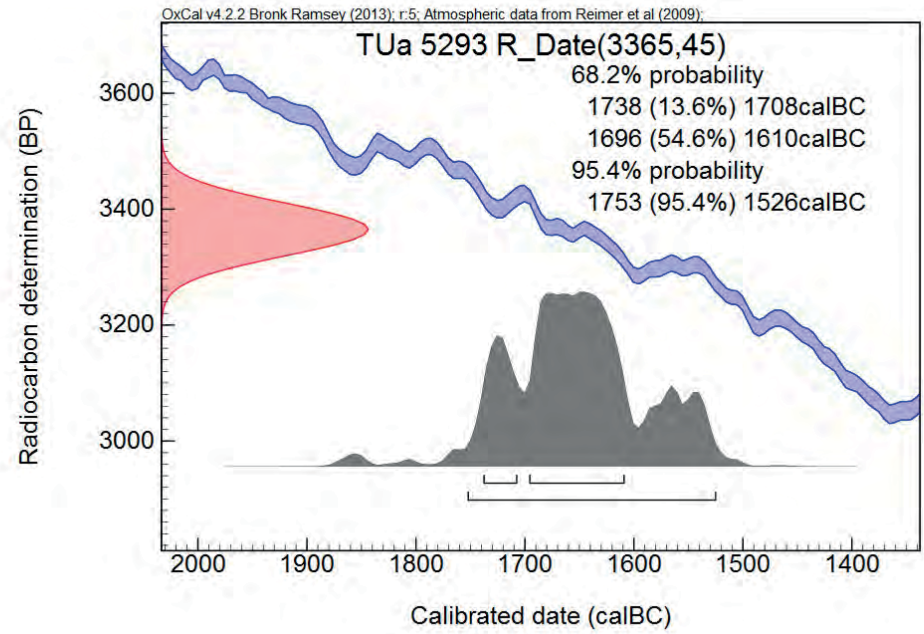

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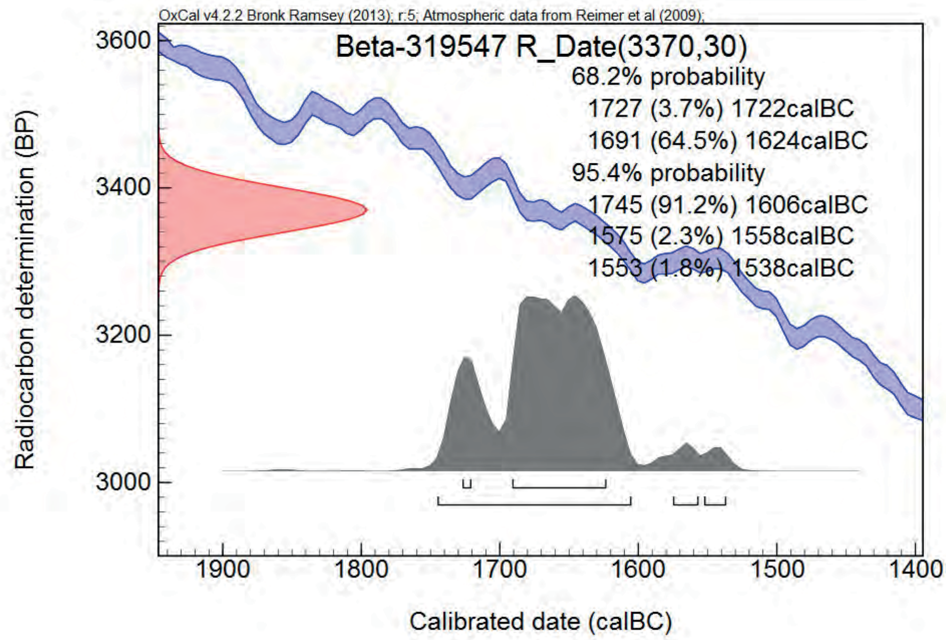

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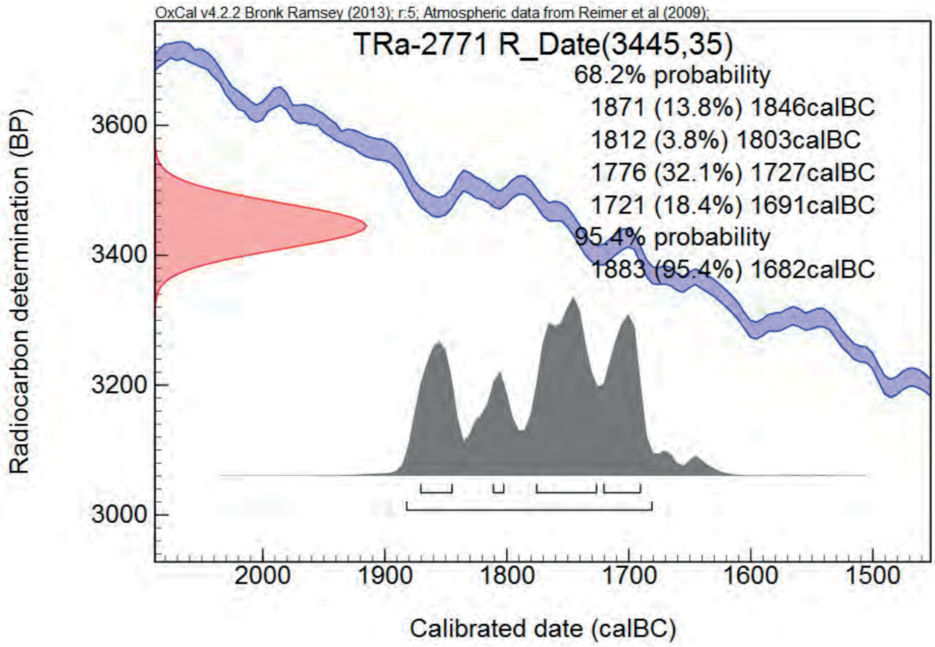

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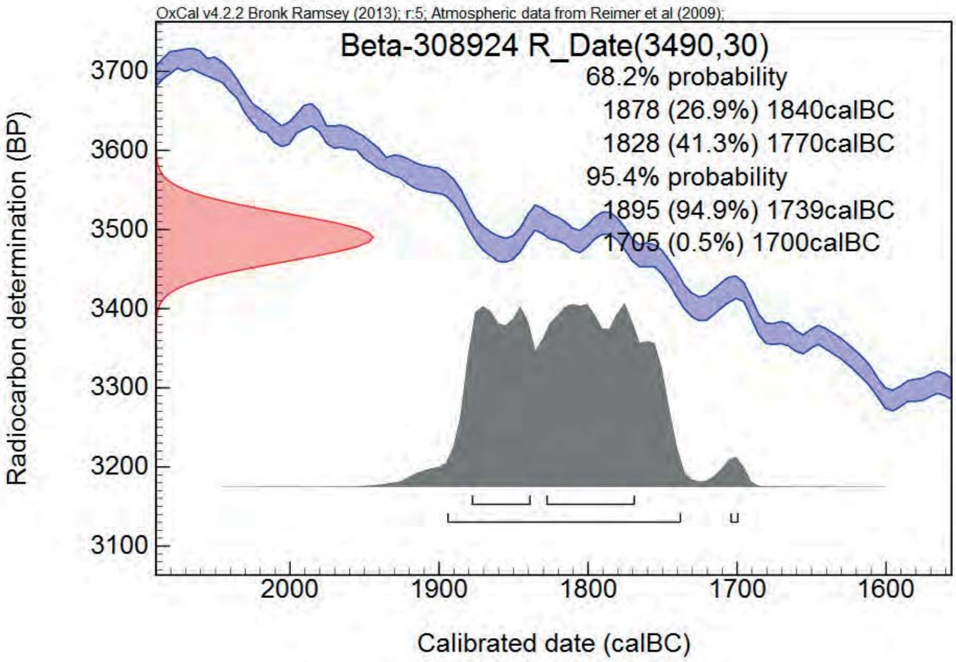

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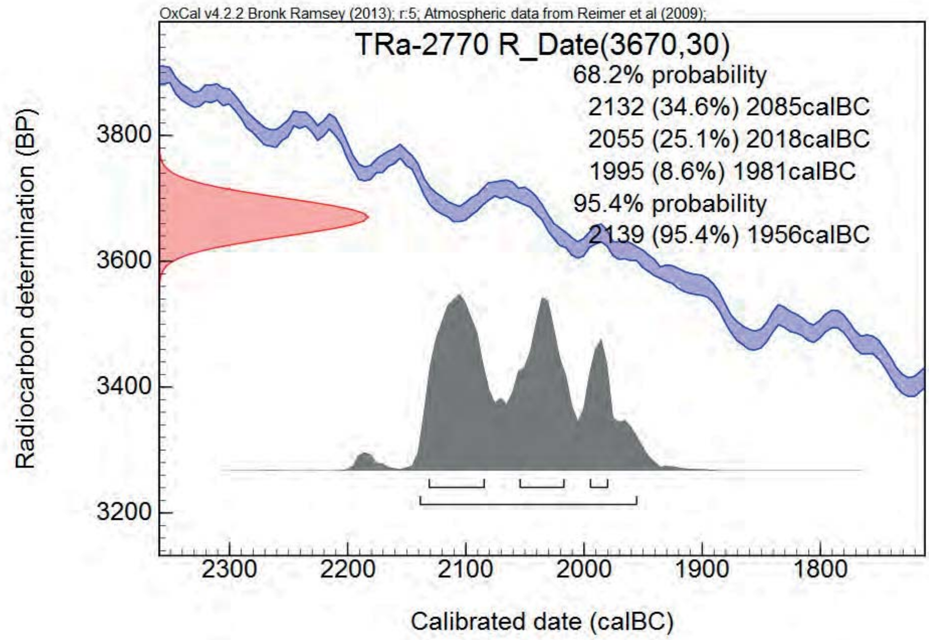

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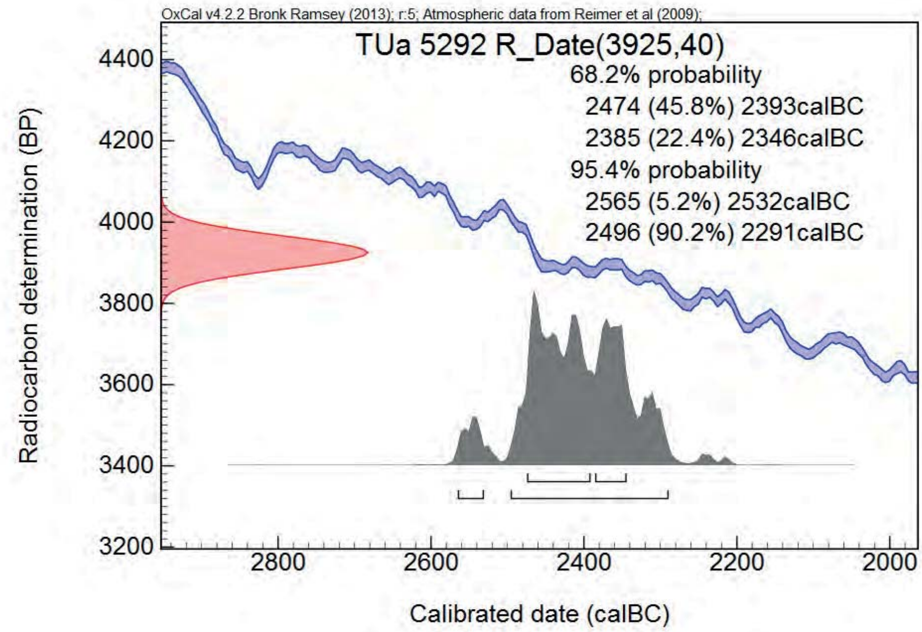

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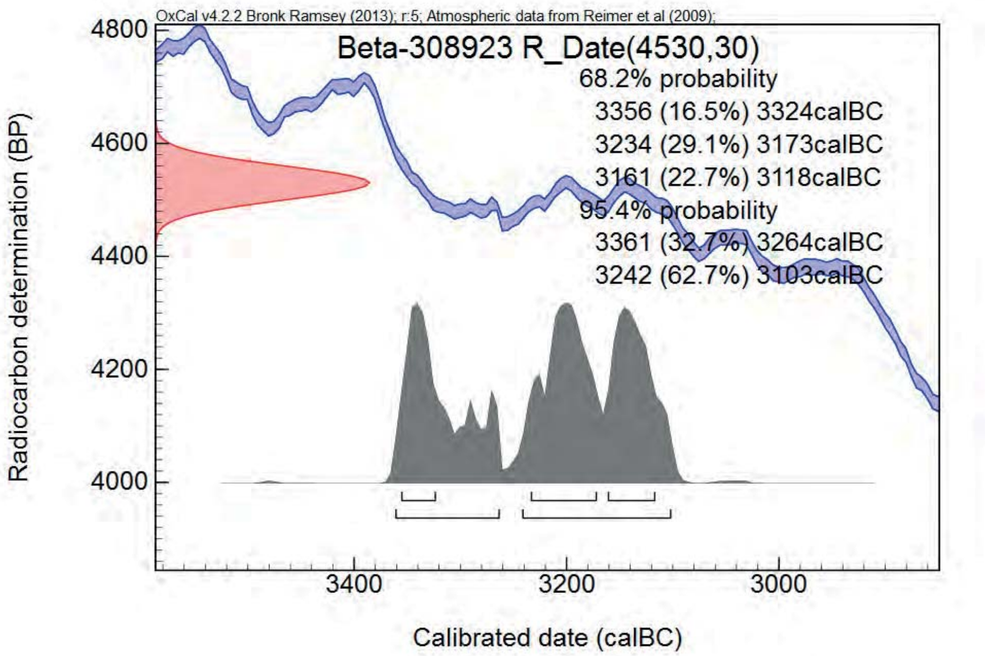

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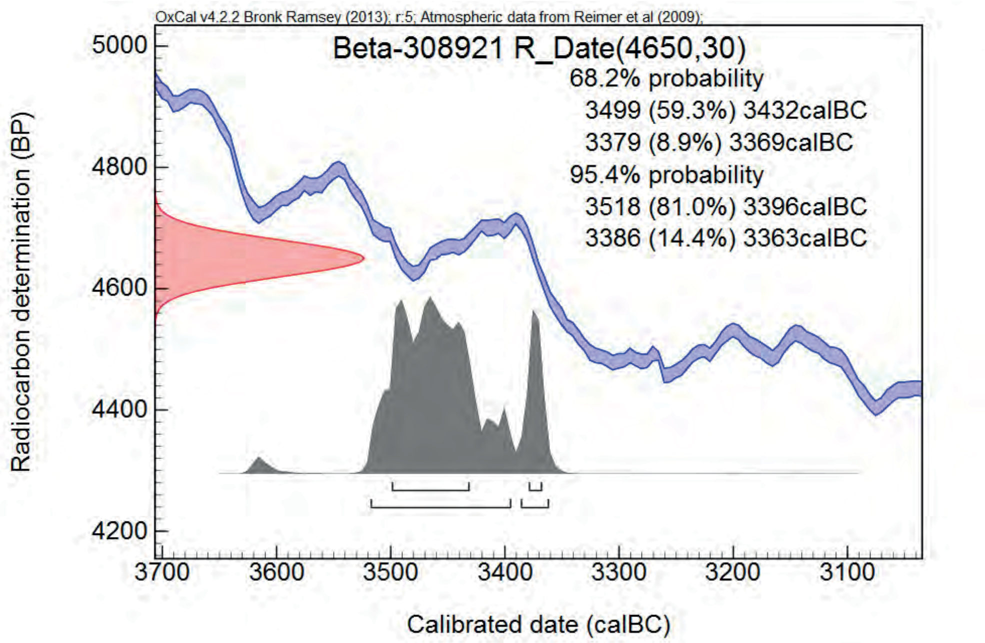

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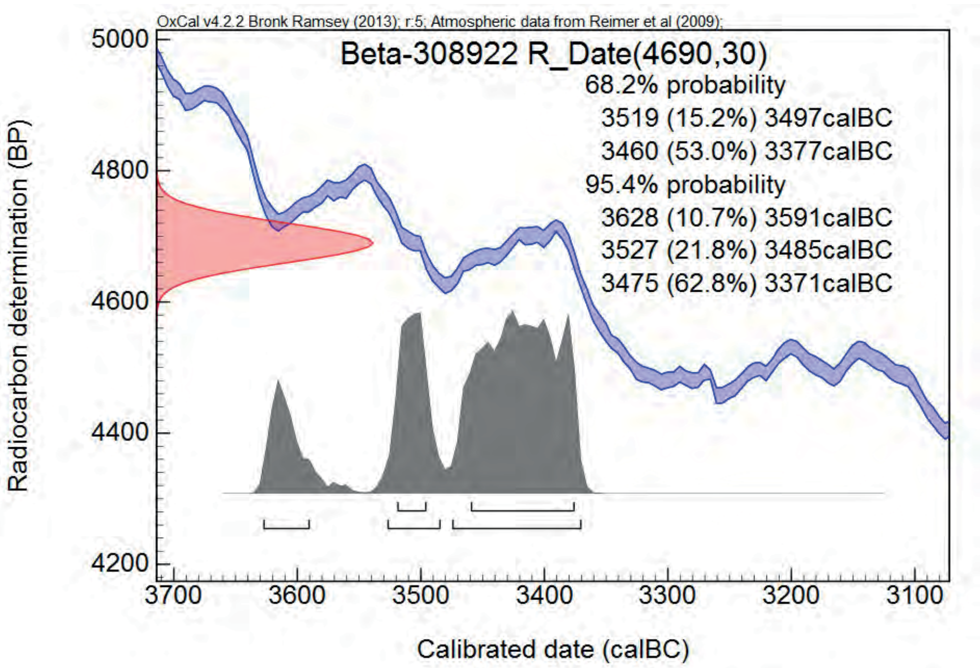

Beta- 308922: ^{14}C result for artefact ID T 25675. See Chap. 5.

Appendix 4: Published Articles

Chapter 4
Northern Snow Patch Archaeology

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Abstract:

Archaeological artefacts from high-lying mountain snow-patches have been coming into the museum in Trondheim for over 80 years. The finds and their peculiar contexts have also been the object of archaeological study for almost 40 years. The finds range from single arrow-heads to fully preserved arrows with shafts, as well as bow fragments and other organic artefacts. Reindeer-hunting forms the cultural historical background for these finds.

As high-mountain hunting grounds, as well as archaeological contexts, these snow patches have a number of parallels in other northern regions.

In this paper we will look at the research that has come out of several decades of snow patch archaeology in Trondheim. A model for understanding the phenomenon of snow-patch hunting is proposed. In addition attention is drawn to the similarities between finds from Central Norway and other northern areas.

Introduction

The term 'Snow-patch Archaeology' refers to the study and management of a set of particular alpine contexts that appear in a number of different regions. Snow-patches are areas of perennial snow and ice, sometimes containing organic arte- and eco-facts that in some cases have survived annual melts for thousands of years. Perennial snow-patches are usually found in mountain areas and differ considerably in size and form (e.g. Lewis 1939). During the last 90 years, hundreds of archaeological finds have been reported from snow-patches from different areas of Norway (Hougen 1937, Farbregd 1972; 1983; 2009, Åstveit 2007, Finstad & Vedeler 2008, Finstad 2009). The frozen conditions associated with mountain snow-patches make for excellent preservation when compared to other contexts commonly found in Northern areas. As a result, the artefacts recovered from snow-patches are often very well preserved.

In this article I wish to give a brief overview of snow-patch finds from Central Norway and other regions in Norway. The archaeological research history and cultural background for snow-patch hunting is also presented. This is followed by a brief description of similar finds in other circumpolar areas. The aim is to draw attention to emerging evidence that snow-patch hunting might be viewed as a new example of a circumpolar convergence based on the interplay of a particular set of faunal, environmental and cultural factors. We begin by looking at the snow-patch finds from Central Norway. The materials and their chronology are described in brief, as is the state of preservation and the manner in which they have been collected.

'Out of the Ice'- An overview of finds from Central Norwegian Snow-patches

The archaeological material from Central Norwegian snow-patches consists mainly of artefacts connected with prehistoric hunting and trapping activities. The main find-categories are iron arrowheads, complete and fragmented arrow shafts and hand-bow fragments. A handful of bone arrowheads and a device thought to be related to bird trapping have also been discovered (Farbregd 1972: 89). Of the over 200 individual artefacts recovered until now, complete and fragmented arrow-shafts make up more than half (c.125) of the total.

A detailed chronological scheme for artefacts recovered from Central Norwegian snow-patches has been developed in a number of works presented during the last 30 years (Farbregd, 1972; 1983; 1991 & 2009). In general, the material is dominated by finds from intermediate periods of the Iron Age (300AD-1030AD), the Medieval Period (1030 AD -1536AD) and historical times up until the introduction of firearms during the 1600's (Farbregd 2009:161-165). However the oldest finds found in association with snow-patches are considerably older than this. Adhesive recovered from a slate arrowhead found close to one of the traditional find-bearing patches was recently dated to between 2480-2340 cal. BC (Åstveit 2007: 15-16). From the same patch, an incomplete arrow-shaft was dated to between 1740-1600 cal. BC (*ibid.).* These and other recent finds support the thesis that increasingly older finds are now appearing as the inner cores of snow-patches continue to ablate (Farbregd 2009: 167). Interestingly, arrow finds are few from the two periods between 600AD-700AD

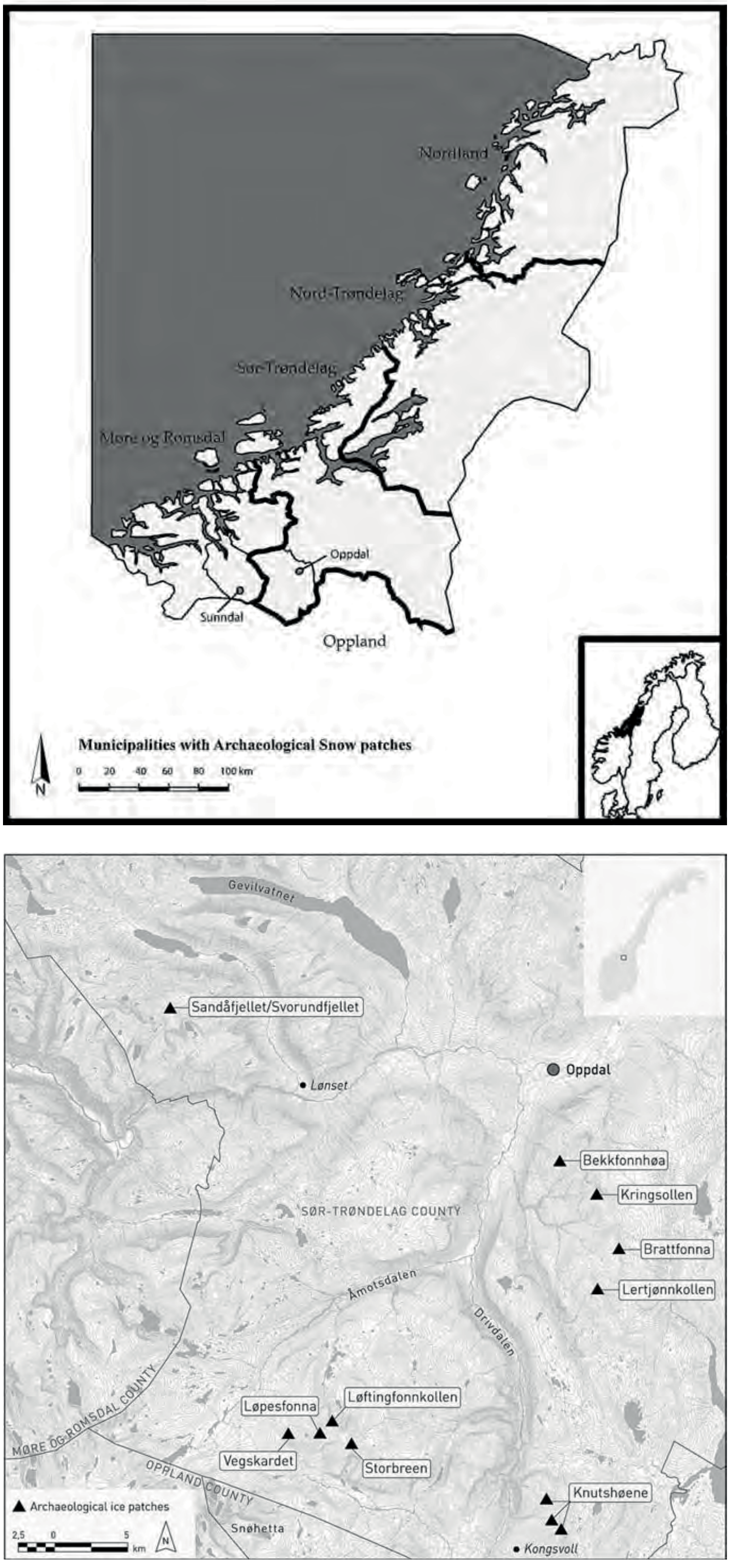

Fig. 1 Overview of the location of find-bearing snow-patches in Central Norway.

and 1000AD-1100AD. Warmer conditions at the time of deposition have been suggested as a possible cause of these distinct *lacunae* (Farbregd 2009: 161).

There is a scale of preservation along which recovered objects can be placed. At one end are single, badly rusted arrow heads that are found, usually without shafts, in the vicinity of snow-patches. At times these artefacts are covered by sediments and debris and can only be recovered with the aid of metal-detectors (e.g. Åstveit 2007: Fig. 2). At the other end of the scale we find a few fully preserved arrows with arrowheads, shafts, fletchings, adhesive and bindings (e.g. Farbregd 2009: Fig. 7 & 8). The majority of finds can be placed somewhere in between these two poles. The degree of preservation exhibited by individual artefacts is subject to a complex of factors that run from the moment of deposition until final discovery and stabilisation. These include the degree and extent to which artefacts have been exposed to mechanical forces associated with both the ice and sub-surfaces, as well as the effects of short and long term weathering as artefacts are extirpated from the ice for shorter or longer periods of time.

One of the special features of the snow-patch collection In Trondheim is the long time-span over which the materials have been collected. The first snow-patch find was made at Løpesfonna, Oppdal in as early as 1914 (Farbregd 1972; 1983:7). Following on from this, waves of finds from mountain snow-patches have appeared at different periods. The main waves occurred during the 1930's and the early 1980's. The low number of finds in the intervening period is real, as surveying activities continued unabated during this time (Farbregd 1983:8). Since the turn of the new millennium, a new wave of finds has begun (Farbregd 2009: 158).

There are two important differences between the current and earlier waves of finds. The first relates to changing viewpoints on the potential for making archaeological discoveries on snow-patches. The second relates to changes in our understanding of the perceived role of weather and climate in the process of snow-patches' melting and archaeological finds appearing. Early finds and find waves were understood as chance-finds and/or the result a series of unusual weather conditions. It was initially not at all certain whether this phenomenon would repeat itself or not. Indeed, in the early 1980's it was still unclear whether one could expect to recover artefacts on snow-patches in the same manner as had occurred in the 1930's (Farbregd 1983:8). Today however, as increasingly older finds are regularly being made on both old and new sites, it remains an open question as to how long these processes will continue before mountain patches are exhausted for prehistoric materials. With regard to the relationship between the environment and the continued appearance of prehistoric finds, the ablation of mountain snow-patches is now viewed in relation to more general climatic warming processes, rather than as a result of chance variations in year-on-year weather conditions.

Another feature of the Oppdal material is the manner in which much of it has been recovered. Since the 1930's, a tradition of snow-patch surveying based on the initiative of a handful of local individuals has developed in Oppdal. This tradition developed in close contact with the Museum in Trondheim, where new finds and details concerning their discovery were regularly collected and archived. The artefact and archival collection, together with much of the knowledge we have about find-bearing snow-patches in the region, is largely a product of the efforts of these collectors. The collection was gathered through countless of hours of hiking and searching on the part of a few men who had a close relationship to mountain-life and who were rightly proud of their achievements and finds. And this tradition continues today. The current generation of collectors has in recent years made a number of important finds that continue to contribute to the local body of snow-patch knowledge (Bretten 2003, Bretten & Røtvei 2004).

Having reviewed the nature, chronology and state of preservation of local snow-patch finds, as well as looking at the manner in which the present collection has been assembled, the following is a short review of the archaeological literature produced during over 70 years of Norwegian snow-patch research. The vast majority of this research has been based on snow-patch finds from Central Norway.

A Short Research History

While early snow-patch finds were reported in the museums' annual catalogues and in newspaper reports, it was not until the late 1930's that the first snow-patch publication appeared (Hougen 1937). In this article a small number of well preserved arrows were presented. The main focus was on the arrows' state of preservation and questions related to the dating of the artifacts themselves. The discoveries were interpreted as chance finds and one failed to grasp the significance of snow-patches as favored hunting sites where finds might be made on a regular basis. Up until that point, it appears as if snow-patch finds were being interpreted as stray arrows from warm periods that had subsequently been covered by snow-patches during colder spells (Petersen, T. 1937). However this was to change in the course of 1937. In that year, many new finds were made in the Oppdal Mountains. In the same season, important field work was carried out by Johannes Petersen at the behest of the museum in Trondheim. Petersen visited three of the snow-patches in the Eastern mountains of Oppdal, accompanied by one of the pioneer-collectors Martin S. lo. Petersen made important observations of both the sites and the contexts from which finds were being recovered (e.g. Farbregd 2009: fig. 6). It was Petersen who for the first time observed that recovered arrows must have originated from within the patches themselves (Petersen 1937). As a result, in a publication from the following year, the focus turned more towards the development of snow-patches as true contexts. In addition, the emergence of archaeological finds from these sites was now being discussed against the backdrop of long- and short-term climatic variations (Fægri 1938). It is unclear when the link between past hunting activities and reindeers' summer behaviors was made

Fig. 2 Iron arrowhead and fragmented shaft found at Storbreen, Oppdal in 2008. c. 5-7th century. The relatively poor state of preservation indicates that this artefact has been exposed to weathering on numerous occasions. Photo: Kari Dahl. NTNU Vitenskapsmuseet.

for the first time. But given that finds were mostly being collected by local men who were intimately familiar with the mountains, animals and local hunting traditions, this was probably implicitly understood from the start, at least by the collectors.

These initial publications were followed by a 30 year long hiatus, which corresponds with a lull in snow-patch finds. In a short article from 1968, Farbregd used the term 'Glacial Archaeology' to describe similarities between snow-patch finds from Central Norway and other glacial and permafrost discoveries made in Alaska and Siberia (Farbregd 1968). This article marks the beginning of a new period of Trondheim-based snow-patch research in the form of papers, reports and articles that continues until today. The bulk of this research was carried out by archaeologist Oddmunn Farbregd based at the Museum of Natural History and Archaeology in Trondheim (e.g. Farbregd 1968, 1972, 1983, 1991, 2009). Farbregd's research has focused largely on finds recovered in the mountain regions around Oppdal, although related finds from other areas are often treated too. The following is an overview of the main research themes pursued through Farbregd's snow-patch publications. With the exception of individual summaries and a recent synthesis (Farbregd 2009), these publications are all published in Norwegian.

- Analyses of chronological and functional patterns in the arrow material (1972, 1991, 2009).
- Geographical/temporal distribution patterns within material from different sites (1983, 1991).
- Aspects of snow patches as archaeological contexts (1973, 1983, 1991, 2009).
- The relationship between snow-patch hunting and other hunting/trapping systems (1983, 1991).
- The relationship between snow-patch finds and long term climate data (1972, 1983, 2009).
- Long term developments in archery and cross-bow technologies (1972, 1991, 2009).

In addition to these works, a number of articles and reports have also been produced locally on topics related to snow-patch finds and archaeology in the region (Farbregd & Beverfjord 2000, Bretten 2003, Bretten & Røtvei 2004, Stuedal 2006, Åstveit 2007, Hoel 2009).

This concludes both the review of snow-patch materials and the history of snow-patch research in the Trondheim region. Up until this point, our attention has been focused on snow-patch finds from the Oppdal area. It is important to note however, that similar discoveries have been made in other areas of Norway both to the North and South of the Oppdal mountains.

Snow-patch finds in other Regions of Norway

Another important area for Norwegian snow-patch archaeology lies in the County of Oppland, to the South of Oppdal (See Fig. 1). Despite some early discoveries, it is not until recently that prehistoric artefacts have been recovered in Oppland with the same intensity as in the mountains further to the North. The Oppland finds have a number of parallels with the Oppdal material. Arrows and shafts of the same chronological and technological background have been recovered from a number of snow patches in Oppland. There are however some striking contrasts too. In general the snow-patch find-complex from Oppland is somewhat broader and includes items such a wooden spades, textiles and a well-preserved 2000 year old leather shoe (Finstad & Vedeler 2008; Finstad 2009). At Juvassfonna a unique, multi-phase hunting system has been discovered in direct association with a large snow patch. This system comprises of a series of stone-set hunting blinds and the remains of a number reindeer leads composed of well-preserved sewels[1]. The sewels themselves consist of thin wooden poles with organic ties affixed to wooden or bark flaps. At Juvassfonna, whole and fragmented sewels have been recovered in large numbers (Finstad 2009, OFK 2009).

Stone-set leads are not uncommon in mountain areas in Norway and through the years a small number of individual flaps have been recovered from different sites (Bevanger & Jordhøy 2004: 18, Weber *et al* 2007: 56). However the discovery of a well-preserved system of scaring fences is an exciting development. Interestingly, at this time there are no parallels between this discovery and finds from the region around Oppdal. Emerging regional differences of this character appear to point towards distinct local traditions within hunting and trapping strategies associated with snow-patches. A number of archaeological patches in Oppland County are now the focus of a multi-disciplinary research programme (OFK 2009).

In 1999, a pair of new finds was discovered in a region of Norway far from the southern mountain areas usually connected with snow-patch archaeology. At Seilandsjøkulen (70° 23' 60"N 23° 06' 37" E), Seiland, Finnmark, a 2-3000 year old decorated bone arrowhead was discovered near a snow-patch at approximately 700masl. (Johansen 2002: 14). There are also reports of another find from the same year consisting of an iron arrow head and wooden shaft recovered near a retreating snow-patch. With regard to latitude, these new discoveries may be compared to a pair of earlier Swedish snow patch finds from Låktatjåkkastugan (68° 24' 23"N 18° 27' 41"E) and Kåppastjårro (68° 22' 07"N 18° 31' 16" E) in Lappland, Sweden, where a pair of complete arrows was recovered in 1962 and 1961 respectively (Lundholm 1976). Seen together, these northern finds point to the uncharted potential that may exist for future snow-patch discoveries in suitable locations over a much wider area than the present distribution might suggest.

We can now turn our attention to the past activities that lie behind the deposition of these artefacts on snow-patches. As we have seen, hunting artefacts have been deposited in these peculiar contexts with a certain regularity over a long time span. In the following we look more closely

[1] A sewel is a thin pole with an attachment on top that flaps in the breeze. The flapping movement catches the attention of the reindeer. These tend to move away from the sewels that are often set up in rows leading towards waiting hunters or pitfalls (see Spiess 1979: 128).

Fig. 3 A c. 70cm long fragmented sewel i situ at the base of the large snow-patch at Juvassfonna, Oppland August 2009. Note the carved notch used to affix the flap. Photo: Martin Callanan.

at snow-patch hunting as a past cultural activity. More specifically we identify the natural and cultural factors that have converged to result in the snow-patch archaeological record as it appears to us today.

Snow-patch hunting as a cultural historical activity

Snow-patches are unusual in that they are true kill-sites, something unusual within the archaeological record (Speiss 1979:103). As a past cultural activity, snow-patch hunting can be seen as dependent upon the interaction of number of interdependent factors. At least 3 important factors can be identified within this interaction. These are:

- Particular and regular behavioral traits on the part of specific faunal species, mainly reindeer.
- A specific interplay of landscape and climate that gives rise to alpine snow-patches.
- Cultural and historical conditions that make snow-patch hunting a viable technological and economic activity.

This is first and foremost a descriptive model and the following presentation of these three sets of factors is schematic. This model is not unique to snow-patch hunting and could indeed be applied to a whole series of different hunting and trapping situations. However, snow-patches, their prehistoric use and archaeological inventories are complex in nature and some organizational format is necessary when describing or analyzing the factors involved. Therefore the model provides a useful preliminary framework within which the phenomena of snow-patch hunting can be broadly approached. Although based on the Central Norwegian *casus,* the model is not chronologically or spatially specific.

Faunal Behavior

Wild reindeer are today dispersed widely throughout the mountains of Southern Norway. They number ca. 30,000 in total and are split into distinct and separate herds (Bevanger & Jordhøy 2004:30). The herd that today populates mountain areas around Oppdal is the *Snøhetta* herd. Our knowledge of past migration patterns is based both on the study of prehistoric hunting and trapping systems and on analogy with observed present day behaviours. For example, the scale and distribution of prehistoric trapping systems indicate that prehistoric herds were considerably larger and roamed in regular annual migrations over a much wider area than is the case at present (Mølmen 1995; Jordhøy 2001; Bevanger & Jordhøy 2004).

Today through the spring and summer months, reindeer in the Snøhetta region seek out protein/rich grazing grounds in areas newly freed from snow cover (Jordhøy2008:84). In mountain areas around Oppdal this has meant a spring migration following the wave of green plant production from winter grounds that lie towards the East, to summer calving and grazing grounds further west with the Driva valley forming an axis between these seasonal areas. (see

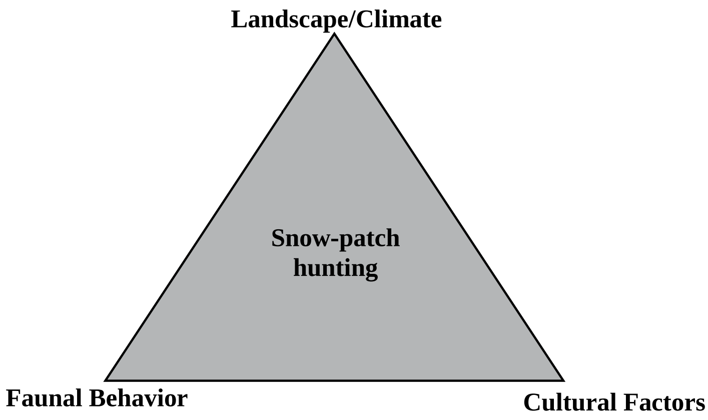

Fig. 4 Descriptive model of the factors involved in snow-patch hunting in the past.

Fig. 1). The landscape varies on both sides of this axis with higher, more alpine areas towards the west. The reindeers' spring/summer migration westwards is thus both spatial and altitudinal. High alpine areas offer reindeer limited grazing possibilities but serve as important cool niches during the summer (*ibid*). Reindeer often congregate on snow-patches in late summer in order to avoid the nuisance of parasitic insects and for the purpose of thermo-regulation (Åstveit 2007:9-10, Jordhøy 2008: 84). Interestingly, archaeological snow patches are found on both sides of this proposed axis.

Landscape/Climate

The alpine areas in which snow-patches are found are often desolate spaces that even today remain largely untouched by human activities. At these altitudes, the combination of landscape and climate play a crucial role in providing the conditions necessary for perennial snow-patch formation and maintenance. In the early summer there are literally thousands of large and small snow-patches to be seen in these mountain areas. However, it is only at higher altitudes (*c.* >1400masl) that certain snow-patches survive through normal summers and only a handful of these again will survive through particularly warm summers. Based on the evidence of ancient artefacts recovered so far, archaeological snow-patches in a number of regions have shown themselves to be remarkably resilient to both long and short term climatic variability and variation. Little is known for certain about what governs the long term survival of certain high altitude snow patches in different areas. But important factors are thought to be altitude, orientation, local topography, local subsurface conditions (i.e. permafrost) as well as local annual weather regimes (precipitation, temperature, wind & sunshine). But this is only one side of the coin. Another matter is the set of factors that have influenced the use of specific snow-patches by reindeer and other animals in the manner described above. Of obvious importance is the location of snow-patches in relation to specific topographical features and migration routes. The permanence (and thus reliability) of certain longeval patches within annual ranges was probably an important factor in this regard too.

Cultural Factors

Reindeer have thus adapted to the seasonality of the sub-arctic region by seeking out high-alpine cold niches during the warmer periods of summer. Interesting though it is, this is largely a natural phenomenon that would hardly be of any archaeological significance at all had it not been for the evidence of regular human utilization of certain snow-patches as favoured hunting grounds over long periods of time.

In general terms we can identify a set of varied human factors that must have influenced the way in which snow-patch hunting and trapping activities were carried out. These include wide-reaching elements such as technology, social and economic structures, scheduling and trade specialisation to mention but some. We can also be sure that some, if not all of these human factors will have varied and developed through time and space. It is beyond the scope of this paper to begin to broach each of these topics in depth, however the following is an attempt at a broad summary of some key cultural elements related to past snow patch hunting based on the current evidence.

In the case of Norwegian snow-patches, the deposition of arrowheads, shafts and other implements in these high alpine contexts appears intimately linked to reindeer hunting. But why should that be the case? Why would hunters choose to use such desolate and remote sites as favoured hunting grounds? Although it is possible to some extent to predict reindeer movements and migrations on a macro scale, they are a difficult prey to track and hunt at close quarters. Groups of animals congregating on snow-patches with a certain regularity seem to have presented prehistoric hunters with a more advantageous situation when compared with a more opportunistic tracking animals in open countryside.

As prey, reindeer offer a number of different products to hunters. These products include meat, blood, marrow, antler, sinew and skin. Differences in the quality of reindeer skins throughout the year might have been a factor that influenced the scheduling of small scale hunting trips on snow-patches to the late summer. Perhaps there was a need for hides of a certain quality that was only available at specific times of the year? Based on North-American ethnography, Speiss describes how skins suitable for clothing were best taken at the end of the summer, when shedding was completed and warble fly holes had healed. Winter skins are described as having been too heavy for use as clothing (Speiss 1979: 27-28). Attempts at finding relevant Scandinavian literature on this matter have until now been unsuccessful, but in time an examination of snow-patch hunting from the perspective of scheduling may prove to be a fruitful line of enquiry.

We might also ask how snow-patch hunting was carried out? Was there one form to this type of hunting or were there several alternative forms? Based on the Norwegian evidence, snow-patch hunting was based mainly on the use of hand bows and crossbows. The hunt probably involved stalking groups of animals gathered on the patches. This form of hunting may have been carried out by individual hunters. Bretten suggests that on patches that are steep or that lie beneath over-hangs it was probably an advantage to be positioned above the animals on the patch below (2003). In this form, snow-patch hunting represents a simple strategic adaptation on the part of the prehistoric hunter to observed behavioral traits amongst animals within a specific and natural landscape setting. Based on the present evidence, this seems to have been the form of snow-patch hunting most common in the Oppdal region.

In contrast, in the case of larger more open patches such as Storbreen, the animals may have been driven into the arms of waiting hunters in a form of collective hunting (*ibid)***.** Another possible strategy may have been the construction of temporary hunting-blinds of snow on the patches themselves. Although no direct evidence of this strategy exists, the recent recovery of a number of discarded wooden-spades on snow-patches in Oppland might support this interpretation (Finstad 2009). Alternatively, the presence of spades may indicate that snow walls functioned as leads that were integrated with other elements to form a trapping system of some kind (Speiss 1979: 106). The recently discovered system of sewels and hunting blinds at Juvassfonna appears to be a system of this kind, where the snow-patch functioned as an integrated part of a larger system. In these cases, we move beyond simple strategic adaption, towards a more active intervention in the natural environment. This involved the construction of a planned kill-situation that was probably more predictable and thus favourable for prehistoric hunters. From this it can be seen that snow-patch hunting as a past activity appears to cover a specter of inter-related hunting strategies from simple through hybrid hunting/trapping forms.

Although reindeer appear to have been the main focus of past hunting activities on these sites, other prey have also been hunted and trapped. A small number of finds indicate that reindeer hunting was complimented by the hunting and trapping of fur and feather too. These finds include club-headed arrows thought to have been used on furred animals and a wooden device apparently related to the setting snares (Farbregd 1972: 89-90, Åstveit 2007). These finds add another dimension to our understanding of alpine snow-patches as kill-sites.

Glacial Archaeological Finds from other Regions

As noted earlier, the term ‘glacial archaeology’ was used already in 1968 in order to relate artefacts recovered from Central Norwegian snow patches to the appearance of frozen prehistoric materials in other regions (Farbregd 1968). The term has been used again recently to describe the present day emergence of a set of inter-related finds from a number of different regions and contexts (Dixon *et al* 2007). These finds range from human remains recovered from true glaciers to single prehistoric and historic artefacts recovered from melting snow patches. Looking beyond Norway, the geographical spread of glacial archaeological finds is wide. The best known of these finds are the remains of The Neolithic Iceman (*Ötzi*) who was discovered in the early 1990’s in the Ötztal Mountains on the border between Italy and Austria (Bortenschlager & Oeggl 2000). However in recent years, a number of other glacial discoveries have been made in regions as far apart as Alsaka (Dixon *et al* 2005;2007, VanderHoek *et al* 2007a & b), Canada (Kuzyk *et* al 1999, Beattie *et al* 2000, Farnell *et* al 2004, Hare *et al* 2004, Dove *et al* 2005, Keddie & Nelson 2005, Helwig *et al* 2008, Andrews *et al* 2009), United States (Lee *et* al 2006), Greenland (Hansen & Gulløv1989), Peru (Ceruti 2004, Reinhard 2005), Sweden (Lundholm 1976), Switzerland (Suter *et al* 2005; Grosjean *et al* 2007). These disparate discoveries are bound together by a number of common factors. Their association with cryospheric contexts is often related to their location in high latitude and/or high altitude areas (Dixon 2005: 129). This said, new discoveries on high altitude/ low latitude sites in Colorado underline the presence of high-potential glacial contexts in other regions too (Lee *et al* 2006).

Conditions of preservation on these sites are often extremely good and the recovery of well-preserved organic materials is characteristic for this group. Another commonality apparent in recent years is that many of these contexts have shown themselves sensitive to both short-term weather events as well as long term climatic variations. The complex nature of both the contexts and discoveries associated with this group of sites has presented archaeology with unique analytical possibilities and serious methodological challenges. Glacial archaeology today has a strong multidisciplinary dimension and is closely linked to conservation sciences (Farnell *et al* 2004: 250-251, Dixon *et al* 2005: 141, VanderHoek *et al* 2007:82).

However, the commonality that the term Glacial Archaeology attempts to express is related first and foremost to the physical properties of this set of sites. If we instead shift the focus to the kind of materials recovered, as well as to the activities that lie behind their deposition other sub-groups emerge. For example based on the physical properties of sites, the closest international parallels to the Norwegian snow-patch sites are found in Alpine sites such as that at Schnidejoch, Switzerland and the group of archaeological snow-patches discovered in Alaska and Northwestern Canada. However once we begin to consider the types of finds recovered from the different sites, further differences emerge. The accumulation of finds at Schnidejoch appears to have been the result of that site's position within a transport network rather than due to regular hunting forays. As a result, the find complex found there is much broader and has been deposited at more irregular intervals that are thought to be connected to specific climatic conditions (Suter *et al* 2005; Grosjean *et al* 2007). In contrast, alpine snow-patches from Alaska, Canada and Norway appear to share a fundamental commonality in respect of both the type of archaeological finds recovered and the manner in which these artefacts have been deposited in the past. By looking closer at the commonalities between the materials from these regions, we can begin to see the contours of a new circumpolar convergence in the form of on snow-patch hunting.

Northern Snow-Patches-A Circumpolar Convergence?

The first North-American snow-patch discoveries were made in 1997 in the Yukon, Canada (Kuzyk *et* al 1999). Since that time, a large number of new finds and sites have been discovered in various regions within a large area from Alaska in the west to North West Territories, Canada in the east (Farnell *et* al 2004, Hare *et al* 2004, Dixon *et al* 2005; 2007, Dove *et al* 2005, VanderHoek *et al* 2007a & b, Keddie & Nelson 2005, Helwig *et al* 2008, Andrews *et al* 2009). The following overview of North American finds and sites is based primarily upon the published literature.

North American snow-patches appear similar to the Norwegian sites with respect to a number of key factors such as size, form and elevation (Farnell *et al* 2004: 248-250 Hare *et al* 2004: 261, VanderHoek *et al* 2007a, Andrews *et al* 2009). Well-preserved prehistoric and historic organic materials have been recovered from a number of sites across the region. This material includes both archaeological artefacts and faunal remains. The recovered archaeological material is dominated by various kinds of projectiles. The main find-groups are throwing darts and to a lesser degree arrows (Hare *et al* 2004:262, Keddie & Nelson 2005, Dixon *et al* 2007: 136-139, VanderHoek *et al* 2007b: 186-195). The projectile materials recovered have been dated to between ca. 8300-90 ^{14}C yrs. B.P. (*ibid.*).

Faunal remains associated with the North-American snow-patches includes, bone, antler and fecal material. Especially noteworthy is the appearance of massive black dung layers on North-American sites during the ends of warm summers. These materials have in some cases proved quite ancient and are an important source of information about many aspects of caribou in the past, often in areas where they are today absent (***e.g.*** Kuzyk *et al* 1999, Farnell *et al* 2004).

The accumulation of hunting projectiles on these sites is interpreted by a number of researchers primarily as the result of caribou hunting on snow-patches. These are viewed as seasonal hunting trips into mountain areas. In some cases snow-patch hunting was probably combined with other activities such as fishing, trapping and berry-picking (Hare *et al* 2004: 261; VanderHoek *et al* 2007a: 78-79).

There are a number of striking parallels and similarities between the North-American and Norwegian snow-patches. In both cases the phenomena of archaeological artefacts appearing on high alpine snow-patches has its base in an apparently common adaptation to specific landscape and faunal conditions. In both regions, this adaptation appears to have involved the interplay of faunal behavioral patterns, topographical and climatic conditions and a range of human factors as described in the model above. Despite obvious differences in both technological and cultural trajectories between these areas, the use of snow-patches as favored seasonal hunting grounds appears to be a striking example of adaptive convergence between two unconnected areas of the Circumpolar North. Interestingly, snow-patch hunting does not appear in Speiss' survey of the various human-reindeer interactions in the circumpolar region (1979). Thus the identification of snow-patch hunting and trapping as an example of circumpolar convergence appears to be a new observation.

This observed commonality opens the way for a number of new possibilities and perspectives. Future comparative studies and exchanges will help to further develop our methods and understanding both of snow-patches as particular archaeological contexts but also of snow-patch hunting as a past cultural phenomenon. Another interesting question is related to the possibility of a wider distribution of this hunting strategy. At present, the regions where evidence of past snow-patch hunting has been discovered are separated by some 5-6000 kilometers. However when we look at the vast map of the northern circumpolar region and in particular at the spread of reindeer within this space, it seems reasonable to suggest that snow-patch hunting was probably practiced in other high altitude areas of this region too. The descriptive model presented in this article might prove useful in identifying new regions where a similar interplay of faunal, environmental and cultural factors would have made snow-patch hunting possible. Perhaps there are other well-preserved hunting artefacts similar to those from Central Norway and North-America waiting to be discovered in other circumpolar regions?

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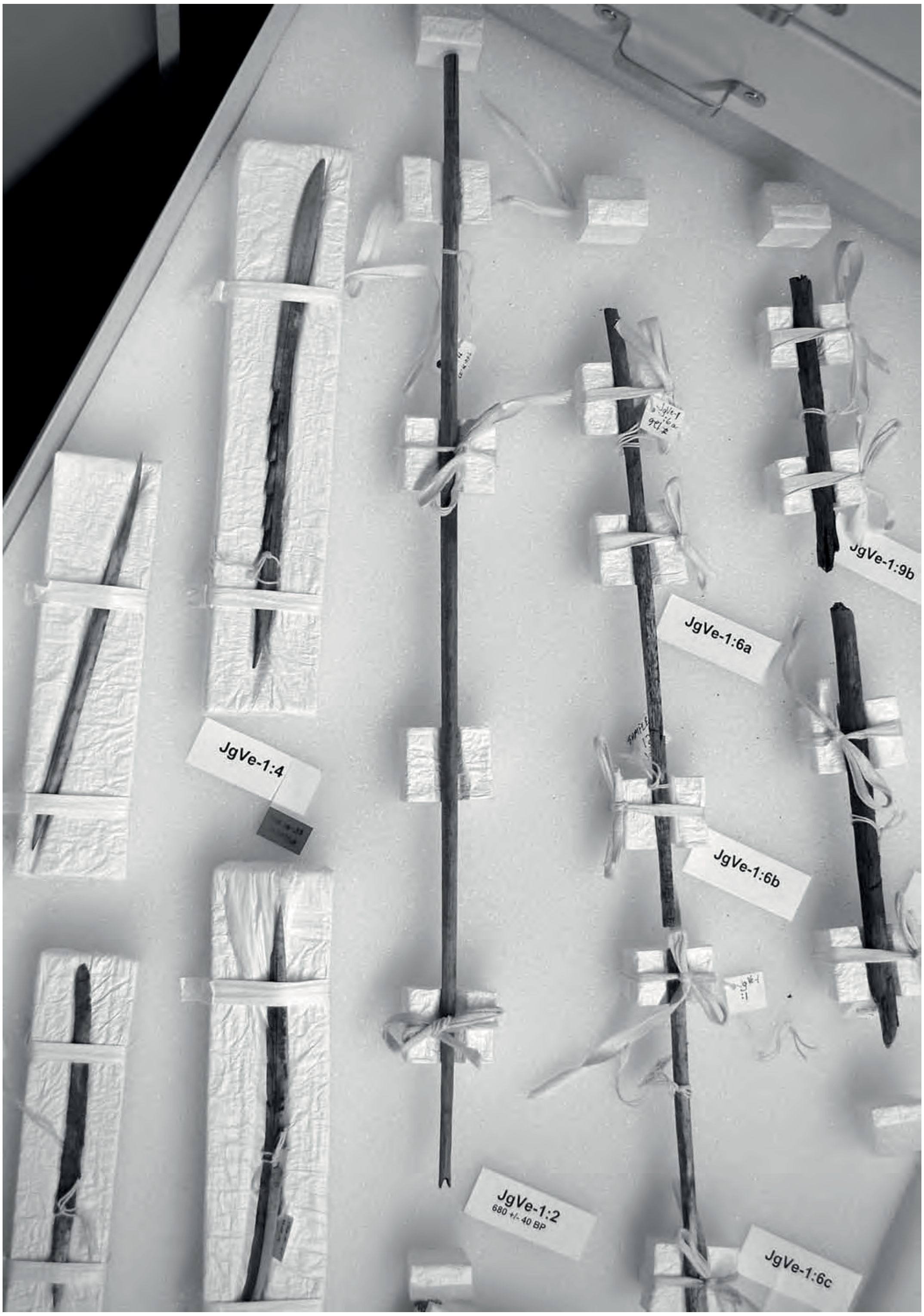

Fig. 5 An example of some of the artefacts recovered from snow-patches in the Yukon, Canada. Photo: Martin Callanan.

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Central Norwegian Snow Patch Archaeology: Patterns Past and Present

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ABSTRACT. Over nearly a century, a large assemblage of archaeological artifacts has been collected from some high-lying snow patches in a number of mountain areas in central Norway. The regional collection now comprises 234 individual artifacts that include both organic and inorganic elements. Many of these are arrowheads, shafts, and other equipment from past hunting expeditions on alpine snow patches. This article outlines three different phases of artifact recovery in the region: Phase I (1914–43) began with the initial snow patch discovery and included large numbers of finds in the 1930s and early 1940s; Phase II (1944–2000) had relatively few discoveries; and Phase III (2001–11) included discovery of 17 new sites and a record number of 145 artifacts. Local reindeer hunters and hikers have recovered many of the artifacts. There are close links between reindeer hunting and snow patch surveying in the region. The majority of snow patch finds were recovered during the period from mid-August through mid-September. The collection can best be viewed as a cohesive long-term record of melting snow patches.

Key words: Scandinavia, snow patch, reindeer hunting, bow and arrow, alpine archaeology

RÉSUMÉ. Pendant près d'un siècle, un large assemblage d'artefacts archéologiques a été recueilli dans les névés en haute altitude de certaines régions montagneuses du centre de la Norvège. Cette collection comprend maintenant 234 artefacts individuels, composés d'éléments organiques et d'éléments inorganiques. Des pointes de flèches, des fûts de flèches et d'autre matériel provenant d'anciennes expéditions de chasse dans les névés alpins s'y trouvent en grand nombre. Cet article présente les trois phases de la récupération d'artefacts dans la région, soit la phase I (de 1914 à 1943) qui a commencé avec la découverte du névé et a donné lieu à de nombreuses découvertes dans les années 1930 et au début des années 1940, la phase II (de 1944 à 2000) qui s'est soldée par relativement peu de découvertes, et la phase III (de 2001 à 2011) qui a permis de découvrir 17 nouveaux sites et le nombre record de 145 artefacts. Grand nombre des artefacts ont été récupérés par les chasseurs de rennes et les randonneurs pédestres de la région. Il existe des liens étroits entre la chasse aux rennes et la couverture des névés de la région. La majorité des découvertes effectuées dans les névés a été faite de la mi-août à la mi-septembre. Cette collection représente un enregistrement cohésif et à long terme des névés en fusion.

Mots clés : Scandinavie, névé, chasse aux rennes, arc et flèche, archéologie alpine

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INTRODUCTION

The large collection of snow patch artifacts housed at the Norwegian University of Science and Technology (NTNU) Museum of Natural History and Archaeology in Trondheim has been the subject of many years of research (Farbregd, 1972, 1983, 1991, 2009). Yet no detailed overview of the entire snow patch collection from central Norway exists at present. A collection of this kind, having been assembled over such a long time-frame (1914–2011), has great potential for both archaeology and other disciplines, especially in light of the current focus on melting alpine snow patches and their perceived relationship with shifting weather patterns and global climate change. A detailed presentation of the collection is an important first step towards more detailed archaeological and multidisciplinary research in the future. Some of the issues raised in this treatment may be relevant for similar collections from other regions as well.

This article presents in detail the snow patch sites and finds discovered in central Norway during the period 1914–2011, focusing on both the composition of the collection and the time when the artifacts were discovered. It seeks to uncover relevant patterns within the snow patch collection as a whole and to identify any methodological issues that may lie behind the patterns that emerge. The central question in this regard is the following: Can this collection be viewed as a cohesive long-term record, or should it be seen as representative of a series of disjointed periods of discovery?

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SNOW PATCH ARCHAEOLOGY IN NORWAY

At present, archaeological snow patch discoveries are known from four different regions of Norway. The most comprehensive finds come from two southern regions: the municipality of Oppdal in Sør-Trondelag County and the area centered on the municipality of Lom, in Oppland County. Oppdal is a municipality in the county of Sør Trøndelag, while Oppland is a large inland county that lies farther to the south (Fig. 1). A handful of individual finds have been recovered in inner mountain areas along the west coast (Shetelig, 1917; Åstveit, 2010). Two arrows discovered in 1999 at Seiland, Finnmark, are the northernmost finds in the country to date (Johansen, 2002).

Roughly 50 snow patch sites and find spots are known in Norway at present. Sites are usually found at elevations of 1400 m asl or above. However, the arrows from Seiland were recovered from sites lying at ca. 700 m asl, which underlines the possibility of making new snow patch discoveries at lower elevations in higher latitudes (Johansen, 2002).

On the basis of the current evidence, two types of sites are associated with archaeological snow patches in Norway: arrow sites and larger hybrid hunting/trapping sites. Both of these snow patch types have a number of particular characteristics, potentials, and challenges associated with them.

FIG. 1. Location of the four snow patch regions in Norway: 1) Oppdal, 2) Oppland County, 3) Vik, Sogn, and Fjordane, and 4) Seiland, Finnmark.

Arrow Sites

Arrow sites are the most common type of snow patch site and are present in all four regions outlined in Figure 1 (e.g., Shetelig, 1917; Farbregd, 1972; Johansen, 2002; Finstad and Pilø, 2010). Materials recovered from arrow sites consist mainly of iron, bone, antler, and lithic arrowheads and wooden arrow shafts. Artifacts usually associated with hunting activities, such as bow fragments, knives, and snare-setters, are also occasionally recovered from arrow sites.

The state of preservation of the recovered artifacts varies from whole arrows with fletchings and adhesive to disassociated arrowheads and shaft fragments (Fig. 2). Artifacts found on arrow sites are interpreted as being largely the result of past reindeer hunting, although prey such as grouse and certain furred animals were trapped and possibly hunted too on these sites (Åstveit, 2007; Farbregd, 2009; Callanan, 2010).

Archaeological materials on arrow sites are found either on, around, or below melting snow patches (e.g., Farbregd, 1972). Earlier research has shown that artifacts were deposited on some arrow sites over long time periods of prehistory (Farbregd, 2009) and thus offer valuable insights into past technical traditions and hunting activities over long time spans. The arrow sites of central Norway form the main focus of this article.

Hybrid Hunting/Trapping Sites

A number of discoveries made in Oppland County since 2006, including that of a well-preserved hunting/trapping system close to a snow patch at Juvfonna, have added a new dimension to Norwegian snow patch archaeology in recent years. The site at Juvfonna (1835 m asl) is likely the result of a hybrid form of hunting and trapping, in which reindeer were led or driven toward hunters hiding in carefully positioned blinds (Wammer, 2008). The archaeological remains

FIG. 2. This well-preserved arrow shaft and iron point were discovered lying directly on the ground close to Storbreen, Oppdal, on 21 August 2010. This kind of context is typical for the majority of finds in the central Norwegian collection. Photo: Martin Callanan.

recovered at Juvfonna consist of both organic finds and stone-set structures. Organic elements include large numbers of whole and fragmented sewels. A sewel is a thin branch or pole, with a light attachment of wood or bark fixed to the top (See Speiss, 1979:128). Lines of sewels were arranged in corridors that led reindeer to kill zones, where hunters were waiting behind stone-set hunting blinds.

Hybrid sites offer a different kind of information compared with arrow sites, producing a large number of organic finds that were probably deposited during single episodes. The organic elements recovered are the result of chronologically contiguous structures and activities and offer evidence of events restricted in time. That said, the indications are that hybrid systems were established and then reestablished on individual sites over considerable time spans. For example, elements of the hunting system at Juvfonna have been radiocarbon-dated to two distinct periods of the Iron Age (Finstad and Pilø, 2010). Since 2006, a number of additional sites of both arrow and hybrid types have been discovered in adjacent areas (Jotunheimen, Breheimen, and Reinheimen) (Finstad and Pilø, 2010). The artifacts recovered from snow patches in Oppland cover a broader range than those from the Oppdal area. Besides arrows and sewels, the Oppland finds include items such as wooden spades, textiles, and even a 3500-year-old shoe (Finstad and Vedeler, 2008; Finstad and Pilø, 2010).

Snow Patch Management in Norway

Cultural heritage management in Norway is organized at county and regional levels, ostensibly under the administration of the Norwegian Directorate for Cultural Heritage. Approaches toward managing archaeological snow patches have evolved differently in counties where the snow patch phenomenon has been identified. Local conditions, available resources, traditions, and not least, the initiative of local curators and managers have all been important factors underlying the various local approaches to snow patch management. In the municipality of Oppdal, snow patch archaeology is based largely on the efforts of local collectors, who survey sites and recover finds in collaboration with the NTNU Museum of Natural History and Archaeology in Trondheim. In the county of Oppland, on the other hand, snow patch management and field surveys are the responsibility of county archaeologists, who also engage actively in public and political outreach activities that help to create an awareness of the significance and fragility of the archaeological heritage appearing from melting snow patches.

SNOW PATCH ARCHAEOLOGY IN CENTRAL NORWAY

Arrow Sites in Central Norway

The term "central Norway," as used in this article, refers to a large, mountainous, inland area that lies roughly between 62° and 63° N. The area includes a number of municipalities within Sør Trøndelag and Møre & Romsdal County Authorities. The landscape in the region is characterized by a generally east-west gradient with respect to glacial re-sculpturing of the pre-Quaternary land surface. The western areas have high relief from deeply scoured major glacial valleys and alpine topography between these valleys, whereas large parts of the eastern areas are still dominated by pre-Quaternary surfaces of low relief and gentle slopes. Some glaciers are present in the region, but the altitude of the equilibrium line rises above the topography east of the Snøhetta mountain massif (2268 m asl).

Wild mountain reindeer still populate portions of this region, and the hunting of reindeer and other prey is still practiced throughout the autumn.

At present, there are 27 archaeological snow patches in this region (Table 1). The majority are found in alpine areas to the south and east of the mountain town of Oppdal (Fig. 3). Find-bearing sites are located at elevations between ca. 1350 and 2000 m asl. Archaeological snow patches vary greatly in size, from large patches such as Storbreen and Evighetsfonna at Sandåfjellet, which measure up to 1500 m along the slope and several hundred meters downslope, to smaller patches such as that at Kaldvellkinn, which measures as little as 100 m by 50 m during the melting season. A map-based survey shows that most of the region's archaeological snow patches are oriented towards the northeast or east. As can been seen from Table 1, the snow patch collection is dominated by finds from five patches. These lie in two areas close to one another to the south and east of Oppdal (Fig. 3).

Snow patches often lie laterally along or under mountainsides, ridges, or tops. Some patches appear almost as if draped or wedged onto the underlying topography, and as a result, they can become very steep, particularly in a reduced state. Such is the case on the patches at Leirtjønnkollen and Løpesfonna, whereas on other larger patches, surfaces are more expansive and relatively flat. Measurable altitude differences on individual patches range from ca. 5 to 250 m.

Snow patches follow irregular annual cycles of accumulation in winter and ablation in summer. Archaeological finds are usually recovered during years of large negative mass balance, towards the end of the summer melt. Under such conditions, patches often appear as areas of snow or ice with dirty surfaces, at times surrounded by halos of lighter, lichen-free ground that outline the patches' previous extent. The archaeological season usually ends towards the end of autumn, once temperatures drop and snowfall returns.

Snow patches are dynamic contexts. Densification processes occur as new snow becomes compacted and transformed from snow through firn to ice, or as meltwater or water-soaked snow re-freezes (Nesje, 1995). During the course of these cycles, the horizontal and vertical form of snow patches varies considerably on an annual basis but especially over longer time scales. During summer months, layers of new snow retreat along the surface of the snow

TABLE 1. Overview of archaeological snow patches in central Norway.

Snow patch	Latitude (N)	Longitude (E)	Elevation (m asl)	Orientation	No. of finds
Storbreen	62° 21′51″	9° 24′48″	1810	NE	48
Kringsollfonna	62° 30′51″	9° 44′38″	1520	NNE	43
Leirtjønnkollen	62° 27′25″	9° 44′37″	1560	NE	35
Brattfonna	62° 28′38″	9° 46′25″	1470	N-E	32
Løpesfonna	62° 22′11″	9° 22′27″	1730	NE	18
N. Knutshø	62° 19′31″	9° 40′26″	1630	NE	8
Vegskardet	62° 21′56″	9° 19′35″	1500	NE	5
Løftingfonnkollen	62° 22′32″	9° 23′20″	1680	NNE	3
Tverrfjellet	62° 28′33″	9° 20′55″	1270	NE	3
Bekkfonnhøa	62° 32′09″	9° 41′34″	1360	NNV	3
Kaldvellkinn	62° 30′47″	9° 44′49″	1550	ENE	3
Sandåfjellet/ Svorundfjellet	62° 37′46″	9° 11′37″	1530	E	2
Langfonnskarven	62° 27′01″	9° 38′59″	1330	E	2
Kinnin	62° 21′24″	9° 26′40″	1720	E	2
Kringsollfonna+	62° 30′52″	9° 45′33″	1400	NNE	1
M. Knutshø	62° 18′42″	9° 40′49″	1545	E	1
Hesthågåhøa	62° 23′59″	9° 35′18″	1530	N	1
Snøhetta	62° 19′61″	9° 17′29″	2000	E	1
Skiråtangan, Sunndal	62° 26′41″	9° 05′50″	1450	NE	1
Råstu, Sunndal	62° 31′18″	8° 47′24″	1547	NE	1
N. Svarthammaren, Sunndal	62° 26′55″	8° 44′59″	1700	NE	1
Grovåbotn, Nesset	62° 21′58″	8° 12′55″	1390	N	1
Sissihøa	62° 33′04″	9° 43′36″	1360	N	1
Gravbekkfonna	62° 27′08″	9° 30′09″	1300	NNE	1
Namnlauskollen	62° 22′25″	9° 25′19″	1750	NE	1
Skirådalskardet	62° 26′32″	9° 11′47″	1765	E	1
Svartdalskardet	62° 28′29″	9° 17′15″	1815	NE	1
Sissihøa-Leirtjønnkollen (10 × 2 km)	–	–	> 1400	–	14
					Total = 234

patch. Patches also contract inwards from the outer edges (Farbregd, 1983). At times, melting beneath the upper and lower edges, which is probably due to heat-transfer from meltwater, makes it possible to peer under the edges of the snow patch. Meltwater is frequently observed flowing out from under the lower edges of snow patches and may also flow internally along denser layers that formed earlier. On larger patches, meltwater gullies often form on the surface and at times cut deeply into the upper snow layer (Farbregd, 1983). The ground directly below snow patches is often severely waterlogged, as frozen ground conditions inhibit meltwater infiltration.

Much of the observable annual and multi-annual variation in the size of mountain snow patches is related to recent layers of new snow. These layers are renewable and shield the central ice core in some way. Changes in the relationship between the upper snow layer and the inner ice core probably play an important role with regard to the transportation of archaeological materials on both long and short time scales (Farbregd, 1983).

The "dirty" surfaces of exposed ice cores appear in years when melting is great. These dark grey, dark brown, and black surfaces are one of the key characteristics used to identify advanced melting on archaeological snow patches. The emergence of dirty surfaces on local snow patches has been documented over a number of years in the photographic and correspondence archive in Trondheim. Surface materials are often explicitly described by collectors as sludge (NOR. *slam*). The indications are that this material is a combination of reindeer feces, sediments carried downslope by meltwater, and wind-blown floral material (cf. Warren Wilson, 1958). From descriptions of snow patch surfaces in the 1930s, it appears that episodes of dense sludge cover were more common in the past than now (Farbregd, 2009: Fig. 6). However sludge layers have occasionally appeared on local snow patches in recent times (Fig. 4). Within a Norwegian context, surface sludge from melting snow patches has not been sampled, and it remains to be demonstrated whether this material is of minerogenic, faunal, or floral origin.

Snow Patch Finds

A total of 234 individual artifacts have been recovered from the 27 patches registered in the period 1914–2011. The central Norwegian snow patch collection comprises arrows, arrowheads, and arrow fragments in addition to a small number of related artifacts: bow fragments, knives, and other tools, such as a snare-setter. A number of unidentified but modified wood and bone fragments are also part of the collection. Until quite recently, unmodified faunal material had not been collected from sites in the region. As preservation of organic components is one of the main characteristics of the snow patch collection, the material composition of individual artifacts forms the basis for this presentation.

In Table 2 the collection is divided into two main groups; organic and inorganic finds. The organic group comprises artifacts made of wood, bone, antler, or with preserved accompanying organic adhesive or sinew lashings. This group also includes composite artifacts with both organic and inorganic elements, and in these cases, the organic

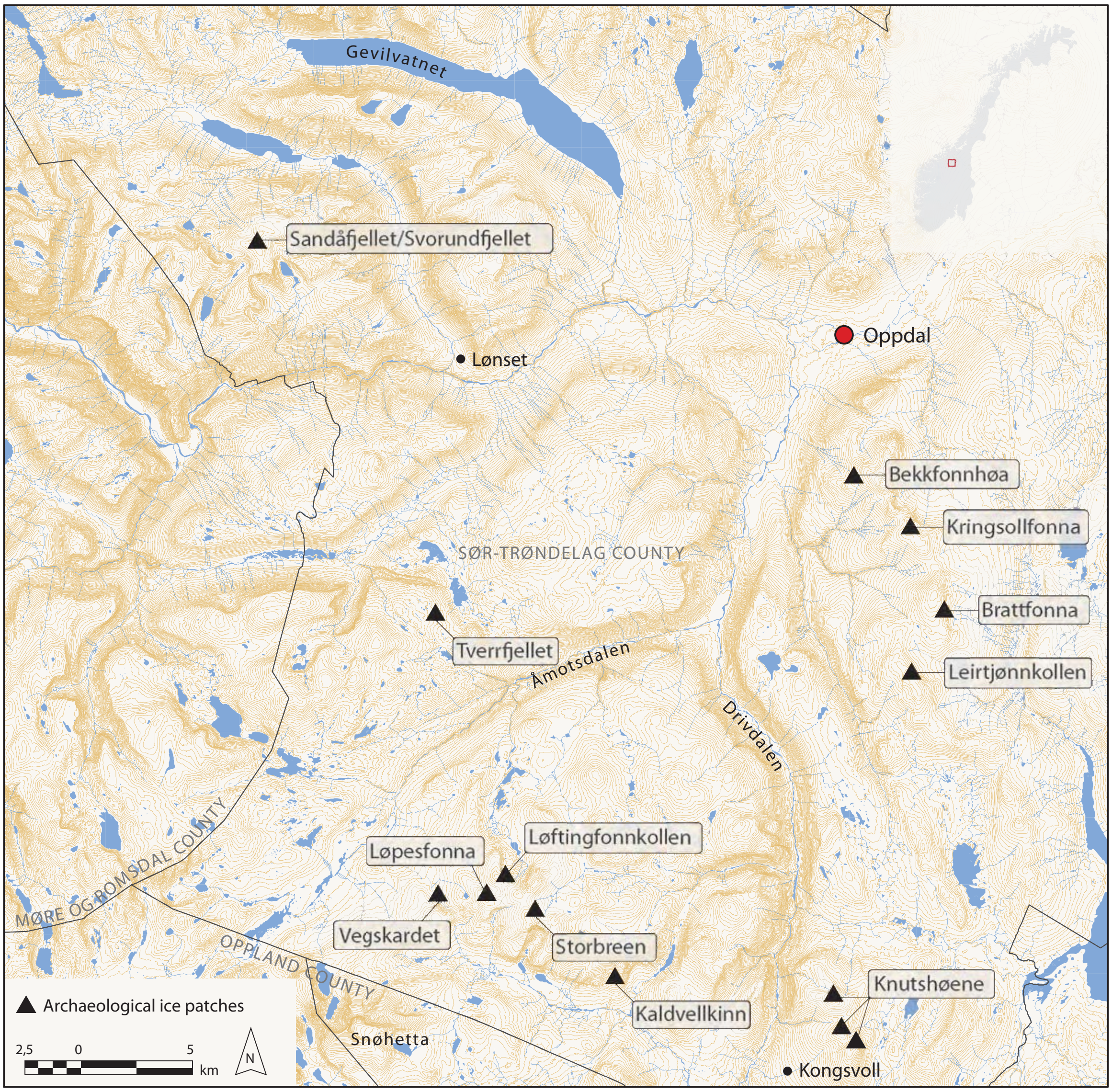

FIG. 3. Location of the principal snow patches of central Norway.

element has taken precedence for classification purposes. For example, a find comprising a complete wooden shaft and iron arrowhead is sorted under "organic finds" within the present system. The material composition of all arrowheads, such as iron, stone, bone, or antler, is also listed under "organic finds." All finds are counted only once in Table 2. For example, the collection contains a total of three bone arrowheads. Two of these are listed under different subgroups as shafts with points, while the third is listed as a loose point. Organic finds dominate the collection, representing 70% of recovered materials.

The group "inorganic finds" is dominated by disassociated iron arrowheads. Moreover, a slate arrowhead, a knife, and a disassociated metal fixture belonging to a club-headed arrow are included in this group. Inorganic elements represent 30% of the present collection.

Basic information regarding the condition of recovered artifacts is also presented in Table 2. As the majority of finds are prehistoric and historic arrows, the completeness of individual arrows forms the basis for organizing recovered shafts into three distinct groups: whole arrows, shaft sections, and shaft fragments. Artifacts are considered

FIG. 4. Sludge layer along the upper slope at Kringsollfonna, Oppdal, on 15 September 2003. Photo: Ingolf Røtvei.

whole arrows if the entire shaft, including both the distal and proximal ends, is present. Contiguous or refitted portions of shafts measuring more than 40 cm in length are classified as shaft sections. Contiguous, discontinuous, or refitted portions of shafts less than 40 cm long are classified as shaft fragments. Extant shaft fragments are grouped in this way because previous research has shown that whole shafts rarely exceed 75 cm in length (Farbregd, 2009: Fig. 9). Setting a metric border between sections and fragments at 40 cm allows us to highlight arrows of which more than half of the shaft is present.

The collection includes a total of 38 complete shafts and 43 arrow sections. The remaining 54 arrows are present as fragments. The general condition of the arrow group as a whole points in two different directions. First, the fact that so many whole arrows and arrow sections have been recovered appears to indicate that snow patches are relatively static environments that allow complex and delicate organic artifacts such as arrows to survive in relatively good condition. On the other hand, the large number of fragments also reminds us that some arrows are being exposed to destructive mechanical or environmental forces, or both.

Dating the Snow Patch Collection

The age of the Trondheim collection of snow patch artifacts has been the subject of a number of studies (Farbregd, 1972, 1983, 1991, 2009; Åstveit, 2007). The chronological framework for snow patch finds has been developed typologically by comparing recovered iron arrowheads with well-established regional chronologies of finds from closed pagan graves. The result is a detailed regional chronology of arrow and crossbow projectile development for the approximate period AD 200–1700 (cf. Farbregd, 2009: Fig. 9). The large majority of snow patch finds can be assigned to two distinct periods: ca. AD 400–600 and ca. AD 1200–1700 (Farbregd, 2009). In recent years, the radiocarbon-dating of a number of atypical artifacts has considerably broadened the collection's chronological horizon. At present, the earliest radiocarbon-dated snow patch find from central Norway is dated to between 2480 and 2340 cal BC. The date is derived from organic adhesive remains recovered from the tang of a slate arrowhead (Åstveit, 2007: Fig. 5).

PATTERNS IN ARTIFACT RECOVERY

Source Critical Issues

The Trondheim snow patch collection has been collected over almost 100 years, between 1914 and 2011. A collection as old as this presents its own particular problems as research questions, perspectives, and especially equipment have changed over time. Today, many people carry mobile telephones with integrated GPS units and digital cameras that can record and send digital photos and accurate GPS positions instantaneously. These capabilities were unthinkable even a few years ago. As a result, one of the challenges in working with the Trondheim collection as it continues to grow lies in aligning contextual information from older finds with that from newer ones, so that the collection forms one cohesive unit.

Fortunately, most of the source-critical work has already been carried out by Farbregd in his 1972 publication. However, there are still some holes in the records. For example, precise geographical information on a group of 14 finds from the area between Sissihøa and Leirtjønnkollen in the eastern mountains has been lost (Table 1). For this reason, the sample numbers vary in the presentation that follows, as finds with incomplete contextual information have been omitted where appropriate.

THREE PHASES OF SNOW PATCH ARTIFACT RECOVERY IN CENTRAL NORWAY

The year of discovery can be identified for 211 of the total 234 finds (Fig. 5). The distribution over time of these discoveries, separated into organic and inorganic elements, is presented in Figure 5. The history of snow patch artifact recovery in central Norway during the period 1914–2011 can be divided into three main phases, which are defined by the numbers of finds recovered and important developments in the way they were collected. Following an initial discovery in 1914, the first phase is marked by a large number of finds that were recovered during the late 1930s and early 1940s. There followed a second phase of almost 60 years with relatively few discoveries. The third phase, during which large numbers of finds are again being recovered, has lasted from 2001 until today.

Phase 1: 1914–1943

Following an initial discovery in 1914, the vast majority of finds from this first phase were made during seven seasons between 1936 and 1943. This was a period of variable weather with a series of mild winters and extremely

TABLE 2. Inventory of the central Norwegian snow patch collection (n = 234).

Artifact	Material	Number of Finds
Organic Finds (n = 165):		
Whole shaft with point	Iron	19
	Antler	2
	Shell	1
	Slate	1
Whole club-headed arrows	Wood	2
Club-headed arrow section	Wood	1
Shaft section with point	Iron	12
	Shell	1
Shaft fragment(s) with point etc.	Iron	13
	Bone	1
	Slate	2
Whole shaft	Wood	13
Shaft section	Wood	29
Shaft fragments	Wood	38
Bow fragments	Wood	5
Bone point	Bone	1
Wood fragments	Wood	23
Bone fragments	Bone	1
Inorganic Finds (n = 69):		
	Metal points	66
	Stone point	1
	Other	2
		Total = 234

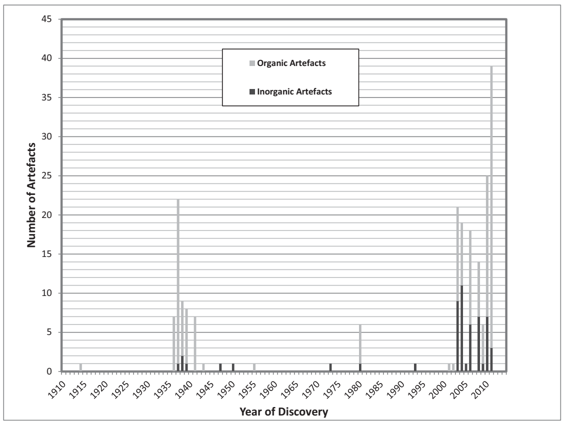

FIG. 5. Central Norwegian snow patch finds (n = 211) by year of discovery.

warm summers in quick succession, during which many of the large maritime and continental glaciers retreated (Fægri, 1938). It was during this phase that the tradition of snow patch surveying and collection first began in Oppdal, in cooperation with the Museum of Natural History and Archaeology in Trondheim (Farbregd, 1972, 1983; Callanan, 2010). A small number of local people began recovering arrows and other artifacts from snow patches in the mountain areas of Oppdal where they hunted and hiked.

During Phase 1 (1914–43), a total of 69 finds were collected from eight sites in the southern and eastern mountains, as well as at Sandåfjellet in Trollheimen (Fig. 3). Judging by the records in the archive at NTNU Museum of Natural History and Archaeology in Trondheim, the intensity of surveying activities varied during this phase. There is no evidence of surveys being carried out as a result of the initial discovery in 1914. However, starting in 1929, a small number of finds were recovered from mountain areas in and around some of the large snow patches, which seems to indicate a certain level of surveying. The main period of regular snow patch surveying in the mountains around Oppdal appears to have begun in the mid 1930s, with intense surveying carried out by a handful of local collectors. Artifacts recovered include iron and bone arrowheads, complete arrows and shafts, and shaft sections and fragments as small as 4 cm long (Farbregd, 1972). The collectors also provided detailed descriptions and observations of sites and contexts, which proved vital in helping archaeologists understand the prehistoric background for these discoveries and the connection between artifact and snow patch. Phase 1 ended with the last snow patch discovery made by a member of the pioneer group of collectors in 1943.

While it seems clear that there is a direct relationship between the discovery of large numbers of finds and the unusual weather patterns during 1914–1943, other factors may also have contributed to these numbers. It seems reasonable to suggest that a proportion of the finds recovered during Phase 1 had probably melted out of the snow patches for the first time at some date prior to their discovery. Under this scenario, the warm weather with mild winters during the 1930s not only caused alpine snow patches to melt and release artifacts for the first time (i.e., primary melt), but also allowed the recovery of artifacts that had accumulated around snow patches as a result of earlier melting events (i.e., secondary melt). At present, without specialist material studies, it is all but impossible to determine exactly which finds resulted from primary melts and which from secondary melts. But it is likely that the "discovery effect" of finding accumulations of artifacts during initial surveys is a general phenomenon associated with newly discovered archaeological snow patches.

Phase 2: 1944–2000

Phase 1 was followed by a 60-year period in which few new finds or sites were discovered. From 1944 to 2000, only 12 finds were recovered and two new snow patches added to the list of known sites. New finds included both organic and inorganic finds (Fig. 5, Table 3). The key question relating to this second phase is why so few finds were recovered. Did collectors stop surveying sites, or are there other factors that could explain the decline in the number of finds recovered?

Members of the pioneer group of collectors eventually retired or passed away, and new names began to appear on find lists. The general impression one gets from the records of Phase 2 is that surveying activities were not as intense as during the late 1930s. But there are signs of continuity too. The collectors of the second phase were younger associates of their predecessors. Some even hunted together with their

TABLE 3. Number of recovered finds[1] in the snow patch collection through three phases in the period 1914–2011.

Period	Total	Organic (n)	Organic (%)	Inorganic (n)	Inorganic (%)
1914–1943	69	60	87%	9	13%
1944–2000	12	6	50%	6	50%
2001–2011	145	97	67%	48	33%

[1] Eight artifacts for which the records are incomplete are excluded from the table.

older colleagues around classic snow patch sites (T. Bretten and I. Røtvei, pers. comm. 2010). It seems unlikely that local awareness of the region's snow patch tradition would be forgotten within such a short time. In support of this view, a search of the Museum's catalogue for this period reveals that of the 29 stray, non-snow patch finds recovered in Oppdal municipality during 1943 – 2001, a total of 17 were recovered in alpine locations or altitudes. The fact that hunters and hikers continued to make archaeological discoveries from time to time in relevant alpine areas lends further credence to the argument that snow patches were indeed being surveyed during this phase, but that the finds or the conditions suitable for their recovery were not present.

A key development during Phase 2 was Oddmunn Farbregd's engagement in snow patch archaeology in the region. Farbregd was based at the NTNU Museum of Natural History and Archaeology in Trondheim from the early 1970s, and his involvement has been central to both the continuation and the development of snow patch archaeology in the region.

From 1968 on, Farbregd carried out a number of small-scale surveys of central snow patches during the late summer melt season. In addition, by conferring with local hunters and other informants, he monitored annual developments on local snow patches during the melting season. Advanced melting is reported to have taken place in 1955, 1970, 1980, and 1986, and some finds were recovered as a result (O. Farbregd, pers. comm. 2011). In 1980, in response to reports of advanced melting, an extensive survey of the region's classic snow patches was mounted. This survey resulted in the recovery of a number of artifacts (Fig. 5, Table 3), the identification of a new site in the southern mountains, and the publication of survey results (Farbregd, 1983).

Farbregd's second important contribution during this phase was his role in continuing and renewing the local network of collectors based in Oppdal. A number of the pioneer collectors were interviewed in the late 1960s (Farbregd, 1972). Towards the end of Phase 2, new members joined the collector group. And thus an important continuity from the pioneer group of collectors was ensured through this second phase.

Other strands of evidence indicate that the paucity of finds during Phase 2 was probably more a result of the general conditions at the time, rather than a break in the snow patch surveying tradition. Regional meteorological records for 1944 – 2000 show generally colder temperatures compared to a high point in the 1930s, while precipitation levels remained relatively stable during the same period (Hanssen-Bauer, 2005: Figs. 2 and 9). In general, we should be wary of applying such regional data uncritically to local snow patches. But these data appear to suggest that the extreme conditions documented in the mid 1930s gave way to conditions more favorable to the maintenance of positive mass balances during the period 1944 – 2000.

Phase 3: 2001 – 11

The third phase of snow patch archaeology in central Norway is again a period of regular advanced melting, with large numbers of finds being recovered. The 2010 and 2011 seasons in particular have produced a record-breaking number of artifacts.

A total of 145 artifacts, both organic and inorganic, have been recovered from local snow patches during Phase 3, and 17 new sites have been identified, bringing the regional total to 27 sites (Fig. 4, Table 3). New sites have been identified both within the core areas around Oppdal and in the neighbouring municipalities of Sunndal and Nesset farther to the west.

The traditional network of local collectors has been renewed and expanded during this phase, building on efforts in the previous phase. Since 2003, site surveys have been more regular and systematic, with collectors spurred on by the increased numbers of finds and repeated advanced melting (T. Bretten, pers. comm. 2010). The period has been characterized by unstable weather conditions, with extreme melting taking place on certain sites in 2003, 2004, 2006, 2010, and 2011.

A new development during Phase 3 has been the regular use of metal detectors to recover iron arrowheads. One of the current collectors has specialized in surveying areas adjacent to snow patches with the aid of a metal detector. The widespread use of iron arrowheads throughout the late prehistoric period in Norway makes metal-detecting a very effective method for recovering artifacts buried in sediments and gravels at the base of snow patches. This approach has proved very successful and has produced significant results during Phase 3 (Table 4). The vast majority of the metal detector finds consist of disassociated arrowheads (See Åstveit, 2007: Fig. 2, for a notable exception).

Many important questions need to be asked about these finds and their contexts. When did they emerge from the snow patches? Are there any patterns in the age of metal detector finds? How and at what rate did they become

TABLE 4. Overview of metal detector finds recovered during Phase 3 (2001–11).

	2001	2002	2003	2004	2005	2006	2008	2009	2010	2011
Total number of finds	1	1	21	19	1	18	14	6	25	39
Metal detector finds	0	0	4	9	1	6	6	4	3	1

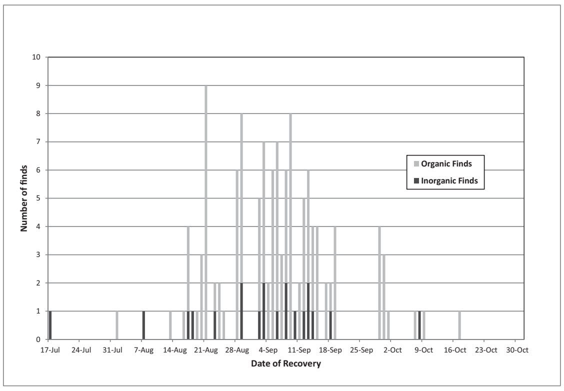

FIG. 6. Date of discovery of 128 artifacts found in the snow patches of central Norway.

buried? And what might the artifacts' locations tell us about the patches' previous extent and development? At present, the hypothesis is that some of these finds were released from snow patches during melting events that probably predate the initial 1914 discovery. The fact that some arrowheads have been recovered with metal detectors as far as 50 m from the edge of current snow patches lends support to this hypothesis. An overview of metal detector finds for the relevant years during Phase 3 is presented in Table 4.

A COHESIVE LONG-TERM RECORD?

Continuity?

The central question behind this review was whether the central Norwegian snow patch collection can be viewed as a cohesive long-term record, or whether it should be looked upon as representing a series of disjointed periods of discovery.

The review indicates that while there may have been some periodic variation in the level of surveying activity on and around snow patches, there was also a strong element of continuity between the three phases.

With regard to the 1944–2000 phase, the fact that from 1968 onward, sites were being visited and regularly monitored, and that focused surveys were carried out when suitable conditions presented themselves, indicates that the demonstrated find hiatus cannot be explained by lack of surveying. There is, however, one final piece of evidence in this regard.

Surveying and Reindeer Hunting?

The dates of recovery for individual snow patch finds in the region are presented in Figure 6. The sample for this analysis is reduced (n = 128) as the precise date of recovery was not always recorded, especially during Phase 1. However, all three phases are represented, and the results are clear: the vast majority of snow patch finds in the region are recovered during a four-week period between the middle of August and the middle of September. This short window of opportunity for making discoveries is characteristic for snow patch archaeology. The period of maximal melting towards the end of the season is the time when one is most likely to recover artifacts. But it is also the time when bad weather and snow can cause problems for collectors in the field and ultimately bring an end to the surveying season (Farbregd, 2009). At first glance, one might easily conclude that it is this short window that is depicted in Figure 6—the period between the release of finds from patches, on the one hand, and the end of the season, as the first snow of winter falls, on the other. In reality, something else is also contributing to this distribution.

The vast majority of finds from central Norway are found by private collectors, many of whom are reindeer hunters. And many of the find-bearing patches lie in areas that are active hunting zones today. Reindeer hunting in Norway is heavily regulated, and there are restrictions on when, where, and how many animals may be felled each year. Although rules and practices have varied through the years, certain levels of regulation have been in place in the area in question since the early 1900s (Jordhøy, 2001). At present, reindeer hunting in central Norway is regulated to the period from the middle of August to the middle of September. This has long been the tradition. Thus it becomes clear that the pattern presented in Figure 6 is as much a record of hunters' activity in areas around snow patches as it is a record of the optimal find window. Reindeer hunting was the key factor drawing hunters up to the alpine zone, where they also made archaeological discoveries. From this perspective, Figure 6 is a clear illustration of the close link between reindeer hunting and snow patch discoveries in central Norway.

This link is highly relevant when trying to assess the changing levels of survey activity around alpine snow patches in Phase 2 (1944–2000), during which few finds were recovered. The history of local reindeer hunting shows that there was a large increase in the number of reindeer hunted in the region between 1950 and 1970 (Jordhøy, 2001). Increased hunting activity probably meant that more hunters were active in the mountains, close to find-bearing snow patches, during the melting season. Given the local awareness of the possibility for snow patch discoveries that existed at the time, it seems likely that more finds would have been recovered from snow patches if they had appeared, or if suitable conditions for find recovery had presented themselves during Phase 2.

CONCLUSION

The question at hand has been whether the record of archaeological finds made around local snow patches is best viewed as a disjointed series of finds in similar locations, or whether the collection is rather a cohesive long-term record of melting alpine snow patches. An initial mapping of the temporal distribution of finds highlighted an uneven development, with two distinct phases characterized by large numbers of recovered artifacts. These phases were separated by nearly 60 years during which few new finds or sites were discovered. There is evidence of fluctuations in the intensity and regularity with which mountain snow patches were surveyed. But the analysis has also shown that there is much to indicate that the perceived pattern is in fact real. This evidence includes the continuity of the local collector tradition in Oppdal, important direct links between the pioneer group and today's collectors, records from local weather data, and evidence from the history of local reindeer hunting in the area. All these data lead to the conclusion that the pattern of temporal distribution demonstrated in Figure 4 is not a product of varying survey activity. And thus, the snow patch collection from central Norway can be confidently viewed as a cohesive, long-term product and record of melting alpine snow patches in the region in the period 1914–2011.

OTHER SNOW PATCH ARCHAEOLOGY ISSUES

This review of aspects of the snow patch collection from central Norway raises a number of issues that might be relevant to similar collections or applied studies in the future. These issues include specific questions that have already been raised, such as the "discovery effect" and the role of surveying intensity in creating patterns of temporal distribution. Other issues are important to highlight because they seem fundamental to the nature of snow patch archaeology and to the kind of data we create. In the future, these and similar perspectives might temper and inform the demands we make of the data we possess, especially within the context of linking snow patch discoveries to climate variation and change.

Visual inspection, as commonly employed in snow patch surveys, is a method with obvious inherent weaknesses. Even when sites have been carefully surveyed, there is no guarantee that an artifact has not been overlooked or that finds will not appear later within the same melt season. Many anecdotes of finds being recovered in locations carefully surveyed just minutes before underline this weakness. In central Norway, we are fortunate that iron was used in the past to produce arrowheads. Metal detectors are therefore a great aid in increasing the reliability and effectiveness of visual surveys for recovering material from these periods. But the potential for error remains, and at present there appear to be no methodological parallels to traditional surveying techniques, such as test pitting and trenching, by which we can create reliable negative data from alpine snow patches.

A related issue is the importance of well-documented negative data. Until quite recently, it was not the norm in central Norway to record details of surveys that did not result in finds. And as we have seen, this omission can cause difficulties when trying to assess the validity of periods during which few finds were recovered. However, it is becoming increasingly clear that the ablation of many archaeological snow patches is a long-term, non-linear process, in which patches might often increase in size or melt in unexpected ways during any given season. In the future, it may be useful to be able to make year-to-year comparisons when trying to identify the causal factors behind long-term snow patch development. From this perspective, documenting the extent and conditions of surveys that do not produce finds may produce valuable data too. Obviously this perspective will have implications for how and over what time spans snow patch surveys might be designed.

Finally, more attention should be given to the proposed differentiation between primary and secondary melting events in relation to individual artifacts. As shown in Table 2, the degree to which artifacts are preserved on snow patches varies considerably, which may be partly explained by the effects of multiple melting episodes after the artifact's initial deposition. We should therefore probably be wary of presuming that the date of recovery for an individual artifact automatically marks the season or period during which it emerged from the snow and ice for the first time (primary melt). On the contrary, the release of artifacts from snow patches is probably more often than not a process that is repeated over time, rather than a singular event. With this in mind, if we wish to draw closer causal links between the appearance of ancient objects on alpine snow patches and developments in present-day weather and climate patterns, greater account needs to be taken of this issue.

Having such an old snow patch collection has its own particular possibilities and problems. Establishing the background and true nature of this collection is an important step forward with a view to future studies. Having confirmed the long-term nature of this snow patch collection, it is now possible to start looking for the long-term causal factors and drivers that lie behind these patterns. This is a complex and multidisciplinary challenge that will have to account not only for recent finds recovered since 2001, but also for the considerable number of finds recovered during the 1930s. Another challenge relates to finding a way to integrate the sizeable group of artifacts found by metal detectors with this larger group. And last but not least, there is the question of what the future will bring and how this archaeological record will continue to develop in the years and decades to come.

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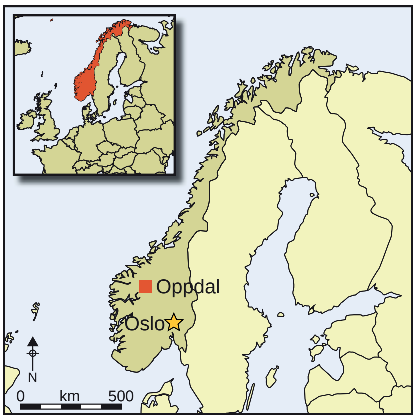
Melting snow patches reveal Neolithic archery

Martin Callanan*



High altitude snowfields provide repositories of well-preserved organic remains of considerable antiquity, as spectacular discoveries such as the Similaun Iceman illustrate. In Scandinavia, melting snow patches have been systematically surveyed by volunteer groups for almost a century, and a growing collection of archaeological artefacts has been recovered. Only recently, however, has AMS dating confirmed that some of the finds go back as far as the Neolithic. Here fragments of five Neolithic arrowshafts and a Neolithic longbow discovered in 2010–11 in the Oppdal area of Norway are described. They throw light on Neolithic bow and arrow technology and tangentially on the hunting techniques which may have attracted hunters to these snow patches in search of game. The progressive and accelerated melting of the snow patches in recent years draws attention to processes of climate change and the urgency of discovering and recovering these fragile perishable artefacts.

Keywords: Norway, Oppdal, Neolithic, snow patches, archery, climate change

Introduction

Snow patches are perennial accumulations of snow and ice, found in the mountains of Norway and other regions of the world at high altitude or latitude. Continually exposed to the varying effects of weather and climate, they are dynamic contexts, prone to constant change and development. On hot summer days, animals such as reindeer, sheep and birds often seek out high-lying snow patches to get some relief from both the heat and from parasitic insects. In the past, this behaviour attracted the attention of hunters who used snow patches as summer hunting grounds. Objects lost or discarded by these hunters are often very well preserved and are discovered when patches melt sufficiently. This chain of events forms the background for snow patch archaeology and the finds described here.

In this paper, a number of Neolithic (4000–1800 BC) artefacts recently discovered from snow patches in central Norway are reported. In 2010 and 2011 fragments of five Neolithic

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arrows and a Neolithic bow were discovered at two mountain sites. Despite a long tradition of artefact collection from snow patches in the region, these are the oldest snow patch artefacts that have yet been recovered in Scandinavia. The finds are significant for two reasons. First, they offer a rare glimpse into the archery technology of the Neolithic period in Scandinavia. Second, the repeated recovery of organic artefacts from melting snow patches serves as a warning to us of changes that are currently taking place in the alpine landscapes of central Scandinavia.

Background/setting

The snow patch region in question lies in the mountainous south-western corner of central Norway between 62° and 63° N. Here, the mountain complexes of Trollheimen and Dovre meet across a series of valleys converging on the town of Oppdal (Figure 1).

The geology of this area is complex, lying in a contact zone between Cambrosilurian and Precambrian bedrocks to the west and east respectively. The overlying landscape was heavily modified during the last ice age, especially in the west. Furthermore, the area has the character of a borderland with regard to climate. Maritime conditions in the west give way to mildly continental conditions in the east. Vegetation in the area follows elevation gradients from middle boreal vegetation in the valleys up to 700m asl. There follows a belt of sub-alpine birch forest up to *c.* 1100m asl. Archaeological snow patches are generally found at elevations above 1400m asl within middle and high alpine vegetation zones. Scattered communities of lichen and mosses between areas of bare bedrock and scree are found around the highest-lying snow patches (Moen 1987: 217). The fauna of the region includes herbivores such as reindeer and musk ox as well as carnivores such as wolverine, polar fox, gyrfalcon, rough-legged buzzard and golden eagle.

There is a long-standing tradition of artefact surveying among a group of local volunteer collectors in Oppdal. Regular surveying is carried out on foot and often involves long treks in demanding terrain, frequently in difficult weather conditions. Nonetheless, no fewer than 234 artefacts have been collected in the region from 27 different snow patches in the period 1914–2011 (Callanan 2012; Figure 2).

The material collected comprises arrowheads, shafts and bow fragments as well as other items associated with hunting activities (Farbregd 2009; Callanan 2012). Since 2006, snow patch discoveries have also been made in other parts of Norway, most notably in Oppland County in the inner mountains of southern Norway, where a series of complex sites, mostly from the Iron Age and medieval periods (*c.* 500 BC–AD 1500) have been identified and surveyed. Moreover, a few Bronze Age artefacts (1800–500 BC) have been recovered, most notably a shoe, a birch bark quiver and more recently a complete bow dated to *c.* 1300 BC (Finstad & Vedeler 2008; Mímisbrunnr n.d.).

Beyond Norway, archaeological snow patches have been identified in a number of high altitude/latitude environments around the globe. In many instances objects related to projectile/hunting technology have been found, as in the Yukon and Northwest Territories in Canada (Farnell *et al.* 2004; Andrews *et al.* 2012), and in Alaska (Dixon *et al.* 2005; VanderHoek *et al.* 2007) and the Rocky Mountains in the United States (Lee 2012). A more varied group of snow patch finds have been recovered from the Schnidejoch site in

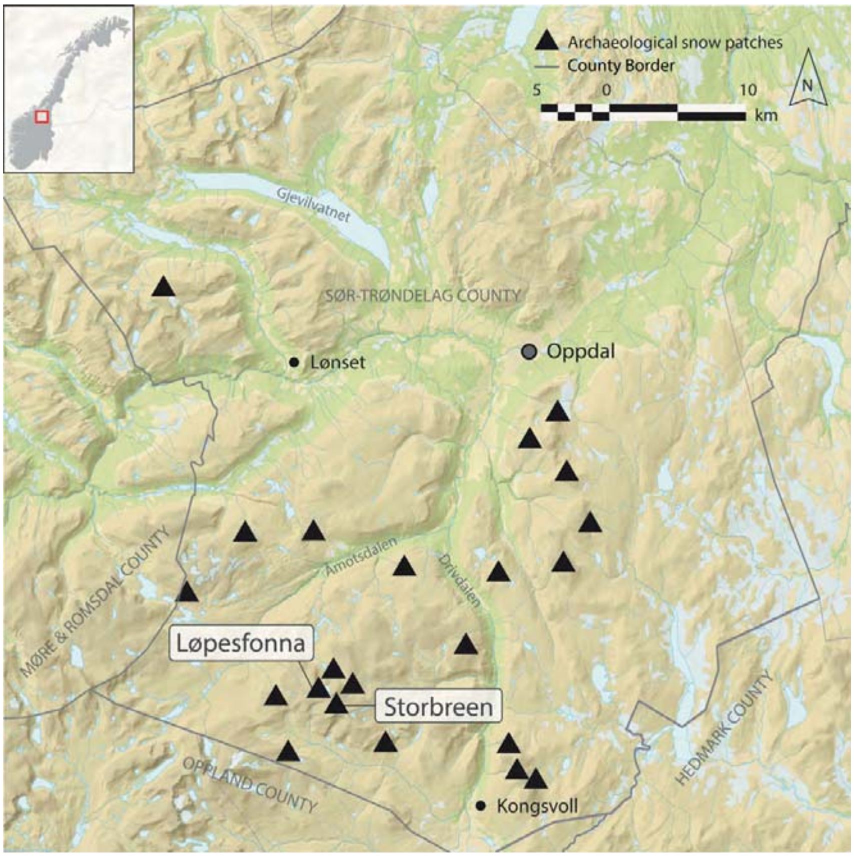

Figure 1. Archaeological snow patches identified in the Oppdal Mountains, central Norway. The sites mentioned in this article, Løpesfonna and Storbreen, are highlighted.

Switzerland (Suter *et al.* 2005). In each region, finds from snow patches offer researchers important chronological and technical information on human movements and on the utilisation of peripheral environments through prehistory. Snow patch archaeology also forms part of a global complex of finds and sites, associated with frozen contexts such as glaciers, permafrost and alpine sites where an increasing number of prehistoric and historic sites and materials are being exposed, often as a result of rising temperatures and changing climates.

Previous snow patch research in central Norway

Chronological patterns have been an important theme for research on the material recovered from the central Norwegian snow patches. Particular attention has been paid to determining

Figure 2. Examples of different contexts from which collectors discover objects around local snow patches. Few objects have been recovered directly from the ice itself (A). Artefacts are usually found on stony surfaces close to the edges of the snow patch (B & C). Photos: (A) Rune Pedersen; (B & C) Martin Callanan.

the antiquity of recovered artefacts. By monitoring the age of the oldest finds, researchers are able to formulate and update theories regarding the chronology of the use, formation and development of snow patches in the past (Farbregd 1972, 1983, 2009; Figure 3).

Until recently it was thought from the evidence available that the dearth of finds older than AD 200 was probably due to a large-scale melting of snow patches during the warm Roman Iron Age (0–AD 400) (Fægri 1938; Farbregd 1972: 95, 1983: 33, 2009: 167). In this scenario, a complete melt-out of snow patches would have exposed artefacts older than AD 200 to the elements, causing them to deteriorate and disappear. However, developments since 2001 make it necessary to revisit this issue. Since then, the assemblage of material from the region's snow patches has increased by 183 per cent as new finds have been recovered (Callanan 2012: 186–87). Further, in 2006, adhesive on a slate point discovered close to a snow patch was ^{14}C-dated to 2480–2340 cal BC and an atypical wooden arrow shaft was also dated to 1740–1600 cal BC (Åstveit 2007: 15–17). In short, we now have a much larger snow patch assemblage available for analysis and there are indications that local snow patches contain artefacts considerably older than the proposed AD 200 boundary. Previous questions hence arise anew. What is the age of the oldest material now appearing at local snow patches? Are the few old finds recovered hitherto simply the result of fortuitous preservation? Or have older finds continued to appear at the snow patches in recent times (Åstveit 2007: 20; Farbregd 2009: 167)? The aim of the research reported here was to

Figure 3. Snow patches melt and reduce in size during the summer. Once dirty surfaces with ice begin to appear, the possibility of finding ancient artefacts increases. A) Løpesfonna seen from the east, 20 August 2010. B) Storbreen seen from the east, 1 September 2008 (photos: Martin Callanan).

analyse systematically and date a selection of recent snow patch finds in order to gain a clearer view of the chronological developments currently taking place at local snow patches.

Method

Snow patches follow a natural annual cycle of growth during the winter months and decline during the summer. Recent investigations with ground penetrating radar (GPR) demonstrate the internal structure of snow patches consisting of a layer of recent snow superimposed on a core of ice (Callanan & Barton 2010). Geomorphic features registered around snow patches show that their size and extent fluctuated during the Holocene. But hunting probably took place on individual snow patches that were similar to those found in the landscape today, even during the coldest periods. Artefacts initially lost in the surface snow layer have probably, over time, become integrated within the ice core. They are subsequently released as the surface snow melts and the ice core reduces in size under warm and unstable weather conditions (Figure 4).

Artefacts are normally recovered from the edges of alpine snow patches towards the end of the summer, when the previous year's snow has melted sufficiently. Objects are often found lying on rocks and gravels surrounding the melting snow patch.

Following conservation, the artefacts were analysed with a particular focus on typological and morphological features. Farbregd has previously shown that certain arrow shaft elements are prone to change through time and are therefore typologically significant. These are the nock and hafting ends, as well as the length and width of the arrow shaft itself (Farbregd 2009: 161–63). Until 2006 the vast majority of the collection in Trondheim was dated

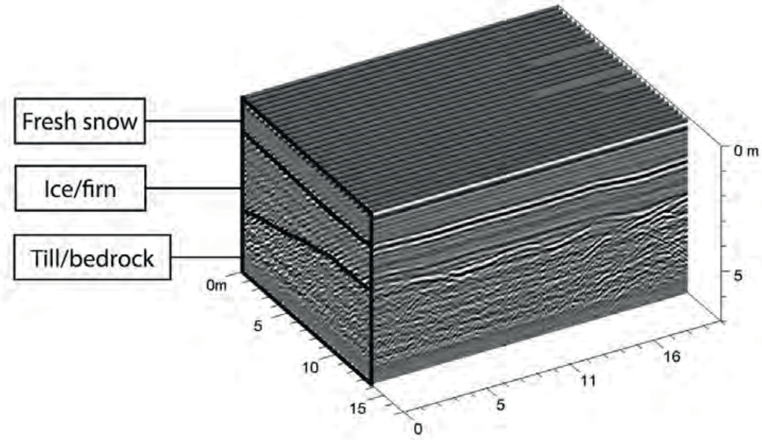

Figure 4. Ground penetrating radar profile generated in 2008 from the northern end of Storbreen, Oppdal, showing the internal structure of a snow patch. In this profile, recent snow has formed a layer over the core of ice, where ancient objects are probably situated. In years of advanced melting, the upper snow layer melts and the core becomes exposed. Under these conditions ancient objects can be found, often at the foot of the snow patch.

typologically to the Iron Age and medieval periods (*c.* 500 BC–AD 1500). For the present study, a selection of recent finds displaying nock ends, hafting ends or metric dimensions unlike examples previously analysed were submitted for radiometric dating. The following is a description of the Neolithic finds identified using this approach.

Results

Artefact A (T25675) (Tables 1 & 2; Figure 5) is an almost complete arrow shaft that is dated to between 3628 and 3371 cal BC. The shaft, identified as *Pinus,* is preserved as six contiguous fragments giving a total length of 420mm. The hafting split is V-shaped. With an internal width of 1–3mm, it was probably intended for a tanged point of bone, antler or lithic material. The nock end is missing, but the imprint of lashings is clearly visible between 25 and 35mm from the extant proximal end. (In the descriptions that follow, the nock end, closest to the archer when being fired, will be described as the 'proximal' end and the tip will be described as the 'distal' end.) A red-brown colouring can also be seen on the proximal end. This coloured area continues for some 150mm along either side of the shaft in two uniform 2–3mm-wide lines. The coloured material has not been identified but is probably decoration.

A volunteer collector recovered fragments of the shaft on two separate occasions from the southern end of Storbreen, Oppdal. During the first survey, four fragments were recovered at the foot of the snow patch. On a later visit, two more fragments were recovered on the surface of the snow patch itself, only 8m from the initial find. The six fragments were subsequently refitted during conservation. The manner in which the fragments were recovered, together

Table 1. Radiocarbon determinations of Neolithic artefacts presented in this paper.

Artefact ID	Museum no.	Snowpatch	Type	Lab no.	Radiocarbon age ^{14}C yr BP	1σ	2σ	Median cal.	^{13}C
A	T25675	Storbreen	arrowshaft	Beta-308922	4690±30	3519–3376 BC	3628–3371 BC	3447 BC	−23.5
B	T25674	Storbreen	arrowshaft	Beta-308921	4650±30	3499–3368 BC	3518–3362 BC	3456 BC	−25.4
C	T25676	Storbreen	arrowshaft	Beta-308923	4530±30	3356–3118 BC	3361–3102 BC	3206 BC	−23.8
D	T25170	Storbreen	arrowshaft	TRa-2770	3670±30	2132–1980 BC	2139–1956 BC	2056 BC	−30.2
E	T25287	Løpesfonna	arrowshaft	TRa-2771	3445±35	1871–1691 BC	1883–1682 BC	1759 BC	−27.5
F	T25677	Storbreen	bow frag.	Beta-308924	3490±30	1878–1770 BC	1894–1700 BC	1816 BC	−23.7

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Figure 5. Artefact A (T25675): an almost complete arrowshaft of Pinus *discovered at Storbreen on 28 August & 13 September 2011, dated to between 3628 and 3371 cal BC. Pigment traces and lashing imprints are clearly visible on the proximal end of the shaft (photo: Åge Hojem/NTNU Museum of Natural History and Archaeology; layout: Martin Callanan).*

Table 2. Technical data on the five arrow shafts and bow limb presented in this paper. The diameter of each arrow is measured at 50mm intervals along the shaft, starting from the proximal end.

Museum ID	Wood type	No. of frags.	Description
T25675	*Pinus*	6	Distal + 5 medial. Contiguous.
0mm/break	6mm	**250mm**	7mm
50mm	6mm	**300mm**	6mm
100mm	7mm	**350mm**	6mm
150mm	7mm	**400mm**	5mm
200mm	7mm	**420mm/haft**	4mm

Museum ID	Wood type	No. of frags.	Description
T25674	*Salix*	3	Proximal, medial and distal. Discontiguous.
0mm/break?	5mm	**350mm**	7mm
50mm	5mm	**372mm/break**	7mm
100mm	6mm	**0mm**	6mm
150mm	6mm	**50mm**	5mm
200mm	6mm	**100mm**	5mm
250mm	7mm	**137mm/haft**	3mm
300mm	6mm	**Point weight**	2.4g

Museum ID	Wood type	No. of frags.	Description
T25676	*Pinus*	1	Distal
0mm	7mm		
50mm	6mm		
70mm/haft	6mm	**Point weight**	13.8g

Museum ID	Wood type	No. of frags.	Description
T25170	*Betula*	1	Medial
0mm/break	3.5mm	**250mm**	5mm
50mm	5mm	**300mm**	5mm
100mm	6mm	**350mm**	4mm
150mm	5mm	**394mm**	4mm
200mm	6mm		

Museum ID	Wood type	No. of frags.	Description
T25677	*Ulmus*	6 + (4)	Bow limb and frags, leather strips
mm	**Location**	**Width**	**Breadth**
20mm	nock	9mm	15mm
50mm		14mm	15mm
100mm		15mm	14mm
150mm	frag. in place	14mm	16mm
200mm	frag. in place	16mm	17mm
250mm	frag. in place	16mm	17mm
290mm	frag. in place	18mm	19mm
300mm	damaged	–	-
310mm		16mm	22mm
350mm	frag. missing	11mm	29mm
385mm	break	–	-

Museum ID	Wood type	No. of frags.	Description
T25287	*Betula*	2	Whole shaft
0mm	5mm	**450mm**	8mm
50mm	5mm	**500mm**	8mm
100mm	6mm	**550mm**	8mm
150mm	7mm	**600mm**	8mm
200mm	7mm	**650mm**	7mm
250mm	8mm	**700mm**	7mm
300mm	8mm	**750mm**	6mm
350mm	8mm	**794mm/haft**	0mm
400mm	8mm		

with the clean, almost fresh nature of the breaks, appears to indicate that the shaft was released from the snow patch only recently.

Artefact B (T25674) (Tables 1 & 2; Figure 6) consists of a fragmented arrowshaft of *Salix,* with a small slate point, found together at the southern end of Storbreen, Oppdal. A sample from the shaft was dated to 3518–3362 cal BC. The shaft was recovered in three fragments, of which two are contiguous to a length of 372mm. The third fragment is 137mm long, but could not be definitively conjoined with the rest of the shaft, giving the shaft a minimum length of 509mm. The proximal end of the shaft is straight and ends in a wide, V-formed nock. Remains of a black adhesive associated with the spiral imprint of sinew lashings are clearly visible along the proximal end to a length of 105mm. Distinct markings are visible around 60mm from the proximal end, each consisting of three clear indentations, evenly distributed around the shaft at approximately 120° intervals. There are two sets of indentations close to one another. These are probably production marks, as they were covered by adhesive, sinew and vanes once the arrow was completed. Markings of this kind have not previously been observed on other shafts in the snow patch collection. However, similar markings are visible on other later finds, for example at the Nydam bog site in southern Denmark (Engelhardt 1865: pl. XIII).

At the distal end, the shaft narrows slightly to a rounded hafting split that measures 1–2mm internally. Here too, lashing imprints and faint remains of black adhesive can clearly be seen, concentrated in a 5mm wide area at the base of the split. In all respects, this shaft is a particularly well-fashioned and finished piece.

A small stone point was found together with the shaft. It is in a green-grey slate with red inclusions and has parallel to converging edges with a straight base and flat tang. The point is 65mm long and 9mm broad at the base of the blade.

Artefact C (T25676) (Tables 1 & 2; Figure 7) consists of a slate point together with a 70mm-long shaft fragment of *Pinus* from Storbreen, Oppdal. Also preserved is the adhesive used to join the point and shaft. The grey slate point is 105mm long and 19mm wide at the base and is slightly asymmetrical, possibly as a result of re-sharpening. The V-formed hafting split is around 22mm deep and between 1 and 7mm wide. From the features preserved, we can see that both the tang and shaft have been covered with adhesive before hafting. Moreover, the adhesive imprints show that the joint was subsequently strengthened by lashings that covered both shaft end and slate tang. A sample taken from the shaft was dated to between 3361 and 3102 cal BC. Although slate points are a common feature of the Neolithic of northern Scandinavia, this is a rare example of a hafted slate point.

Artefact D (T25170) (Tables 1 & 2; Figure 2c) consists of an incomplete shaft in two fragments, preserved to a total length of 420mm. Neither the haft nor the notch is preserved. The shaft was discovered on gravels below the center of Storbreen, Oppdal, and is dated to between 2139 and 1956 cal BC. The arrow is formed from a narrow sapling of *Betula*. This is only the second prehistoric arrow in the collection that was produced from a sapling, the other example being dated to the Bronze Age (Åstveit 2007: 15–17). This contrasts with the extensive use of shafts fashioned from staves split from solid tree trunks during the Iron Age and medieval period.

Artefact E (T25287) (Tables 1 & 2; Figures 2a & 8) from Løpesfonna, Oppdal, is one of the few artefacts recovered directly from within a snow patch. The arrow consists of a shaft of *Betula* preserved to a length of 794mm, with two small rings of sinew thread still attached. Lashing imprints are visible over *c.* 300mm adjacent to the split at one end. The split is 8mm deep × 4mm at its widest and has subsequently cracked along the arrow shaft. The other end is pointed and slightly askew. The shaft has been dated to between 1883 and 1682 BC and as such represents an arrow from a transitional phase between the local Neolithic and Bronze Age.

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Figure 6. Artefact B (T25674): arrowshaft of Salix *with accompanying slate point found on 28 August 2011 at Storbreen, dated to between 3518 and 3362 cal BC (photo: Åge Hojem/NTNU Museum of Natural History and Archaeology; layout: Martin Callanan).*

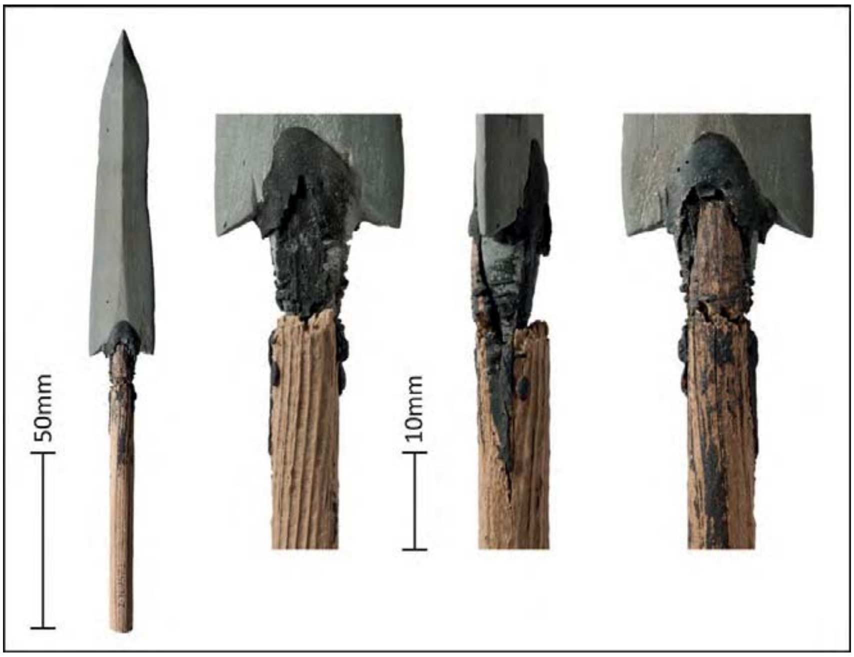

Figure 7. Artefact C (T25676): detail of a slate point hafted on a shaft fragment of Pinus *discovered on 29 August 2011 at Storbreen, dated to between 3361 and 3102 cal BC (photo: Åge Hojem/NTNU Museum of Natural History and Archaeology; layout: Martin Callanan).*

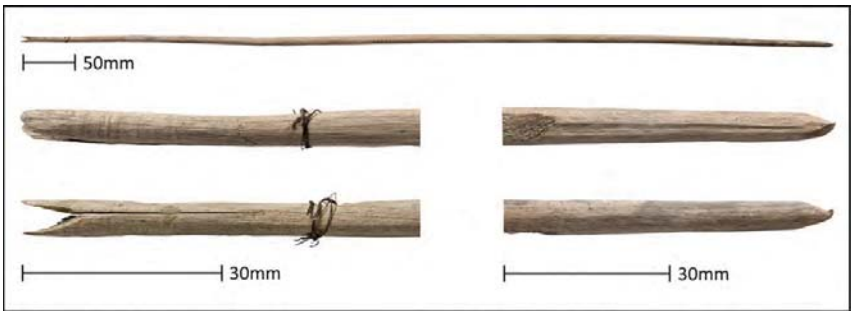

Figure 8. Artefact E (T25287): discovered at Løpesfonna on 21 August 2010, this complete shaft of Betula *is dated to between 1883 and 1682 cal BC (photo: Åge Hojem/NTNU Museum of Natural History and Archaeology; layout: Martin Callanan).*

This arrow is something of a conundrum as it is impossible to identify positively the function of the preserved split. This may be a self-pointed arrow (e.g. Waguespack *et al.* 2009), in which case the split would represent the proximal end. That seems unlikely, however, given the crude nature of the split, since nock ends are usually particularly well finished. Alternatively, we might interpret the split as the distal end. However, this would imply that the arrow, if used in its current form, had a pointed proximal end. Again this seems unlikely as it would have damaged the valuable bow-string. Perhaps some nock component such as a bone or antler blunt, used to hunt birds or furred animals, is missing from the distal end? The arrow might also be an anomaly. Perhaps, for example, a hunter was forced to improvise and use an unfinished arrow such as those found with the Neolithic Iceman at Similaun in the Tyrolean Alps or more recently at Schnidejoch, in the Bernese Alps (Egg 1992; Suter *et al.* 2005).

Artefact F (T25677) (Tables 1 & 2; Figure 9) is a bow fragment that was discovered lying exposed on stones and gravels by the upper edge of Storbreen, Oppdal. The find consists of a 385mm-long bow limb that begins with a well-formed plano-convex to oval nock, continuing to a *c.* 14–15mm rounded square section before widening out to a width of around 38mm at the break. Also recovered were four 2–4mm-wide hide lashings, found in direct association with the bow limb. Context photographs and imprints on the bow show that the lashings were attached to the limb between 255mm and 292mm from the nock end and may have formed a contiguous band. Given the short length and form of the extant limb, the lashings probably functioned as reinforcement. No other imprints have been located along the limb.

The bow is made from *Ulmus,* a raw material often chosen by northern bow makers in the past (Clark 1963: 51; Bergman 1993: 101; Junkmanns 2010). The site at Storbreen lies within the current northern border of European elm distribution, where the local upper limit is around 500m asl (Nedkvitne & Gjerdåker 1995: 18, 28). *Ulmus* appears in a mountain pollen diagram at Ølstadsetri (820m asl), some 25km to the south of the snow patch at Storbreen, at around 6000 BC, but the levels decline again as the post-glacial climatic optimum draws to a close around 5000 BC (Gunnarsdóttir & Høeg 2000: 39). The bow must therefore be of lowland origin.

Discussion: Neolithic archery

Slate points are signature artefacts of the Neolithic period in Scandinavia and are found throughout the region. The bow and arrows reported here span the whole period and were lost or discarded by groups or individuals on hunting expeditions. These early snow patch hunters probably originated from small, semi-sedentary, hunter-fisher communities based either in coastal areas to the west or further inland to the north or south (Alsaker 2005; Olsen 2009). Indicators of animal husbandry and cereal cultivation are clearly present in the region from around 2500 BC (Hjelle *et al.* 2006). However, the use of inland and mountain resources, a recurring feature of prehistory in western Norway, remained an important part of the economy throughout the Neolithic and subsequent periods.

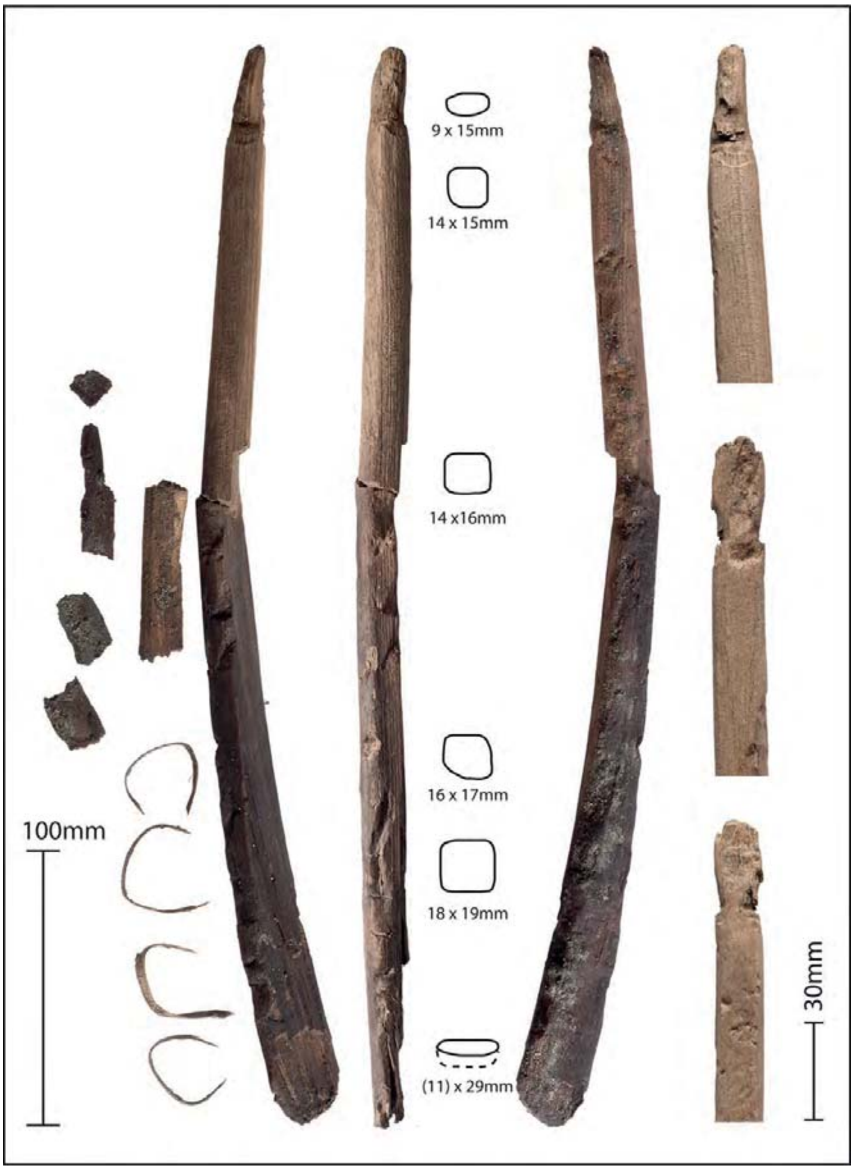

Figure 9. Artefact F (T25677): Neolithic bow limb from Storbreen (photo: Ole Bjørn Pedersen/NTNU Museum of Natural History and Archaeology; layout: Martin Callanan).

These finds from melting snow patches in central Norway offer, for the first time, insights into the organic component of Neolithic bow and arrow technology in central Scandinavia. In the following, these discoveries are discussed in relation to other European finds that are relevant from a morphological or typological perspective.

In Europe, between 140 and 150 Neolithic bow finds are known, a large proportion of them coming from lacustrine settlement sites in central Europe. In a recent analysis, Junkmanns (2010) organised these bows into two main groups based on their morphology. Bows in the propeller group (e.g. Rotten Bottom, southern Scotland, and Meare Heath, southern England) have broad, flat limbs with a narrowing at the grip. Bows in the staff group (e.g. Similaun, Ashcott Heath) are more regular along the length of the bow (Junkmanns 2010: 55–65). The Storbreen bow belongs to the staff group. Viewed diachronically, the preserved nock end closely resembles Bow 2 from Agerød V, southern Sweden, dated to *c.* 5500 cal BC (Larsson 1983). The oval/square section is reminiscent of Bow 1 from La Draga in northern Spain that is dated to between 5440 and 5045 cal BC (Junkmanns 2010: 61). These few scattered parallels indicate that the Storbreen bow was anchored within a broader European technical template. Locally, there are few bow finds to which the Storbreen bow can be compared. A complete, 1.31m-long bow, dated to *c.* 1300 cal BC, was recently discovered at Lendbreen, Oppland (Mímisbrunnr n.d.). The Lendbreen bow also belongs to the staff group, but has a triangular profile, similar to the older bow from Koldingen, northern Germany (Beckhoff 1977; Junkmanns 2010: 490–93). A few bow fragments have been found at local snow patches through the years, but these belong to later periods and a different, laminated bow tradition (Farbregd 2009: 162–65, fig. 10).

As regards the Neolithic arrows, the degree of variability demonstrated by the finds is striking. There is considerable variation in the choice of shaft wood as well as in the size and morphology of shafts and points. However the sample of Neolithic finds recovered from snow patches is very small when compared with the 1600-year time period they span. The variability might be the first emerging sign of older archery traditions in the region. On the other hand, it might be the result of a production mode based on individual manufacture and technological choices.

It is interesting to compare the length of the Neolithic arrow shafts with the few Mesolithic shafts found in Europe. As a group, Mesolithic shafts are rather long, varying between *c.* 650mm and 1200mm in length (e.g. Junkmanns 2010: 54). Arrows of this period were probably hafted with small, light points of flint or similar lithic materials.

The Neolithic shafts presented here appear shorter than their Mesolithic counterparts. The incomplete shaft A which was probably tipped with a stone point is at present 420mm long. From vane lengths measured on later Iron Age arrows, the missing proximal fragment was probably no longer than 100–200mm (see Farbregd 2009: 163). This brings the total length of shaft A to between 500 and 600mm. The same is also true of shaft B, to which a small 2.4g slate point was hafted. The shaft has a complicated medial fracture, but the whole shaft has been recovered and its total length comes to 510mm.

Shaft E is the only complete shaft recovered in this group and with a total length of 794mm is within the Mesolithic range quoted above. There are, however, considerable problems in interpreting this shaft. Furthermore, it is dated to the Neolithic–Bronze Age transition, a period when the use of slate projectiles had ceased, to be replaced by either bifacial stone or antler and bone points. In conclusion, this shaft is probably not typical of Neolithic shafts, especially those used in conjunction with slate projectiles.

One of the characteristic traits of slate point technology is the large variation in both morphology and size of the point. The four slate points found at snow patch sites in central Norway, for example, weigh 2.4g, 7g, 10.5g and 13.8g (Åstveit 2007; Table 2). Slate points are generally larger and heavier than the lithic points used earlier, such as microliths, tanged points and transverse points. As the total weight (point plus shaft) is one of the technical parameters important for a well-functioning arrow, the Neolithic bowyer probably had to take varying slate point weights into account when fashioning individual shafts (Kooi 1983: 28, 164–65). Seen in this light, one might suggest that the Neolithic shafts were shorter in order to compensate for the heavy weight of the slate points. Of course the weight of the bow would also be an important variable in the total equation, but for the time being we are limited to posing hypotheses based solely on the arrows. Should this hypothesis prove correct, however, the same technical dynamic may also be visible in other arrow configurations. We might expect, for instance, that lighter arrowheads of antler and bone were fitted to relatively long shafts in order to increase the total weight. As yet, however, the sample of Neolithic arrows is very small and these questions have to remain open. But if current trends at local snow patches continue, we can expect more clarity on this and related issues in the near future.

Melting snow patches

In recent years we have seen repeated instances of advanced melting at local sites. This has led to a number of record-breaking seasons with increasingly large numbers of finds being recovered on classic sites. Many finds have been also been discovered at new sites in new areas (Callanan 2012). Since snow patches are natural, dynamic formations, it is logical to view these developments in the light of ongoing weather and climate processes. The message from the foregoing is thus unequivocal: something is afoot in the mountains of central Norway. Ancient alpine ice is melting and yielding large numbers of organic artefacts. And the number and antiquity of some of these artefacts is unprecedented in the almost century-long history of snow patch surveying in the region.

These discoveries can also be viewed alongside the results of studies from other disciplines in the same region. Those studies map recent developments in the natural environment which, like the ablating snow patches, are presumed to be linked to unstable or extreme weather conditions and rising temperatures. Recent investigations at Snøhetta, close to Storbreen, have shown that alpine permafrost is retreating and becoming shallower (Isaksen *et al.* 2007). Other research maps early evidence for altitudinal creep in sub-alpine and alpine flora, as lower-lying plants begin to appear at increasingly high altitudes (Michelsen *et al.* 2011). Local fauna are also being affected, as can be seen by a recent outbreak of deadly pneumonia in the local musk ox herd during a particularly warm and humid summer (Ytrehus *et al.* 2008). Taken together, these studies paint a troubling picture of the episodic and systemic changes currently taking place in the sub-alpine and alpine environments of central Norway.

The relationship between current climate change and archaeology in its various intellectual, ethical and practical aspects is a theme that has been the focus of a number of recent contributions (e.g. Mitchell 2008; Brook 2009; Rowland 2010). Snow patch archaeology is situated at the frontline of this issue. As new objects continue to appear at melting snow patches, all efforts are focused on recovering as much as possible. Not only the finds but their contexts too are important as fragile sources of information that are disappearing before us. This is a demanding rescue mode that requires both being in the right place at the right time and asking the right questions before it is too late. The institutional challenge is to provide the reliable funding and flexible routines that permit effective field responses in the face of changing conditions.

For local collectors and snow patch archaeologists and managers, climate change has an immediacy of its own. On the one hand, there is the possibility of recovering unique ancient objects that will occupy and inform us for many years to come. At the same time, as the climate continues to heat up and the snows melt away, one wonders what long-term price there will be to pay for these precious glimpses of the frozen past.

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