

Bronze Age Arrows from Norwegian Alpine Snow Patches

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The number of archaeological finds recovered from alpine snow patches in central Norway has increased dramatically during the last decade. In this article, eight Bronze Age (1800–500 B.C.) arrows are presented in detail. The arrows are of great interest to our understanding of Bronze Age archery in general. The finds include two arrows with projectiles made from the freshwater mussel *Margaritifera margaritifera*, as well as two reindeer antler arrows. These finds are further evidence of the fact that artifacts emerging from melting snow patches in central Norway are getting steadily older. Some contextual observations specific to snow patch sites in a reduced state due to extreme melting are also highlighted.

Introduction

Alpine snow patches in central Norway have produced large numbers of archaeological finds over many years (e.g. Farbrege 2009 and Callanan 2012). 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 recovered in relatively good condition. Well-preserved snow patch artifacts 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.

Keywords: Snow patch archaeology, bow and arrow, Reindeer, Hunting, Norway, Bronze Age

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 2012, 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 artifacts on sites where objects were lost

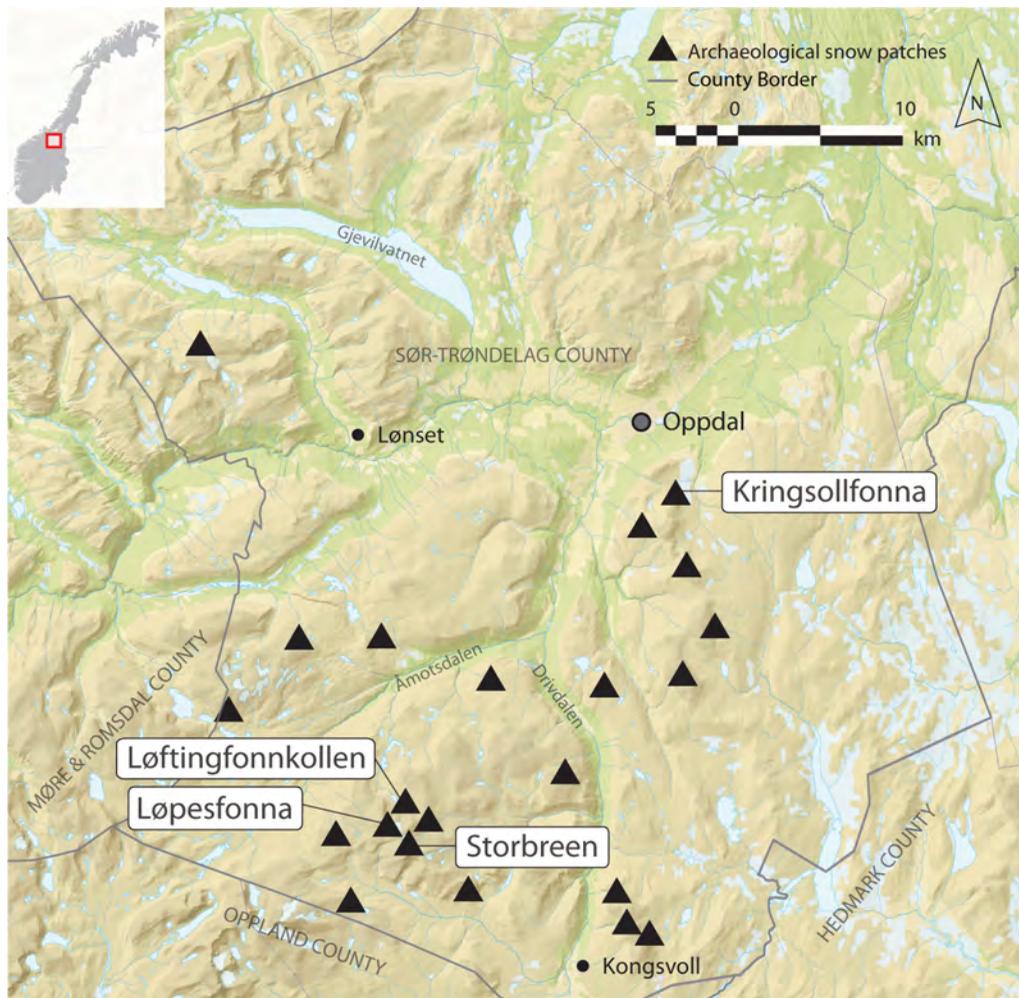


Figure 1 Overview of snow patches sites with archaeological finds in central Norway. Sites mentioned in the text are labeled.

or discarded during late summer hunting events.

Archaeological artifacts emerge from alpine snow patches under special conditions. Ancient arrows and bows can usually only be recovered from around 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 2012, 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 artifacts have been recovered from 28 different sites in the region (Figure 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. AD 200–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, the number of finds recovered from local snow patches has increased and several new sites have been discovered. (Callanan 2012, 185–186). These new discoveries raise new questions and perspectives. For example, in 2007 it was shown that at least three of the new artifacts were significantly older than the Iron Age (Åstveit 2007). Among the artifacts 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 artifacts 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 artifacts were among the material coming from snow patches. To this end, all recent shaft and points were carefully examined and analysed in terms of their metric and morphological traits. A selection of artifacts 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 artifacts from snow patches (e.g. Callanan 2013). The Bronze Age artifacts presented in detail in this article 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	<i>Betula</i>	2010	Beta-319547	3370±30 BP	1745-1538BC	-25.1	
T23069	Kringsøllfonna	arrow shaft fragment	<i>Corylus</i>	2004	TUa 5293	3365±45 BP	1753-1526BC	-27.0	Previously published in Astveit 2007.
T25684	Løpesfonna	shell point & shaft fragments	<i>Betula</i>	2011	Beta-308925	3340±30 BP	1728-1529BC	-25.5	
T23411	Storbreen	arrow shaft fragments	<i>Betula</i>	2006	TRa-1049	3295±30 BP	1663-1499BC	-24.1	
T24981 & T25284	Storbreen	arrow shaft fragments	<i>Betula</i>	2009	TRa- 1048	3290±35 BP	1669-1494BC	-26.7	
T24138	Løftingfonnkollen	arrow shaft fragments	<i>Betula</i>	2008	TRa-1047	3275±30 BP	1626-1461BC	-28.4	
T25167	Storbreen	antler point & shaft fragments	<i>Betula</i>	2010	TRa- 2767	3030±30 BP	1396-1135BC	-27.3	
T24367 & T24982	Løpesfonna	antler point & arrow shaft	<i>Betula</i>	2008	TRa- 1050	2935±30 BP	1261-1041BC	-24.3	
T16056	Frøya (Non-snow patch)	flint point & shaft fragment	<i>Pinus</i>	1941?	TRa 2766	2710±40 BP	968-801BC	-26.1	Non-snow patch find. Dated as reference.
T25286.1	Løpesfonna	arrow shaft fragments	<i>Betula</i>	2010	TRa-2768	2455±30 BP	754-412BC	-25.4	
T25286.2	Løpesfonna	arrow shaft fragments	<i>Betula</i>	2010	TRa-2769	2350±30BP	484-386BC	-26.0	
T17698f & T17694/ T17698e	Storbreen	Bone point & shaft fragments	<i>Pinus</i>	1937	TRa-1051	1705±30BP	AD255-409	-25.0	Older snow patch find. Dated as control.

Table 1 Calibrated radiocarbon dates for the artifacts 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 artifacts are included in table 1.

Two other artifacts were also radiocarbon dated as part of this analysis. The purpose of these dates was to cross-reference the new finds 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 and T17694/T17698e) found at Storbreen in 1937. These dates are also presented in Table 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 and 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 (Figure 2). The shell points were compared to a modern study collection and have been

Bronze Age Arrows from Norwegian Alpine Snow Patches

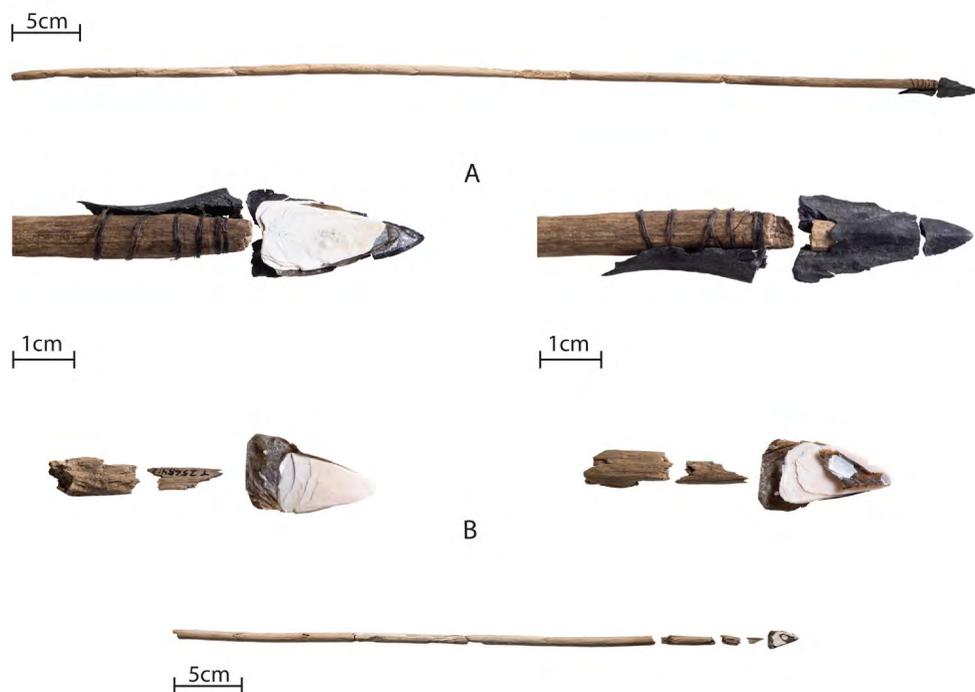


Figure 2 Arrows with shell points recovered from the Løpesfonna snow patch. (a) T25172; (b) T25684. Photo by Åge Hojem/NTNU-Museum of Natural History and Archaeology. Layout Martin Callanan.

visually identified as the freshwater pearl mussel *Margaritifera margaritifera*. In both instances, portions of the periostracum and calcareous 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 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 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 entire length of the shell point. Also preserved are several rounds of lashing of an unknown plant

material at the distal end. The imprint of lashings is also visible 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 3 is a reconstruction suggesting how the main components might have been combined to complete the shell arrow at the time of production.

The second shell arrow (T25684) was discovered in 2011, in close proximity to the pervious 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 (Figure 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 form. The width values measured on individual fragments (6.5–7mm) are all within the range of the first shell arrow (Table 2). Comparison of the two shell arrowheads shows that they differ in both size and form. This rules out any possibility that

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

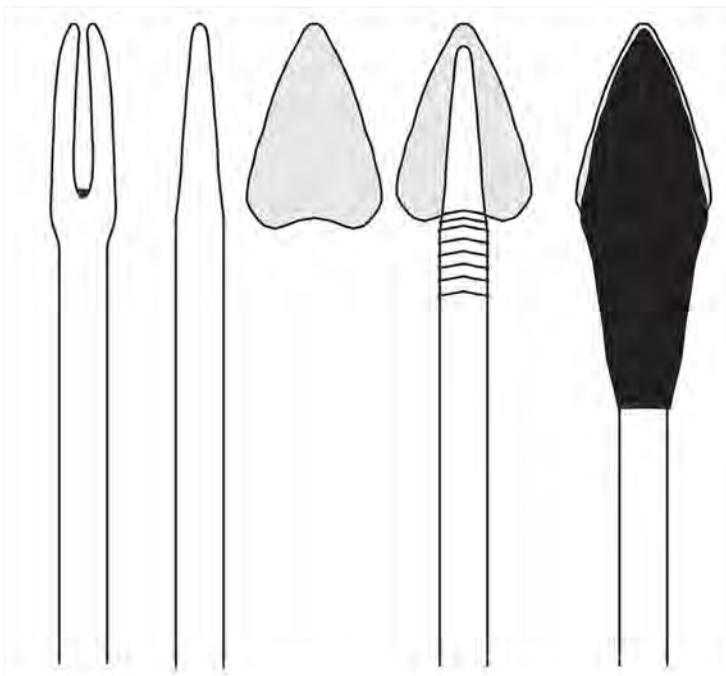


Figure 3 Suggested reconstruction of the Bronze Age shell arrows. The form and dimension of each technical element is based closely on the two arrows discovered at Løpesfonna.

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.

The radiocarbon dates returned on the samples from these two shafts are nearly identical and overlap completely at 2σ (see Table 1). When one considers the technical similarities these arrows share, 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 and 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 (Figure 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



Figure 4 Discovery of the shell arrows at Løpesfonna. (a) T25172. 21 August 2010. (b) T25684. 2 September 2011. (c) Shows the distance between both find locations. Photographs by Martin Callanan (a) and Tord Bretten (b and c).

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 its 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



Figure 5 (a) The antler point (T25167) from Storbreen. (b) Close-up comparison of the beveled ends of both point and shaft in section. Photo by Åge Hojem/NTNU-Museum of Natural History and Archaeology. Layout Martin Callanan.

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.

The second antler arrow (T24367/T24982) consists of an osseous point with a complete shaft, discovered along the lower slope of Løpesfonna, Oppdal (Figure 6). The arrow was 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,



Figure 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.

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 radiocarbon date of 1261–1041 cal. BC which corresponds to the start of the Late Bronze Age (1200–500 BC).

Plain shafts (T23411 and 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 at 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 artifact below the eastern end of the snow patch at Løftingfonnkollen.

Refitted shafts (T24981/T25284 and 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. 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 radiological dating. The date returned was 1669–1494 cal. BC, indicating that the shaft was deposited on the site during the Early Bronze Age (1800 BC–1200 BC).

In September 2010, five shaft fragments were discovered lying close together at the eastern end of the snow patch at Løpesonna. 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 of 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 radiocarbon dated. The proximal section returned a date of 754–412BC, while the distal fragments were dated

to 484–386 BC. 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 (1200 BC–500 BC) and subsequent Early Iron Age (500 BC–AD 570).

This concludes the detailed presentation of recent Bronze Age artifacts 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 artifact 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 1 and Figure 10). 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 several 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 (Figure 7).

Long armed hafts are found on both the shell points and the flint arrow from Frøya (Table 1 and 2, Figure 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 nineteenth 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. Figure 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).

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 and 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. Figure 8). The points



Figure 7 Bronze Age haft ends presented in this study. (a) T23411; (b) T24138; (c) T25167; (d) T24367. Photo by Åge Hojem/NTNU-Museum of Natural History and Archaeology. Layout Martin Callanan.

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) (Figure 7b).

At present, we have three dated examples of beveled hafts (T25167, T24367/T24982 and 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 (Figure 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 and Figure 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).

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 and 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?



Figure 8 Bronze Age nock ends. (a) T24367. (b) T25286.1. Photo: Åge Hojem/NTNU-Museum of Natural History and Archaeology. Layout Martin Callanan.



Figure 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 by Per Fredriksen/NTNU-Museum of Natural History and Archaeology. Layout Martin Callanan.

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 and 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. Figure 6) or where remnants of the black material are still present (Figure 2a and 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) (Figure 2a). Here an elongated wing of adhesive runs along the haft and shaft probably to stabilize the flat or round based point (e.g. Figure 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 Fivavé-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 coastal 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 and 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 calcareous 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 be 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 artifacts 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 recognise 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 projectile 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 (Figures 5 and 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 and 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 1925). 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 1930s (Farbregd 1972, 118–119, pl. 1 nos. 1 and 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 1930s 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 AD 255–409 (see Table 1). Analysis of the point shows it to have been made from reindeer bone. The radiological 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. 45km 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 were 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 find a 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 2000 cal BC (Gunnarsdóttir and 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 produc-



Figure 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 by Åge Hojem/NTNU-Museum of Natural History and Archaeology. Layout Martin Callanan.

tion 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 artifacts from central Norway dated to the Bronze Age. Eight arrow shafts are 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 shafts and to the projectile raw materials utilised. 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.

Other general snow patch issues

We now turn our attention to the contextual conditions surrounding some of the Bronze Age artifacts 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

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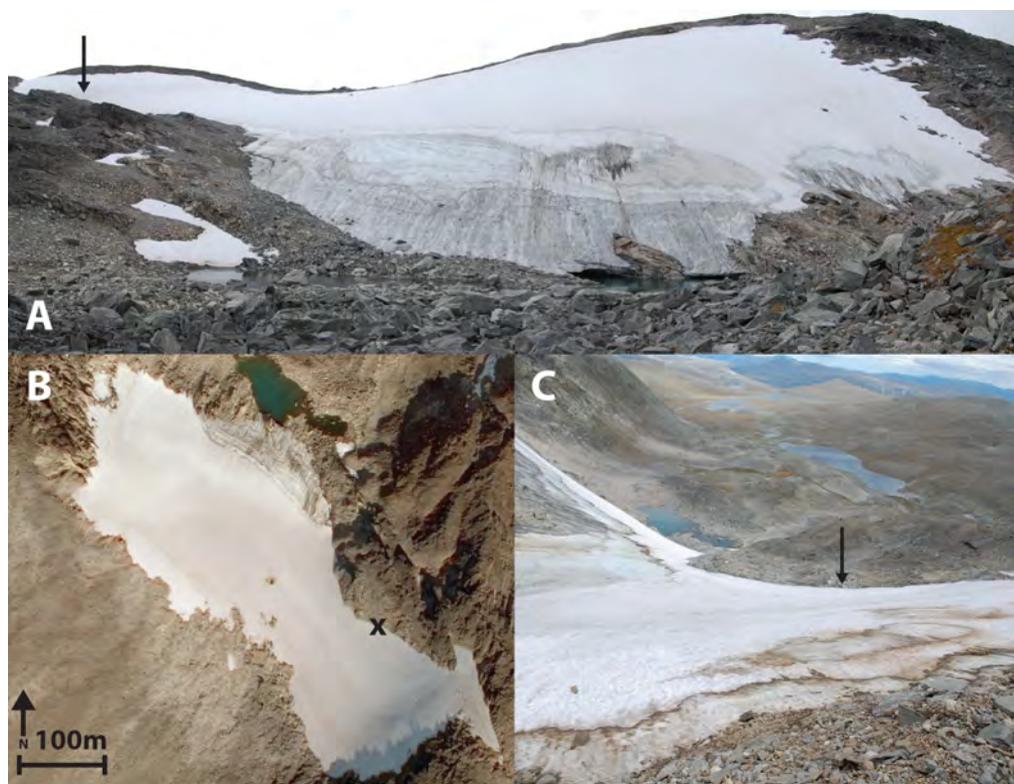


Figure 11 The snow patch at Løftingsfonnkollen on (a) 14 September 2008. (b) 17 September 2008. (c) 21 August 2010. The find location of the Bronze Age shaft (T24138) is marked. Photo by Geovekst, Statens kartverk, Norkart AS (b) and Martin Callanan (a and c).

arrowhead typologically dated to between AD600–800 was discovered below the patch at some date prior to the 1950s (Farbregd 1972, 125). Nevertheless it was considered unlikely that this snow patch would produce organic artifacts. 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 artifacts the patch might contain. It was therefore a surprise when in 2008 a local collector recovered two wooden artifacts 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 artifact preservation. Løftingsfonnkollen is a case in point. Aside from the steep, active main body, 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 artifacts 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 relatively 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 artifact preservation at the macro-level, small differences in the surrounding topography have created favorable micro-level circumstances from which well-preserved organic artifacts 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 artifact 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 artifact 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. Farbregeid 2009, fig. 1). These are the last remains of the patches' ice cores that once covered much larger areas. Two of the finds (T25167 and 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 e.g. 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 artifacts. 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 artifacts 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 artifacts 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 artifacts 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 artifacts have slowly decreased in size. This is especially obvious in relation to shaft diameters on some of the artifacts 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 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 artifacts. If there is a suspicion that individual artifacts have changed significantly following discovery, it is important that these are instances are flagged or excluded as has been done here (Table 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 artifacts as minimum values in terms of past archery technological parameters.

Conclusion

The eight archery related artifacts 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 appear are getting successively older. Several of the sites that have produced Bronze Age and Neolithic artifacts, 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.

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