

Glacier Archaeology Program in Innlandet

Secrets of The Ice



Innhold

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Front page: An intact 1500-year-old arrow that melted out of the ice in the Jotunheimen mountains.
Photo: Andreas Nilsson, Innlandet County Municipality.
Lay-out: Department of graphic design, Innlandet County Municipality.

Introduction

Objects from the past have been preserved in the ice for thousands of years, like artefacts in a giant prehistoric freezer. Climate change is having a profound impact, which is also evident in Norway's high mountains. Ancient finds emerging from the ice have become striking symbols of these changes.

Norway's Innlandet County is the global epicentre of glacial archaeology, with more than half of all finds from glacial ice discovered here. Climate researchers predict that by the end of this century, 90% of Norway's ice will have melted. This is challenging to grasp and serves as a powerful reminder of the urgent need to mitigate global warming and adapt to its effects.

In this booklet, you can learn about our work, our discoveries, how we secure the finds, our exciting results, and our engagement with the public.

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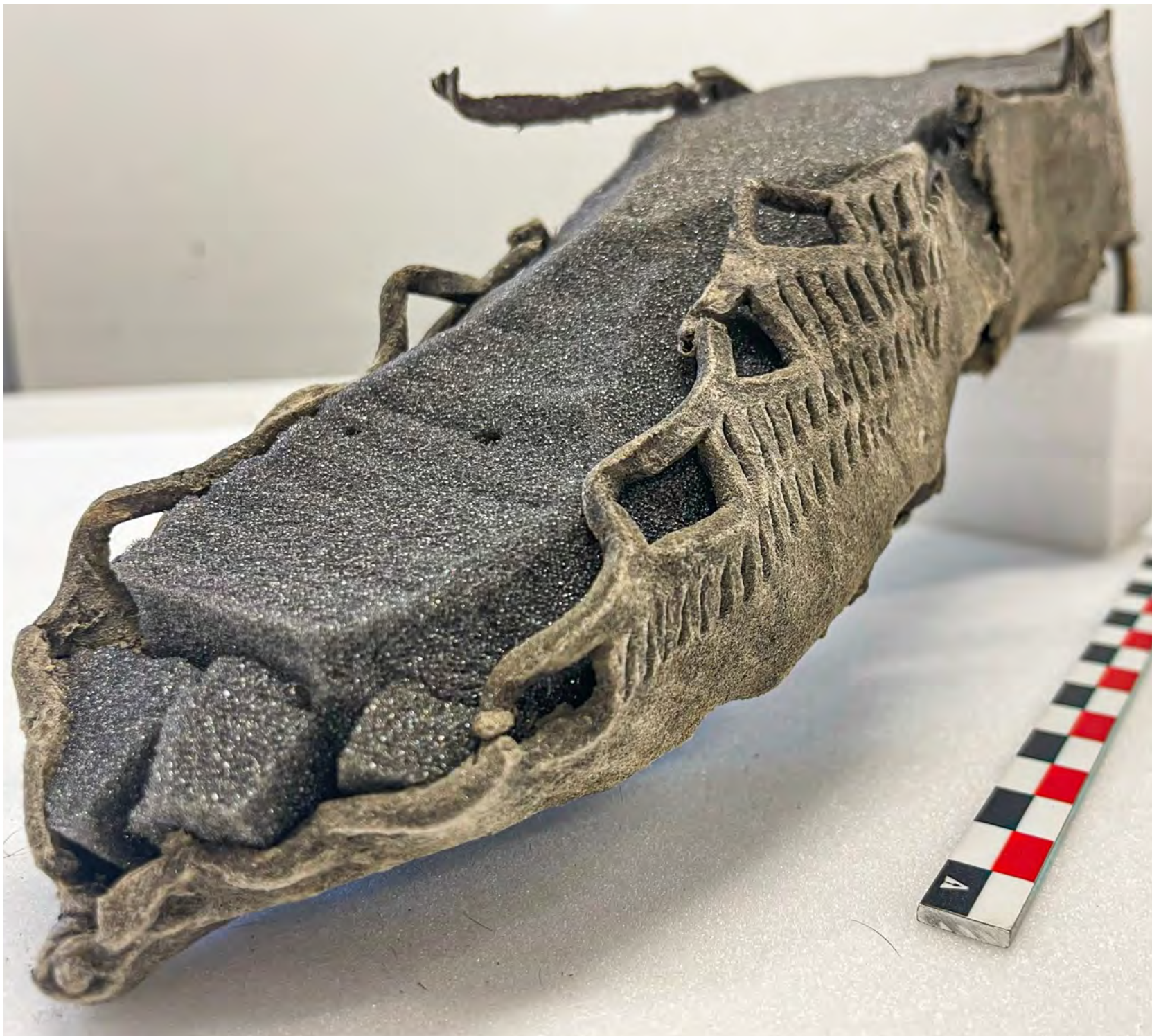
Unique finds from the Innlandet Ice

Archaeological treasures are melting out of the ice in the high mountains of Innlandet County, Norway, revealing unique and well-preserved artefacts, such as:

- The oldest shoe of Norway, 3,300 years old
- The oldest bow of Norway, 4,000 years old
- The oldest clothing of Norway: The Lendbreen tunic, 1,700 years old
- The best preserved prehistoric ski pair in the world, 1,300 years old
- A horse snowshoe, 1,800 years old
- A shoe with a design inspired by fashion in the Roman Empire, 1,700 years
- More than 200 arrows, with the earliest dating back 6,000 years
- A dog with collar and leash, 500 years old



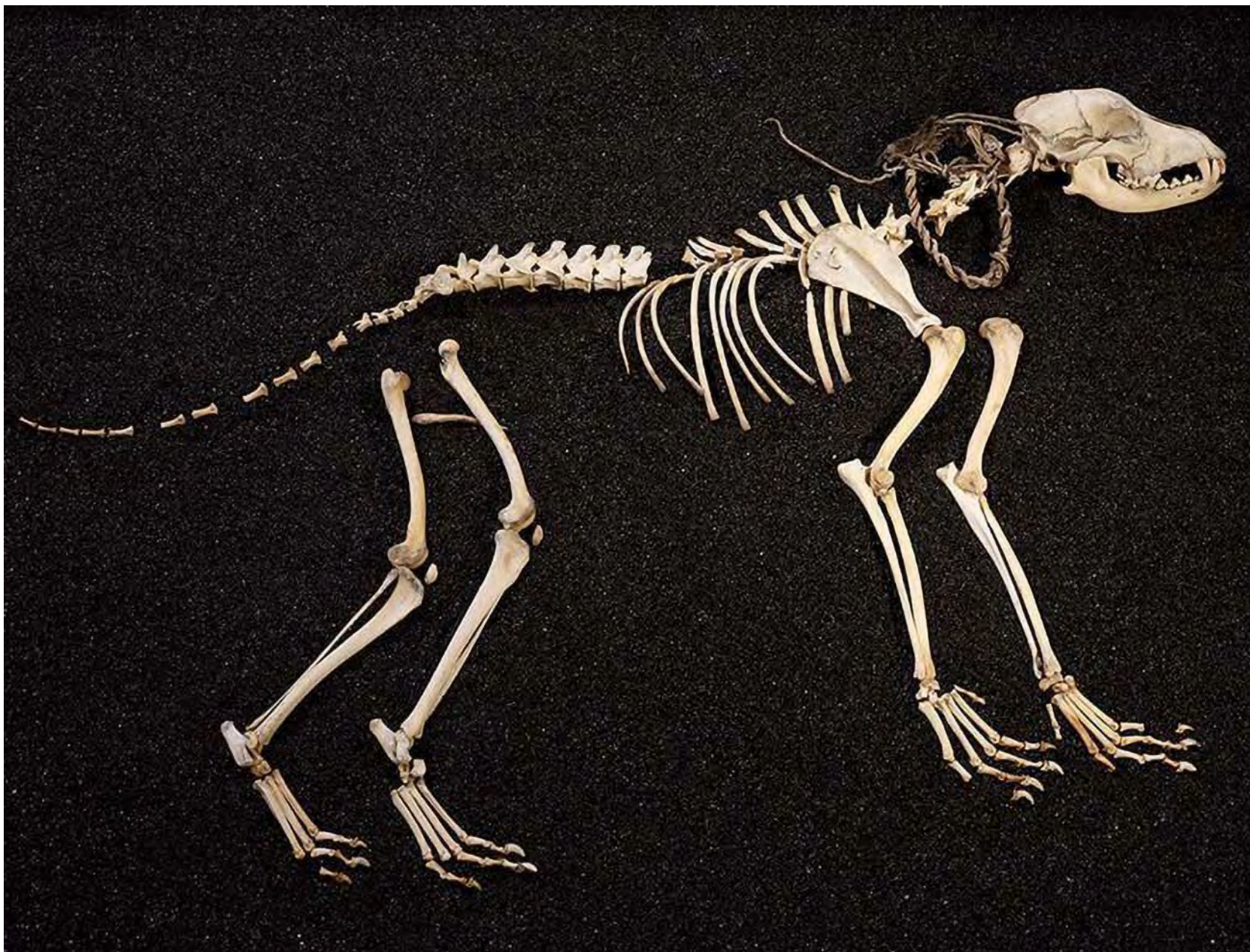
A 1,300-year-old ski melted out of the ice in Reinheimen National Park in 2021, only 5 metres from where a similar ski was found in 2014. The skies are the best preserved prehistoric ski pair globally. Left: Espen Finstad, Innlandet County Municipality (ICM), right: Julian Post-Melbye, Museum of Cultural History (MCH). Photo: Andreas Nilsson, ICM.



A 1,700-year-old hide shoe with a design inspired by fashion in the Roman Empire. It was found on the ice in a glaciated mountain pass in the Lomseggen mountain range. Photo: Espen Finstad, ICM.



A 1,800-year-old horse snowshoe found on the ice at nearly 2,000 metres, along an ancient mountain trail leading over the Lomseggen mountain range. Photo: Espen Finstad, ICM.



The dog – our best friend. A 500-year-old dog with a collar and leash melted out of the ice. Photo: Trond Andersen, MCH.

The Glacier Archaeology Program in Innlandet (Secrets of The Ice)

The Glacier Archaeology Program is a collaboration between Innlandet County Municipality (program owner), the Museum of Cultural History in Oslo, the Norwegian Mountain Museum and Climate Park 2469.

The Department of Cultural Heritage at Innlandet County Municipality is responsible for the rescue of the archaeological finds melting out of the ice and the public outreach connected to the effort. The Museum of Cultural History (MCH) curates the finds and make them available for exhibition. Research on the finds is done in cooperation between the two institutions.

The work at the ice started in 2006. Permanent funding for the Glacier Archaeology Program started in 2011. The main aim of the program is to salvage as many of the emerging archaeological finds as possible.

As of 2024, 4,500 finds from 70 sites have been documented. The oldest finds are 6,000 years old. The large amount of finds in Innlandet is more than half of such ice finds worldwide.

The reason that there are so many finds in Innlandet is a combination of the landscape, history and climate change, and the long term ongoing effort to discover finds and sites.

The program cooperates with scientists from the Norwegian Meteorological Institute, the Museum of Natural History (University of Oslo), The Norwegian Water Resources and Energy Directorate, and the Norwegian University of Science and Technology. In addition, the program cooperates with glacial archaeologists in the Alps and North America.



The Lendbreen tunic (1,700 years old), the earliest clothing item in Norway, is one of the many unique artefacts that have been found. Photo: Mårten Teigen, MCH.

Archaeological Fieldwork at the Ice

Each year in August, after the winter snow has melted, the archaeologists conduct fieldwork at the ice. They survey and collect finds until the snow from the coming winter starts to cover the landscape, normally from mid-September.

If there is a large number of finds, the archaeologists will stay near the site in a basecamp during fieldwork. Part of the fieldwork each year is to scout for new sites.

When the ice retreats further from known sites that have already been systematically surveyed, then the archaeologists return to survey the newly exposed areas along the edge of the ice.

Searching for artefacts along the melting ice can be a thrilling experience, but the conditions can be challenging.



Watching the glacial ice melt makes a serious impression. This has led to the program suspending the use of helicopters to reduce the carbon footprint of the program. Packhorses are used instead. Photo: Espen Finstad, ICM.



Snowfall during fieldwork is not uncommon. This is from our basecamp at Storfonne Ice Patch in the Jotunheimen Mountains. Photo: Espen Finstad, ICM.



The archaeologists conduct a systematic survey of the areas that have been exposed by ice melt, as shown here at the Storfonne Ice Patch. Photo: Torje Bjellaas, NRK.

How Have the Finds Been Preserved?

Innlandet County has the highest mountain ranges in Norway with many glaciers and ice patches. The ice can preserve the archaeological finds like a time machine when conditions are right. However, not all ice preserves finds. Large glaciers which move will destroy the finds. The artefacts will be crushed inside the ice and end up being dumped in front of the glacier.

Fortunately for us, there is also ice which does not move much and which can preserve archaeological finds. Such ice can be found in ice patches - a kind of small glacier which is frozen to the ground. It can also be seen in non-moving ice fields along the edges of glaciers. Such ice can be thousands of years old, and it is there we discover most of our finds.

For this reason, we have studied aerial photos and computer models to find this type of non-moving ice in the high mountains of Innlandet, so we know where to look for finds. The resources are limited and we need to target our efforts for the best results.



Inside the deepest part of the Juvfonne Ice patch, we find the oldest ice in Norway – radiocarbon-dated to be c. 7,600 years old. Photo: Kathrine Dokken, Kreativ Strek.



The Langfonne ice patch in Jotunheimen is a typical ice patch, where one can see layers upon layers of old ice. A large-scale systematic survey has taken place here, leading to the recovery of 68 arrows, some of which are 6,000 years old. Photo: Lars Holger Pilø, ICM.

Climate Change and the Melting of Ice

The climate has varied for natural reasons in the past. In our area, the ice in the high mountains melted almost completely away 8,000-9,000 years ago. This was caused by small and gradual changes in Earth's orbit. Thus, the glaciers and ice patches we can see today are not remnants of the ice of the last Ice Age. The oldest dated ice in Norway is from the bottom of Juvfonne ice patch, at the bottom of the ice tunnel in Climate Park 2469. The ice there is c. 7,600 years old.

We are now experiencing climate change caused by human activities. If there had been no such activities, the Earth system should have gradually cooled. Instead, we are witnessing a rapid rise in temperature, especially due to the emission of greenhouse gases. The world is getting warmer, the sea level is rising, and the weather is becoming wilder.

The global community has committed to limiting global warming to well below 2 degrees C and to strive to limit it to 1.5 degrees C, compared to pre-industrial times. Most climate scientists believe that the 1.5 degree C target is unrealistic and that we are looking at a 2.5 degrees C temperature increase by 2100.

One of the consequences of the ongoing climate change is that the ice in our high mountains is melting. The temperature in the mountains of Innlandet has already increased by 1.5 degrees compared to pre-industrial times.

The area covered by glaciers in Innlandet has decreased from 280 to 247 km², a 12 % decrease, from 2003-2019. The future prognosis estimates that 60-80 % of all ice in mainland Norway (excl. Svalbard) will melt away in this century alone, even if the 1.5 degree target is met (which is not likely).

The reality is that Innlandet will lose most of its glaciers and ice patches within the next 80 years, and perhaps even faster, depending on how quickly the greenhouse gas emissions are cut. This will have dire consequences for nature, tourism, agriculture, and hydroelectric power. The archaeological finds from the ice are thus not only a harbinger of the past but also of the future.

Sources: see page 29-30.



The roof of Norway with Galdhøpiggen (the highest peak in Scandinavia) in the centre of the photo. This is a high mountain landscape that still has glaciers and ice patches. The picture is from 2006 and the ice has retreated a lot since then. Photo: Helge J. Standal.



The climate prognosis indicates that almost all ice in Jotunheimen will have melted away by the end of this century. In that case, the landscape may look like this. Photo: Helge J. Standal. Graphics: Eva Bjørseth and Atle Nesje, Institute for Earth Science, University of Bergen.

Why Are There so Many Finds in the Ice?

The Reindeer, the Ice and the Hunters

The reindeer is an animal adapted for a cold climate. During summer, the reindeer migrate to areas with an arctic ecology and with snow and ice. Mountain areas such as Jotunheimen, Breheimen, Reinheimen and Dovrefjell contain attractive summer pastures for the reindeer. On hot summer days, the reindeer move higher up and onto the ice to cool down and to avoid pestering botflies. This behaviour has been targeted by hunters all the way back to the Stone Age.



The reindeer move onto ice and snow on hot summer days to avoid pestering botflies – here at Langfonne ice patch, where the earliest arrow is 6,000 years old. Photo: Espen Finstad, ICM.

Ancient Mountain Trails Across the Ice

After the mountain people became more sedentary with farms and agriculture, the mountains and the reindeer remained an important resource. In the 8th century, the century preceding the Viking Age, a market developed for reindeer products outside the region, and reindeer hunting increased. Several mountain trails led from the Innlandet mountains to the western coast. Some of these trails crossed glaciated mountain passes. The Lendbreen ice patch is one such mountain pass, where the archaeological remains provide us with a unique insight into the mountain traffic from around AD 200 onwards towards the end of the Middle Ages.



Archaeologist Elling Utvik Wammer holds a horse skull. It is one of the finds which shows that an ancient mountain trail crossed the Lendbreen Ice Patch in the Lomseggen mountain range. It was a challenging route. Photo: Espen Finstad, ICM.

New Knowledge

Important new knowledge about the history of Innlandet is melting out of the mountain ice.

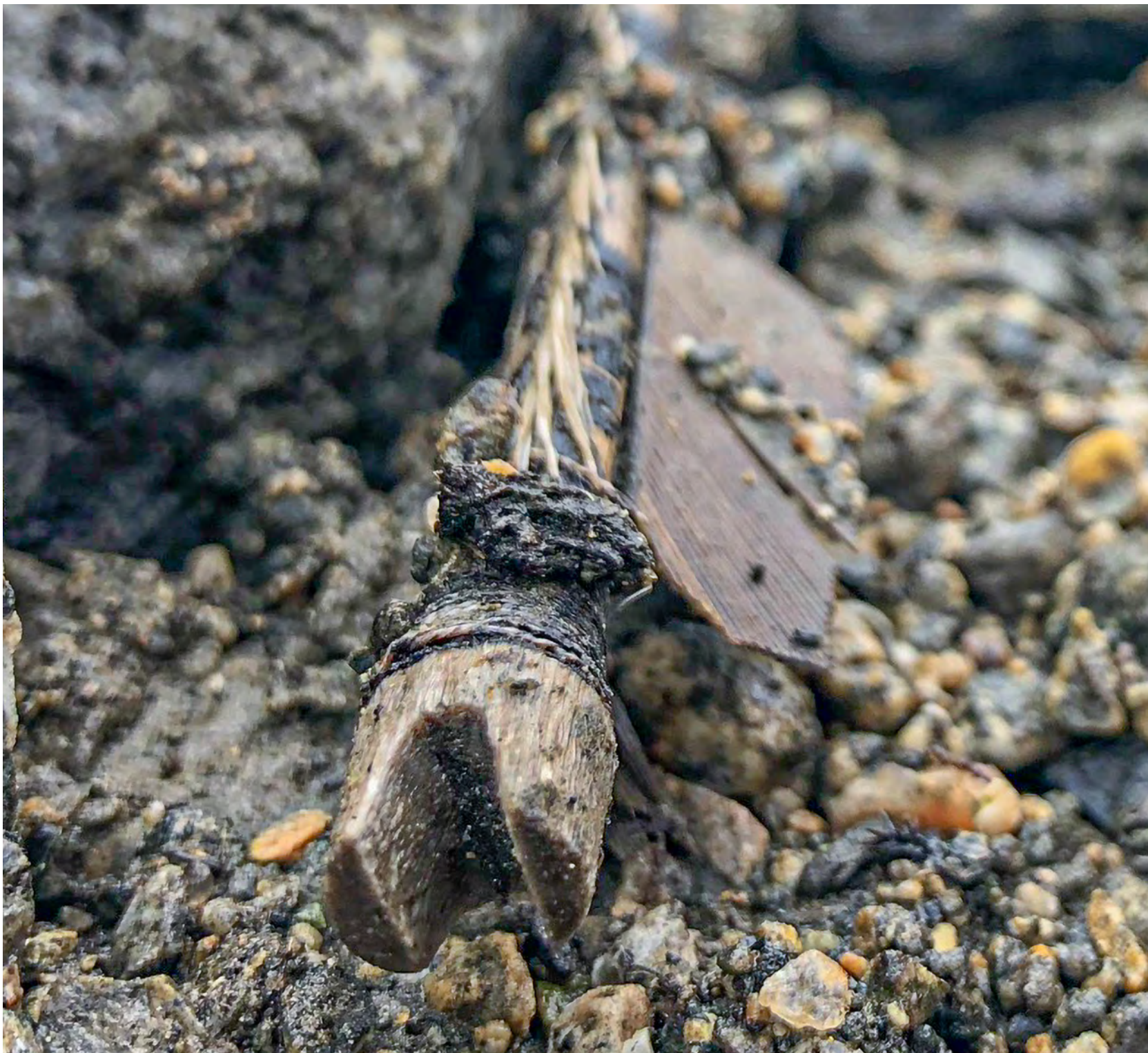
Some of this new historical knowledge is immediately visible as the oldest shoe from Norway, the oldest clothing item from Norway or the best preserved prehistoric ski pair in the world. Other knowledge appears more gradually through radiocarbon dates and other types of analysis of the artefacts, and through studies of the find spots. This type of research goes on in parallel with the fieldwork.

The glacial archaeological finds tell us that humans used the high mountains and the ice much more intensively than was previously believed, even during wintertime. The finds from the lost mountain pass at Lendbreen are tell-tale signs of substantial mountain traffic, which peaked about 1000 years ago. The traffic was not only local but extended to the western fjords. Innlandet was connected to the wider world.

Currently, studies of the more than 200 arrows from the ice are ongoing. Many of the arrows have preserved fletchings, sinew and arrowheads, which are incredibly rare to find elsewhere. The unique preservation of the arrows from the ice has created international interest.

Glacial archaeology is a new discipline in archaeology, and very different from archaeology in the lowlands. The Glacier Archaeology Program has had to both adapt traditional archaeological methods for the challenging conditions and to develop its own new methods. The methods increase the chances of discovering finds and allow for a deeper understanding of how the extreme environments have influenced the finds. We have published our methodological guidelines in a paper in the *Journal of Field Archaeology*, and hope that our experience from working in Innlandet may be useful for the international glacial archaeological community.

Sources/list of references: See pages 24 and 25.



Some of the finds from the ice are just incredible. Here we can see the nock and the fletching of a 1,500-year-old arrow. Photo: Espen Finstad, ICM.

Collaboration on Research, Cultural Heritage Management and Public Outreach

Innlandet County Municipality, the Museum of Cultural History (University of Oslo), the Norwegian Mountain Museum and Climate Park 2469 have a written cooperation agreement concerning the glacial archaeological finds from Innlandet where research, cultural heritage management, and public outreach are considered as a whole.



Archaeologist Karin Lindboe (MCH) and Thea Dalen (NMM) are arranging artifacts in the exhibition Frozen in Time at the Norwegian Mountain Center in Lom. Photo: Live Andrea Sulheim, NMM.



Archaeologists and a technical conservator from MCH are displaying arrow finds in the Frozen in Time exhibition at NMM. From left: Line Petzold, Margrethe Felter, and Karin Lindboe. Photo: Live Andrea Sulheim, NMM.

Collection Management, Museum of Cultural History, Oslo

Collection Management

The archaeological finds from the ice are to be preserved for the future by being incorporated into the scientific collections of the Museum of Cultural History. The Museum of Cultural History (MCH) is a university museum at the University of Oslo. At the museum, the finds are processed by systematic cataloguing, conservation, and preparation for researchers and the general public.

Systematisation

To incorporate the finds into the collection, the objects are catalogued by archaeologists with expertise in the field. Their design and characteristics are described, their age determined, the materials they are made of are examined, and their function is established. The objects are also compared with other known finds to place them in a broader context. Most of the items are related to reindeer hunting on the ice patches and can therefore be studied in connection with our knowledge of large mass hunting structures in the mountains of southern Norway. An important part of the documentation work takes place in KHM's photographic studio. All of this data is included in the museum's object and photo database. The purpose of cataloguing is to ensure the scientific source value of the objects is properly safeguarded. The documentation is essential for future research on the finds, long after the ice patches in the mountains have melted away.



Textile conservators at the Museum of Cultural History are working to clean the Lendbreen tunic of sediment. The tunic is from the Late Roman Iron Age and is approximately 1,700 years old. From left: Nalini Sharma, Margunn Veseth, and Madelen Skogbert. Photo: MCH.

Conservation

The exceptional preservation of the materials from the high mountain ice provides conservators with an outstanding foundation for stabilising the finds against further degradation. The ice has preserved organic materials that are thousands of years old, which is truly unique. Wooden items require careful condition assessment. If the water content is high, the objects may crack upon drying, and measures must then be taken. Textiles and leather must be cleaned of sediment and reindeer droppings accumulated from thousands of years in the ice. Although there are few salts on the mountain surface, iron still needs to be checked for corrosive elements, that may cause rust. Objects in need of conservation are lightly surface-treated with sandblasting, as necessary, to curb corrosion.

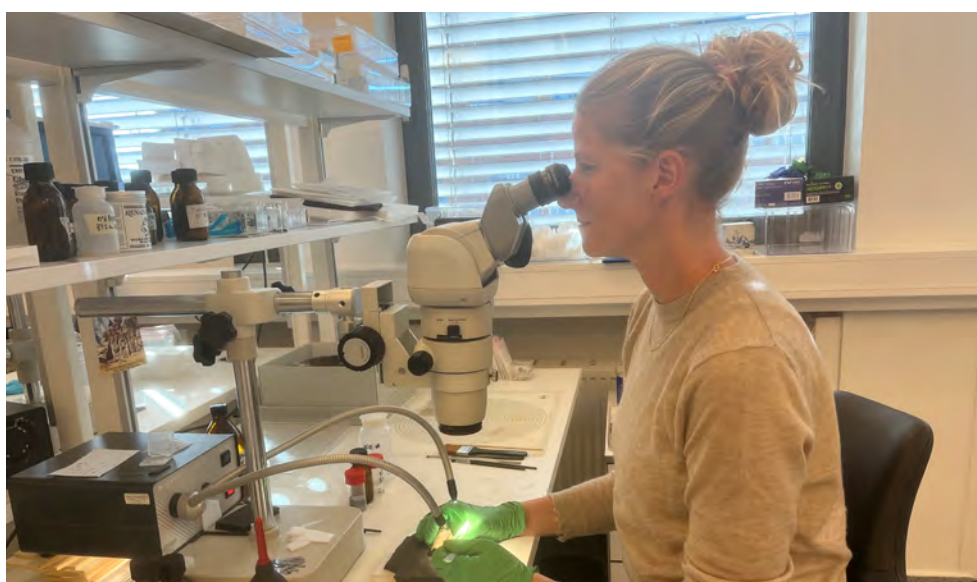
Selected items made of fragile wood, leather, and textiles undergo freeze-drying. This is a carefully controlled drying process in a vacuum at sub-zero temperatures, causing moisture to sublime directly from the object into gas. This gentle water removal prevents the item from expanding or contracting, ensuring that textiles retain their resilience and softness.

Making the Finds Available

Through the systematisation and conservation of the materials, they are made available to the public, the heritage sector, and the research community. The finds will become publicly accessible online via the university museums' shared portal, where anyone can explore and view the archaeological collections. The materials have also been prepared for loan for exhibitions and are available for the training of future professionals. The archaeological collection, as source material, is made available as research material so it can contribute to a new understanding of our past. The significance of outfield resources related to hunting and trapping in the southern Norwegian forests and highlands is strongly underrepresented in comprehensive works on Norway's history. The research team working with the material continuously shares their findings and has published several articles in international scientific journals.



A 1,300-year-old ski is being documented.
Photo: Julian Post-Melbye, MCH.



Technical conservator Margrethe Felter examines finds under a microscope. Photo: Julian Post-Melbye, MCH.

The Norwegian Mountain Museum, Lom

The Norwegian Mountain Museum is located in Lom, surrounded by Norway's highest mountains and the national parks of Jotunheimen, Reinheimen, and Breheimen. Here, the stories of the mountains, the development of the national parks, and mountain tourism in Norway are told. For over 8,000 years, people have lived in and from the mountains in these areas, leaving many traces behind.

Now, large ice-covered areas are melting, and the climate and nature are changing. Through lectures, exhibitions, and school programmes, visitors gain insights into these changes. In recent years, glacier archaeology has contributed new knowledge about life in the mountains, dating back to the Stone Age.

In the exhibition **Frozen in Time**, 12,000 visitors yearly experience 100 of the best-preserved glacial archaeological finds that have emerged from the ice. In an evocative landscape filled with sounds, lights, and animations, stories are shared about hunting, fishing, and travel in the mountains during prehistoric times, as well as the reasons these exciting finds are now appearing due to climate change.

So far, 4,500 finds have been made, the oldest dating back 6,000 years. The artefacts are exceptionally well preserved, allowing for detailed study of techniques, materials, and shapes in the exhibition.

Children and young people are the primary target audience for the Norwegian Mountain Museum, and school students in the district are invited to various outreach programmes related to glacier archaeology. Throughout the year, around 1,000 school students visit the museum.

Through the VR experience **Melting Mountains**, the Norwegian Mountain Museum has also embraced digital communication tools. In videos, poetry, and animations, students can witness the melting ice, explore the hand-carved ice tunnel on Juvfonne with 7,600-year-old ice, and have a unique, thought-provoking experience of climate and nature in transition.

Since autumn 2023, the museum has toured Innlandet County with Melting Mountains as part of the cultural school bag programme. So far, over 2,000 secondary school students have participated in this experience.



The Norwegian Mountain Museum/Norwegian Mountain Center is located in the National Park Village of Lom.
Photo: Kristoffer Mæle Thuestad.



100 of the finest artefacts from the ice are on display at the Norwegian Mountain Museum in Lom in the exhibition Frozen in Time. Photo: Live Andrea Sulheim, NMM.

Climate Park 2469, Lom

Climate Park 2469 is an exciting outdoor research dissemination arena located in Jotunheimen at an altitude of 1,850 metres. Here, you can explore a mountain landscape with a history that stretches back thousands of years. Climate Park 2469 is also an important site for climate monitoring in the high mountains. Through informative interpretation stations and guided tours, visitors gain research-based knowledge about changing climate and nature, permafrost, temperature trends, melting glaciers, archaeology, geology, flora, and fauna.

The tour follows prepared walking paths and culminates in the spectacular hand-carved ice tunnel in Juvfonne. Here, the public can see ice sculptures inspired by Norse mythology, as well as replicas of fascinating glacial archaeological finds. The tunnel spans nearly 400 square metres and contains the oldest dated ice in Norway, which is 7,600 years old.

The summer season is characterised by high activity with daily guided tours. During the spring and autumn seasons, more than 1000 school students, university students and groups who want to gain insight into nature and climate changes up close, visit the park. In total the park has around 6000 visitors every year

Climate Park 2469 collaborates with leading research and monitoring organisations in climate and geosciences to establish the park as a national monitoring area for climate and environmental changes in the high mountains.

Together with the Norwegian Mountain Museum, a digital classroom called Fjellviten (Mountain science) is being developed, which will make research results and data from climate monitoring easily accessible. Here, you will find tailored educational programmes for children, youth, and young adults.



Visitors walking along the pathways in the Climate Park.
Photo: Climate Park 2469.



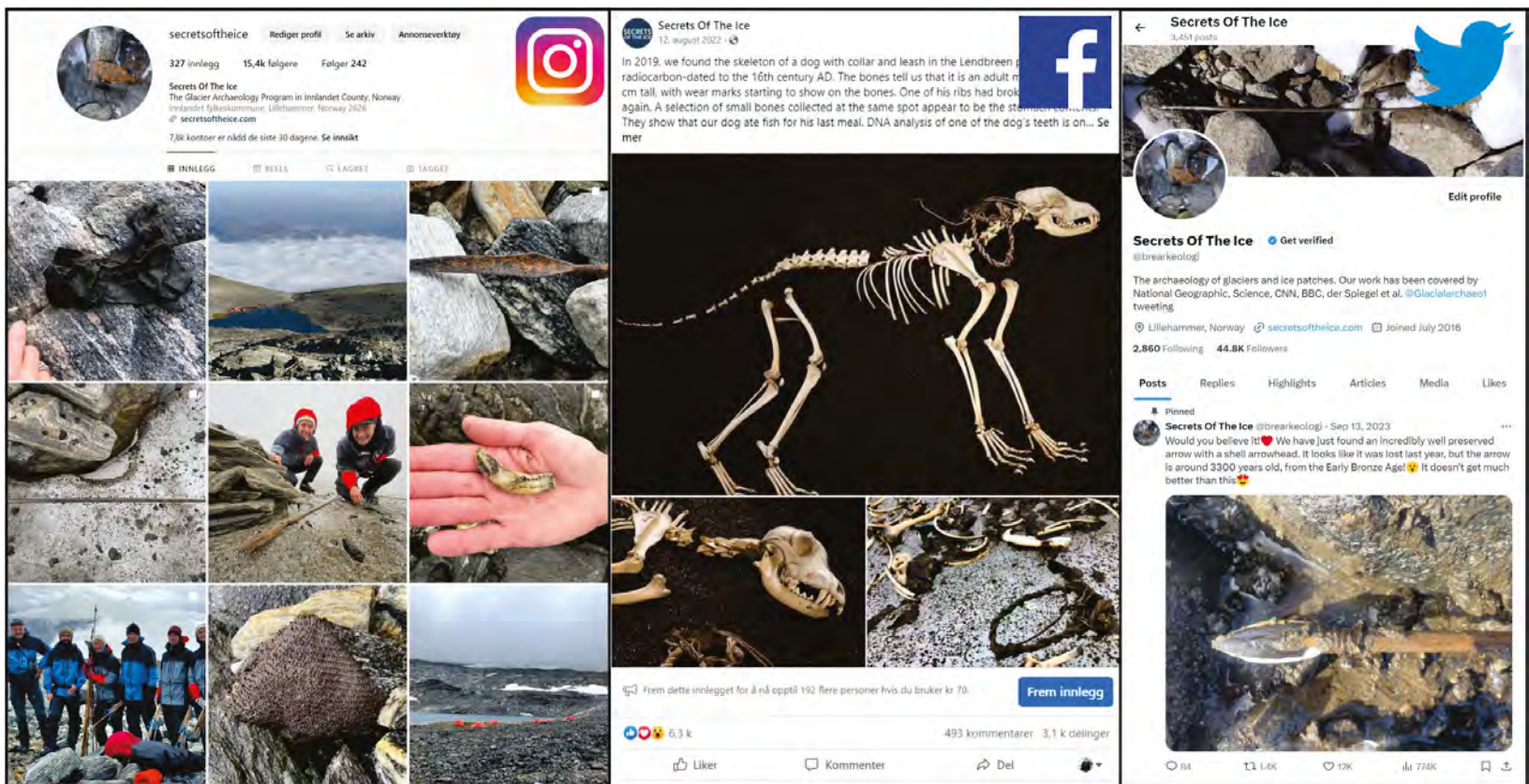
From the ice tunnel in the Climate Park. The ice here is approximately 7,600 years old. Photo: Kathrine Dokken, Kreativ Strek.

Secrets of the Ice – Global Outreach

The Glacier Archaeology Program in Innlandet established the dissemination platform Secrets of the Ice in 2016. It has become the most important platform for glacial archaeological outreach worldwide.

Secrets of the Ice has 111,000 followers on Facebook, 44,000 on Twitter and 15,000 on Instagram. Some of the blog posts on the webpage have been read more than 100,000 times.

The public outreach is noticed by international news media. National Geographic, Science, New York Times, Der Spiegel, Washington Post, BBC, CNN, Reuters and many other international news media have published stories on the glacial archaeological finds from Innlandet.

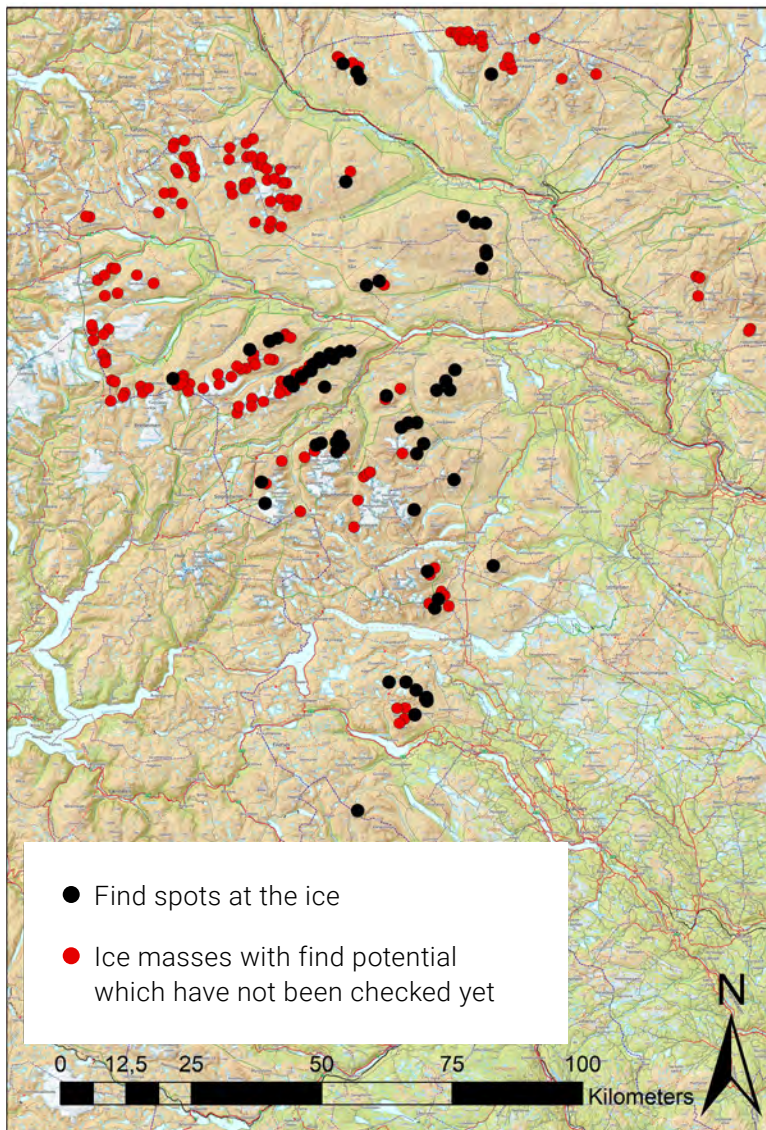


Examples of social media posts on the glacial archaeology in Innlandet. Illustration: Lars Pilø, ICM.

The Future for the Ice and for Glacial Archaeology in Innlandet

Most of the mountain ice in Innlandet will disappear in this century. So far, 70 glacial archaeological sites have been found. In addition, there are more than 150 potential ice sites that have yet to be visited by archaeologists.

The main conclusion is that more and even older finds will melt out in the years to come.



The map shows find spots at the ice (black dots) and ice masses with find potential which have not been checked yet (red dots). Map: Espen Finstad and Lars Pilø, ICM.



A beautiful and incredibly well-preserved arrow that is 3,000 years old. The tip is made of quartzite. Photo: Espen Finstad, ICM.



Proud archaeologists have made a great discovery of a 1,300-year-old arrow. Photo: Espen Finstad, ICM.



May-Tove Smiseth is very happy to have found a 1,500-year-old arrow. Photo. Espen Finstad, ICM.

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At the ice patches, it is as if time has been standing still for thousands of years. Now the past emerges from the melting ice. The earliest finds are still inside the ice but they will soon appear. Photo: ICM.

«Our planet is losing its ice»

David Attenborough