Torbjørg Bjelland and Gitte Kjeldsen

Status quo, ongoing challenges, and future perspectives -

after more than 20 years of practice in rock art documentation, conservation, and management in southwestern Norway.

Introduction

The county Rogaland, in southwestern Norway, has identified 186 rock art sites. The majority are large concentrations of open-air localities in a maritime environment, as well as boulders with carvings. In addition, one rock painting site has been registered in Rogaland (Høgestøl *et al*. 2018).

In 1995, the Directorate for Cultural Heritage prepared a status report, "Plan for Measures to be Taken to Preserve Rock Art". The report concluded that approximately 92% of the Norwegian's rock art sites have major damages (Directorate for Cultural Heritage 1995). Based on this report, the Ministry of the Environment allocated funds for a national project for the conservation and safeguarding of Norwegian rock art. The Norwegian Directorate for Cultural Heritage's national project formally started in 1996, it was called *Protection of Rock Art* – The Rock Art Project (Hygen 2006). The aims of the project plan included condition and damage registration, documentation, preservation, and management strategies (Hygen 2006). The Norwegian University museums have continued their work with rock art until today (Kjeldsen 2012).

During the project, the Museum of Archaeology, University of Stavanger (AM-UiS), built up expertise in several fields, with a particular focus on jointing methods, conservation of rock and documentation. The work has been organized into an interdisciplinary group of archaeologists, botanists, curators, meteorologists, as well as an external geologist.

AM-UiS and University Museum of Bergen established a collaboration where the intention was that AM should have the primary responsibility for development and research on conservation methods, as well as long-term effects, while University Museum of Bergen was responsible for research on factors influencing degradation, environmental monitoring and methods to slow down the degradation.

The learning processes

After Eva and Per Fett's investigations in the 1930s, there was generally no documentation until the latter half of the 1960s. In 1966, a photographer was engaged to photo-document some of the rock art sites in Rogaland. Reports and other documentation on/from this work are missing. In the late 1960s a number of sites was painted, and from the 1970s until the start of the national rock art project, various interdisciplinary groups have been appointed to work on weathering and conservation issues. Rock art is "objects" (memories) in a special position, as they are mainly on open and unprotected rock surfaces, conservation and protection must

take place on the site. The natural degradation as e.g. frost weathering, water seepages, lichens, and plant roots etc., as well as human activity (trampling injuries), and lack of consideration, all pose a risk to the rock carvings.

The challenges are complex in the relationship between preserving, conveying and at the same time keeping the landscape as authentic as possible (Kjeldsen 2012). The rock art in Rogaland was last painted in the early 1990s. In the event of a subsequent decision from the Directorate for Cultural Heritage, it is not permitted to paint rock carvings without a pre-approved application (Hygen 2006).

Different methods of documenting

At the start of the project, the documentation was carried out in accordance with the Directorate for Cultural Heritage's documentation standards. This was a comprehensive documentation and the collected data was entered into the "Rock Art Database", which the Norwegian Institute for Cultural Heritage Research (NIKU) had the responsibility for administrating as well as the maintenance of the system. The database had no search function making it possible to search for data within other regions, so access was only for local use. Later, the database was closed, and only a small amount of information was transferred to the national database "Askeladden". Thus, some information from the first Rock Art database was lost during this process.

In Eva & Per Fett's publication *Sydvestnorske rock carvings. Rogaland and Lista* (Fett & Fett 1941), there are illustration charts available for every tracing at each locality they examined. The results from this work is sufficient as high standard documentation even today. At AM-UiS we have mainly documented type of figure and damages on the rock art panels with photos (professionally by the museum's photographer). In the documentation work in Scandinavia, there have been a tradition with different methods, in addition to photos, e.g. tracing, frottagé, and 3D-documentation (Bjelland & Helberg 2006). Eventually, it was concluded that it would be an advantage with unified solutions.

During the "Protection of Rock Art" – The Rock Art Project-, several objectives in the hedging work have been achieved, while other and new goals have been initialized, including digital documentation methods. In the nearest future, the program Intrasis (Intrasite Information System) (https://www.intrasis.com/) will probably be adapted to documentation work, jointing and monitoring of rock art sites in Norway. Intrasis is already used as a documentation system for archaeological excavations at all university museums in Norway, and as a documentation system used during the restoration of Stavanger Cathedral. With Intrasis it is possible to both visualize, interpret, and analyze information, as it is a combination of a complex database and geographical tool where you can register and relate different types of geographical and object information (https://www.intrasis.com/). Applying a standard documentation system, will be an important part of securing the documentation for the future, as well as making it possible to store previous and future GIS-documentation in one unified system. If type of program or system access were to change, this will make it easier to pass on a uniform documentation to alternative systems. In addition, the application of a unified system will make sharing and exchange of data possible and easy.

In 2018 AM-UiS tested landscape documentation with drones for the first time (Kjeldsen 2019). Due to the promising results we have continued with drone documentation of landscapes in the context of rock art, both inland and along the coast (figure 1). AM-UiS further plans to test a new 3D-handhold scanner as a tool for documentation of some of the rock art panels.

Fig. 1. Landscape documentation of site X at Åmøy, southwestern Norway 2020. Photo: Annette Græsli Øvrelid.

Conservation

In Rogaland, as well as at other rock art sites in Scandinavia, both methods related to preventive and direct conservation have been tested, however the long-term effect are still not evaluated for all methods. Today, the question is if these methods have had any effect. What is status quo? After 20 years, is it possible to conclude anything about the long-term effect of the conservation?

Preventive conservation

Preventive conservation of rock art is all actions done outside the actual image surface. The intention is to remove factors that lead to increased weathering by conducting relatively simple interventions and maintenance, and that this will prevent the development and enlargement of damages that require direct conservation (Bjelland & Helberg 2006).

Vegetation control both prevent root action and initiate a more favourable climate on/around the rock art surface. With a dense vegetation surrounding the rock art site, the drying of the rock surface is slower. To keep the rock art site open, not surrounded and/or overgrown by trees and shrubs, it is necessary to continue management of the vegetation every year (figure 2). Today, twenty years after all the effort done on vegetation control during the rock art project, this give rise to concern as, effort without a serious follow up will only make things worse and the monetary investment will be futile. Vegetation management must have a long-term perspective. Similar experience and conclusions have been done at several rock art sites in Norway (Bjelland *et al*. 2010, Peacock *et al*. 2014, Ernfridsson *et al.* 2019a, Ernfridsson *et al*. 2019b).

The intention by reducing the amount of periodically flowing water on a rock art panel have been that there mainly will be less frost action, but in addition less chemical weathering (Bjelland & Helberg 2006). Sometimes the water can have importance for the archaeological interpre-

Fig. 2. Vegetation control at site I, Åmøy. A: In 1997 the site was surrounded by trees. Later the same year, the trees in front of the rock art panel were cut down. Photo: Åge Pedersen. B: In 2017 there is no trees in front of the site. This is due to continuous vegetation control, which includes grazing animals (2B). Photo: Torbjørg Bjelland.

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B

tation of the cultural resource (Kjeldsen 2012, 2017). It is thus important to be in a continuous dialog with the responsible archaeologist regarding what to do with the water seepage. An important consequence of keeping periodically flowing water on the rock surface will be a faster rate of weathering.

A long-term effect, which is obvious after 20-years, is that by involving and changing processes in an ecosystem, this can give consequences for the living organisms on a rock art panel. The change might be better regarding one condition but can turn out to give other undesirable conditions. E.g. by cutting down trees or removing the lowest branches on trees that surround the panel, more sun will penetrate to the surface. The conditions in the ecosystem on the rock surface are changed. The surface is drier, and this reduce and partly prevent the growth of humidity demanding species as algae, cyanobacteria, and some mosses. At the same time, the new drier conditions and a new available surface will be more favourable for some lichen species to establish. The likelihood for a lichen-covered surface will thus increase, and another probably unfavourable condition in this context is a fact.

Many rock art sites are located within the cultural landscape (figure 1). Continuously grazing is an important method to prevent establishment of trees and bushes. In addition, if the climate is wet as in western Norway, it is important to ensure good drainage of the cultural landscape.

Poor drainage can lead to a shift from plant communities that are typical for the cultural landscape to plant communities more adapted to moist soil, which is much less favourable to grazing animals (Bjelland & Helberg 2006).

Heavily weathered rock carvings are very vulnerable to any additional destruction. Most of these panels are not available for tourists. However, at sites, which are already well-known, different methods as signs and guided tracks, can secure against mechanical wear. At sites with grazing animals, a fence can prevent animals to walk over the rock panel. However, these methods only have an effect if they sustain maintenance of these actions.

Direct conservation

Direct conservation of rock art involves intervention in the actual image surface. The purpose is to prevent or delay weathering processes that lead to deterioration or complete disappearance of the rock art. This often involves repairing damages that have already occurred (Bjelland & Helberg 2006). To what extent one should carry out intervention directly on the rock art surface is a constantly recurring discussion and are not discussed further in this publication. In theory, all actions should be reversible, but in practice, this will be impossible if it involves intervention in the original material. In Norway, the attitude in general is to emphasize preventive action and to make the fewest possible interventions and reduce their scope to a minimum (Bjelland & Helberg 2006).

Covering

The purpose of covering a rock art panel have been to limit physical and biological weathering processes. Sometimes the aim is to have a short-term covering, other times it is to have a periodic covering. In Scandinavia different insolating and sun proof materials are tested such as black plastic, different types of mats/goretex, soil, sand, and clay (Löfvendahl & Magnusson 2000, Bjelland & Helberg 2006, Ernfridsson *et al*. 2019a, Ernfridsson *et al*. 2019b). In Litsleby, southern Sweden, the protective effect of a roof was evaluated (Löfvendahl & Magnusson 2000). The technical properties of the materials are very important to achieve a functional, long-lasting cover. As regards a more short-term cover, the challenge is to choose a material, which in addition to be solid, is practical to work with. One intention with the test cover at Åmøy, was to prevent plant vegetation to grow in the phyllite cracks. However, when the cover was removed, both vegetation and small pieces of the bedrock phyllite were removed. Further, transport and storage of equipment consisting of thick mats, steel wires and sandbags, was too resource-intensive compared to a relatively short-term result. Further, due to the mild and windy climate in Rogaland, it is not the same need for a covering, as at other Norwegian sites with a colder climate. Thus, AM-UiS stopped testing and using a cover on rock carvings. In the 1930-ies and 1970-ies, when archaeologists discovered new rock art panels in Scandinavia, many of them were partly or totally underneath a cover of soil. As a thick soil cover will prevent the growth of lichens and mosses, and freezing and thawing processes, most of these newly exposed rock art panels were clearly visible, "clean" and looked very well preserved. It has thus, frequently been discussed if soil is a recommended cover material. Even if the first impression is a well-preserved rock panel underneath a soil cover, the rock art panels could hide a thick weathering rind underneath the surface (Bjelland *et al*. 2001). This depends on the composition of the soil cover and the type of bedrock. A peat turf is an acid soil type and can increase the chemical weathering of the bedrock (Bjelland *et al*. 2001). By removing, an existing peat soil cover, this will lead to exposing a weathering rind to weathering processes and the visible damages can soon increase (Bjelland *et al*. 2001). Today, archaeologists in general do not look for undiscovered rock carvings underneath soil cover. Even 20-years after the Rock Art Project, there is still too much uncertainty about alterna-

tive recommended and long-term tested cover materials. Further, keeping a newly exposed rock art panel as stable as possible, involves a lot of management.

Removal of vegetation

Lichens cover many rock-art panels in Scandinavia, and it is often difficult or impossible to see the cultural heritage below the cover. To document rock carvings, to carry out conservation, or to show them to tourists, archaeologists and conservationist have removed lichens from rock art panels for a long time. In Rogaland and in Scandinavia in general, mainly three different methods are used: (1) brushing, (2) chemicals and (3) a cover. Usually a combination of several methods is applied.

Lichen species with a foliose and fruticose growth form are easy to remove from the surface with a brush or by hand. On the other hand, crustose lichens are tightly attached to the substratum by their lower surface and it can be extremely time consuming and almost impossible to remove them from the surface. For a long time, a steel brush was an efficient method to remove lichens at rock art panels. However, as a steel brush often leaves traces on the rock, and there is, a high risk of removing the upper weathered rock surface in addition to the lichen cover, a change to use more soft brushes was practised most places (Bjelland Helberg 2006).
It is easier to remove lichens from a rock surface if they are dead. Thus, archaeologist and conservationist have used different chemicals to kill lichens. Both in the county Rogaland and at other rock carving sites in Scandinavia, tests of different chemicals have been performed (Bjelland & Helberg 2006). Pingo, a quaternary ammonium salt, is one of the chemicals commonly used to kill lichens in the 1980-1990's in Norway. However, the experience was that Pingo was not optimal and questions asked about the effect. Test panels with Pingo indicated an increased growth of algae (Bjelland *et al*. 2001). Pingo contains ammonium, which could be a nutrient for the algae.

In 1982 and in 1987, Pingo was used on the rock art panels at Åmøy in Rogaland (Høgestøl *et al*. 1999). Some of these panels had a high cover of the yellow lichen *Rhizocarpon spp*. in 1998 (figure 3). It is possible that this treatment lead to the increased growth of some *Rhizocarpon* species on the rock art panels. Another possibility is that it could be due to the, in general, high content of nitrogen in the air in Rogaland, which is caused by the long tradition of intensive agriculture. It is worth noting that the same lichen group occurred in high amount at the rock art site Fykanvatnet, Nordland, in northern Norway in 2004 (Bjelland 2004). In 1987, they used Pingo to remove lichens. The rock art site is close to a factory (Glomfjord producing fertilizer rich in ammonium (calcium nitrate). There is a possibility that the production could have led to the high amount of lichen cover on the rock art panels close by (Bjelland 2004). In some lichen species, experiments indicate that increased nitrogen supply, stimulate growth (Palmquist & Dahlman 2006). The change in nutrient supply will thus lead to the dominance of some specific lichen species.

At the end of last century, archaeologists and conservationists stopped using Pingo in Norway, and ethanol (70-96%) started becoming a common chemical to use at the lichen-covered panels (figure 4). In general, only the rock carvings and the closest surrounding surface is treated with ethanol, while the surrounding rock surface remains rich in lichens. After approximately two years of chemical treatment with ethanol and then brushing, there is no, or only very little, lichen vegetation left on the rock-art panel, but the surface usually has a paler colour then the surrounding panels. The rock carvings might be clearer after the treatment, but the visual impression is different. To avoid this unnatural colour difference on a treated rock art panel, one test performed in Rogaland was to only treat the rock carving figures with ethanol, and not the surrounding rock surface. Even if the first impression after this treatment was a more

uniform rock art panel regarding colour, the long-term effect was not satisfactorily. The method turned out to be very time-consuming and the dense lichen cover surrounding the rock carvings was soon growing over and covered the rock carvings again. In addition, the visual impression of the rock art panel soon changed and turned out not to be satisfactorily. After a few years we stopped with this method.

Other chemicals used in Rogaland to kill lichens on rock art panels is the biocides "grønskekrutt" (http://www.plenkrutt.no/), Boracol and "Isola BioRen". To test these biocides, they were either, added only in the figures or on the entire rock art panel. However, there are not systematically tests regarding any potential influence of these three biocides on the weathering effect of the rock. Either if the treatment e.g. increased the growth of other microorganisms within the weathering rind. These are biocides designed for household. The visual effect of these compounds is that they are short term efficient, but we have no documented knowledge about the long-term effect. Another method to remove lichens from a panel, both living and dead lichens, which have been frequently used in Scandinavia, is to rinse the rock surface with water, both low-pressure and high-pressure washer are practised. A high-pressure washer will remove the loose rock surface/flakes/mineral grains on heavily weathered rock surface in addition to the vegetation. Thus, the Norwegian rock art project did not recommend using a high-pressure washer. Low-pressure washer can be useful to remove loose vegetation and soil.

Todays, recommendation regarding removing lichens

It is not recommended, or necessary, to remove lichens from rock art panels with easily visible carvings. However, for rock art panels which are hardly visible, well known and often visited, it can be necessary to keep cleaning the rock art panels with a chemical every year, to keep them visible for tourists. This will prevent the

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Fig. 3. Microvegetation on rock art panel site IV, Åmøy. A: In 1997 lichens, and especially the yellow Rhizocarpon spp., are partly covering the rock carvings. Photo: Torbjørg Bjelland. B: Due to frequently spraying with ethanol since 1997, there is very little lichens growing on the panel in 2017. However, the colour of the surface is darker due to the establishment of microorganisms like algae and cyanobacteria. Photo: Torbjørg Bjelland.

Fig. 4. Lichens on the rock art panel site I, Åmøy in 1997 (A) and in 2017 (B). Due to frequently spraying with ethanol, there is very little lichens growing on the panel in 2017. Photo: Torbjørg Bjelland.

A

B

lichens to re-establish on the rock carvings. Unfortunately, the experience is that tourists want pictures with visible rock carvings, if not, some tourists make new rock carvings by scratching new or by editing existing rock carvings to get a nice photo.

Today, if it is regarded as necessary, ethanol is still the recommended chemical to use to kill lichens. There are as far as we know, no new published scientific work indicating a better method. To use ethanol is in accordance with the recommendation from the Norwegian Rock Art project (Bjelland & Helberg 2006). The recommendation was based on experience from several rock art sites in Norway, and the results of the tests at the University Museum of Bergen, which indicated that the most efficient and gentle way of removing lichens is first to spray with water, then ethanol and finally cover the rock art panel with black plastic (Bjelland *et al*. 2001). The lichen cover is sprayed with water first to activate the photosynthesis in the lichen, and then a cover was added to stop the photosynthesis after it was sprayed with ethanol. Ethanol had no documented effect on the weathering of the rock. However, it is important to be aware of that ethanol should not be used at rock surfaces consolidated with Mowilith, as it swells if ethanol is added (Bjelland & Helberg 2006).

It is, not recommended to use ethanol, or any other chemicals, only within the carvings on a rock art panel. Lichens easily disperse to a lichen free surface close by. Further, as crustose lichens penetrate the

rock, there are fungal hyphae left within the rock, even if the surface looks clean (Bjelland *et al*. 2001, Bjelland & Ekman 2005). These fungal hyphae can probably grow to the surface, and when the right algae/cyanobacteria enter the rock surface, a new lichen can establish. Only two years after the ethanol treatment, a new lichen establishment can be seen (Bjelland *et al*. 2001). To keep the rock art panel clean, the surface must be sprayed with ethanol every, or every second year. The closer a lichen cover surface is to a lichen-free rock surface, the higher amount of lichen propagules is in the surroundings, and the higher potential there is for a lichen establishment on a lichen free surface. Further, regarding the esthetical view of the rock art panel, it is important to consider how much of the surrounding rock surface should be treated with ethanol. A rock surface newly cleaned for lichens has another colour, usually lighter, than a rock surface covered with e.g. lichen and mosses. The colour contrasts on these rock art panels, both with and without a lichen cover, can sometimes give an odd impression.

A soft brush or a low-pressure washer can remove dead lichens, or lichens not tightly attached to the surface anymore, from a rock art panel. However, it is worth noting that by removing the lichen cover without killing it first, the brushing results in thousands of small pieces of lichen thalli on the surface. Each of the small pieces can establish and grow to a new lichen. To avoid an early re-colonization, it is import removing all the small pieces of lichen on the rock art panel.

At the end of last century, as part of vegetation management, trees and bushes surrounding some of the rock art panels at Åmøy, were removed (figure 2). The ecological conditions for the saxicolous (rock inhabiting) organisms thus changed to a dryer environment as the rock surface receive more light, and the daily temperature is changing more rapidly than before. The lichen species documented on the rock art panel's at Åmøy 20-years ago are not the same as today. This of course regards the surrounding vegetation, not the surfaces treated with ethanol. Both the species composition and which species is dominating have changed (Bjelland 1999). Today there are in general fewer mosses on rock art panels, which is dryer due to a previous cutting of the surrounding vegetation (Kjeldsen & Høgestøl 2017).

Another reason for a change in the lichen vegetation at some sites, may be due to a change in the drainage surrounding the rock art panel. It could be that the direction of the water seepage on the rock art panels, changed, stopped, or started a new direction. Different lichen species have different ecological demands regarding both humidity, temperature, and light. The composition of the lichen cover will thus change depending on the combination of these factors.

By removing a saxicolous lichen and moss cover, other microorganisms like non-lichenised fungi, algae and cyanobacteria may get an advantage and establish on the rock surface. This can result in another colour on the rock surface, usually a darker colour (figure 3). After a wet period, it is common that the rock carvings have a darker colour due to the growth of algae and cyanobacteria. However, some of these microorganisms will disappear after some days without rain.

Even if lichens have, an effect on the degradation of rocks (Bjelland & Thorseth 2002, Bjelland 2003, 2005), it is important to consider if it is strictly necessary to remove the lichen cover. By removing a crustose lichen cover, the removing involves the lichen including a few millimetres of the upper rock surface. After some years, the lichen will cover the rock art panel again. By repeating this method several times, at the end the rock carvings will disappear. If it is not necessary to remove the lichens due to documentation or to show them to tourists, leave them on the rock surface. If you start to remove the lichen cover from a rock art panel, it is important to keep cleaning the surface with ethanol to prevent lichens to establish. Each rock

art panel should have a realistic following up plan/management plan.

Before deciding what to do with the vegetation on, and close by, a rock surface, it is important to take into consideration the consequences for this act on the biological diversity at the site. There is still little awareness about the act relating to the management of biological diversity in each country. In Norway, the Nature Diversity Act is an act of 2009, thus 20 years ago this act did not exist. The Red list of endangered species in each country has existed for a long time, but as most of saxicolous lichens and mosses are hard to identify, there has so far been little attention to if they grow on rock surfaces with rock art. If a rock art panel is located within a nature reserves, be especially aware of restrictions regarding the site. Our neighbour countries have acts too, to protect and manage their biological diversity.

Strengthening/consolidation/gluing

At rock surfaces with extensive weathering damage, consolidation (strengthening) has been and is still used. In Scandinavia, the most used and recommended consolidation material is Mowilith DM 123 S (Bjelland & Helberg 2006, Ernfridsson *et all.* 2019b). The experience with Mowilith from Rogaland is so far good, if water is not continuously flowing over the consolidated rock, then it is naturally not that stable. There is little information about different types of glue tested during the Norwegian Rock Art project or in other projects (Bjelland & Helberg 2006). As far as we know there have been no scientific publication regarding the evaluation of the long-term effect of other consolidates in our climate.

Management and monitoring

The objective of management is to safeguard the value of rock art through physical protection of the locality/panel and its immediate environment. Management can include different types of preventive conservation actions, including maintenance and presentation, communication of the significance, and vulnerability of the rock art (Bjelland & Helberg 2006).

It is important and necessary to have a following up plan or a management plan for each site to prevent further damage to the rock art panel. This will make it easier to avoid direct action on the rock art panel in the future. Further, the short-term effect could indicate a positive effect, while the long-term effect could turn out to be negative. Ideally, each site ought to be visited every year.

During management of the rock art site, it is important to be aware of potential archaeological materials within the soil close to the site or in the cracks on the rock art panel (Lødøen & Mandt 2010). Thus, the effort to conserve rock art sites should even include the underlaying source material (Lødøen & Mandt 2010).

Monitoring forms a central element in all management and conservation, and is an important aid in the protection of rock art. It could be periodic inspection and methods with a technical and long-term character. Monitoring helps us to study relationship between action and effect and helps us to point out problems before they become serious (Bjelland & Helberg 2006). An example of a remedy in monitoring rock art, is to use a unifying system like Intrasis.

Concluding remarks

The world moves on, and even after 20-years the rapid technological change has affected methods used in documentation of rock art in a positive direction. Today, both the practical carrying-out, results and, not at least, the costs of e.g. 3D-scanning is much cheaper than during the Rock Art Project. Landscape documentation with drones, and user-friendly database systems combining a complex database and geographical tool, are other methods which were science fiction, and at that time unthinkable. Hopefully, the documentation process for rock art will even continue getting better, as technol-

ogy keep improving. It is a fact; documentation of rock art is still alpha and omega. Open-air cultural heritage is especially affected by the impacts of climate change at present and in the future. We don't know the consequences of climatic change for rock art in Rogaland, or the rest of Norway, and we need more scientific research to be better prepared to respond to them effectively.

The Norwegian rock art project-initiated work has given valuable new information about processes related to degradation, conservation, and management. However, there are still many unsolved questions. Further, after more than 20-years of practice, it is obvious how a long-term perspective is especially essential for open-air cultural heritage. We must still be patient and wait for the results of the long-term effects of some of our acts and methods tested. To proceed in research regarding preservation and management of rock art, new science is essential. And as new science is available, recommendations might change. All used and recommended methods regarding conservation must always be science-based.

Torbjørg Bjelland
Archaeological Museum of Stavanger, Department of Conservation,
University of Stavanger 4036, Norway
torbjorg.bjelland@uis.no (author of correspondence)

Gitte Kjeldsen
Archaeological Museum of Stavanger, Department of Collection,
University of Stavanger 4036, Norway
gitte.kjeldsen@uis.no

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