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A MULTIDISCIPLINARY APPROACH TO CONSERVATION OF ROCK ART IN HONNHAMMER, NORWAY

Keywords: rock art, Stone Age, x-ray
fluorescence, Honnhammer, multidisciplinary, nanoparticle consolidation

ABSTRACT

The rock art paintings in Honnhammer, Norway are endangered due to the visible deterioration of the stone on which they are painted. The surrounding landscape, weathering rock surface, painting materials and techniques, local climate, and biodegradation have all had a significant impact on the appearance and state of preservation of the paintings. Consolidation of the most seriously affected paintings is necessary, preceded by thorough research to guide a well-informed intervention. This paper highlights the results of multidisciplinary attempts to document the paintings and examine their state of conservation at different stages. The application of a temporary consolidation method is described and a suggestion is made regarding a potential long-term conservation treatment.

RÉSUMÉ

Les peintures rupestres à Honnhammer, en Norvège, sont en péril en raison des dégradations apparentes de la roche sur laquelle elles sont peintes. Le paysage environnant, les altérations de la roche en surface, les matériaux et les techniques de peinture, le climat local et la biodégradation ont tous exercé un impact significatif sur l'apparence et l'état de conservation des peintures. La consolidation des peintures les plus sévèrement touchées est nécessaire, après avoir mené des recherches approfondies pour garantir une intervention pleinement informée. Cet article met l'accent sur les résultats de plusieurs initiatives multidisciplinaires destinées à documenter les peintures et examiner leur état de conservation à différents stades. L'application d'une méthode de consolidation temporaire est décrite et un traitement possible de conservation à long terme est suggéré.

INTRODUCTION

The rock art at Honnhammer is divided between “Honnhamneset” and “Hinna”, in Tingvoll in the county of Møre and Romsdal, Norway (Figure 1). There are seven known sites with groups of rock paintings comprising around 30 figures and figure fragments. Site VII, while recorded, is not known today. The paintings are situated on steep walls (80–90°) and one site is in a rock overhang. The sites face southwest towards the Tingvoll fjord. Today they are between 10 and 30 meters above sea level. The rock paintings date to the Stone Age, 4000 to 1800 BC. The motifs consist of moose, deer, fish and geometrical patterns.

HISTORY OF THE SITE

During the summer of 1773, bishop Johan Ernst Gunnerus and Professor Gerhard Schøning travelled from Trondheim through North Møre. In an account of his journey published in 1778, Schøning described a figure on a rock surface close to the farm of Hindhammer at the Tingvoll fjord and recorded his impression that the figure was not man-made. In 1879, B.E. Bendixen ascribed the rock paintings of site I to Dutch or Scottish seamen. At the beginning of the 20th century, Gutorm Gjessing and Gustaf Hallström rediscovered the paintings (sites I, II and III) and dated them to the Stone Age. Hallström also wrote about red paint traces under site II, which is now named site VIII. The paintings at sites IV and V were discovered by two locals, Egil and Lars Arild Nielsen, in 1987¹. Kalle Sogannes, from the Museum of Science and Technology in Trondheim, confirmed the existence of these rock paintings in 1990. He also found other paintings in Hinna and Honnhamneset during the early 1990s (Lindgaard 2002).

PREHISTORIC FINDS

No archaeological excavation has been conducted so far for remains that could shed light on the interpretation of the rock art. Archaeological surveys have revealed several grave-mounds close to the rock paintings at Honnhamneset. At three farms in the neighbourhood, Bergsli, Sagli and Skar, flint tools from the older Stone Age (10,000 to 4000 BC) were found (Lindgaard 2002).

RESUMEN

El arte rupestre de Honnhammer, en Noruega, está en peligro debido al visible deterioro de la piedra en la que ha sido pintado. El paisaje que lo rodea, el intemperismo de la superficie rocosa, los materiales y técnicas pictóricas, el clima local y la biodegradación han tenido un impacto significativo en el aspecto y estado de conservación de estas pinturas. Es necesario consolidar aquellas pinturas que se encuentren más gravemente afectadas, precedida por una investigación detallada que sirva de guía para una intervención informada. Este artículo destaca los resultados de varios intentos de acción multidisciplinaria para documentar las pinturas y evaluar su estado de conservación en diferentes fases. Se describe la aplicación de un método de consolidación temporal y se propone una opción en relación con un posible tratamiento de conservación a largo plazo.

MULTIDISCIPLINARY COOPERATION

The Norwegian Directorate for Cultural Heritage started a rock art protection program in 1996. During the next ten years the condition of the rock art in Norway was documented and plans were developed to protect 300 selected sites, including Honnhammer. A group of national experts drawn from different professions – archaeology, geology, botany, chemistry and conservation – collaborated on the study and documentation of the rock art. By the time the project was concluded in 2005, it was reported that better knowledge and experience about the rock art and promotion of collaborative engagement had been achieved (Hygen 2006).

The rock paintings in Honnhammer are mostly painted on a very thin rock layer measuring approximately 1 mm. At sites II and VIII in particular this thin rock layer is flaking off badly (Figure 2). There has been increased flaking and losses have been observed during recent years. Although documentation of their condition is insufficient in itself, it paves the way for proper conservation strategies. In 2005 conservators were involved in assessing the damage and evaluating the conditions. The damages are complex and an appropriate consolidation method has to meet many requirements. The relationship between the condition of the paintings and the environment is also complex. To understand some of the environmental influences, all the archival data was reviewed and new data was collected to gain better insight into the relationship between the climate, the stone and the painting materials.

The main focus of recent research is site VIII; this is the most challenging site as it is in a critically unstable condition. Site II, nearby, also has many of the same problems; however, it is much less accessible since it requires a difficult climb. The other sites are in a relatively better state of preservation. The main figure of site VIII shows a cross with two zigzag lines over it. The figure is 58 × 41 cm and some reddish paint is washed out (Figure 3).

In June 1992 the first documented treatment was conducted (Sognnes 1992). At that time site VIII was completely overgrown with dark and thick lichen (Figure 4), which was removed in order to document the site. During a warm, dry period, this site was first cleaned mechanically with a brush, then a fungicide with the product name “Pingo” was sprayed over the rock surface.

Site VIII was thoroughly described in 1997 when archaeologists, geologists and botanists visited Honnhammerneset and Hinna. Archaeologists stated that the damages were moderate to critical, and urgent control of the conditions was recommended as parts of the stone layer were flaking off.

Examination by geologists provided further information on the stone’s condition. Stone samples taken from sites I and III were analysed by transmission and scanning electron microscopy (SEM). The rocks were determined to be granitic gneiss, consisting of medium to large grains. The upper layer of the rock was flaking off, especially along the cracks. The

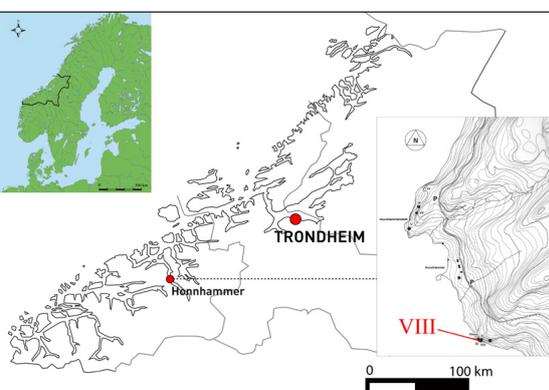


Figure 1
Map of Scandinavia, Middle Norway and Honnhammer

main mineral grains detected were microcline, quartz, plagioclase, biotite and epidote. Some of the biotite grains close to the surface were exposed and were in danger of disintegration. No samples were taken from site VIII (Ronaldset and Prestvik 1998). A geologist later described the flaking off of the thin upper granite rock layer at site VIII as being related to cooling stress at the time when the stone reached the surface of the earth's mantle and he compared this process to "peeling off an onion" (Binns 2008).

Botanists documented both macro and micro vegetation. In 1997 some parts of site VIII appeared to have no lichen or moss, while three types of lichen and one moss were identified on other parts of the stone surface (Bruteig and Moila 1997). *Parmelia omphalodes* var. *discordans* was widespread over the surface; the lichen appeared dark brown in colour and was strongly bound to the stone surface. *Racomitrium lanuginosum*, a moss, was the second most widespread biological infestation in this area; it had a grey appearance and was very loosely attached to the stone. *Rhizocarpon* sp., an undefined lichen type, covered less than 10 percent of the stone surface; it appeared yellowish, created a crust and was attached very firmly to the stone. The last documented lichen was the grey *Lepraria* sp., also an undefined species. This type is sterile and must be identified by chemical tests. The spreading was minimal, but it was firmly attached to the stone. The lichen and moss have been largely removed, but in their place a soft blackish micro-vegetation is now growing in between the parent rock and the thin upper stone layer containing the painting. It has not been identified, but appears to be a type of algae or bacteria.



Figure 2
Detail of the damages from site VIII. Photo:
D. Pawel, NTNU-VM

DAMAGES

At the left side of the cross figure, the stone layer with the painting is peeling off the parent rock. A number of factors are contributing to this process, such as the natural process of rock formation that started millions of years ago, and the tendency of the rock to undergo exfoliation as well as chemical dissolution and physical weathering of the outer layer. Water moving through the cracks in the rock exacerbates the damage. The most critical condition occurs when the water finds its way through the deep stone cracks and in between the stone layers. The expansion and contraction of water in the freeze-melt cycle leads to detachment of the thin stone layer. Before the 1990 intervention, micro vegetation covered the cross figure. The roots of the lichen and moss grow into the stone, promoting bio-deterioration. The new biological growth between the thin upper stone layer and the solid stone extends the damages. The painting's location on a cliff side open to the fjord, wind, sun and rain has hastened the deterioration.

CONSOLIDATION

Early attempts

The first attempt at consolidation was made in 2005 (Norsted 2005). At that time many flakes were nearly falling off the rock painting at site VIII.



Figure 3

Overview of site II (the upper site) and VIII in 2009. Photo: D. Pawel, NTNU-VM

Figure 4

Condition at sites II and VIII in 1990. Photo: L. Smith, NTNU-VM

These dramatic conditions led to a consolidation experiment using epoxy with some lead white pigment to kill the biological growth. The test field was approximately one meter from the cross figure. It was concluded that a better consolidation technique and medium needed to be developed. In 2006 epoxy was used again but without lead white pigment (Norsted 2006). Epoxy was chosen once more because of the site's exposure to widely varying weather and the fear that parts of the painting were on the verge of detaching. In 2007 stone conservators were invited to participate in an attempt to find an effective consolidation medium. Over time more and more algae had grown under the painted foliating stone layer. The application technique therefore had to include a cleaning process before a viable consolidation treatment could be applied. It was clear that research into an effective consolidation intervention would take time, thus steering the focus to a temporary consolidation.

Temporary consolidation

In preparation for future consolidation, certain tests were carried out. The water absorption of the stone was tested by the "Karsten's tube method" on heavily weathered and intact stone surfaces. As anticipated, the weathered stone surface took up quite a lot more water than the intact stone surface. This has to be taken into account because a temporary consolidation medium should not penetrate too deeply into the damaged stone since it could be difficult to remove before the final consolidation. In the end cyclododecane was chosen as a volatile consolidation system which would ideally allow for several more years of research, while preventing aggravated deterioration from environmental exposure. Cyclododecane disappears without leaving traces, especially in outdoor conditions of wind and sun exposure. In order to slow down this process it was necessary to find a coating for the cyclododecane that blocks unwanted evaporation. Tests have been carried out in Germany to find the best coating material for this purpose. Since the consolidation medium should not transmit deep into the stone, the cyclododecane was applied as a melt. Test areas with different weather exposures were chosen, all of them located in proximity to the rock paintings. The layer of cyclododecane covered an area slightly larger than that of the heavily weathered stone. A coating layer was applied over the cyclododecane to avoid rapid sublimation, in such a way as to leave a small border of freestanding cyclododecane to avoid contamination of the stone by the coating material. The whitish surface of the test areas was then camouflaged with moss, lichen and sand from the nearby locality. The cyclododecane sublimates along the interface, leaving the coating layer over the stone surface (Schmeikal and Seibel 2008). In August 2009 an additional temporary consolidation test was applied closer to the rock painting at site VIII. In the summer of 2010 this sample was found broken into small pieces and scattered around, whereas most of the other test areas were still attached to the stone. The cause of damage could not be found, but it appears likely to have

been the result of human intervention. This experience suggests that there is risk associated with applying this temporary treatment method over the damaged rock painting.

Suggested consolidation

The vertical orientation of the rock paintings, the nature of the painting materials and the complex causes of damage make the search for an appropriate consolidation method challenging. The application technique and the consolidation medium must fulfil many demands, including applying the consolidant to a vertical painting panel, compatibility with the rock material, ability to withstand the wide variation in temperature and moisture, as well as exposure to direct sun and wind. Most traditional consolidation materials, such as epoxy, will create a thin layer that affects the physical condition of the stone. They may eventually exacerbate the deterioration process by creating greater thermal expansion or/and an impermeable layer in the stone (Scott et al. 2002). Ideally the consolidation medium should be compatible with the stone composition after treatment to ensure that the consolidated stone layer behaves identically to the surrounding untreated stone.

Lime or lime-based products meet the demands of fresco paintings to some extent; however, limewater is too weak a consolidation medium for stone. Even a saturated limewater solution would not be strong enough and would leave whitish traces onto the surface of the stone. On the other hand, $\text{Ca}(\text{OH})_2$ -based and similar nanoparticles dispersed in short chained aliphatic alcohols are being developed and have been applied for more than ten years to consolidate frescoes (Giorgi et al. 2000, Ambrosi et al. 2001). The extremely small particle size, the ability to penetrate deep into damaged areas, and high and quick reactivity in the treated area are promising features for applying the method to rock art consolidation (Giorgi et al. 2010). As lime is less likely to be an effective consolidant for this particular purpose, the nanoparticle-based approach could be effective if tried with other materials compatible with granitic rock. More research needs to be conducted in this regard.

CLIMATE OBSERVATION

It is necessary to obtain information about the temperature and moisture of the rock painting surroundings as these are regarded as the most important environmental factors affecting weathering. The data on maximum and minimum temperature as well as the number of freeze-melt cycles will determine whether a particular consolidation medium is suitable for Honnhammer. In June 2008 two data loggers were installed close to site VIII to provide hourly temperature and relative humidity monitoring of the painting locality. Although the rock painting location is not well known to the wider public, local people tend to visit it from time to time; therefore, the data logger located on a tree to measure the open air climate has been camouflaged. The other data logger is in direct contact with a stone surface fixed to roots of a tree (Figures 5, 6).

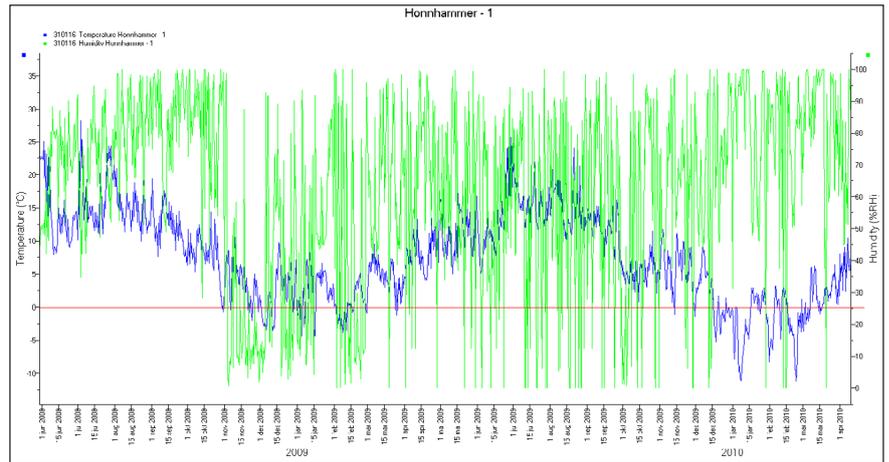


Figure 5
Graph with climate data for air (1)

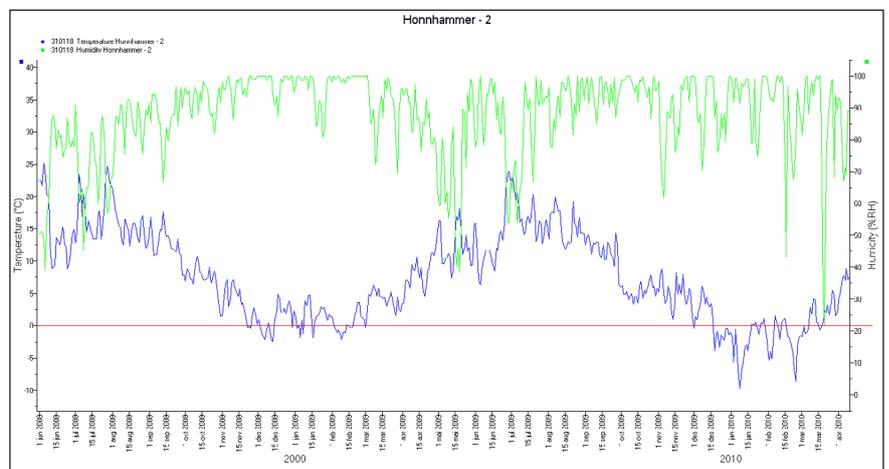


Figure 6
Graph with climate data for stone (2)

The climate data show a temperature change on the stone surface ranging from -10°C to 38°C . The main freezing and melting cycles at the stone surface occur between November and March. The wide variation observed in temperature and humidity indicates the extent to which the weathering of the rock surface can be attributed to climate. Considering the high porosity and strong water absorption as indicated by tests using “Karsten’s tube method”, the wide fluctuation in moisture on the weathered granite will have a strong impact on its state of conservation. Appropriate materials and techniques compatible with these cycles of weather variation must be chosen for effective consolidation.

CHEMICAL INVESTIGATION

A portable, hand-held X-ray fluorescence (XRF) analyser was used in situ in 2009 for preliminary identification of inorganic elements in the painting and rock materials. The results of this investigation can also be used for targeted sampling, for example, to characterize particular deterioration products. Soluble salts were detected in the whitened trace left by water oozing from the overhanging rock in site I. The

analyser was also used to compare the relative concentration of iron in the painted portions within a single figure and among the paintings at the sites investigated. The results obtained are in accordance with the visible degree of colour fading. Iron was detected in all the red paintings, indicating the possible use of red ochre at all sites (Figure 7). The purplish-red hues with a greasy appearance in the figures at site I contained the highest concentration of iron. The non-painted rock was also found to contain iron, although often at a lower level than that obtained in the paintings. This is attributed to iron-bearing rock components. The site of greatest interest in this examination, site VIII,

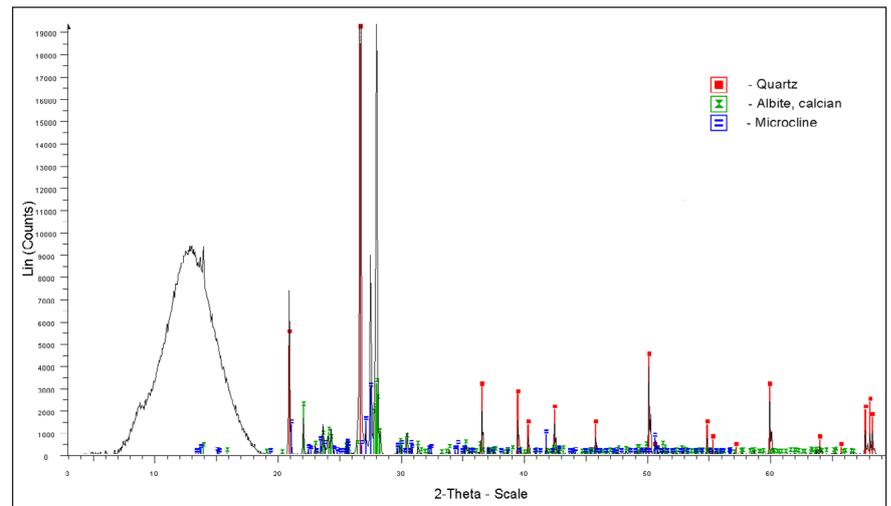


Figure 7

XRF spectrum of the red paint on the cross figure of site VIII indicating the presence of iron

has paint with a low concentration of iron. In order to enhance the light element detection, the XRF analyser was purged with helium gas in an attempt to detect soluble salt indicator elements on the surface. The analysis gave a negative result as most of the weathering soluble salts had been washed away from the surface.

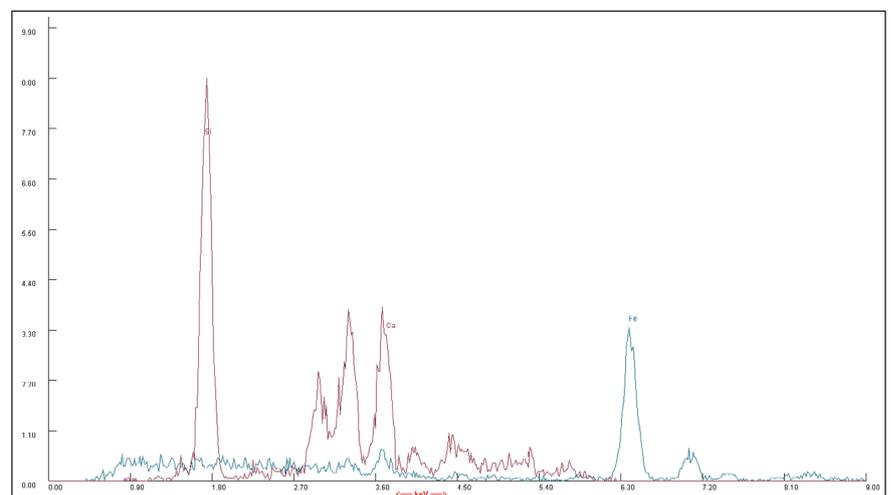


Figure 8

XRD spectrum of rock sample collected from site VIII

Rock samples taken from the ground in the vicinity of site VIII were examined by X-ray diffraction (XRD). The results revealed the rock materials to be typical of granite, with quartz, albite and microcline also detected (Figure 8). Scanning electron microscopy-energy dispersive X-ray spectroscopy (SEM-EDS) investigation of similar samples indicated these minerals plus additional ones such as biotite, hornblende and muscovite. Microscopic analyses under cross-polarized light indicated muscovite by its characteristic interference colours showing high birefringence. SEM-EDS analysis carried out on grains of pigment samples taken from the site VIII painting indicated the use of red ochre. Further investigations on samples collected from this and other sites are underway using a combination of analytical techniques. The main purpose of these analyses is to identify the type of pigments and additives used. Attempts will also be made to get some insight into the methods used in the preparation of the pigments and changes brought about in the composition of the colouring materials due to environmental factors. Besides the importance of this kind of information for conservation decision-making, for example, the selection of an appropriate consolidation medium, it can be helpful in comparative archaeological investigations.

CONCLUSION

Since the discovery of the rock paintings in Honnhammer, various studies from a number of multidisciplinary fields have been conducted, leading to better knowledge about the paintings. This approach should be strengthened to enable further well-informed intervention and management of the rock art sites. Monitoring of the local climate will continue. Attempts will be made to test effective consolidation based on diverse nanoparticle materials in a laboratory setting and close to the rock painting site before it is applied to the deteriorating figure. This in turn will lead to even more multidisciplinary collaboration.

ACKNOWLEDGEMENTS

The authors express their gratitude to all the professionals that have contributed to a broader knowledge of this site. Special thanks go to stone conservator Katja Schmeikal for her research on the temporary consolidation method. Financial support from the Norwegian Directorate for Cultural Heritage and Norwegian University of Science and Technology - Museum of Natural History and Archaeology is gratefully acknowledged.

NOTE

¹ Newspaper article from Saturday, 15 August 1987, *Aura Avis*, Norway.

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