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WET ORGANIC ARCHAEOLOGICAL MATERIALS

Wet archaeological leather conservation: A survey of contemporary practice in the Nordic countries

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Abstract

The aim of the ongoing Trondheim Archaeological Leather Project (TALP) is to carry out a review of past and present methods used for the conservation of wet archaeological leather at NTNU University Museum and other institutions to highlight possible needs for re-evaluation and development. Contemporary methods used to conserve wet leather in the Nordic countries were mapped using a qualitative semi-structured interview survey study of fourteen institutions. PEG 400 impregnation in combination with vacuum or atmospheric freeze-drying continues to be the most common method, with each institution having its own version. An inter-collection condition assessment, the impact of chemical cleaning, and the use of higher molecular weight PEGs are areas identified for future collaborative research. The use of both qualitative semi-structured interview and thematic analysis methods is not common in conservation research. Although very time consuming, this semi-structured text-based data approach was appropriately rigorous for this study.

INTRODUCTION

A large influx of wet archaeological leather artifacts from recent excavations in the medieval city of Trondheim, Norway, initiated the need and opportunity to re-evaluate conservation methods in use for this material at NTNU University Museum (VM). The Trondheim Archaeological Leather Project (TALP) (2019–2023) developed to systematically and formally address this. The aim of TALP is threefold and organized in three work packages: (1) a state-of-the art literature review of the conservation of wet archaeological leather; (2) a qualitative interview survey study of current practice in the Nordic countries; and (3) a condition assessment of VM's stored conserved collection and method development.[1]

VM has a well-documented history of wet archaeological leather conservation (Peacock 2001). In the 1970s–80s, extensive redevelopment-led excavations in Trondheim recovered quantities of leather materials on a scale not previously experienced. Initially, conservation methods based on replacing the water with natural and synthetic oils and waxes were used. Following the discovery in 1980 of mold infestation in the conserved collections housed in unmonitored, uncontrolled post-treatment stores, the methods were re-evaluated (Peacock 1984). Impregnation with polyethylene glycol (PEG) 400 in combination with glycerol followed by vacuum freeze-drying became the principal conservation method (1983–2019) (Peacock 2001). Similar method development was carried out at other institutions, coinciding with the introduction of and access to freeze-drying. Fat-based conservation methods, often combined with solvent drying, were gradually abandoned in favor of water-based, low molecular weight (LMW) PEGs and/or glycerol impregnation in combination with freeze-drying (see Starling 1984, Jensen 1987, Cameron et al. 2006). Most literature reviewed compares these methods or variations thereupon (e.g., Williams and Harnett 1998, Botfeldt et al. 2009, Graham and Karsten 2011, Storch et al. 2016), which have dominated in the Nordic countries and further afield since the late 1980s.

There has long been concern both about the use of LMW PEGs and, especially, glycerol for the impregnation of wet archaeological leather. In particular, the long-term chemical stability and hygroscopic nature of these agents have been suggested to pose a risk to conserved objects (e.g., Ganiaris et al. 1982). The results of several follow-up condition studies of LMW PEG- and glycerol-treated objects in longer-term storage

report minor (Bonnot-Diconne and Barthez 1998, Goodman et al. 2016) to moderate (Williams and Harnett 1998) signs of degradation.

No published inter-institutional comparative surveys of current methods were found. There are several method-comparison studies that focus on one or more methods in use at an individual institution or in a small group of institutions (e.g., Montembault 2001, Botfeldt et al. 2009, Lafrance 2012). The European JPI-CH project "Development of storage and assessment methods suited for organic archaeological artefacts (StAr)" (2020–2023) is studying the effect of storage of archaeological leather (among other materials) pre- and post-treatment at several institutions (Ribechini et al. 2022, The Research Council of Norway n.d.).

A noteworthy outcome of the literature review is a lack of comprehensive comparative practitioner overviews of current methods for the conservation of wet archaeological leather. To address this practitioner overview gap, it was decided to carry out an interview survey study of colleague institutions with practical experience in this field (WP2). Its geographical scope was limited to conservation institutions and museums in the Nordic countries. This paper focuses on WP2, namely the qualitative interview survey study of colleague institutions. The first part introduces the methods of data collection and analysis employed, whereas the second part presents the results of the interview survey, including the needs for further research uncovered in the study.

PART I—DATA COLLECTION USING INTERVIEWS

Qualitative semi-structured interviews

Based upon our experiences with an ever-increasing number of conservation questionnaire requests, especially by mailshot e-mail, it was surmised that a personal invitation to a conversation would be more appealing to colleagues than an anonymous questionnaire. It would be less time consuming for interviewees, requiring no form filling, elicit extensive replies, and would maximize the response rate. Practicing conservators are familiar with the use of questionnaire survey studies; however, an informal literature search of questionnaire survey data collection and analysis strategies conducted in conservation-related studies highlighted the extent to which many of these lack research rigor.

The qualitative semi-structured interview survey method was selected for the data collection in this study. Nilsson (2005) used this method in her survey of support methods for costume conservation. This method typically consists of a dialogue between researcher and participant, guided by a flexible interview protocol and supplemented by follow-up questions. The method allows for the collection of qualitative, open-ended data from informants who have personal experiences with the topic of interest (DeJonckheere and Vaughn 2019). It is a method that can produce highly meaningful results even when a study is small-scale.

The questions were preset and specific but did not have fixed multiple-choice answers. Relevant information provided during the interviews that did not address the questions was recorded as well. New questions were added to the questionnaire for upcoming interviews and were sent out to

previously interviewed institutions in follow-up correspondence, together with an update on the progress of the project. The interview was pilot tested to systematically trial the questions and protocol (Peacock et al. 2022).

The TALP survey study was registered with and approved by the Norwegian Center for Research Data (NSD), required for all research carried out in Norway that collects personal data. NSD ensures that a project manages personal data in accordance with European law. In line with NSD guidelines, a letter of consent and project description, together with an interview request, were sent out by e-mail to potential participant institutions. Invited participants were informed that they could refuse to answer questions or withdraw at any time. Those that agreed to participate were sent the list of questions prior to the interview.

Twenty-five conservation laboratories and museums in all five Nordic countries were contacted via e-mail; of these, eighteen responded. Four replied that they had little or no leather conservation activities and were not interviewed. The response time for the initial contact varied from a few days to several months. Conservators representing fourteen institutions in Denmark, Finland, Norway, and Sweden consented to be interviewed. The institutions are listed in Table 1, with each institution's associated number used when referenced in Part II.

Interviews were carried out between 2019 and 2022 by telephone or video chat and recorded for later transcribing. The transcribed interview was sent to the interviewed conservator for approval. Upon approval, the conservator's name was removed and replaced with that of their institution; the audio file was permanently deleted.

Table 1. List of interviewed institutions in alphabetical order

1. Acta KonserveringsCentrum AB (SE) (https://www.actakonservering.se/english.html)
2. Kalmar läns museum (SE) (https://kalmarlansmuseum.se/en/)
3. Kansallismuseo (FI) (https://www.kansallismuseo.fi/en/kansallismuseo)
4. Konservointipalvelu Löytö Oy (FI) (https://www.konservointiloyto.fi/)
5. Kulturhistorisk museum (NO) (https://www.khm.uio.no/english/index.html)
6. Langelands Museum (DK) (https://langelandsmuseum.com)
7. Lunds universitets Historiska museet (SE) (https://www.historiskamuseet.lu.se/english)
8. Norsk Maritimt Museum (NO) (https://marmuseum.no/en)
9. Det danske Nationalmuseet (DK) (https://en.natmus.dk/museums-and-palaces/the-national-museum-of-denmark/)
10. Norges arktiske universitetsmuseum (NO) (https://en.uit.no/tmu)
11. NTNU Vitenskapsmuseet (NO) (https://www.ntnu.edu/museum)
12. Odense Bys Museer (DK) (https://museumodense.dk/en/)
13. Studio Västsvensk Konservering (SE) (https://www.vgregion.se/f/kulturutveckling/natur-och-kulturarv/konservering)
14. Vasamuseet (SE) * (https://www.vasamuseet.se/en)

* No. 14 carries out preventive conservation, condition assessment, and re-conservation of older finds and is excluded from results concerning conservation of newly excavated leather.

Qualitative thematic analysis

Although the data analysis strategy method was investigated during the planning stages of data collection, it was not until after the pilot interview study that the final method was selected. A qualitative thematic data analysis strategy was developed using mainly pre-defined themes and codes. The general process for analyzing and interpreting most interviews involves reviewing the data, applying descriptive codes, and condensing and categorizing codes to look for patterns (Ziebland and McPherson 2006, DeJonckheere and Vaughn 2019). Computer-assisted qualitative data analysis (CAQDAS) packages are available to manage data manipulation. Simply labeling and storing data in different files using a word-processing program is an option, and the one that was used. This was complemented by "OSOP" ("one sheet of paper") analysis to summarize issues within each theme (Ziebland and McPherson 2006).

The first step of the analysis was to define the themes, for which the interview questions were used. A digital document was created for each question and all interview replies were entered into the document and sorted by institution. The second step was to define codes for each theme. Codes were used to sort information and are more specific than themes. For example, the question "Which type of wet leather objects do you work with?" had the following codes: marine, terrestrial, urban, rural, prehistoric before AD 1000, medieval AD 1000–1537, post-medieval, specific objects, composites, and leather only. Each code was assigned a color that was subsequently used to identify parts of the document relating to that specific code. When defining the codes, the level of information detail needed to be decided. For example, to code the period of the objects, the broad categories—prehistoric, medieval, and post-medieval—were selected and corresponded closely with the degree of detail in the replies. When more specific information needed to be extracted from the transcripts, a worksheet was created. Relevant information was color-coded and then detailed information such as PEG concentration was entered.

Discussion—Qualitative data collection and analysis

The respondents found the interview questionnaire easy to understand. Anything that was unclear was clarified during the interview. All interviewees had read the questions in advance and prepared for the interview, which took 15–20 minutes to conduct. The conservators who partook in the study were all friendly, helpful, and enthusiastic about the project.

During transcription and data analysis, it was discovered that some questions had not been completely answered; consequently, follow-up questions were then sent out. This was especially the case for questions requiring detailed comparable answers, such as on impregnation methods where temperature, concentration, or duration were not provided. The need for further research was not directly addressed in the initial questionnaire. Several institutions shared their view on the topic, and the question was sent out by follow-up e-mail(s) to all those who had not already answered. This was also the case for the topic of condition assessment before conservation and its impact on choice of conservation method.

One topic that came to light during subsequent data analysis that was not included in either the primary or follow-up correspondence was microbial growth during wet storage and impregnation. This was identified too late in the survey process and the topic was not pursued. The authors found the semi-structured qualitative interview survey method provides comparable answers and encourages dialogue while minimizing misunderstanding(s). Some questions, such as those about impregnation and freeze-drying methods, could have been more structured and could have benefited from predefined multiple-choice answers. The overriding drawback was the long response times. In the initial contact phase, replies could take several months; some institutions did not reply at all. During post-interview correspondence, all institutions replied, again with response times of a few days to several months.

Qualitative thematic analysis enabled a systematic yet flexible sorting of textural information. If additional or more-detailed coding was needed during the process, this was simple to add to the working documents. Information could be sorted and coded parallel with data collection, because adding new replies did not affect previous work. In hindsight, it would have been more efficient to have begun analyzing the replies at an earlier stage in the interview process. Information that was found lacking in the early interviews could have been gathered in ensuing interviews, reducing the amount of back-and-forth follow-up correspondence and delay. Thematic analysis was time consuming but saved time because it was easy to go back and follow our train of thought during review and quality control of the replies.

PART II—CONSERVATION OF WET ARCHAEOLOGICAL LEATHER IN THE NORDIC COUNTRIES

The findings of the interviews and follow-up discussions with institutions in the Nordic countries are reported according to the sequence of the questionnaire as follows: what types of objects are conserved, what methods are used, how satisfied the conservators are with the results, and what they view as important topics for future research.

Types of objects and pre-conservation storage

The most common types of wet archaeological leather artifacts conserved in the Nordic countries are shoes and parts of shoes, mainly from urban contexts but also from marine contexts. Only one institution conserves archaeological leather objects from rural contexts (10); prehistoric leather finds are rare. Seven institutions treat post-medieval finds (1, 2, 3, 4, 5, 7, 8). Non-composite leather objects are far more common than composites; twelve institutions occasionally treat composite objects, most commonly with wooden and/or metal parts (1–9, 11–13).

All institutions store leather wet and cool before treatment; one institution stores the leather frozen following initial cleaning (10). Ten institutions store items in plastic bags or foil with a small amount of water, with three storing them submerged in water (3, 5, 8). Of the latter, two conserved mainly marine finds (3, 8) and submersion in freshwater aids desalination.

Conservation treatments

The earliest systematic leather conservation reported in the interviews dates back to the 1960s (3, 11) and the latest to 2013 (12). Of methods in use today, the oldest have been in use since the 1980s (6, 13); only three institutions have further developed their methods since 2010: two in 2013 (8, 12) and one in 2019 (11). Seven institutions have over twenty years' experience with their current methods (1, 2, 3, 5, 6, 10, 13).

All but one institution condition-assess their objects before conservation and report that this influences the selected treatment: most commonly, the cleaning method and type and concentration of impregnation agent. It can also guide the impregnation bath temperature, the possibility to reshape the object (pre-treatment/post-treatment), and the choice and construction of packing material.

All institutions use water-based mechanical cleaning as the first step in the conservation process. Most institutions use chemical cleaning if deemed necessary. Ethylenediaminetetraacetic acid (EDTA) is used by three institutions as a chemical pre-treatment for most objects (1, 7, 12). Five institutions use EDTA on objects with visible iron contamination (4–6, 8, 10); two institutions use diethylenetriaminepentaacetic acid (DTPA) in a similar manner (3, 13). The institutions that use chemical cleaning report that it improves the color and flexibility of the objects. Heavily degraded objects are generally not chemically cleaned. Two institutions never use chemical cleaning (2, 11).

All institutions use a solution of PEG in water for impregnation prior to drying, with PEG 400 (concentrations of 10–30%) the standard molecular weight at nine of them (1, 2, 5–8, 12, 10, 13). One institution employs PEG 600 as its standard method (3). Two institutions use PEG 2000 (11) or a mixture of PEG 2000 and other molecular weight PEGs (9) (see Jensen 2022). One institution reported the use of glycerol in combination with PEG as part of its standard method (4). Ten institutions impregnate at room temperature (1, 3, 4, 6–8, 10–13) and four in cool storage (2, 5, 9). Most adjust their methods for deteriorated leather by changing the concentration; two add small amounts of PEG 600 or PEG 1500 (11 and 4, respectively) and two add glycerol (3, 8). Interviewees were not asked about microbial growth; however, five institutions mentioned cases during pre-treatment storage and/or impregnation (3, 4, 8, 11, 12) and two institutions reported no such issues (5, 7). This was not further investigated with the other institutions.

All institutions use freeze-drying as their principal drying method. Vacuum freeze-drying is most common, used at nine institutions (1, 2, 5–7, 9–11, 13), with two pre-freezing artifacts submerged in a solution of PEG 2000 (9) or water (11). Four institutions employ atmospheric freeze-drying (3, 4, 8, 12). Drying time is determined by weight change (1, 2, 6, 12), temperature (5, 11), and/or by visual and tactile inspection (4, 6–8, 10, 13). Drying time varies from less than one day (10) to several weeks (9) depending on the method and volume of leather.

No institutions reported impregnation using cellulose ethers (Lemoine and Bonnot-Diconne 2002) or silicone oil (Smith 2003).

Post-conservation storage and care

All institutions house the leather in materials recommended for storage of organic archaeological objects, such as archival paper, plastic boxes and bags, acid-free tissue, etc. The type of packaging is selected based on the shape and condition of the object. Fragmented objects and flat objects may be grouped in bags or boxes with or without support; whereas well-preserved objects may be reconstructed and stored on specially constructed supports. Eight institutions have climatized storage for their own objects, all with a relative humidity (RH) around 50% (4, 5, 9–12, 14). Two institutions store leather in storage facilities lacking RH control (2, 7). All these institutions report that their objects seem to be doing fine in these conditions. The institutions that carry out contracted conservation for other organizations do not have control over the storage environment once the objects leave their facilities (1, 4, 6, 8, 9, 13).

Satisfaction with current treatments and need for further research

All institutions are satisfied or mostly satisfied with the results of their current conservation method. None has set criteria for judging the success of the treatment or records the results systematically. All institutions report that their conservators use their senses and experience to assess the results. The most frequently mentioned criteria for treatment success are flexibility, surface touch, physical integrity, shrinkage, and color. Two institutions have carried out a condition assessment of previously treated material; one found the items to be in good condition (5), while the other (14) had observed concerning signs of deterioration. At the time of the interview, the latter was about to undertake a condition assessment of their collection and an eventual re-treatment project. Of the institutions that condition-assess for exhibitions, loans, etc., five have not noted any degrading of the objects over time (2, 3, 6, 7, 12). One noted surface sweating of LMW PEG and adjusted their method; they also noted some stiffening of objects (9).

Four institutions have published or presented work on the development of or experiences with their conservation methods for wet archaeological leather (5, 6, 9, 14); three institutions plan to do so (3, 11, 12).

The topic of further research generated a wide range of suggestions. The lack of long-term evaluation of treatment stability was the most frequently mentioned (2, 5, 11, 13, 14). Case studies and method descriptions on topics such as impregnation, drying, reconstruction, and supports for exhibition were requested (1–5, 10, 11, 13, 14). The need for sustainable conservation methods and research on re-conservation was mentioned by two institutions respectively (6, 12 and 13, 14). Additionally, the issue of microbial growth (11, 12) and investigating 3D-scanning as a documentation and monitoring tool (8) were recommended.

Discussion—Conservation methods and the need for further research

Results indicate no apparent correlation between the context, age, or type of object and choice of treatment method for finds. The thickness of the leather and condition of the objects do influence the choice of treatment.

Some institutions report that adjusting the concentration or adding glycerol or higher molecular weight PEGs when impregnating highly deteriorated objects improves the results. Chemical cleaning is reported to improve the color and flexibility of objects as well as aid in the removal of metal deposits on the surface. These are areas worthy of further investigation where collaboration between institutions would prove beneficial.

Long-term evaluation of different methods was the most requested topic for further research. Several institutions have used the same methods over several decades and a collaborative condition assessment study could provide valuable insight into the long-term effects of various treatments. Although no institution uses "standard" assessment criteria, most respondents mentioned them as being important when judging the results. This indicates that agreed-upon criteria could be established for a collaborative study.

CONCLUSION

The TALP study demonstrated that a qualitative semi-structured interview survey method, not common in conservation research, was well-suited to obtain a comprehensive comparative overview of current conservation practice. It allowed for an organic workflow with the possibility for follow-up dialogue(s) with interviewees throughout the analysis process. One drawback is that it is time consuming. Qualified thematic analysis worked well for sorting and analyzing the semi-structured interview data.

The study found that the Nordic countries have a similar approach to the conservation of wet archaeological leather. PEG 400 impregnation in combination with freeze-drying has long been and continues to be the principal method. Each institution has its own version of the method that it has developed and adjusted to fit its specific needs and preferences. A collective condition assessment of this resource would provide invaluable insights into the long-term stability of this method and inform the recommendation, or not, for its continued use. The impact of chemical cleaning and the use of higher molecular weight PEGs are topics where a collaborative study might provide valuable results.

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NOTES

[1] TALP WP3 investigates using PEG 2000 in combination with freezing in a shallow block of water followed by vacuum-freeze drying. This has been the primary method used since 2019. The subjective sensory-assessed results are promising, but a systematic review remains to be done.

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