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wall painting conservation

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Church of the Nativity of the Virgin, Gelati Monastery, Georgia

Wall painting conservation plan

SUMMARY

Defining and implementing a conservation plan for the Gelati wall paintings is a complex and long-term undertaking. Extensive and severe deterioration and damage from moisture and salts impose critical constraints on the normal range of conservation options, especially remedial treatment measures, which must now be viewed with extreme caution considering past failures, and current and future risks. As such, the conservation plan will be carried out according to rigorous, science-based criteria and be governed by recognized standards of theory and practice. Conservation measures will be selected to achieve greatest efficacy with least intervention. Recognizing that all conservation actions made to address an identified problem disrupt a pre-existing state, which may have unforeseen consequences, the conservation plan must be broad-based and carefully planned, and gradually implemented over long timeframes, and coordinated with other planned major fabric measures. Given their current state, the conservation of the wall paintings depends on a wider framework of passive environmental measures, which will themselves need to be adjusted to changes over the long term. Specific prerequisites of the conservation programme include further investigation and analysis of original technologies, in-depth salts investigations, establishing the moisture status of the fabric, the continuation and expansion of environmental monitoring and assessment, and establishing an improved monitoring base and system. For these components, specific additional expertise is generally required and access to better instrumentation and equipment. However, considering the multiple complexities involved in these areas of further investigation, it is also recommended that expertise is best provided based on broad-based consultation and consensus.

Although the limitations and risks of remedial intervention are well evidenced and recognized, ongoing loss of original materials and conditions of imminent risk need to be addressed by specific stabilization interventions. In addition to the normal range of acknowledged intervention criteria, such as stability, compatibility and retreatability/reversibility, the conditions and circumstances at

Gelati require emphasis on transparency of selected procedures; thorough testing and evaluation with respect to performance criteria and working properties; treatment based on prioritized need; minimal and localised interventions that are confined in their impact; gradual implementation; and surveillance and modification of outcomes. Specific stabilization and other treatments that are provisionally identified as being required include mechanical reduction/removal of salt efflorescence in selected trial areas; treatment of unsupported/separating plasterwork, based on the development of compatible repairs and grouts; replacement of failing repairs where these present risk to original materials; localized consolidation; and trials to reduce/remove modern applied materials.

1. Overview

Extensive and severe deterioration of the wall paintings at Gelati is ongoing due primarily to the adverse action of moisture and salts. The continuing effects and consequences of deterioration on the paintings are not fully known and remain to be better evaluated based on collected data. Complicating factors include the diverse nature of the wall paintings with respect to their differing periods of execution, and their varying technologies, states of preservation and treatment histories. A long-term, multi-component conservation plan is required for the wall paintings. This must take account of the following general circumstances and factors:

- **ongoing and permanent nature of deterioration:** that salt-related contamination is probably now a permanent addition of the fabric, which will continue to contribute to change over the long term;
- **dynamic conditions:** that salt conditions represent a dynamic situation, to which conservation efforts will require continual, evidence-based adjustment;
- **remedial treatment limitations:** that the efficacy of remedial treatment interventions will be constrained and limited by these deterioration conditions and circumstances;
- **coordination and integration with fabric measures:** that conservation measures directed at the wall paintings need to be carefully coordinated and integrated with wider measures carried out in relation to the fabric, in particular the controlled opening of the roof spaces and drying of the interior fabric;
- **dependency on passive environmental control:** that the conservation of the wall paintings under the prevailing conditions depends on being implemented in a wider framework of passive environmental measures, which will themselves need to be adjusted to changing circumstances over the long term.

In brief, the wall painting conditions represent a situation where imposed solutions made with the intention to arrest adverse change will cause greater harm than good. Conservation efforts are therefore best devised and implemented as a series of gradual and cautious long-term adjustments, which should be viewed as being part of an ongoing process of calibration to continual change.

2. General approach

The general approach to conserving the Gelati wall paintings is based on an agreed understanding of ethical considerations and technical constraints. Principles of site conservation oblige us to preserve wall paintings *in situ* in their existing condition and to focus our efforts on slowing deterioration.

Taking account of the past and current risks to the paintings, the task of their preservation is therefore best approached as a diagnostic undertaking, in which science-based decision-making maximises conservation efforts and their outcomes. Conservation measures are selected so that they achieve greatest efficacy with least intervention, choosing from preventive, passive and remedial options.

Thus, the **general intervention criteria** for the conservation of the wall paintings are:

- **preservation of significance;**
- **minimal intervention;**
- **knowledge of the original and added materials;**

- **understanding of physical history and present condition;**
- **knowledge of conservation materials and methods;**
- **retreatability / reversibility, stability, and compatibility;**
- **health and safety; and**
- **documentation.**

3. Prerequisites of the conservation programme

Knowledge acquisition and assessment will form the basis of the conservation programme, incorporating documentation and recording, condition assessment and deterioration diagnosis, investigation and analysis of original and added materials, investigation of the principal deteriogens (primarily salts) and environmental monitoring and assessment.

Some of these activities have been initiated and are ongoing. Other components need to be fully developed. To fulfil the wide-ranging remit of the conservation programme, a number of general and specific investigative requirements can be highlighted, as follows:

3.1 Salts investigations

Salts are the principal deteriogen adversely affecting the wall paintings. Rigorous site-based observations and studies are required to indicate the nature, extent and behaviour of the salt activity on the church interior, so as to define short- and long-term risks and determine appropriate mitigation measures.

Possible interventions, depending on the nature of the salts present, include:

- **preventive:** intervening against the principal salt sources;
- **passivation:** controlling the activation mechanisms of the salt phase changes (RH); or
- **reductive:** remedial interventions to remove/reduce salts from the wall paintings (eg, mechanical removal of efflorescence, aqueous extraction, conversion).

To inform conservation decision-making in relation to salts contamination, however, the following specific questions and issues need to be addressed in the pre-treatment phase of the conservation programme:

- **qualitative and quantitative analysis:** at present, very little is known about the nature of the salt-forming ions present in the fabric, their sources, quantities and distribution. The identification of the salts species present as efflorescences is essential, as this information will help indicate the environmental parameters for phase transitions, as well as suggest possible sources. It is also important to recognise that environmentally driven phase changes may result in the formation of different salts species under different conditions and at different times, so vigilance is required to ensure that consideration of salts contamination informs interpretation of environmental data and any environmental measures resulting from this. Identification of sources of salts is crucial in any attempt to control salts-related damage. This will inevitably require analysis of original and added materials constituting the fabric. Salts investigations may require a range of sample types, analytical techniques, and invasive or non-invasive sampling procedures, as shown in **table 1**, **overleaf**.

Expert advice and input are required to determine the most appropriate sampling and analytical approaches for the conditions at Gelati.

This must be a component of the conservation programme

Table 1: sampling types and analytical techniques for salt investigation of samples [after Bläuer Böhm 1996]:

sample type	invasive	information obtainable	analytical techniques
efflorescence sampling	no	qualitative for salt species	aqueous ion analysis; instrumental analysis (XRD, FTIR-ATR, IC etc.)
superficial fabric sampling	no	qualitative and semi-quantitative information on major salts-forming ions	aqueous ion analysis
incremental in-depth fabric sampling	yes	nature and stratigraphic distribution of major salts-forming ions	micro-core drilling into the fabric/ aqueous ion analysis/ instrumental analysis (FTIR etc.)
whole samples	yes	identification of salts sources; morphology; distribution within stratigraphy; elemental and limited species analysis	polarised light microscopy; cross-section/limited stain testing; SEM-EDS; thin-section etc.

- **salt sources and distribution:** salt sources are likely to be various, including from autochthonous and added materials (the latter including by-products of recent conservation materials), and mixed salts species can be expected to be present in the system.

  To diagnose risks and determine mitigation measures, salt sources and their distribution patterns (**topographically** and **stratigraphically**) need to be investigated and established. The

sampling procedures and analytical techniques summarised in **table 1** will play a role in this component of the salts investigations. Expert advice is again required. Other recommended components may need to include **specific salt mapping and visual characterization; survey and mapping of building materials; building materials characterization/analysis; assessment/analysis of added materials; suitability and applicability of ancillary techniques such as ion selective electrodes/ground penetrating radar etc. should be explored (also for liquid moisture investigations);**

- **rates of change:** the salts deterioration is a dynamic process, in which salt phase changes (and deterioration and loss of painting) occur in response to environmental fluctuations. A component of the investigations should include **multi-temporal and/or real-time monitoring** of salt activity, to enable correlations to be made with collected environmental data (see also **section 3.4 Monitoring**).

3.2 Liquid moisture status

A principal activation mechanism of deterioration has been rainwater infiltration/percolation through the fabric, mainly via the multiple roofs. Fabric investigations have been carried out to determine general moisture pathways, but the moisture status of the walling and vaults has not been investigated and established.

This must be incorporated as an essential component of the conservation plan.

Determining the moisture status of the fabric is key to understanding rates and processes of deterioration, and for sequencing conservation measures and interventions.

As with salts investigations, different *in-situ* procedures, both invasive and non-invasive, have been developed for investigating and/or measuring the moisture content of wall paintings and their porous supports. They include **infrared thermography, electrical resistance measuring and portable unilateral Nuclear Magnetic Resonance (NMR)**. For in-depth quantitative information, **core sampling** is traditionally utilised to provide gravimetric data about moisture content. It is, however, an invasive procedure.

It is recommended that the available procedures are reviewed and evaluated to determine and implement the most informative and safe investigative measures for the wall paintings at Gelati. Further expert advice and consultation may be required.

This investigative component must be carefully coordinated with the roofing works and the proposed opening-up of the fabric during these interventions. Combined salts and moisture investigations should also throw light on the extent to which the removal of the roofing materials will mitigate problems in the interior fabric, and whether these are necessary.

3.3 Original technology

The original technologies of the wall paintings are various, reflecting the work of different painting teams at different periods of time. Partly in consequence, diverse deterioration processes affect the plaster and paint materials, although a range of other factors – such as differing circumstances of condition, deterioration, environmental exposure and physical history – also influence the multiplicity of material changes in the original materials.

Inadequate understanding of these features and of the likely vulnerabilities of original materials to further deterioration or damage can lead to the adoption of inappropriate and potentially harmful conservation interventions.

To avoid this and determine safe treatment parameters, establishing a fuller understanding of the original materials and techniques of plastering and painting, and of their deterioration risks, is essential.

Areas of concern that can be highlighted for further investigation include:

- **binding media/glazes/coatings:** based on current investigations and observations, it can be safely assumed that the wall paintings utilised organic binding media, and there is a possibility that painting techniques also included organic glazes and coatings. The use, nature and extent of these materials remain to be fully explored. Their presence is a concern for two main reasons:

  (1) since these original materials may be vestigial and easily overlooked, risks of causing damage and loss from interventions (such as cleaning) are very high; and

  (2) the presence of these materials, even as trace remains, adds another component to the complex interrelationship of deterioration processes that affect the paintings, which need to be better understood to inform conservation decisions;

- **altering/altered paint materials:** the palette includes paint materials that have or are undergoing various forms of alteration and degradation. Preliminary analysis and examination of the paintings indicates that pigments present that are susceptible to physio-chemical change include azurite, smalt, lead pigments and possibly orpiment. These pigments are highly vulnerable to potential damage from a range of remedial treatment interventions due to their inherent deterioration tendencies. Observations suggest that the palette employed in the various parts of the church may be more various and complex than has been established during initial analysis. Other pigments used in the paintings may remain unrecognised or overlooked due to degradation.

- **plaster inclusions and their role in deterioration:** there are preliminary indications that aggregate and other component inclusions in the plasters may also be functional in deterioration processes. These need to be further characterized and identified.

Defining the range of risks associated with the original materials and technologies employed in the wall paintings is essential.

Since many aspects of aged wall painting technologies are difficult initially to recognise, let alone interpret and comprehend, further investigations must be planned and sequenced as a step-by-step undertaking, including the following components and procedures:

- **technology survey, examination, characterization and recording:** although studies and mapping of technological features are already underway, key technical questions need to be identified and addressed. For this, a technology-focused survey is required in which the visible phenomena are examined, characterized and recorded in detail. This will form the basis of the plan for further required investigation and analysis;

- **plan for further investigation and analysis, and phased implementation:** based on the findings of the technology survey, a plan of further investigation and analysis will be formulated. A multifaceted scientific approach is required to yield the best results. In accordance with current standards, this should privilege the complementary use of non-invasive analytical and imaging techniques alongside microscopic and instrumental analysis of samples.

  ***Implementing the investigative plan will therefore depend to a considerable extent on access to external expertise and equipment**, the nature and extent of which will be determined based on an evaluation of requirements.*

3.4 Environmental assessment and related investigations

Environmental monitoring has been ongoing at Gelati since 2020 [Sagaradze 2021]. Other hygrometric and micro-environmental studies have also been made [Massari 2021]. The collected data form a critical basis of knowledge about environmental effects on the paintings, but as the conservation programme progresses additional and/or expanded investigations are likely to be required. These may include the following:

- **reconfiguration/expansion of environmental monitoring:** the current configuration of environmental sensors may need to be reconfigured/increased/improved to reflect emerging data collection requirements. An important additional recording requirement is likely to be that of the roof spaces when these are opened up;

- **monitoring of separate micro-environments within the building envelope:** as the comprehensive remit of the conservation programme extends to all painted parts of the church interior, environmental monitoring will probably need to be also extended to side-chapels and other painted areas where there are separate micro-environments;

- **measurements of air change:** the rate of air change in the church probably has a significant effect on interior environmental conditions. Air movement may be influenced by the number and movement of visitors, the architectural layout of the interior, effects of ventilation, and diurnal and seasonal environmental variations. Measurements of air change may need to be

considered as a component of the environmental investigations. Complementary studies such as correlating environmental data with visitor numbers may also be required;

- **environmental control monitoring:** at some stage environmental monitoring will need to shift from evaluating existing conditions to those that incorporate stabilizing adjustments, formulated on the basis of collected data (eg, reducing ventilation, introducing closed door policies, etc.). Consideration will need to be given to how to select and implement fabric and other measures to stabilize microenvironment conditions, and how best to evaluate their effects;

- **hygroscopicity of original materials and contaminants:** the potential of original plaster and paint materials, and contaminants (principally salts) to absorb and desorb moisture may need to be investigated to determine risk parameters.

Understanding the dynamic nature of the environmental problems and the adjustments that need to be made to stabilize conditions at Gelati is a complex, multifaceted undertaking. As in other areas of knowledge acquisition, data collection may be viewed as the more straightforward component (although this must still be carried out on an informed basis and with appropriate expertise), whereas data interpretation is the more difficult task. More difficult still will be determining and implementing appropriate mitigation measures and assessing their impacts.

Additional expert advice and input are required to address these numerous issues. However, it is recommended that given the various complexities involved, this is not vested in a single person, but is approached as a wide-based, open and consultative endeavour. A collective body of expertise is required to review environmental protocols and collected data, and provide advice based on informed consensus.

3.5 Establishing an improved monitoring base and system

Many failings in conservation can be attributed to poor observation of effects over timeframes that are too short. Long-term multi-temporal studies are rare, despite their importance for assessing gradual processes of adverse change and evaluating the efficacy and durability of conservation measures.

Recognising that the conservation process at Gelati must be planned and implemented as a long-term endeavour, establishing an efficient monitoring base and system are key components. To date, periodic repeat recording of aspects of condition and deterioration has been based on traditional 2D imaging.

This needs to be improved to accommodate numerous aspects of gradual change on a micro-level over long time periods (eg, paint flake movement and loss; effects of decohesion, powdering and loss; and salt phase transitions and their effects on original materials).

The requirements of the monitoring base and system should include the following:

- accurate recording of 3D micro-conditions;

- accurate recording of visual phenomena such as changes in the appearance/opacity of painting surfaces;
- replicability of recording base over time;
- ability to extend monitoring to representative areas of concern, reflecting the widespread nature of the conservation problems;
- and technical sustainability/accessibility of the recording system (eg, shelf-life of software, accessibility of large electronic files, ease of dissemination and use, etc.).

To establish rates of adverse change consideration should be given to both **multi-temporal** and **real-time recording**.

Expert advice and input are required to determine the most appropriate monitoring procedures and equipment for the conditions at Gelati.

4. Planning and implementing remedial measures

Recent treatment failures and associated worsening of condition indicate the limitations of remedial options at Gelati. Even well-formulated remedial measures identified as necessary must now be viewed with extreme caution, recognising the high risks of exacerbating harm and causing other unintended consequences. A critical consideration is that salt contamination can be regarded as a permanent addition to the fabric, which introduces conditions of continual change that constrain remedial options and undermine their outcomes. ***A further important consideration that must be recognized is that the paintings cannot tolerate new cycles of major retreatment and treatment failure.***

Even so, ongoing loss of original materials and conditions of imminent risk of loss need to be addressed by specific stabilization interventions. It is not useful to view these conditions as emergency situations that require an immediate, one-time response, however. ***Rather, a cautious and incremental approach must be adopted based on a case-by-case evaluation of need, and the calibration of remedial treatments to particular and differing circumstances.***

The **general intervention criteria** for remedial treatments are listed in **section 2, General approach**, above. These provide the standard framework for planning and implementing stabilization interventions. The conditions and circumstances at Gelati require additional emphasis on the following criteria:

- **transparency of selected procedures:** documentation and disclosure of treatment rationale and methodology, and of proposed materials and procedures;

- **testing and evaluation:** that both the interventions and the materials used are properly scrutinised with respect to their **performance criteria** and **working properties**, based on recognized standards;

- **treatment based on prioritized need:** that areas of intervention are selected on the basis of essential need, which in this context may be defined as where loss of original material is occurring or can be judged to be imminent;

- **retreatability /reversibility, stability and compatibility:** that these criteria are applied with particular consideration of the risks associated with salt contamination (ie, selection of treatment materials and procedures that avoid or minimize water content and release; avoidance of film-forming materials that interfere with moisture movement; selection of treatment materials based on compatibility with original technologies, etc.);

- **confined impact:** given the constraints and risks of harm, treatments will also only be undertaken in areas where impacts and potential side-effects of interventions may be judged to be limited, based on pre-treatment assessment of conditions (eg, salt testing);

- **minimal and localized interventions:** that interventions are also confined in their number and extent;

- **gradual implementation:** that treatments are implemented on a gradual basis, allowing for assessment of results over long timeframes;

- **surveillance and modification of outcomes:** that surveillance of outcomes is a component of treatment implementation, alongside possibilities to modify and adjust interventions;

Specific stabilization and other treatments can be identified as potentially required, although decisions on their selection and implementation require further scrutiny and consideration. Provisionally they are:

- **treatment of areas of salt efflorescence:** treatment to mechanically reduce/remove accumulated salt efflorescence from selected areas, principally where paint layers are mostly already lost and powdering plaster is exposed. Objectives are to assess the potential for safe (dry) mechanical removal of salts from the system and to assess rates (and types) of renewed salt efflorescence, if any. While this may be regarded as a relatively non-invasive intervention, it is recognized that the removal of efflorescences may also affect moisture transport processes and the thermodynamic behaviour of the remaining salts [Sawdy *et al.,* 2008]. Therefore, the intervention will be carried out initially in trial areas with close surveillance and monitoring of results of long timeframes. An improved monitoring strategy is required for this (see **section 3.5 Establishing an improved monitoring base and system**). Verification of results will also require salt sampling and analysis.

- **treatment of unsupported / separating plasterwork:** in many areas of the painting schemes at Gelati, areas of unsupported and/or separating plasterwork present conditions of imminent collapse and loss. As a priority, an integrated treatment strategy needs to be developed based on the development and trialling of repair materials and grouts. Formulation of repair/grout materials will be based on characterization of original plasters, principles of compatibility and stability, low water content, appropriate strength properties, etc. Pre-treatment procedures will include salts investigations to determine implementation risks. In cases where salt risks are too high, temporary support measures may be implemented instead;

- **selective replacement of failing repairs:** numerous types of repairs have been made in the wall painting schemes at different periods of time. Many of these are stable and provide adequate stabilization. Others are failing and present risks of associated collapse and loss of adjacent original materials. It is recommended that a survey is carried out to establish the risk status of the existing repairs, to be followed by their selective removal and replacement with specifically developed new repairs (as described above). Interventions will be made on a case-by-case basis and based on prioritized need. Universal repair removal/replacement is not advocated;

- **localized and limited consolidation:** in conjunction with the introduction of new stabilizing repairs, localized and limited consolidation of decohesive original plaster materials is likely to be also required. Considering the salt conditions at Gelati, film-forming materials should be avoided, as also consolidants and delivery systems that introduce risks from liquid water content. Inorganic consolidation with nano-limes may be considered a preferable alternative. These offer compatibilty with the lime-based plaster technologies present at Gelati and they would not compromise the porosity of original materials. Their dispersal in alcohol systems may also limit liquid water risks. Nevertheless, recognizing the general risks of consolidation interventions regardless of selected materials, treatment would be carried out on a trial basis and be accompanied by rigorous surveillance and evaluation of results;

- **reduction / reversal of modern applied materials:** documented treatment materials applied to the wall paintings in previous interventions include acrylic emulsions and resins, cellulose fixatives, di-ammonium phosphate and ammonium oxalate. Other materials may also be present. Some of these materials may be themselves potentially salts-forming. Their exact location and extent are not in all cases known, although multi-layered applications of some added materials are likely to be present in some areas.

  Acknowledging that salts contamination is probably a permanent feature of the fabric, continuing salt-phase transitions (and associated paint disruption) can be expected. In this context, an appropriate treatment aim is the reduction/removal of applied materials that may interfere with the porosity of original materials and reduce surface evaporation of moisture. As treatment risks are high and outcomes are uncertain, however, strict intervention criteria will be observed, including: pre-treatment evaluation of condition and technology to ensure safe intervention parameters; treatment implementation based on small-scale trials only; research and use of optimal treatment procedures and materials; and surveillance and scrutiny of results.

5. References

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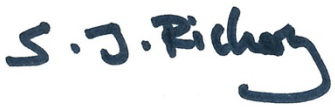

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