



Gelati Monastery Complex
Wall Painting Conservation
Programme

Remedial Treatment

Phase 1

Development of treatment
strategy and methodologies;
Stabilisation of critical areas

Stakeholder:
Gelati Temporary Rehabilitation
Committee

2024
March – April

Development Remedial Intervention Methodologies

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Appendix: Graphic documentation of the remedial intervention areas



Remedial Treatment Programme

1. Context



1. Context

As part of March 2024 mission, conservation remedial intervention was undertaken on the wall paintings of the Gelati monastery complex. Interventions aimed to stabilize the “critical areas” and determine the long-term conservation remedial treatment methodology.

Remedial works included locations that were at high risk of loss and at the same time allowed conservators for conservation intervention (deterioration was not ongoing and/or no intervention was implemented in 2020-2021).

Such locations can be found in all the painted spaces of the monastery complex. Before starting the remedial conservation works, the physical condition of the critical areas have been reassessed/ revised. That allowed team to determine intervention criteria and outline a plan of priority works to be performed in the short-term period.

The March 2024 mission plan included: 1. invasive and non-invasive studies (see report), 2. in-situ lab-based testing of materials, 3. development of conservation materials (phase 1) 4. remedial intervention-testing on the wall paintings (phase 1).

A focus of concern associated with recent events in the physical history of the Gelati wall paintings is extensive salt-related deterioration and damage. However, it is evident from the building’s centuries-long history that multiple forms of deterioration have undermined the condition of the paintings on a continual basis. In consequence, large expanses of painting exist in altered and deteriorated states and many areas are at risk of loss. The overall requirement of the treatment programme is therefore to formulate and implement an integrated programme of remedial measures to stabilize multiple problems on an ongoing basis.



Above Revision of the condition of critical areas by Wall Painting Conservation Supervisors and Gelati Rehabilitation Committee members



1. Context

In the wider context, the treatment programme is intended to provide a model of conservation planning and implementation, by:

- acknowledging diagnosis of deterioration, risk assessment, and variable aspects of condition and technology in treatment design and implementation;
- adhering to modern conservation standards and principles, in particular minimal intervention and compatibility;
- challenging a culture of use of poorly selected conservation materials through a program of testing and development that stresses assessment of performance criteria and working properties, compatibility, stability, etc.;
- observing implementation criteria that emphasize restraint and surveillance of results;
- demonstrating the importance of placing remedial treatment within a wider context of other conservation measures (salts and moisture investigations, environmental monitoring and control).



Above: The process of assessing wall paintings and determining the need for urgent conservation intervention. The cause of the damage in the mentioned area is the activity of salts, which causes the painting layer to fall, therefore, for paint stabilisation, it is necessary to select a consolidant that prevents the mobilization of salts.

1. Context



***Above:** The working ethics of the conservation group considers the principle of individual approach. Each deteriorated wall painting fragment is examined not only in terms of technology and condition, but also explores the working environment, including access to the wall, safety measures and scope of equipment and material placement.*

***Above** One of the main criterion in the development of the methodology of remedial interventions is the long-term stability, which should be achieved in the context of the relevant environmental conditions. The photo shows the discussion process by the group on the issue of discussing interventions in a broader context.*

Remedial Treatment Programme

2. Specific stabilization requirements and considerations



2. Specific stabilization requirements and considerations

For treatment of the Gelati wall paintings, the aims are specific and confined:

- the interventions are mainly intended to treat only those areas that require essential stabilization;
- the interventions are not being undertaken primarily for presentation purposes.

The following stabilization requirements have been identified:

- **consolidation/readhesion of deteriorated plasters:** for areas of exposed and vulnerable plasterwork (eg, plaster edges, eroded surfaces). Since deteriorated plasters typically exhibit combined problems of decohesion and lack of adhesion, these aspects of plaster failure need to be addressed simultaneously;
- **plaster edges:** to protect and stabilize damaged and exposed plaster edges;
- **plaster readhesion:** to readhere and secure areas of endangering plaster separation;
- **paint layer readhesion:** for areas of paint flaking at risk of imminent loss.
- **Salt reduction:** partial removal of the salt efflorescence from the surface of the wall paintings, using mechanical dry method



Above: Testing areas for remedial interventions have been selected by supervisors. The areas were selected based on their critical state and need for appropriate conservation interventions. The mentioned locations were used to develop a safe treatment methodology.



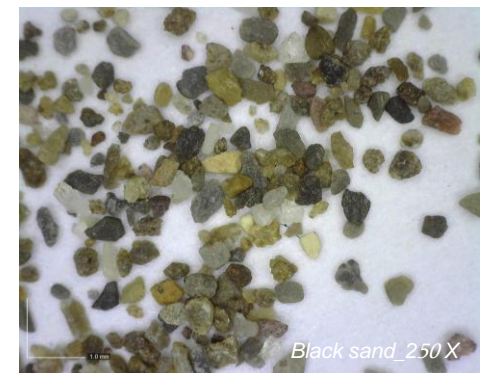
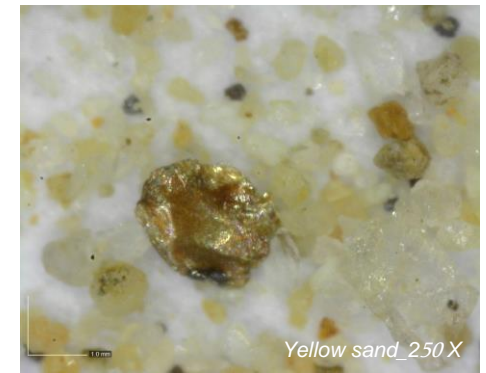
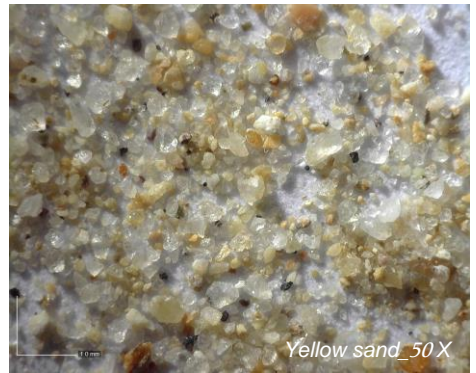
Above: One of the objectives of the remedial treatment undertaken in March 2024 is to develop a methodology. The photos show the working processes of the development of the intervention methodology. Images present the consolidation treatment and mechanical removal of the salt.

2. Specific stabilization requirements and considerations

The stabilization requirements therefore span a spectrum of problems in their scale, from sub-mm level (for consolidation issues) to the macro scale (for readhesion of plaster layers).

Specific considerations influencing treatment design and implementation are:

- **risk of new deterioration:** given conditions of widespread salt contamination, there are risks that new treatment interventions, if poorly formulated and delivered could initiate new deterioration;
- **compatibility:** compatibility of materials is a key component of treatment design, so that original materials and added repair materials behave similarly together;
- **limiting added materials:** a consideration related to compatibility is limiting and streamlining of materials, so that a small range of like/similar materials are used to fulfil each of the identified treatment requirements. This brings the added benefit that fewer added materials are introduced to the wall paintings, which is a desirable objective.



Above: In-situ lab-based investigations - selection process for compatible conservation materials. Microscopic study of Georgian fillers to select according to their characteristics - morphology, color and size.

2. Specific stabilization requirements and considerations

The risks of mobilizing and activating salts in the system are considerable, with implications for treatment design and implementation. To mitigate risks, the following precautions are being followed:

- **emergency situations:** limiting of treatment to areas where emergency situations have been identified (= high risk of loss);
- **trials basis:** treatment implementation initially to be made on a trial basis, subject to surveillance and assessment;
- **exclusion of salt-contaminated areas:** areas of salt activity to be excluded from major treatment interventions;
- **treatment material choices:** careful selection and implementation of treatment materials, privileging systems that do not compromise porosity of the original plasters, limit or avoid use of water, and avoid use of film-forming materials.

In addition to these stabilization interventions (which involve the addition of repair materials to the original plasters), mechanical salt removal/reduction is being trialled (during which no new materials are added but contaminants are removed).



Above: The use of compatible and safe materials is required for the wall painting of the Gelati monastery complex. Based on the principle of minimum intervention, this material should be used minimally (in terms of quantity and scale), but the result should be focused on the maximum. In order to follow these and other criteria, selection-preparation of conservation materials were undertaken through testing in in-situ lab-based environment.

Remedial Treatment Programme

3. Main remedial interventions

3.1 Plaster consolidation/adhesion



3. Main remedial interventions

To address the identified stabilization issues, a range of interrelated remedial treatments are being developed and trialled. So far these are consolidation/readhesion, ‘micro-grouting’, injection grouting and repairs. These are considered and explained below. Finally, salt reduction/removal trials are considered.

3.1 Plaster consolidation/readhesion

As a result of long-term and prolonged environmental deterioration, much of the plasterwork is severely deteriorated, lacking cohesion between its aggregate components and/or breaking down at internal interfaces. Typically, these conditions occur together and therefore need to be treated as a combined consolidation/readhesion procedure.

Consolidation/readhesion trials are being carried out with nano-limes dispersed in alcohol systems (CaLoSil®). Use of colloidal dispersions of Ca(OH)₂ nanoparticles offers the following advantages for the deteriorated Gelati plasters:

- **compatibility:** as a lime-based system, compatibility with the original plasters is maintained;
- **avoidance of water:** no introduction of added water, thereby reducing risks of mobilizing/activating salts;

- **stability and efficacy:** proven efficacy and stability in limiting carbonation of the nano-lime particles by CO₂ before they have been deposited in the substrate, and achieving appropriate penetration depth, strength, hardness, surface cohesion, capillary absorption, etc.; little to no change in the internal surfaces and structure of the substrate to affect moisture transport through the porous plasters;
- **research base:** widely studied and verified in terms of performance and working properties.

Of the available CaLoSil® formulations the following were trialled and assessed: CaLoSil® E25, CaLoSil® E50, CaLoSil® IP25, CaLoSil® NP25, CaLoSil® Micro and CaLoSil® Paste-Like.

Their specifications are shown in the following table:



3.1 Plaster consolidation/readhesion

Name	Contains/ Mixture	average particle size	concentration	Solvents
CaLoSiL E25 / E50 / IP25 / NP25	nano-particles of (Ca(OH) ₂) suspended in different alcohols.	150 nm (approximately 100 times smaller than conventional air lime)	between 5 g/L and 50 g/L.	Ethanol, iso- propanol, n- propanol
CaLoSiL Micro	(Ca(OH) ₂) particles	between 1 and 15 µm	120 g/L.	dispersed in Ethanol
CaLoSiL Paste-like	calcium hydroxide nano-particles in concentration s much higher than in all other products.	between 50 nm and 1 µm. (they are greater than in the colloidal CaLoSiL® products but still much smaller than in conventional lime hydrate suspensions)	120 g/L	dispersed in Ethanol

The formulations were trialled in situ to assess their efficacy for different conditions, which vary widely. As expected, the known properties of the different formulations (ie, varying particle size, concentration and solvent dispersant) allow them to be targeted to address different problems. For example, a formulation with larger particles dispersed in a solvent of medium volatility may be used for consolidating loose particles in depth (eg, CaLoSiL® E50); a formulation of smaller particles in a faster evaporating solvent might be more appropriate for superficial consolidation of very fine, cohesive materials (eg, CaLoSiL® NP25).

General conclusions and observations of the trials so far may be summarised as follows:

- effective results in consolidating/readhering areas of deteriorated plaster;
- no activation of salts;
- ability to address different conditions by alternating a select group of formulations, including readhesion of laminar flakes.

See treatment trial areas on following pages.



3.1 Plaster consolidation/readhesion



Above: Application of consolidant via syringe and need to allow conservation material penetrate in powdered substrate in pointed areas; Images present process of testing different consolidating materials.

3.1 Plaster consolidation/readhesion

The main space of the Church of the Nativity of the Virgin, North arm, east wall (scene E7),

Consolidation of powdered layer:



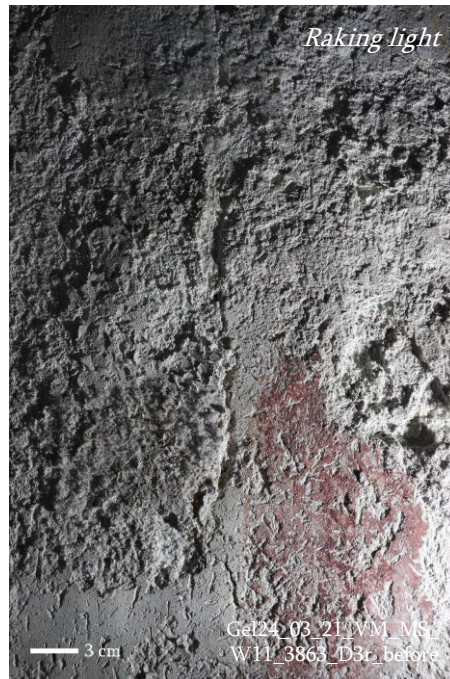
Above: Photos before plaster consolidation –
In a given area, the plaster layer is powdered, cohesive bond between plaster particles is weakened.
The powdering of the plaster is assessed using application of soft brush. In case of detection the removal of loose plaster particles and its extent, consolidation treatment trial requirements are set.

Above: Photos after consolidation of the deteriorated plaster –The area is treated with a consolidant, the consolidant is applied to the surface of the plaster (in the areas of paint loss) through a syringe, during which the needle head is directed towards the surface, the syringe allows the conservator to determine the amount of the consolidant, control the pressure and direction during application. Application of consolidant may occur several times, depending on conservation needs.

3.1 Plaster consolidation/readhesion

The main space of the Church of the Nativity of the Virgin, North arm, west wall (scene W11),

Consolidation of powdered layer:



Above: Photos before plaster consolidation –In addition to the powdering of the plaster on the given section, there are salt activity and painting layer deterioration (powdering, flaking). The main cause of wall painting deterioration are water infiltration and unstable environment.



Above: Photos after consolidation of the plaster – In order to restore the cohesive bond, the plaster was treated with a lime-based consolidant compatible (of similar nature) to the original material. The consolidant restores bonds (builds so-called bridges) between the loosened particles of plaster, not only on the surface, but also in the depth of the material (as a result of penetration). The working mechanism of the used consolidant is based on the carbonization process, therefore, its final setting time (compared to acrylic-based consolidants) is longer. The consolidant does not change the texture of the coating, the rough surface of the plaster is preserved, therefore, at the macroscopic level, the result is not reflected visually (on the photo). The hardening and setting of the consolidant is assessed via soft brush (the degree of loose plaster is checked by amount of the removal of the plaster particals).

3.1 ნალესობის კონსოლიდაცია/ფენებს შორის კავშირის აღდგენა

ღვთისმშობლის შობის ტაძრის მთავარი სივრცე, ჩრდილოეთი მკლავი, დასავლეთი კედელი (სცენა W7),
კომბინირებული ჩარევა – ნალესობის ფენის კონსოლიდაცია და მარილების მოხსნა (იხ. 3.5 მარილების შემცირება/ მოხსნა):



Above: Photos before plaster consolidation –The main reason of plaster powdering is the salt activity. We find salts both on the surface and in the wall structure. Due to the complexity of the situation, the section requires both the removal of salts and the consolidation of salty areas. The main outcome of the intervention is to prevent the migration and mobilization of salts.

Above: Photos after consolidation of the plaster – One of the main criteria in the development of the intervention methodology was the minimal addition of water to the structure (to prevent the activation of salts), therefore, nano-lime consolidating materials dispersed in alcohol were added, which, on the one hand, prevents the migration of salts (due to the absence of water), and, on the other hand, the lime content (unlike polymer) does not create impermeable film on the surface of the plaster, therefore the permeability of liquid and gas is maintained in the plaster.

Remedial Treatment Programme

3. Main remedial interventions

3.2 Micro-grout



3.2 Micro-grout

Some conditions of plaster disaggregation cannot be adequately treated with the nano-lime formulations, and a 'micro-grout' has been developed (to be delivered as droplets from a pipette, or syringe with thick needle). This is intended to consolidate/bridge larger disaggregated particles in deteriorated plasters.

The trialled formulation comprises (all parts by volume):

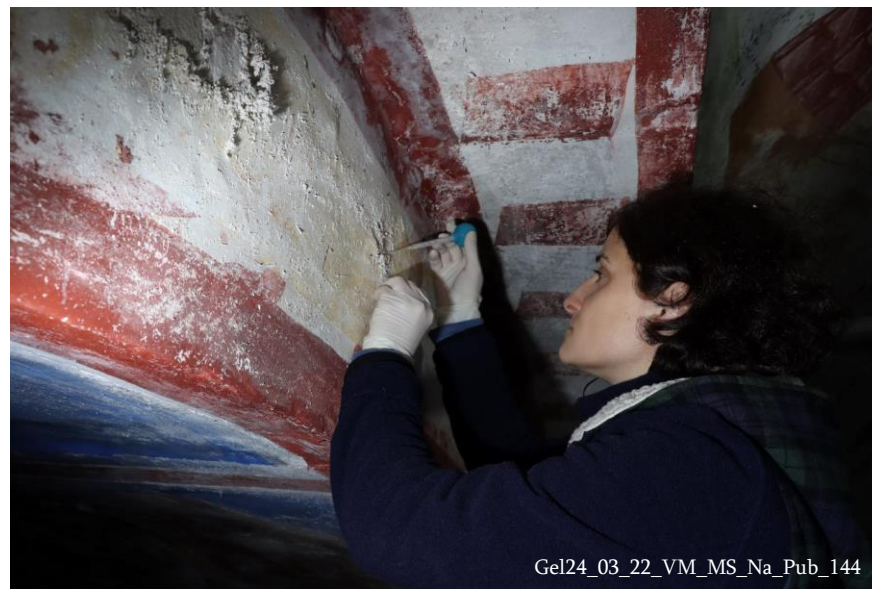
- 1 part lime
- 1 part chalk
- 1 part pumice (0–240 m)
- + added water to desired consistency for effective delivery



Above and right: Application of a "micro-injection solution" via pipette and testing different micro-injection materials

"Use of this 'micro-grout', in some cases, requires prior pre-wetting of substrate materials with alcohol:water (1:1v/v). While observable results have so far been good, further testing of the 'micro-grout' will examine using alcohol as a fluidizer, to avoid adding unnecessary water to the deteriorated plasters (and to simplify the two-stage delivery process involving pre-wetting followed by 'micro-grouting').

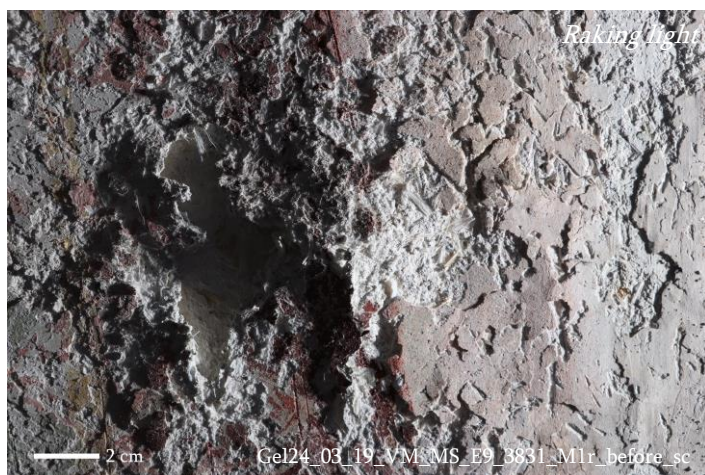
3.2 Micro-grout



Above: Consolidation of a "micro-grout" solution using a syringe and pipette.

3.2 Micro-grout and fills

The main space of the Church of the Nativity of the Virgin, North arm, east wall (scene E9), Plaster re-adhesion:



Above: Condition before micro-grouting and filling - The given area has two layers of plaster: lower and upper plaster layer. Those layers are separated by several millimeters (micro delaminations), and the upper layer of the plaster is additionally characterized by micro fragmentation.

Above: The condition after micro-grout and filling. Mentioned intervention requires following working properties: flow, tack, appropriate density, drying time. The conservation material was developed to have those properties, therefore, micro delaminated areas of the plaster were filled and the adhesive bond between the layers was restored.

3.2 Micro-grout

The main space of the Church of the Nativity of the Virgin, west arm, arch, Plaster re-adhesion:



Above: Plaster delamination from primary support. The area is in critical condition, where the half-cm-thick layer of plaster was completely removed from the stone support, and the risk of losing this section of plaster was high.

Above: the condition of the plaster after micro-grouting and edge stabilization - since the bond was preserved on one side of the plaster fragment, it was decided to return/readhere back to its primary support. The mentioned method was selected only as an exception in this specific area. The inner side of the plaster was treated with a micro-grout solution, it was fixed on the stone and the edges were stabilised.

3.2 Micro-grout and consolidation

The main space of the Church of the Nativity of the Virgin, north arm, arch, plaster re-adhesion and consolidation:

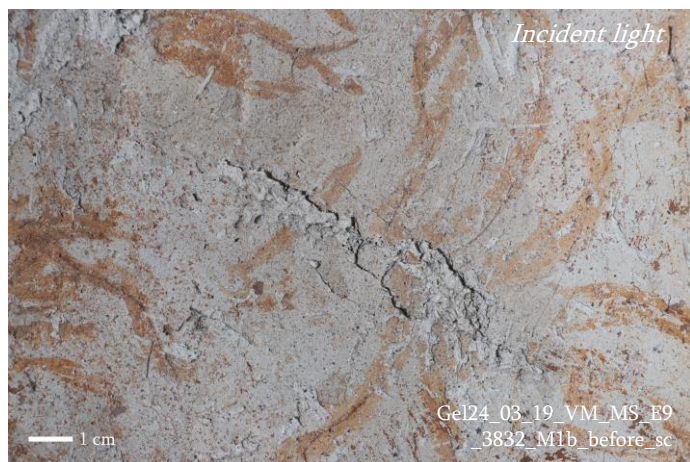


Above: images before stabilisation – Powdered plaster layer is separated from primary support. Loose plaster fragments are hanging on the organic inclusions.

Above: Loose plaster fragments was re-adhered to the wall with micro-grout mixture. The plaster was also consolidated with nano-lime consolidant.

3.2 Micro-grout and consolidation

The main space of the Church of the Nativity of the Virgin, North arm, east wall (scene E9), Plaster re-adhesion:



Above: Photos before the plaster treatment – thin layers of plaster are separated and fragmented. Adhesion problem and exposed edges of painted plasters make area under the risk of loss.

Above: Photos after plaster consolidation and micro-grouting - The micro-grout solution re-adhered separated fragments and strengthened the fragile edges. In this area, the evaluation process of the treatment is in progress. In the next stage, it is planned to fill the loss.

Remedial Treatment Programme

3. Main remedial interventions

3.3 Injection grouting



3.3 Injection grouting

Cracking, fragmentation and separation of plaster are widespread problems. In many places large areas of painting are at risk of collapse and loss. Plaster edging repairs made in the past to secure these areas are insufficient (and in many cases are also failing). This situation of uncertainty cannot remain unaddressed. Injection grouting is now the accepted treatment procedure for addressing issues of endangering plaster separation. Injection grouting re-establishes adhesion between the separated layers of a wall painting by introducing an adhesive material with bulking properties. Building on considerable grouting research, a custom-made, light-weight, fast-setting lime-based grout is being used.

Methodology

Since injection grouting is an irreversible operation and is carried out for paintings at risk, several important criteria are applied to its formulation and implementation. A comprehensive methodology has been researched, tested and established. Since a grout becomes an integral part of a wall painting, its performance characteristics are key. These relate to the long-term performance of the intervention and are most important because the stability of the treated wall painting depends on them. For grouts, they include:

Performance criteria

- minimal physical or chemical alteration of painting
- minimal volume change
- similar porosity to plaster
- similar water vapor permeability to plaster
- similar mechanical strength to plaster
- similar hygrothermal behavior to plaster
- no soluble ions
- good adhesion
- durability and chemical stability
- microbiological resistance
- low density
- retreatability (since grouting is irreversible)

Working properties are concerned with short-term behaviour while a grout is still in a liquid/fluid state, and include the following:

- injectability
- viscosity
- tack (initial adhesion)
- minimal water content
- slow water release
- reasonable setting time
- low toxicity



3.3 Injection grouting

Grout components and treatment approach

Components of the grout are as follows:

- **slaked lime:** acts as the binder, as in the original plaster;
- **pumice (0–240 m):** in addition to being an angular filler, selected for its pozzolanic properties, enabling a faster rate of set;
- **glass microspheres:** being non-absorbent, selected for their extremely low wet and dry densities; their spherical morphology also promotes good viscosity and injectability;
- **albumin:** provides additional adhesive properties, combining with the unreacted calcium hydroxide in the lime to form extremely stable calcium albumin compounds; additionally, it functions to entrain air in the grout mixture, helping to keep its components in suspension during injection; and reduced water content;
- **aluminium powder:** oxidises in the alkaline conditions of the grout with the gradual development of hydrogen gas, which acts as a grout expander, helping to counter problems of shrinkage.

This tested and previously implemented grout formulation is a product of considerable refinement regarding the proportions and reactivity of its components, its range of particle sizes, and its particle morphology.

Grouting implementation follows a number of strict criteria:

- **protection/support measures:** as the condition of separated plaster is typically very fragile, temporary protection/support is often required during treatment. Cyclododecane (CDD), a wax-like material (C₁₂H₂₄), is applied where necessary to provide temporary protection and consolidation. After a brief period, this sublimates from a solid to a gaseous state, leaving no residue;
- **grout preparation:** to maintain quality control, grouts are prepared in small batch quantities. Reliable formulations depend on accurate measurement and combination of the wet and dry (and reactive and inert) components;
- **grout delivery:** existing holes or cracks are used for injection points where possible; new holes are made as a last resort, kept to a minimum, and are made in areas of existing damage;
- **gradual implementation:** as grouting is a risky operation, treatment is carried out slowly and incrementally, allowing small areas to stabilise before proceeding further;
- **avoidance of excessive weight/moisture:** to avoid adding excessive weight or too much moisture, not all voids are grouted. Rather, grouting is done to break up the internal volume of the voids and provide strategic “anchoring”;
- **treatment assessment:** since the effects of grouting cannot be seen, assessment of its impact and efficacy are constrained. Infrared thermal (IRT) imaging is used to assess wetting and drying states, to guide treatment progress and assessment outcomes.



3.3 Injection grouting

Below and right: Plaster re-adhesion between plaster layers and plaster and the support. Injection of grout mixture with syringe in some cases via catheters , in other cases though the thick needle



Left: Assessment of injection grouting through Infrared thermography in order to determine grout flow and distribution. Checking on voids.



3.3 Injection grouting

Injection grout preparation in in-situ lab-based conditions.

Based on the composition of the injection grout materials, it is important to follow health and safety protocol.

Grout preparation stages:

- Mixing of the dry (fillers) materials
- Mixing of lime and low amount of water
- Gradual adding of the lime mixture to the dry components together with water
- Mixing of the additives (in order to reinforce tackiness and lightness) and adding to the grout mixture.
- Final stage is addition of the volume expander additive.

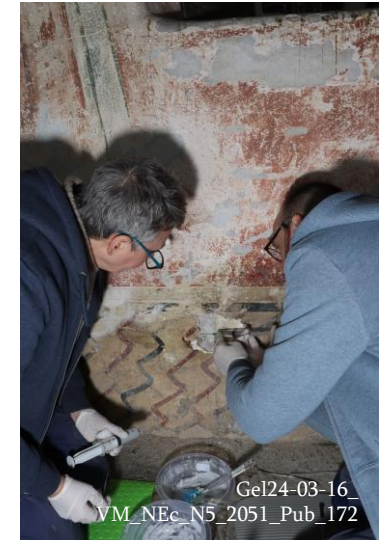


! The solution needs to be composed of the exact amount of each component; therefore, the necessary technical equipment provided in Gelati lab is necessary: a scale, a mixer, measuring flasks, elastic spatulas, etc.

3.3 Injection grouting

Images: Re-adhesion of the plaster to the primary support.

- *Mechanical cleaning of the void between stone and separated plaster. Cleaning tools (puffer, brush, spatula); Checking the width and depth of the void.*
- *Pre-wetting – for the purpose of cleaning and making injection grout to easier transportation through voids;*
- *Temporarily putting cotton in the voids to prevent grout to come to the surface and allow it to flow in depth.*
- *Delivery of the injection grout through catheter and syringe,*



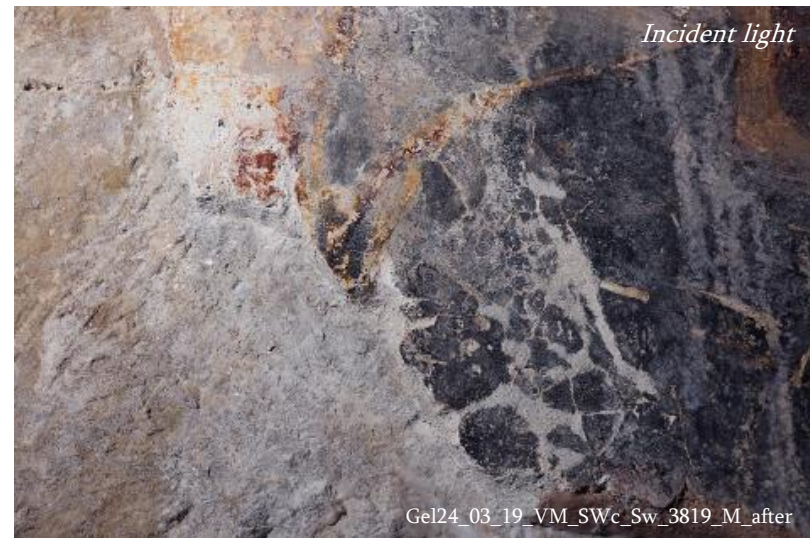
3.3 Injection grouting



Images: In certain areas, where the risk of loss plaster is high, cyclododecane is applied before injection to temporarily harden the surface and prevent the solution from flowing through cracks. Cyclododecane (C₁₂H₂₄) is a waxy material that sublimates in air and leaves no residue on the painting.

3.3 Injection grouting

South-west chapel, south wall, Injection grouting for plaster delaminated from primary support

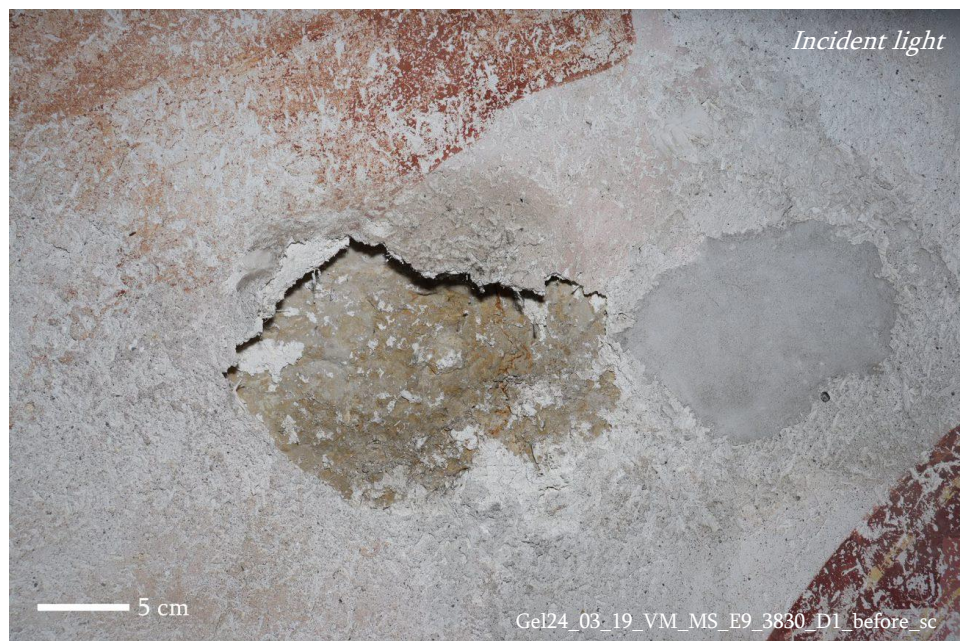


Above: Condition before intervention – loss of previous edge repair and original plaster. Plaster separation from stone support.

Above: Stabilisation treatments: injection of the lime-based lightweight grout material between plaster and stone. Securing exposed plaster edges with lime-based plaster mixture

3.3 Injection grouting

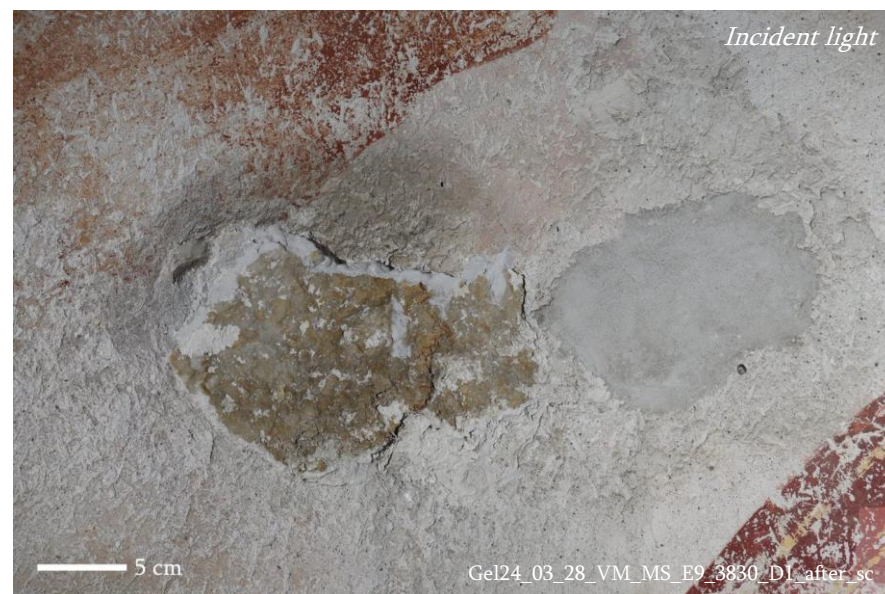
The main space of the Church of the Nativity of the Virgin, North arm, east wall (scene E9), Plaster re-adhesion:



Above image: Wall painting condition, before injection grouting treatment. Plaster bulging from the surface, the gap between plaster and stone is few centimetres.

Upper right image: The temporary facing of the plaster, using cyclododecane (white layer on painted plaster).

Lower right image: re-adhesion of the plaster layer to the primary support through filling the gap with injection grout material. For assessing purposes, the area was left without applying edge repair. After assessment of treatment required fills or edge-repairs will be made.



3.3 Injection grouting

North-east chapel, north wall, plaster re-adhesion



Above: plaster delaminated from stone support.

Above: plaster after re-adhesion and edge repair.

Remedial Treatment Programme

3. Main remedial interventions

3.4 Repairs



3.4 Repairs

Plaster fills and edge repairs probably constitute the main remedial treatment carried out on the Gelati wall paintings.

Several phases and types of intervention are distinguishable in the site's conservation history, representing shifts in approach over time (including use of gypsum repairs). In all cases, single-type repairs have been applied on an overall basis to all situations/conditions. Additionally, the range (and differences) in original plaster technologies (for instance: Main space: Early scheme 3 types, XVI c scheme 6 types, XVII c scheme 1 type.) have not been recognized in previous repair strategies. Many of the repairs are evidently too hard and dense in comparison with the weaker original plasters, resulting in preferential moisture/salts movement into the original materials, with detrimental effects. Repair plasters that are too hard/dense tend also to fail at their interface with the weaker original plasters, rather than internally, leading to separation and loss. The gypsum repairs appear to have been a source of added salts.

Plaster repairs have been also used to support large expanses of separating plaster, which would now be secured by injection grouting (see above). In consequence, an emphasis in their formulation was to maximize strength properties. This has been detrimental to the weaker original plasters.

Repairs are an important but neglected aspect of conservation design and implementation. For the Gelati wall paintings, repairs need to be:

- broadly compatible with the technologies of the original plasters in terms of their principal binder type and aggregate ratios;
- individualised to varying aspects of both condition and technology;
- good performance characteristics (low shrinkage, appropriate strength properties, appropriate porosity, etc.)
- ability to be formulated and applied with minimal water content; and
- constituted from dependable and locally available supplies of binder and aggregate components.



3.4 Repairs

Technological observations and investigations of the original plasters form the basis for the development of the repair plasters. Although there are significant differences between the several original plasters, they are generally characterized by having low aggregate ratios (with particles ranges that are small) and high binder ratios; fibre additives are typically used to compensate for the high binder, low aggregate content. Micro-chemical testing carried out in the Gelati laboratory confirms that all the original plasters have lime binders. The results of the previous analytical investigations has been also taken into consideration.

As the original plasters were formulated to fulfil specific requirements (ie, expansive coverage of interior surfaces) and repairs are applied for a different purpose (ie, to secure/protect exposed and fractured plaster edges) and are targeted and small-scale in their nature, different performance properties are required (eg, adequate adhesion to small surfaces).

Based on the diverse range of original plasters presented in Gelati wall painting technology, several types of plaster mixtures were prepared and their physical characteristics (wet/dry density, hardness, color, texture, drying time, adhesion, water release, shrinkage etc.) were evaluated during the field work.

Repair plasters are still in process of being formulated, refined and assessed. Current formulations are shown in table, and it is expected that further refinement of these is required.

Parameters/properties being examined include:

- defining two principal aggregate types and proportions that fulfil properties such as adequate mechanical strength while not being too strong; maintaining porosity, etc.
- defining appropriate particle ranges that are similar to the original plasters and are workable in repair plasters;
- wet and dry weights: determining formulations that do not add excessive weight in either their wet or dry states;
- water release: determining formulations that limit water content and release.

In addition, constituent materials – including the lime being used – are being examined and analyzed to determine their purity, stability, etc. Avoidance of introducing new salts is a principal concern.



3.4 Repairs

Solution N	binder		filler		additive		Proportion (binder : filler)	Use on the wall painting for testing
	type	part	type	part	type	amount		
1	Georgian air lime	1	Marble powder	2	no		(1:3)	×
			black sand (25 mesh)	1				
2	Turkish air lime	1	Marble powder	2	no		(1:3)	×
			black sand (25 mesh)	1				
3	Georgian air lime	1	Marble powder	3	no		(1:3)	√
4	Georgian air lime	1	Marble powder	3	no		(1:3.5)	×
			black sand (25 mesh)	1/2				
5	Georgian air lime	1	Marble powder	2	no		(1:2)	×
6	Georgian air lime	1	Marble powder	2	Jute	0.3 g	(1:2)	×
7	Georgian air lime	1	Marble powder	1	no		(1:1)	×
8	Georgian air lime	1	Marble powder	1	Jute	0.3 g	(1:1)	×

3.4 Repairs

Solution N	binder		filler		additive		Proportion (binder : filler)	Use on the wall painting for testing
	type	part	type	part	type	amount		
9	Georgian air lime	1	Marble powder	1	No		(1:1.5)	×
			Yellow sand (50 mesh)	1/2				
10	Georgian air lime	1	Marble powder	1/2	No		(1:1.5)	×
			Yellow sand (50 mesh)	1				
11	Georgian air lime	1	Marble powder	1	No		(1:2)	×
			Yellow sand (50 mesh)	1				
12	Georgian air lime	1	Marble powder	1/2	Jute	0.3 g	(1:1.5)	×
			Yellow sand (50 mesh)	1				
13	Georgian air lime	1	Marble powder	1	Jute	0.3 g	(1:2)	×
			Yellow sand (50 mesh)	1				



3.4 Repairs

Solution N	binder		filler		additive		Proportion (binder : filler)	Use on the wall painting for testing
	type	part	type	part	type	amount		
14	Georgian air lime	1	Marble powder	1/2	No		(1:1.75)	×
			Yellow sand (50 mesh)	1				
			Black sand (50 mesh)	1/4				
15	Georgian air lime	1	Marble powder	1	No		(1:1.75)	×
			Yellow sand (50 mesh)	1				
			Black sand (50 mesh)	1/4				
16	Georgian air lime	1	Marble powder	1	Jute	0.3 g	(1:1.25)	√
			Black sand (50 mesh)	1/4				
17	Georgian air lime	1	Marble powder	1	No		(1:1.25)	√
			Black sand (50 mesh)	1/4				

შენიშვნა: სატესტოდ დამზადებული ხსნარების 1 წილი = 50 მლ



3.4 Repairs

Lab-based testing to develop repair materials for plaster losses and exposed edges.

Images right presents lab-based testing processes.

Preparatory works:

- *Analysis of original technology*
- *Preparation of lime putty*
- *Preparation of filler materials (washing, sieving, sorting according to mesh sizes)*
- *Filler materials investigation through microscopy*
- *Testing for salt ion content*
-

Preparation of mixtures:

- *Selection of mixture components (binder, fillers and additives)*
- *Selection of materials proportions in mixture*

Plaster material properties were characterised through:

- *Wet and dry densities*
- *Strength*
- *Colour, texture*
- *Drying and setting time*
- *Adhesion*
- *Shrinkage*
- *Water release*
- *Workability (elasticity)*



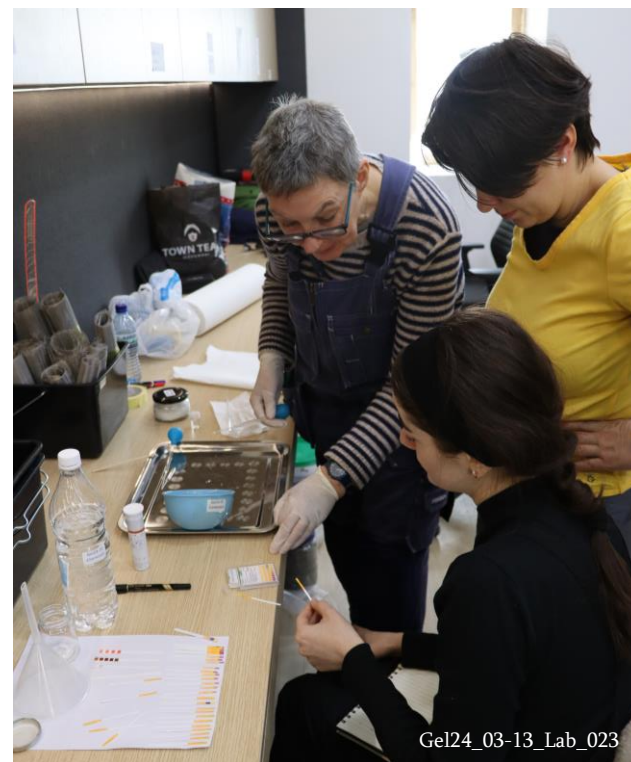
Gel24_03-14_Lab_055



Gel24_03-14_Lab_077



Gel24_03-14_Lab_030



Gel24_03-13_Lab_023



Gel24_03-16_Lab_097

3.4 Repairs

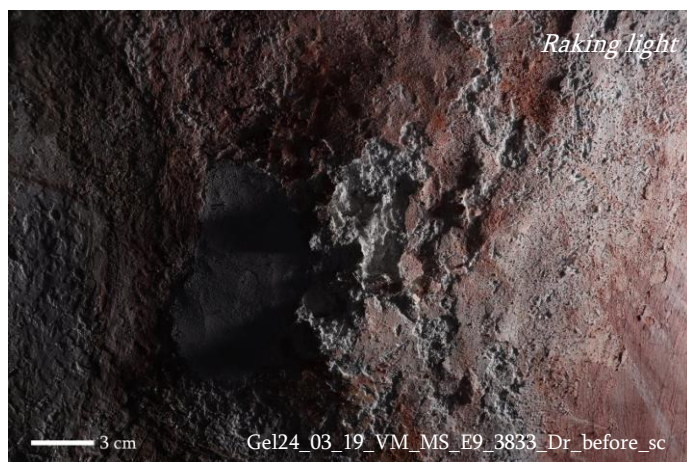
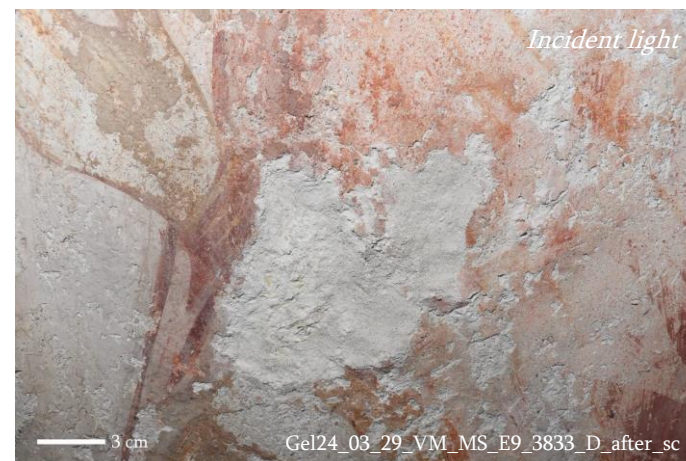
Plaster repairs:



Above and right: Process of edge repairing

3.4 Repairs

The main space of the Church of the Nativity of the Virgin, North arm, east wall (scene E9), Plaster repair



Above: The state of the plaster before filling –the plaster loss has been filled with repair material in XX c. Afterwards further loss has happened, therefore plaster edges are exposed.

Above: condition after repair – the previous repair has been removed and the original topography of the surface is maintained with new repair material. The visual difference of the filling from the original plaster is achieved by a specific texture. The color of the fill corresponds to the lower layer of the painting and fits into a visually unified context with the painting. (The new filling does not visually focus on the loss of plaster). Used plaster mixture - N16.

3.4 Repairs

North-west chapel, north wall, plaster edge repair:



Above: The condition of the plaster before injection and edge repair - the plaster is delaminated requires grouting and edge reinforcement.



Above: The mentioned location, due to its critical condition, was selected for the following test interventions: injection and selection of the appropriate edge repair mixture.

In the first stage, injection was carried out, and then the edges were repaired using mixture N3. The testing area was evaluated by checking the characteristics, including the aesthetics. Based on the summary of the results, additional test will be proceeded.

Remedial Treatment Programme

3. Main remedial interventions

3.5 Salt reduction



3.5 Salt reduction

Mechanical intervention was carried out to remove/reduce salts from selected areas.

The salts were mainly removed from areas where the painting layer has already been lost and the plaster was powdering.

The removal of salts was also carried out for the purpose of monitoring.

The goal of the intervention was to determine the possibility of mechanical (dry) safe removal of salt from the structural system and, at the same time, to determine the frequency (and types) of new salt crystallisation (if any).



Soft small brushes were used to gently remove salt efflorescence. Wet tissue was used to capture the salts to prevent redeposition on the painted surfaces.



3.5 Salt reduction

The Church of the Nativity of the Virgin Mary, North-west pendentive, salt reduction.

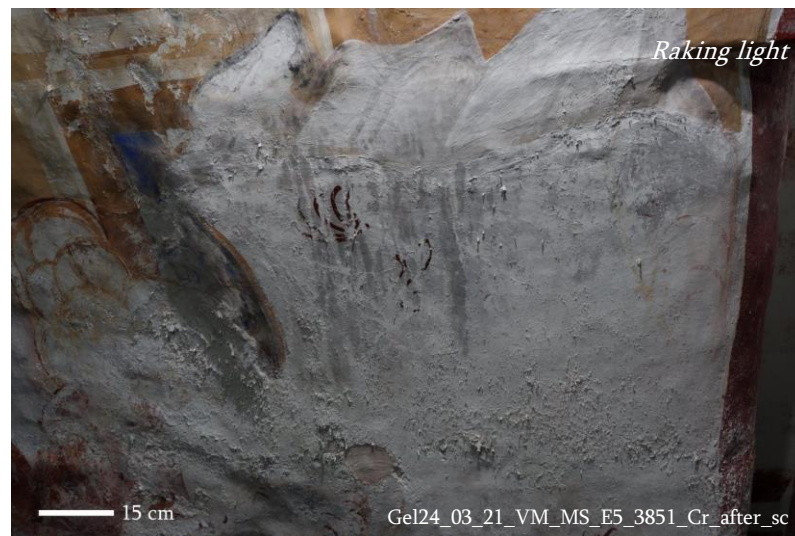
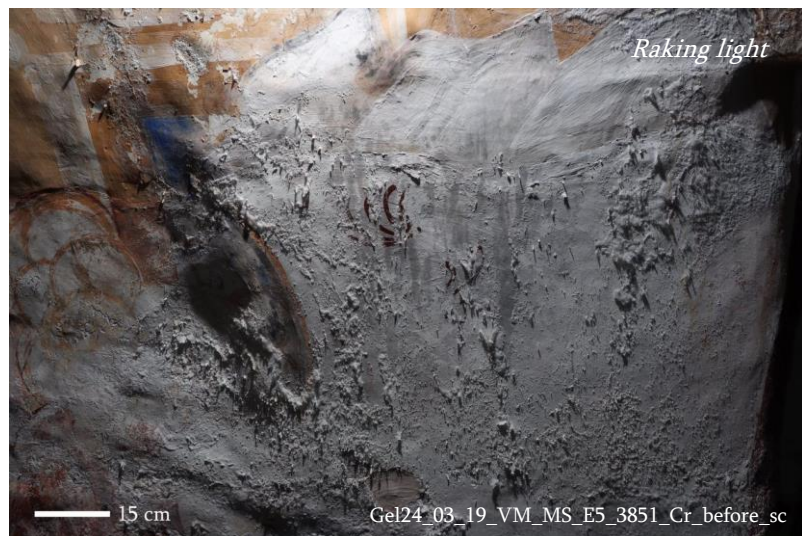


Above: Condition before salt removal

Above: Condition after salt removal

3.5 Salt reduction

The main space of the Church of the Nativity of the Virgin, North arm, east wall (scene E5)



Above: Condition before salt removal

Above: Condition after salt removal

3.5 Salt reduction

The main space of the Church of the Nativity of the Virgin, west arm, south wall (scene S8)

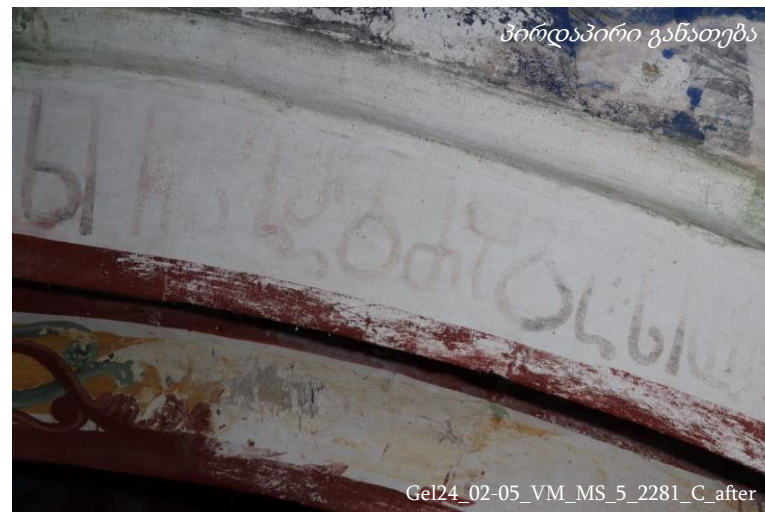


Above: Condition before salt removal

Above: Condition after partial salt removal

3.5 Salt reduction

The main space of the Church of the Nativity of the Virgin, north arm, arch, plaster re-adhesion and consolidation:



Above: Condition before salt removal

Above: Condition after salt removal

Remedial Treatment Programme

3. Main remedial interventions

3.6 Paint re-adhesion



3.6 Paint re-adhesion

Deterioration of the painting layer on Gelati wall paintings, especially flaking (loss of adhesion between the painting layer and its support) is a widespread phenomenon and is caused by complex problems. The deterioration is related both to the composition of the painting layer and to the activity of the salts in the system.

The paint layer is the most vulnerable layer of the painting stratigraphy, on which the activity of environmental factors has the strongest and fastest impact.

Strengthening the painting layer requires a unified, holistic approach, where both the type of deterioration and the material and the causes of the deteriorations will be taken into account.

Due to the physical state of the painting layer of the Gelati wall painting and the diverse range of detrimental factors, both critically deteriorated (where the painting layers were at high risk of loss due to salt activity) and relatively stable ones were selected for testing interventions.

Based on the first stage testing results, selected consolidant worked.

For treatment testing - re-adhesion of the paint layer, following criteria have been developed:

Performance criteria:

- Minimal chemical and physical change to the paintings
- Minimal optical change
- Adequate adhesion
- Equal or lower mechanical strength
- Similar hygral and thermal behaviour
- Resistance and chemical stability
- Resistance to the biodeterioration
- Retreatability
- No film forming material

Working properties:

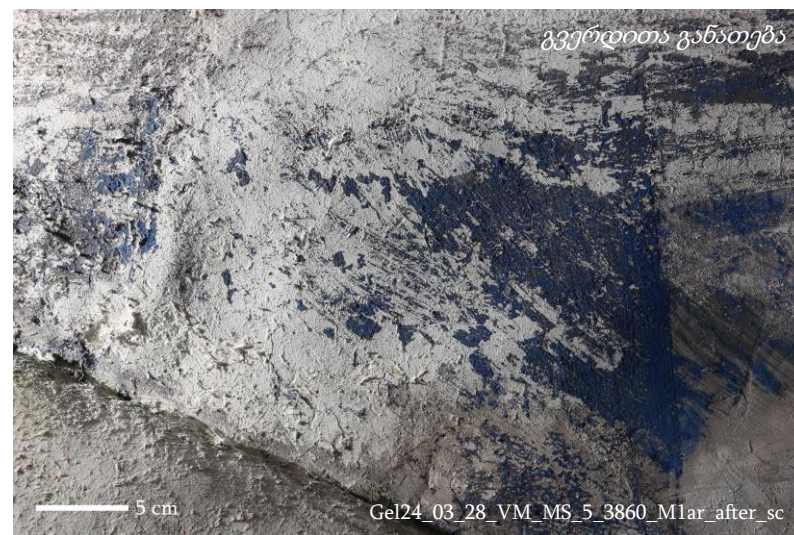
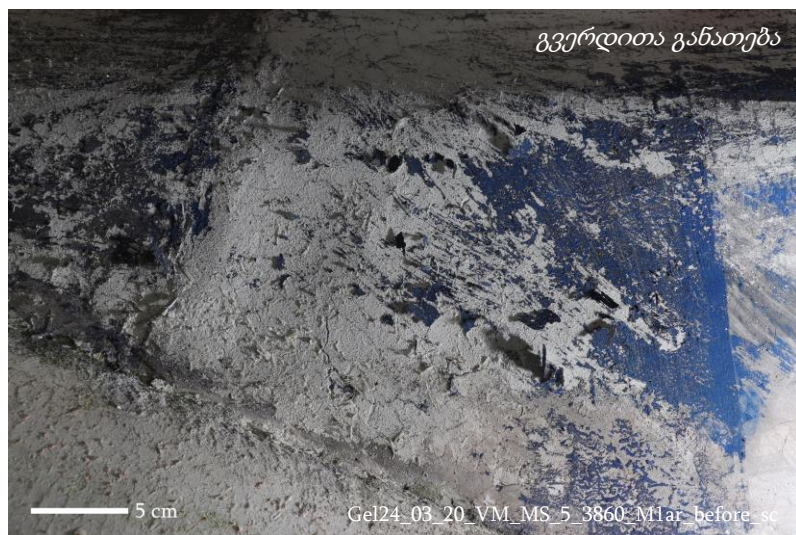
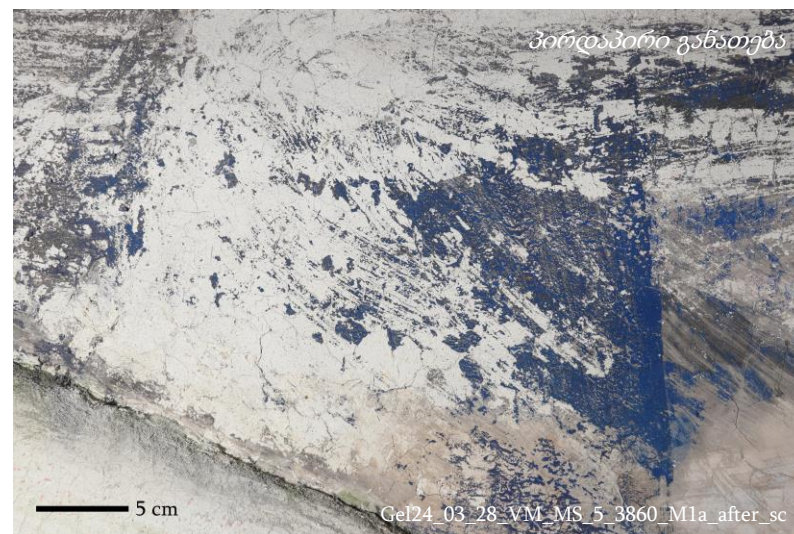
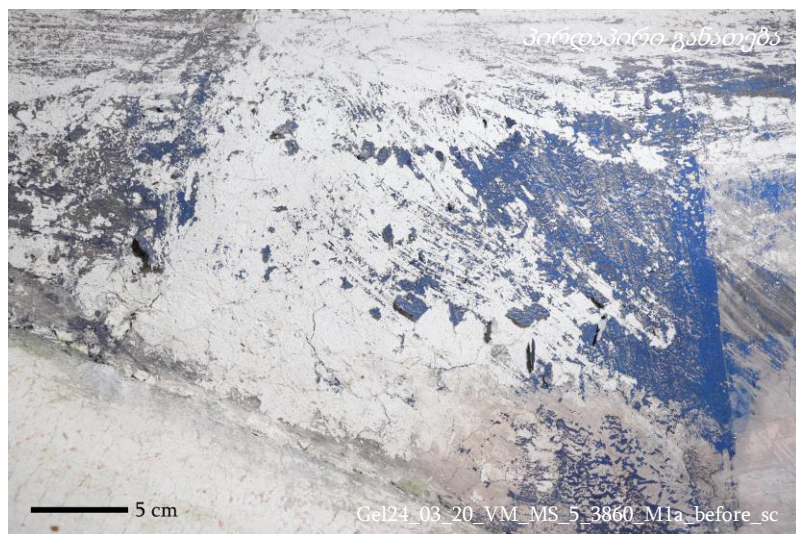
- Consolidant system control: penetration and deposition
- Good wetting properties
- Evaporation time
- Surface tension
- Tack
- Reasonable hardening and setting time
- Compatibility with other interventions

At the initial stage of the testing nano-limes were trailed (CaLoSil® IP25, CaLoSil® NP25, their long-term effects will be assessed in following phases.



3.6 Paint re-adhesion

The Church of the Nativity of the Virgin Mary, North-west pendentive, salt reduction.



Above: paint flakes before re-adhesion

Above: After re-adhesion of the paint layer

Appendix

Graphic documentation of treatment areas



გრაფიკული დოკუმენტაცია / Graphic Documentation

აღმოსავლეთის ზრდილი
East section

ქედლის მხატვრობის გადაუდებელი საონსერვაციო
ქარვის და საონსერვაციო მეთოდოლოგიის
შერჩევითი განხორციელებული ტექნიკები

გელათის სამონასტრო
ხომავლასი ღვთისმშობლის
შობის ტაძარი

Church of the Nativity of
Virgin Mary

№1



№2



№3



№1, №23
განხორციელებული ჩარევა

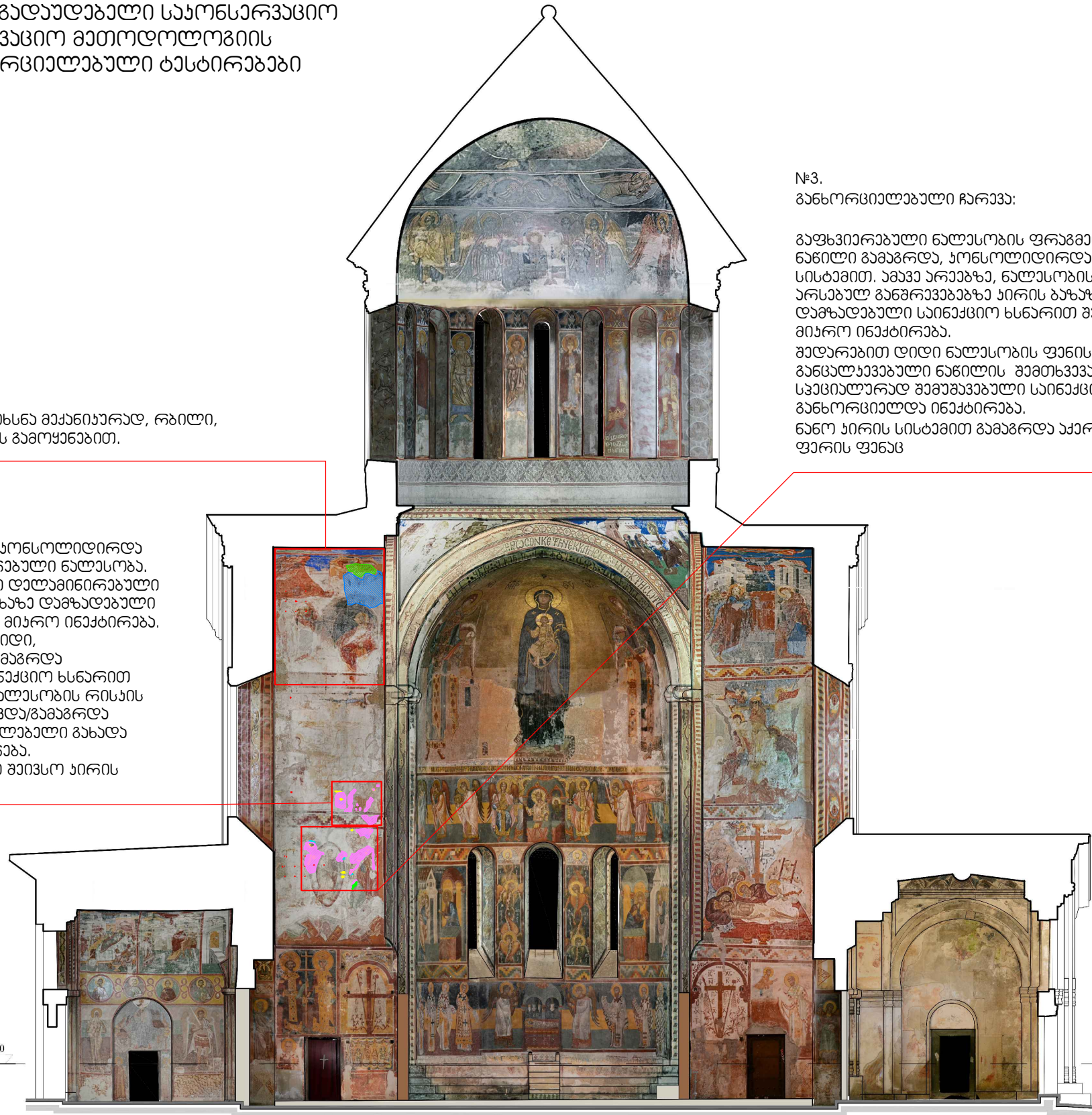
მარილის ქარკი და ნაფიფი მოხსნა მკანინურად, რბილი,
სინთეტიკური ფაჩით და ლაგებინ გამოყენებით.

№2.
განხორციელებული ჩარევა

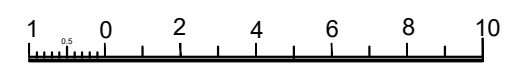
ნაო ჰირის სისტემით გავგრდა/ქოსოლიდირდა
გაფხვიარაული და ფრამბებიარაული ნაოსოა.
ნაოსოის მვირა ზომის/თხელი დლაშინიარაული
ფრამბებიარის არაბში ჰირის ბაზაა დაშადაული
საინეჰციო ხსნარით შესრულდა მიარო ინეჰტიარაა.
ნაოსოის ფანის შადარებით დიდი,
განცალაჰვიარული მონაჰვიარაი გავგრდა
სჰვიარაული შაშაჰვიარული საინეჰციო ხსნარით
(ინეჰტიარაი), ინეჰტიარაიარაული ნაოსოის რისაის
ჰვიარ მონაჰვიარაი დაშაჰვიარა/გავგრდა
ცილოლოდაჰანით, რამც შესაჰვიარაული განადა
შადარებით უსაფრთხო რჰვიარარაა.
ნაოსოის ნაჰვიარული მონაჰვიარაი შვიჰვიარ ჰირის
ხსნარით.

№3.
განხორციელებული ჩარევა:

გაფხვიარაული ნაოსოის ფრამბებიარაული
ნაილი გავგრდა, ქოსოლიდირდა ნაო ჰირის
სისტემით. აბაჰვიარაა, ნაოსოის ფანეს შორის
არსაბულ განრეჰვიარაა ჰირის ბაზაა
დაშადაული საინეჰციო ხსნარით შესრულდა
მიარო ინეჰტიარაა.
შადარებით დიდი ნაოსოის ფანის
განცალაჰვიარული ნაილის შამთჰვიარაი
სჰვიარაული შაშაჰვიარული საინეჰციო ხსნარით
განხორცილდა ინეჰტიარაა.
ნაო ჰირის სისტემით გავგრდა აჰვიარული
ფარის ფანც



- Injection
ინეჰტიარაა
- Salts removal with a brush
მარილის მოხსნა ფაჩით
- Edge repair
ჰიში
- Micro injection
მიარო ინეჰტიარაა
- Salts removal with scalpel
მარილის მოხსნა სააღვიარაულით
- Filling
შაჰვიარაა
- Consolidation of plaster layer
ნაოსოის ქოსოლიდაჰვიარა
- Paint layer consolidation
ფარარაული ფარის გავგრდა



გრაფიკული დოკუმენტაცია / Graphic Documentation

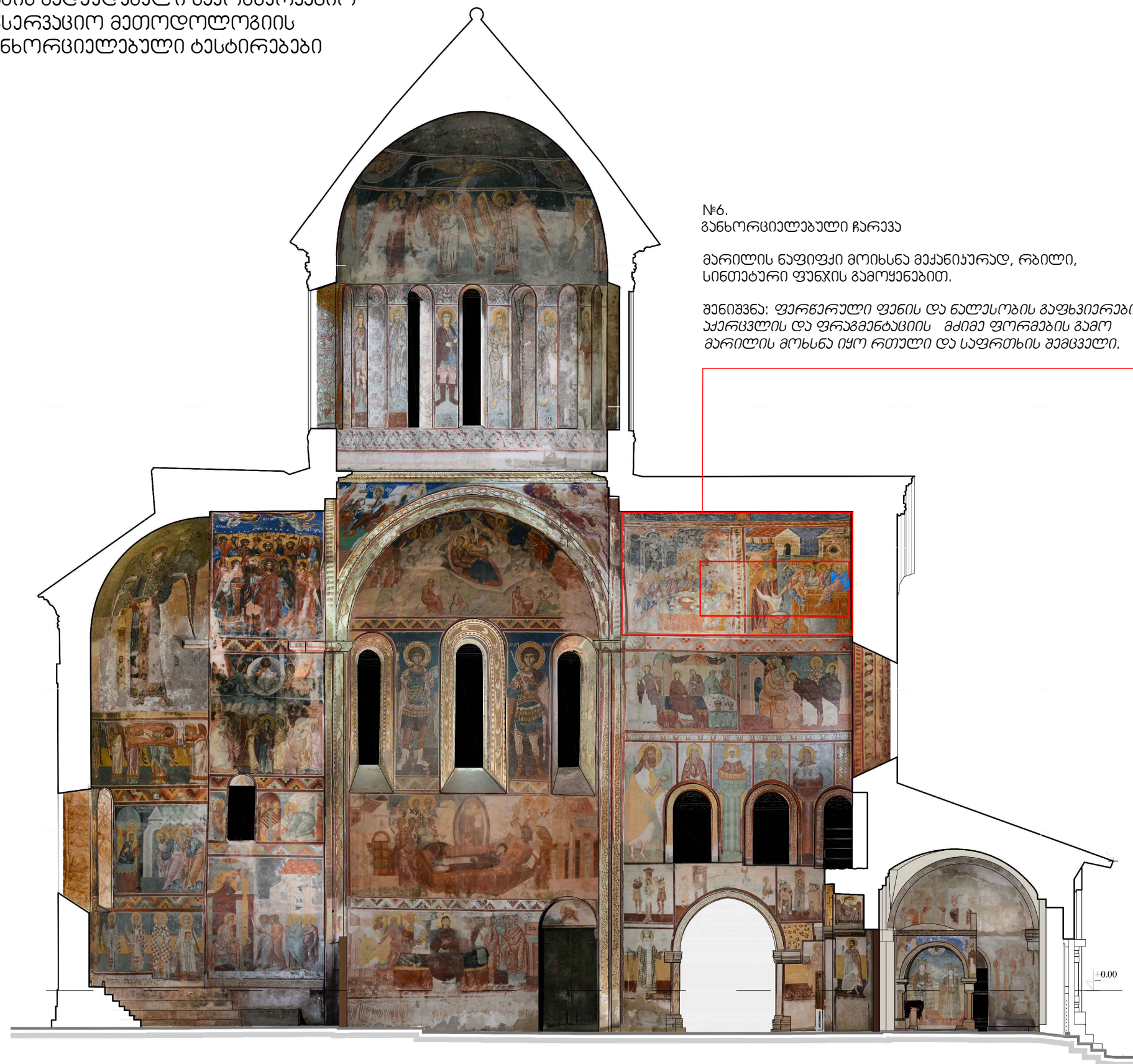
ქედლის მხატვრობის გადაუდებელი საკონსერვაციო
ჩარკვის და საკონსერვაციო მეთოდოლოგიის
შერჩევითვის განხორციელებული ტესტირებები

სამხრეთის ზრდილი
South section

გელათის სამონასტრო
ქომპლექსი ღვთისმშობლის
შობის ტაძარი

Church of the Nativity of
Virgin Mary









№6

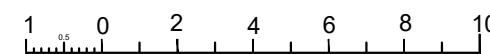


№6.
განხორციელებული ჩარკვა

მარტილის ნაფიფი მონსნა მქაქნიურად, რბილი,
სინთეზური ფუნჯის გამოყენებით.

შენიშვნა: ფარგარული ფუნჯის და ნალასობის გაფხვირების,
ქარცვლის და ფრკგებაცის მქიმა ფორგების გამო
მარტილის მონსნა იყო რთული და საფრთხის შემცველი.

- | | | |
|--|---|---|
|  Injection
ინექცია |  Salts removal with a brush
მარტილის მონსნა ფუნჯით |  Edge repair
ქიმი |
|  Micro injection
მიკრო ინექცია |  Salts removal with scalpel
მარტილის მონსნა საალვალით |  Filling
შავსება |
|  Consolidation of plaster layer
ნალასობის კონსოლიდაცია |  Paint layer consolidation
ფარგარული ფუნჯის გამგრება | |



გრაფიკული დოკუმენტაცია / Graphic Documentation

დასავლეთის ზრდილი
West section

ქედლის მხატვრობის გადაუდებელი საკონსერვაციო
ჩარვის და საკონსერვაციო მეთოდოლოგიის
შერჩევითი განხორციელებული ტექნიკები

გელათის სამონასტრო
ქოხლქასი ღვთისმშობლის
შობის ტაძარი

Church of the Nativity of
Virgin Mary

№12.
განხორციელებული ჩარვა

განვლენიერება/დალაშქრება ვალსოვასა და
საფეხვალს შორის ავსების უდგანე მოხდა
ინექტირებით (სპეციალურად შეამზავებული სინექციო
ხსნარით), ვალსოვის აიდაები გამაგრდა აირის
ხსნარით, ვალსოვის მცირე ზომის განვლენიერება
ფრაგმენტები გამაგრდა აირის ბაზაზე დაზარალებული
სინექციო ხსნარით, მიწრო ინექტირებით,
ვალსოვის დანაწარმი შეივსო აირის ხსნარით.

№11.
განხორციელებული ჩარვა:

გამოვლინდა იქიდან რომ ამ არეალზე ძალიან
მაღალია ზღვარიანი მარტივების ქონებრაცია,
რისთვის შემცირების და ახალი დანაწარმის
თავიდან აცილების მიზნით ამ აბაზაზე შესაძლებელი
გახდა მხოლოდ უკვე დაზიანებული და ფუჭი
დაწარმული დამცავი ფენის გადაგრაბა იანონარი
ქალაქის და ალჰაინის (Paraloid B72) გამოყენებით.

№7.
განხორციელებული ჩარვა

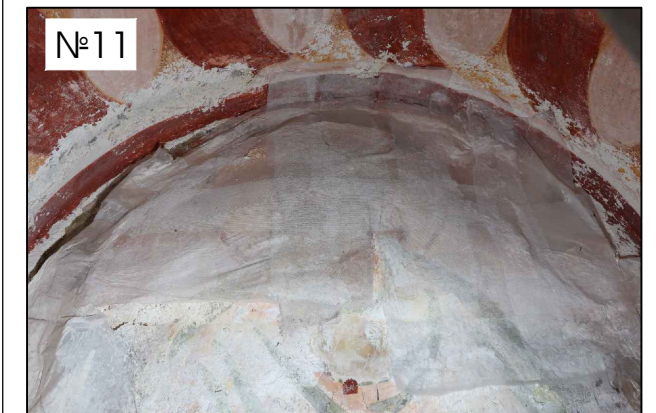
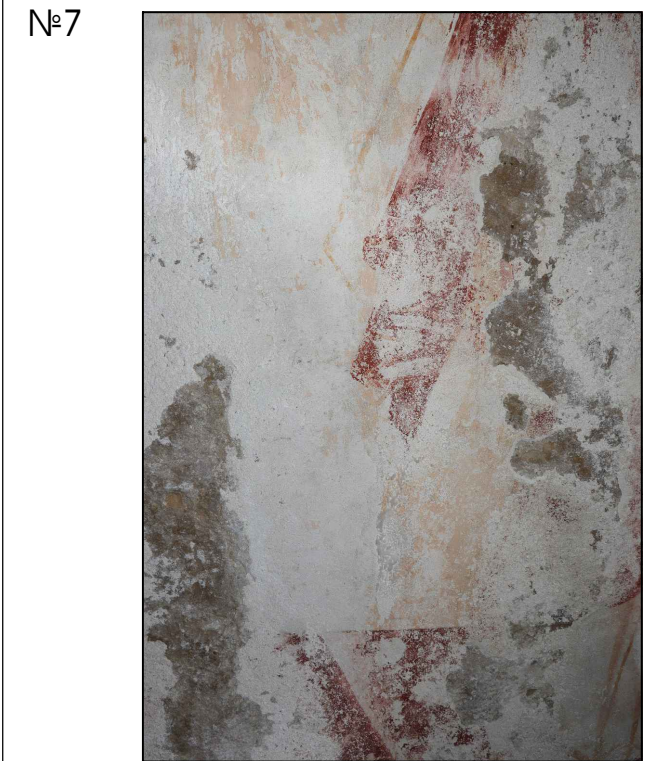
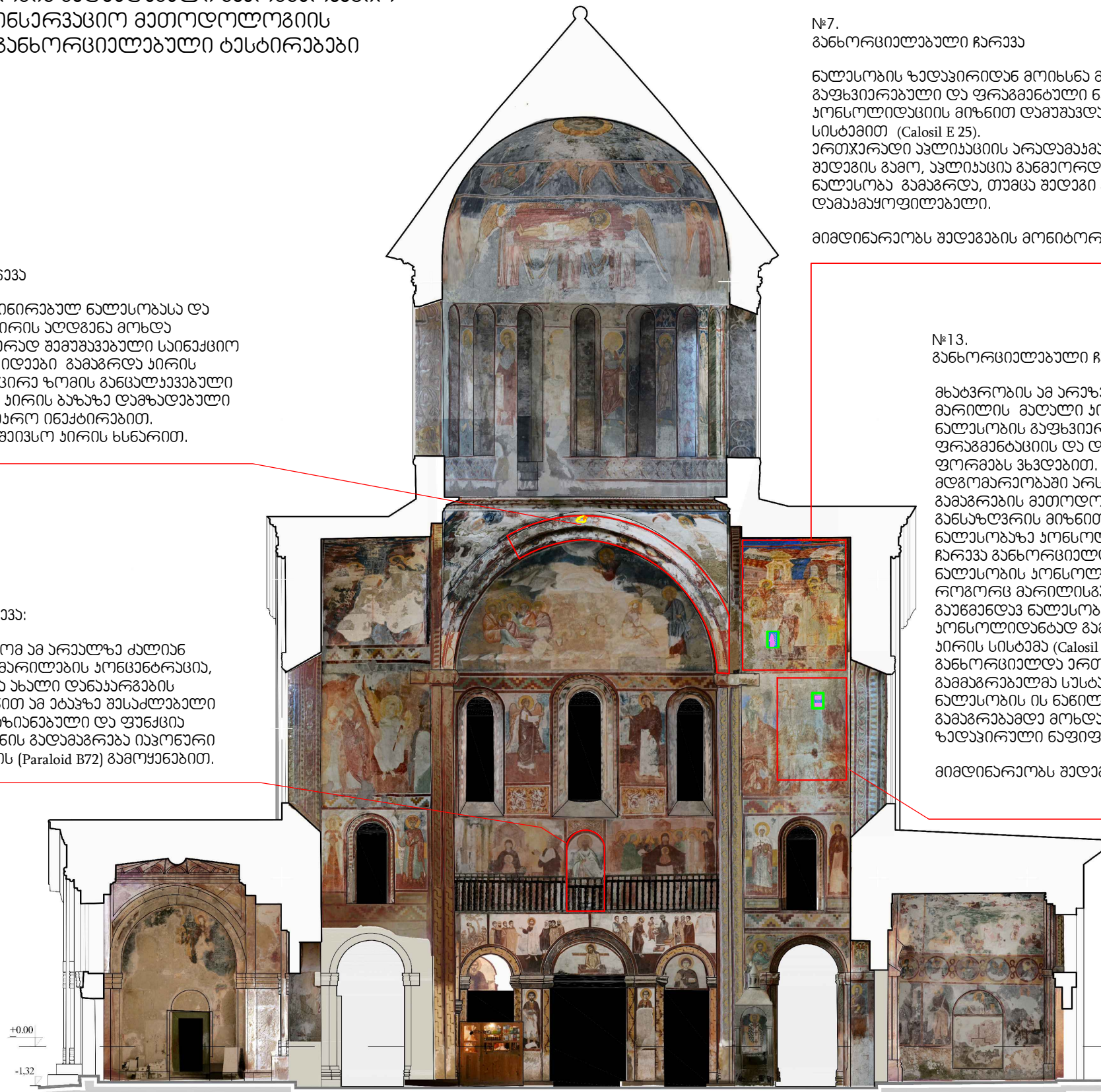
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განვლენიერება და ფრაგმენტული ნაწილი
ქონსოლიდაციის მიზნით დაუზავდა ვანო აირის
სინექციო (Calosil E 25).
ერთჯერადი ავსების არადაზიანებული
შედეგის გამო, ავსებისა გამოვრდა, რის შემდეგაც
ვალსოვა გამაგრდა, თანვე შედეგი არ იყო
დაზიანებული.









მიმდინარეობს შედეგის მონიტორინგი

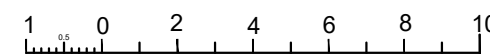
№13.
განხორციელებული ჩარვა

მხატვრობის ამ არეალზე სტრუქტურული
მარტივის მაღალი ქონებრაციის გამო
ვალსოვის განვლენიერების,
ფრაგმენტაციის და დალაშქრების რთულ
ფორმებს ჰხვდებათ. ამგვარ ფიზიკურ
მდგომარეობაში არსებული ვალსოვის
გამაგრების მეთოდოლოგიის
განსაზღვრის მიზნით, დაზიანებულ
ვალსოვზე ქონსოლიდაციის საბაზო
ჩარვა განხორციელდა.
ვალსოვის ქონსოლიდაცია შესრულდა,
როგორც მარტივების განვლენიერება ისე
განვლენიერება ვალსოვზე.
ქონსოლიდაცად გამოყენებულ იქნა ვანო
აირის სინექციო (Calosil Np 25) ავსებისა
განხორციელდა ერთჯერადად,
გამაგრებაზე სუსტად გამაგრდა
ვალსოვის ის ნაწილი სადაც
გამაგრებაზე მოხდა მარტივის
ზღვარიანი ნაწილის მოხსნა.

მიმდინარეობს შედეგის მონიტორინგი



- | | | |
|---|--|---|
|  Injection
ინექტირება |  Salts removal with a brush
მარტივის მოხსნა ფუჭით |  Edge repair
ქიმი |
|  Micro injection
მიწრო ინექტირება |  Salts removal with scalpel
მარტივის მოხსნა სააღვალთით |  Filling
შავსება |
|  Consolidation of plaster layer
ვალსოვის ქონსოლიდაცია |  Paint layer consolidation
ფრაგმენტული ფენის გამაგრება | |



გრაფიკული დოკუმენტაცია / Graphic Documentation

ჩრდილოეთის ზრდილი
North section

გელათის სამონასტრო
ქოხლასი ღვთისმშობლის
შობის ტაძარი

Church of the Nativity of
Virgin Mary

ქაღალის მხატვრობის გადარღვებითი საკონსერვაციო
ჩარკვის და საკონსერვაციო მეთოდოლოგიის
შერჩევითი განხორციელებული ტექნიკები

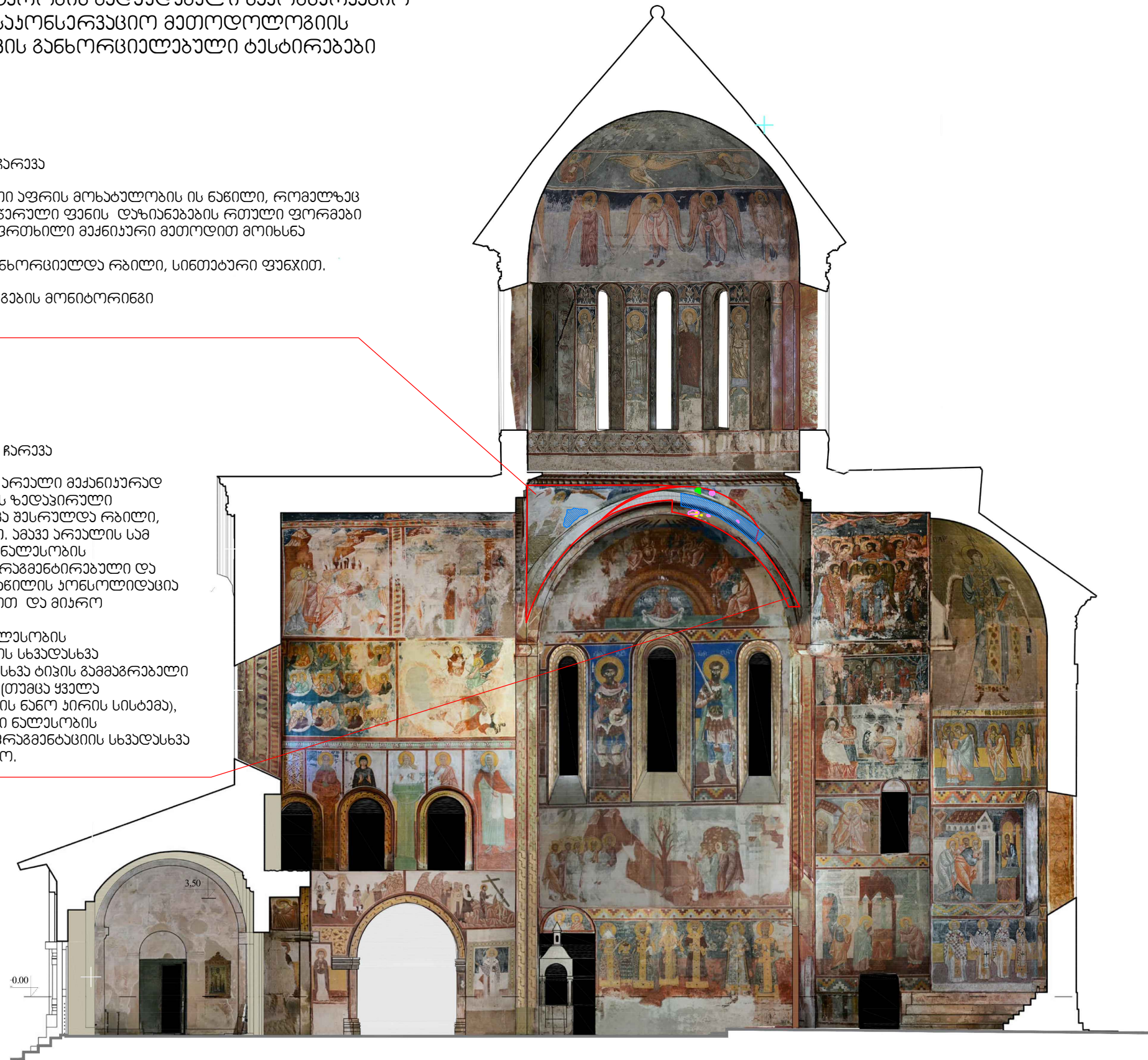
№14.
განხორციელებული ჩარკვა

ჩრდილო-დასავლეთი აფრის მონახულების ის ნაწილი, რომელზეც
ნაღვლის და ფრესკული ფანის დაზიანების რთული ფორმა
არ აღინიშნებოდა, ფრესკული მანქანის მეთოდით მოიხსნა
მარილის ნაფიფი.
ფიზიკური ჩარკვა განხორციელდა რბილი, სინთეტიკური ფაფით.

მიმდინარეობს შეღებვის მონიტორინგი

№16.
განხორციელებული ჩარკვა

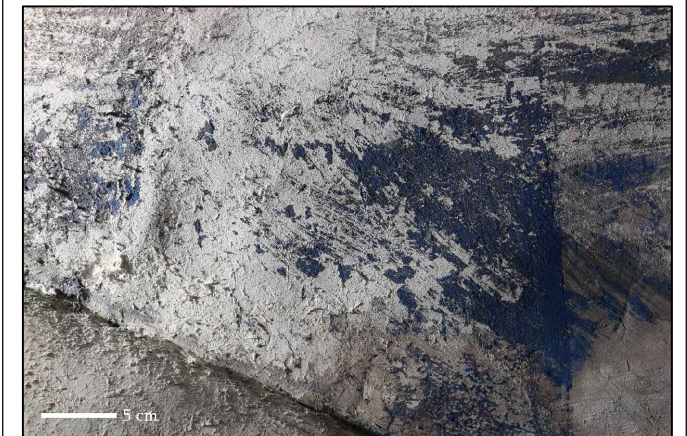
თაღის მონიშნული არააღიარებული მანქანის
განხორციელება მარილის ზღვრული
ნაფიფისგან. ჩარკვა შესრულდა რბილი,
სინთეტიკური ფაფით. ამავე არააღიარებული
ლოკაციაზე მოხდა ნაღვლის
გაფხვირება, ფრესკული და
განხორციელებული ნაწილის ქონსულიდაცია
ნაწილის სისტემით და მთავრო
ინექტირებით.
გაფხვირება ნაღვლის
ქონსულიდაცის სხვადასხვა
ლოკაციაზე, სხვადასხვა ტიპის გამგებრებალი
იქნა გამოყენებული (თუმცა ყველა
შემთხვევაში Calosil - ის ნაწილის სისტემა),
აღნიშნული მიზანი ნაღვლის
გაფხვირების და ფრესკულიდაცის სხვადასხვა
ტიპი და ხარისხი იყო.











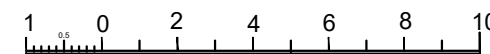
№14



№16



- | | | |
|--|---|---|
|  Injection
ინექტირება |  Salts removal with a brush
მარილის მოხსნა ფაფით |  Edge repair
ქიმი |
|  Micro injection
მიკრო ინექტირება |  Salts removal with scalpel
მარილის მოხსნა სააღვრულით |  Filling
შავება |
|  Consolidation of plaster layer
ნაღვლის ქონსულიდაცია |  Paint layer consolidation
ფრესკული ფანის გამგებრება | |



შეღებვის თარიღი
31.03.2024

გრაფიკული დოკუმენტაცია / Graphic Documentation

ხედლის მხატვრობის გადაუდებელი საკონსერვაციო
 ჩარვის და საკონსერვაციო მეთოდოლოგიის
 შერჩევითი განხორციელებული ტესტირებები

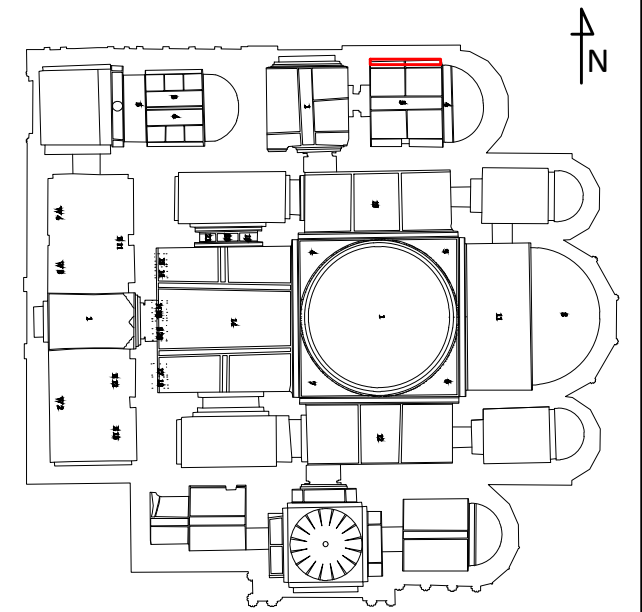
ჩრდილო-აღმოსავლეთი აპსიდა
 North-East Chapel

გელათის სამონასტრო
 ეკლესიის ღვთისმშობლის
 შობის ტაძარი

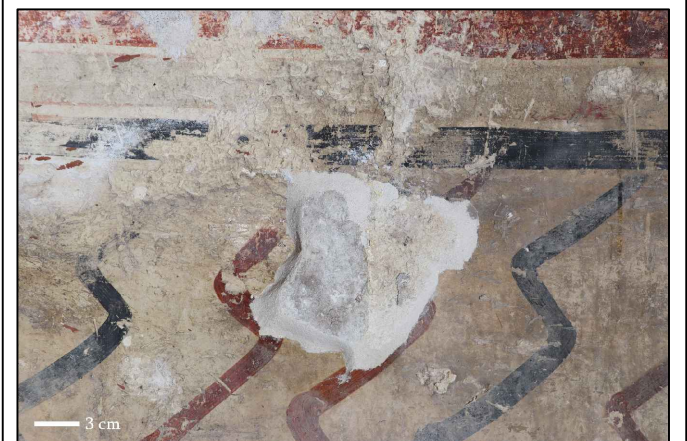
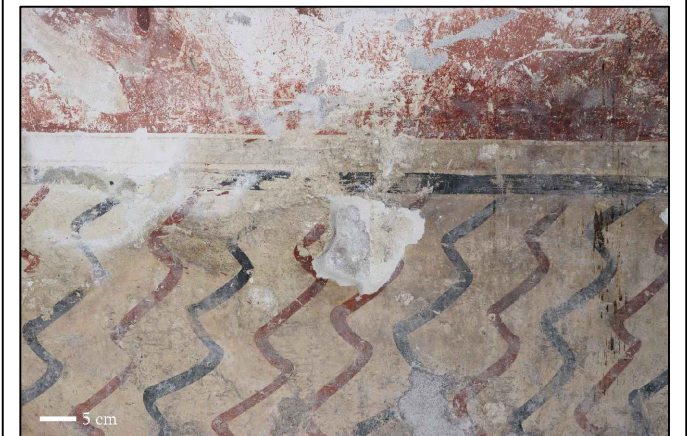
Church of the Nativity of
 Virgin Mary



გეგმა / Plan











№19



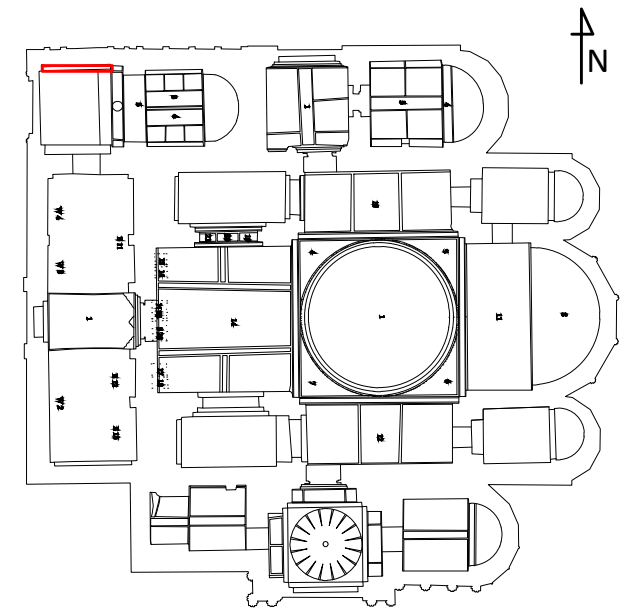
№19.
 განხორციელებული ჩარვა

ნაღვლის დაზიანებული მოწვეთში განხორციელდა ხირის ბაზა დაზიანებული ხსნარის ინექცია, ნაღვლის ქიმიკატი
 გამგრდა ხირის ხსნარით, ხსნარის შევსება და შევსების თანაფარდობა განისაზღვრა ორიგინალი
 ნაღვლის ფიზიკური მახასიათებლების მიხედვით.

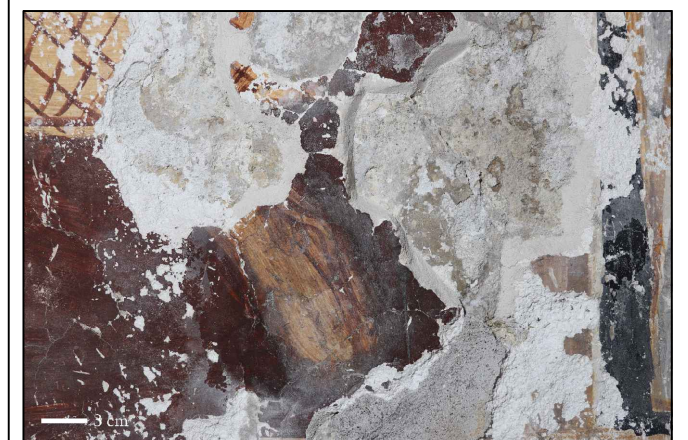
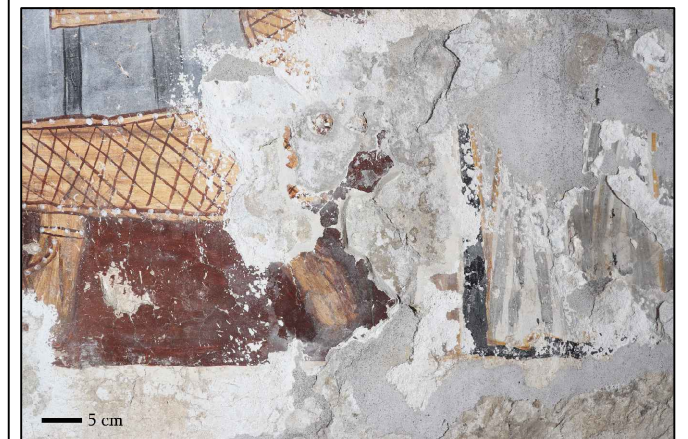
- | | | |
|--|--|---|
|  Injection
ინექცია |  Salts removal with a brush
მარილის მოხსნა ფურცლით |  Edge repair
ქიმი |
|  Micro injection
მიკრო ინექცია |  Salts removal with scalpel
მარილის მოხსნა სააღვალით |  Filling
შავება |
|  Consolidation of plaster layer
ნაღვლის კონსოლიდაცია |  Paint layer consolidation
ფერადი ფენის გამგრდა | |

ქალღმერთის მშობიარობის გადგომის საკონსერვაციო
ქარვის და საკონსერვაციო მეთოდოლოგიის
შერჩევითი განხორციელებული ტექნიკები

გეგმა / Plan











№20



№20.
განხორციელებული ჩარევა

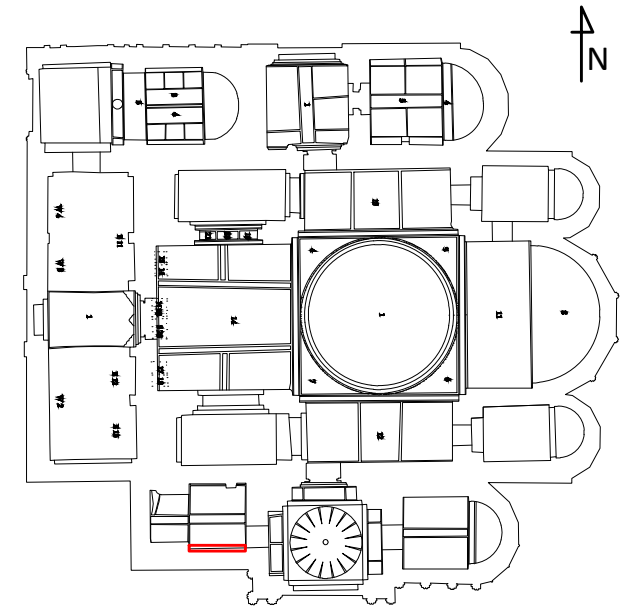
ნაღვლის დაზიანებული მოწვეთში განხორციელდა ჯირის ბაზა დაზიანებული ხსნარის ინექცია, ნაღვლის
ქიმიკატების გამოყენება ჯირის ხსნარით, ხსნარის შევსება და შევსების და შევსების თანაფარდობა განისაზღვრა
ორიგინალი ნაღვლის ფონური მასალის მიხედვით.

- | | | |
|--|---|---|
|  Injection
ინექცია |  Salts removal with a brush
მარილის მოხსნა ფურცლით |  Edge repair
ქიმი |
|  Micro injection
მიკრო ინექცია |  Salts removal with scalpel
მარილის მოხსნა სააღვლებით |  Filling
შავება |
|  Consolidation of plaster layer
ნაღვლის უზრუნველყოფა |  Paint layer consolidation
ფერადი ფენის შევსება | |

ქედლის მხატვრობის გადაუდებელი საოქსერვაციო
ჩარვის და საოქსერვაციო მეთოდოლოგიის
შერჩევითი განხორციელებული ტექნიკები



გეგმა / Plan



№21.1











№21.2



№21.1- №21.2. განხორციელებული ჩარვა

მოხატულობის არჩიებული მდგომარეობის გამო ჩარვის პროცესში, ჰიკვალ ებაჟა სავირო განლა ნაუსობის დროებითი გამაგრება, რაც ციკლოლოლოდაანის საშუალებით განხორციელდა, აღნიშნულმა ჩარვამ უსაფრთხო ოპერირების შესაძლებლობა მოგვცა, მეორე ებაჟა მოხდა დალაშქრებული/გაცელაჟებული ნაუსობის ფრთხილი და ებაჟორივი ინექტირება. ნაუსობის გაშიშვლებული ჰილაბი გამაგრდა ჰირის ხსნარის ქიმიით.

შენიშვნა: ფოტოები გადაღებულია ციკლოლოდაანის სალინაციამდე

- | | | |
|---|--|---|
|  Injection
ინექტირება |  Salts removal with a brush
მარილის მოხსნა ფუჯით |  Edge repair
ქიმი |
|  Micro injection
მიკრო ინექტირება |  Salts removal with scalpel
მარილის მოხსნა სააღვალით |  Filling
შავსება |
|  Consolidation of plaster layer
ნაუსობის აოქსერვაციის |  Paint layer consolidation
ფერადრული ფრის გამაგრება | |

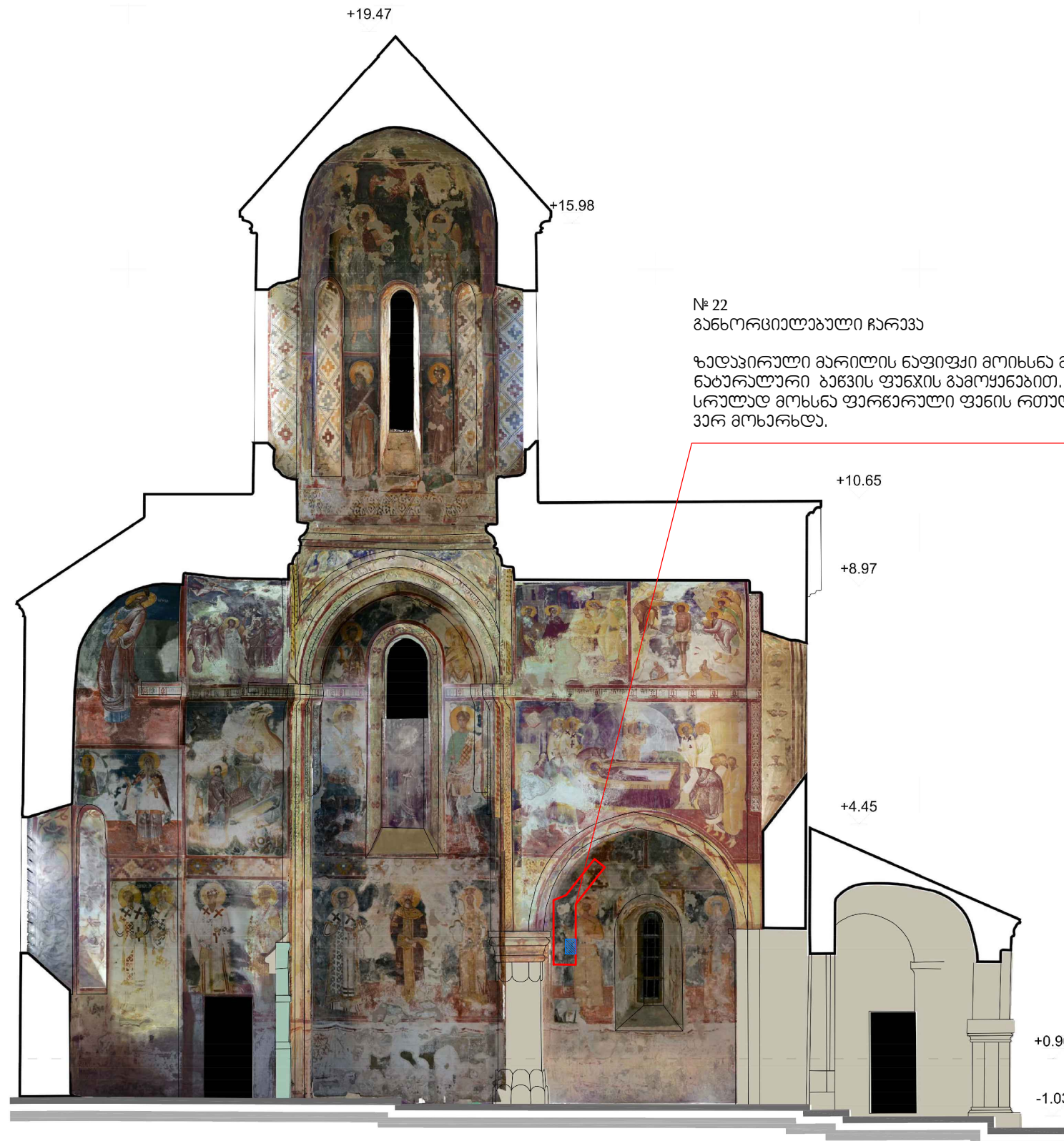
გრაფიკული დოკუმენტაცია / Graphic Documentation

სამხრეთის ჰრილი
South section

გელათის სამონასტრო
ჯოგლაქსი
მ. გიორგის ეკლესია
Church of ST. George

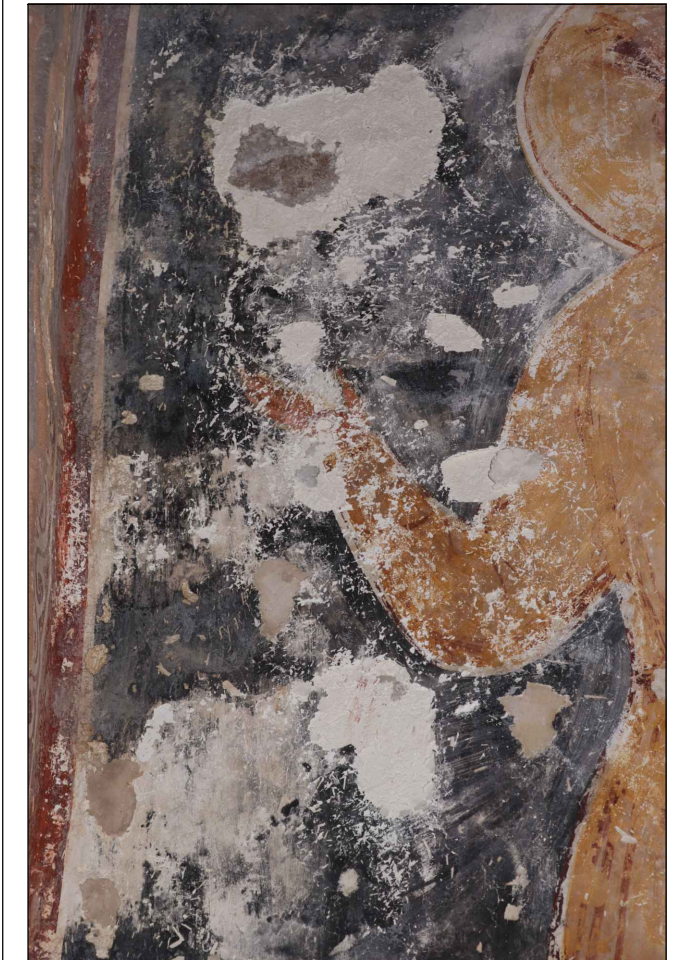
ქედლის მხატვრობის გადაუდებელი საკონსერვაციო
ჩარკვის და საკონსერვაციო მეთოდოლოგიის
შერჩევითვის განხორციელებული ტესტირებები









№22

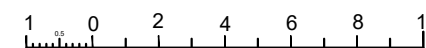


№ 22
განხორციელებული ჩარევა

ზღაპირული მარილის ნაფიჭი მოიხსნა მკაფიურად, რბილი, ნატურალური ხაზის ფაქის გამოყენებით. ზღაპირული მარილის სრულად მოხსნა ფარგარული ფანის რთული მდგომარეობის გამო ვერ მოხერხდა.



- | | | |
|--|--|---|
|  Injection
ინექცია |  Salts removal with a brush
მარილის მოხსნა ფაქით |  Edge repair
ქიმი |
|  Micro injection
მიკრო ინექცია |  Salts removal with scalpel
მარილის მოხსნა სააღვალით |  Filling
შავება |
|  Consolidation of plaster layer
ვალსოვის უმსრლიდაცია |  Paint layer consolidation
ფარგარული ფანის გამგრება | |



გადახედის თარიღი
31.03.2024