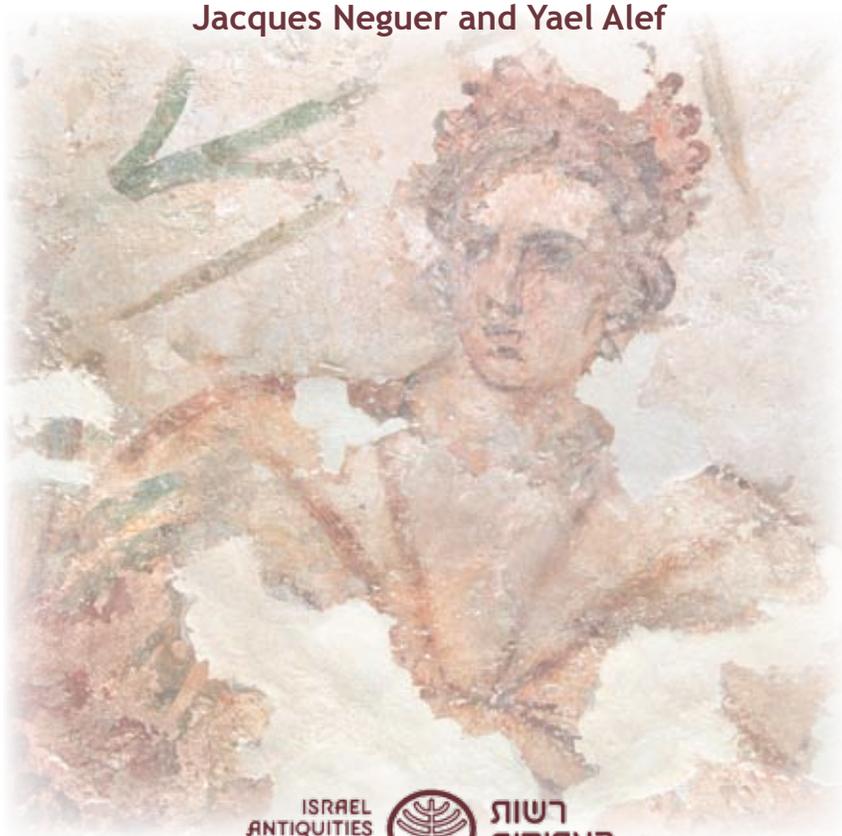


Excavation and Treatment of Plaster, Stucco and Wall Paintings in Archaeological Sites

A Guide for Archaeologists and Conservators

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Introduction

Plaster, stucco and fresco painting from archaeological sites represent a rich source of information for archaeologists and for those conducting research in fields such as building materials and techniques, painting media, and the history of art. For visitors, such remains have historic and artistic value in illustrating the past. The archaeological dig exposes the remains to the elements after they have been buried for decades in stable conditions. ‘Excavation shock’—the rapid drying out, shrinking and expansion caused by fluctuations in humidity and temperature, as well as UV radiation—results in immediate destruction and deterioration processes. The exposure, conservation and study of such sensitive elements present a complex challenge demanding full cooperation between archaeologists, conservators and other specialists, in order to manage the site’s excavation and treatment in keeping with the archaeological research goals and conservation needs. These include collecting environmental data to plan the appropriate preventive conservation: shelter, salt testing, microbiological analysis and deterioration patterns, and researching wall-painting materials and conservation techniques.

The guide to the excavation and treatment of plaster, stucco and wall paintings is designed to help archaeologists and conservators plan the appropriate treatment for such fragile components of the archaeological excavation, from the moment they are identified and excavated. It aims to provide a common language for archaeologists and conservators, to prevent the loss and destruction of plaster, stucco and fresco elements, whether due to incorrect excavation methods, insufficient documentation, inappropriate collection and transfer from the site to the laboratory, or insufficient protection for those elements remaining *in situ*.



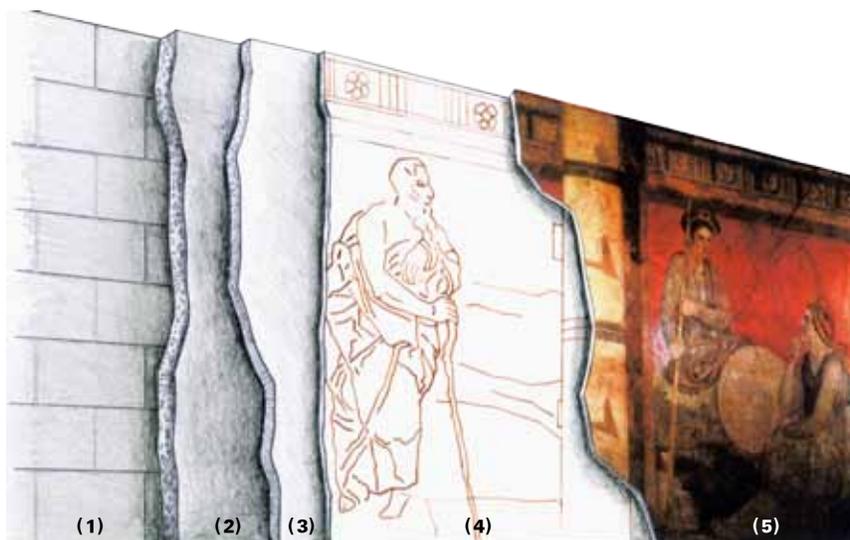
Wall painting from Gethsemane.

Plaster. A soft, plastic material that can be spread on a wall, ceiling, or other surface, where it subsequently hardens. In the context of art and architecture, plaster is a mixture of water, lime and sand, often combined with other materials, such as animal hair, to give the resulting material the required strength, texture and porosity.

Stucco (molded plaster). A type of malleable plaster, made from slaked lime mixed with powdered marble (*stucco romano*), or with gypsum and stone powder. The stucco sets more slowly than “regular” plaster, and therefore lends itself to sculpting and the decoration of external and internal architectural elements.

Fresco. A painting technique in which dry pigments ground with water are brushed onto a thin layer of wet plaster (*intonaco*). As the plaster dries, there is a chemical reaction between the calcium hydroxide (CaOH) and the air, and it stabilizes as calcium carbonate (CaCO₃) to become durable. Fresco paintings are known to have survived from the Minoan period in Crete (1700 BCE) and also from the Roman period at Pompeii (79 CE). Fresco paintings were used to decorate interior walls in Italy, particularly in churches, from the thirteenth century CE onward.

Secco. A technique in which aqueous slurry (pigment) is applied to dry plaster. This technique requires a binding medium, such as egg (tempera), glue or oil to attach the pigment to the plaster. Secco was often used over the fresco painting to correct mistakes, and to add details in shades that were impossible to achieve in fresco because of the alkaline nature of the fresh plaster. Blue presented a particular problem; for example, blue robes were usually added using the secco technique, since neither of the two minerals commonly used to produce blue in ancient times, lapis lazuli and azurite, are chemically compatible for working on wet plaster.



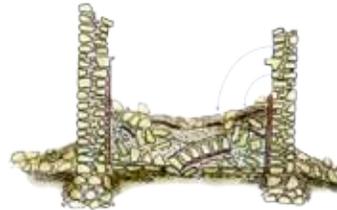
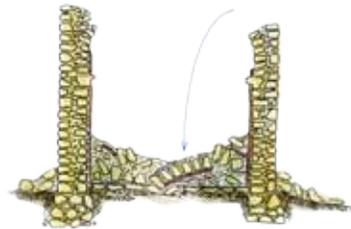
Structure of a wall painting: (1) First layer of plaster (*Trullisatio/Rinzafo*)—foundation layer leveling the stone wall surface; (2) Second plaster layer (*Arriccio*)—rough lime-based plaster layer; (3) Plaster layer (*Intonaco*)—thin and fine finishing layer on which the painting is drawn; (4) Sinopia—outline of the painting, usually drawn in a reddish color; (5) The wall painting.

Archaeological Excavation of Plaster, Stucco and Wall Paintings

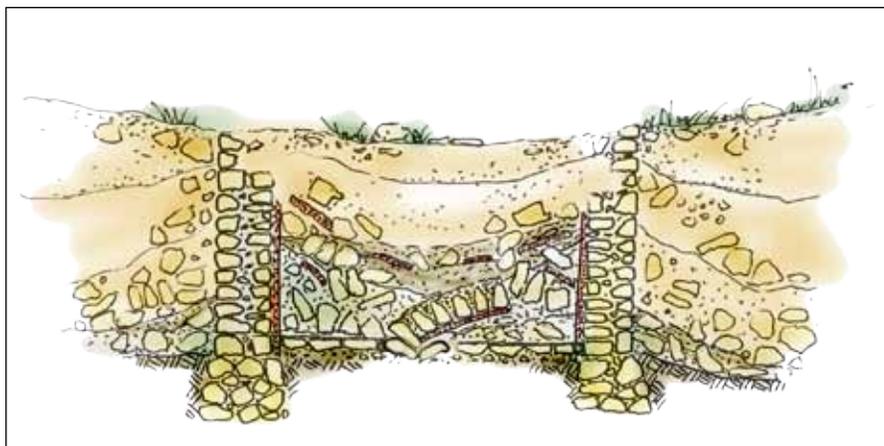
Wall paintings excavated at archaeological sites will usually be found in the following conditions or combinations thereof:

- A. Loose fragments that are no longer *in situ*;
- B. Fragments connected to collapsed walls, including interconnected plaster fragments;
- C. *In situ* painting on plaster, still attached to a standing wall.

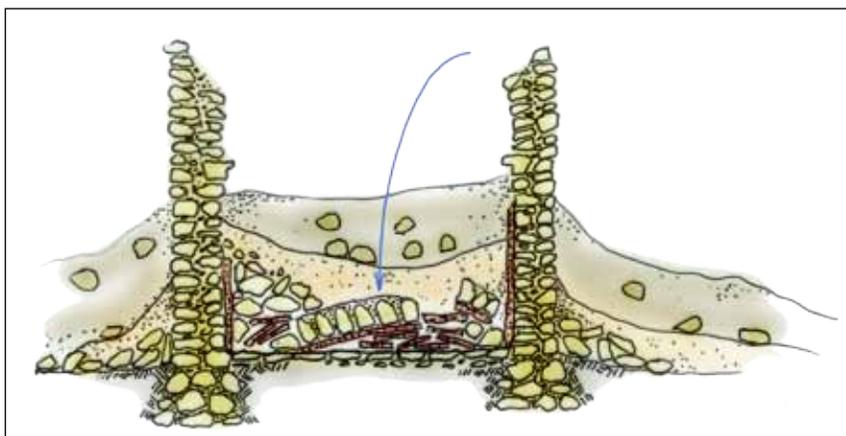
These conditions are the outcome of the way in which the building collapsed. In a gradual process of collapse, the ceiling and roof collapse first, followed by the upper parts of the wall and then the lower parts of the wall. During the excavation, the upper sections of the painting are generally found furthest from the wall, toward the middle of the room, whereas the lower parts are usually found closer to the wall. Therefore, the order and location of the wall-painting fragments may well indicate their original location in the structure. If the collapse occurs over time, as a result of the building being abandoned and deteriorating, layers of dust and debris may accumulate between fragments of the wall and the destroyed wall painting. If destruction was sudden, due to an earthquake for example, the plaster and collapse will be found on the floor covered by accumulated layers of debris from later periods.



Effect of degradation and destruction on the preservation of wall paintings in a building; the location of loose plaster fragments may indicate their original location on the wall.



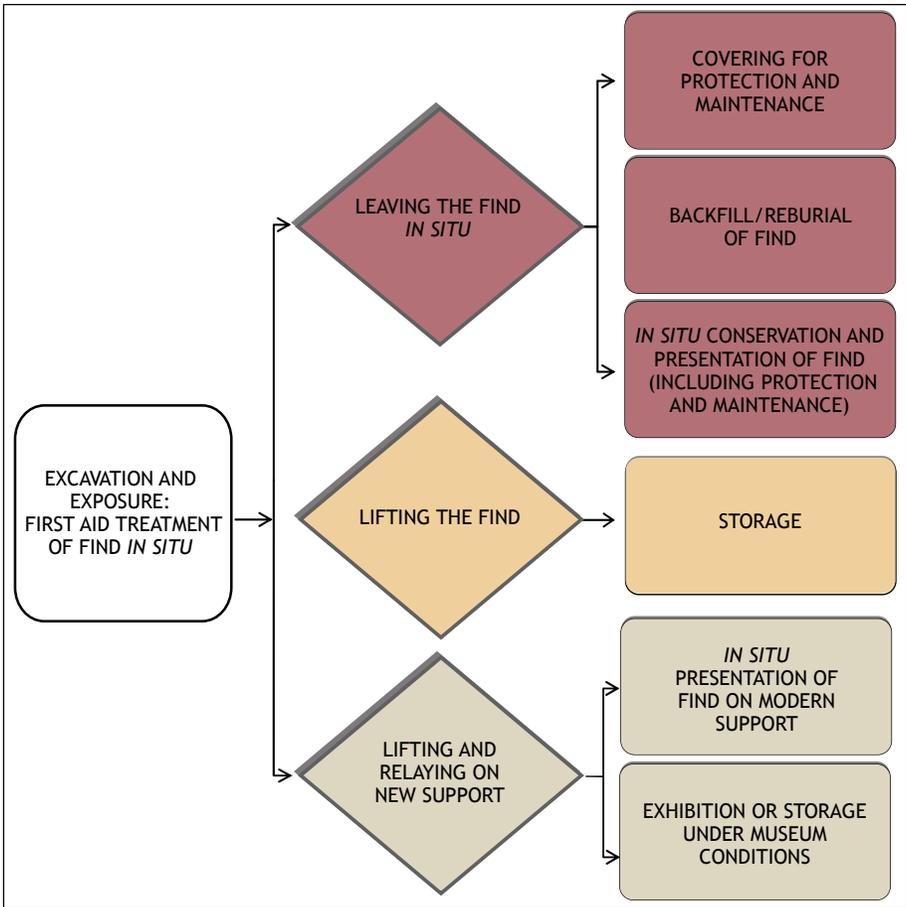
Accumulation of layers of dirt between parts of the building and the destroyed wall painting.



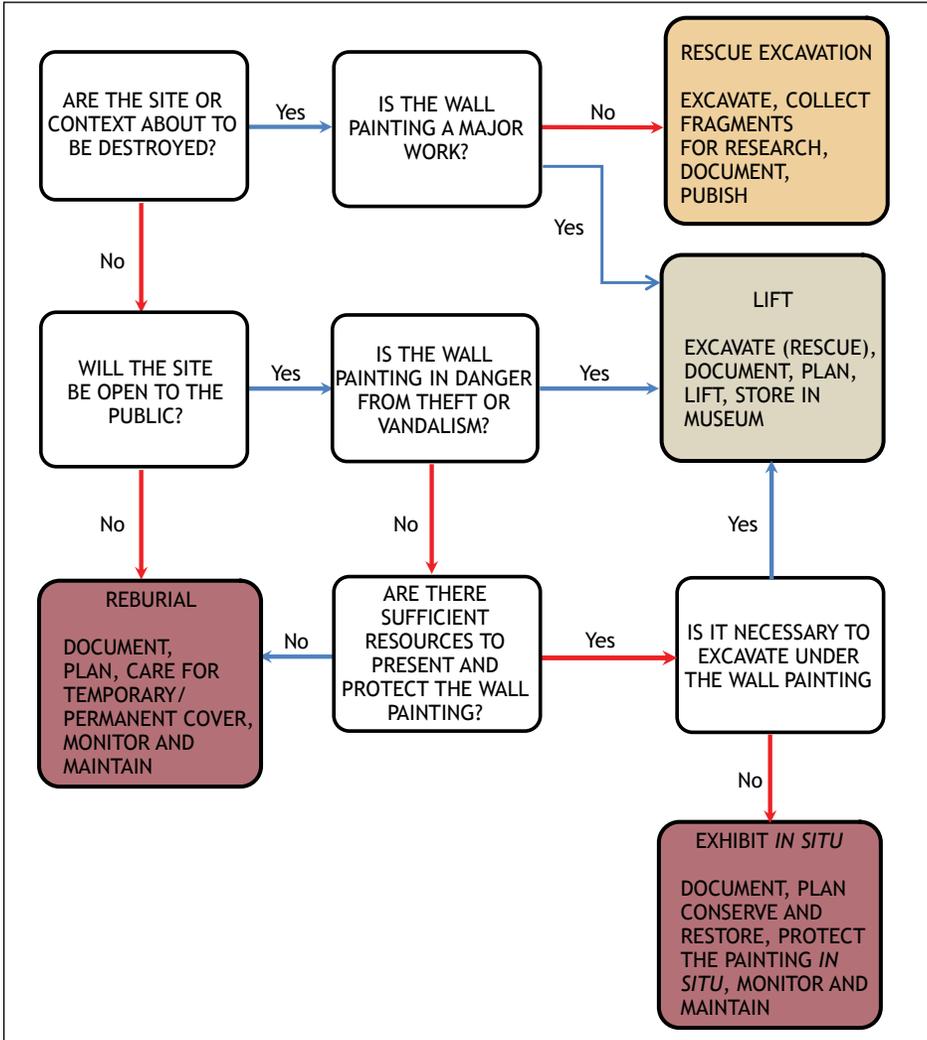
Fragments of plaster and collapse on the floor, covered with an accumulation of later fill layers, in cases when an earthquake has caused sudden destruction.

Decision Making during Excavation, Conservation and Presentation of Wall Paintings

The importance of wall paintings or artistic elements, and their particular vulnerability to climatic conditions from the moment they have been exposed, require careful and knowledgeable management of all aspects of the excavation. The options for conserving and exhibiting the remains are listed here, followed by a flowchart detailing the questions and guiding principles for choosing the preferred option.



Scenarios for conserving and exhibiting wall paintings.



Wall-painting conservation and exhibition decision-making process (after Gaël de Guichen's diagram for mosaic treatment).

The Main Work Stages

The main stages of excavation and conservation of plaster, stucco and wall paintings are described below, according to three states of preservation and means of intervention:

1. Exposure and treatment of detached fragments;
2. Exposure of the wall painting, removal and treatment in the laboratory;
3. Exposure and treatment of plaster, stucco and wall paintings *in situ*.

In many cases, different conservation methods will be combined: treatment of fragments, lifting of mural panels and *in situ* conservation of the rest of the wall painting. Recording and excavation will be conducted as a first step in all cases, as a basis for decision making regarding the continuation of treatment. Documentation of the intervention will also be conducted in all cases, according to standard procedures. The other work stages depend upon the condition of preservation.



Treating a wall painting in a laboratory.

1. Recording

Recording provides information about the position and stratigraphy of the wall painting, enabling an understanding of the archaeological context and assisting in the artistic reconstruction of wall paintings. Recording is the basis of the conservation process, and is mandatory before any intervention. The archaeologist is responsible for the excavation.

- 1.1. Recording in relation to the structure on a scale between 1:25 and 1:50, and surveying the location of the painting in the site.
- 1.2. Measuring, detailed recording and photographing all the collapsed fragments to document their precise location relative to each other (including detached fragments or fragments connected to walls which have collapsed), on a 1:1 scale.
- 1.3. General photography of the site and its finds from every direction according to standard practice, with the scale-bar parallel to the plane of the photo. Careful attention must be paid to ensure that the camera is held perpendicular to the find, and to observe a balanced contrast between light and shade.

2. Excavation

The aim of the excavation in this instance is to expose the wall painting in a controlled manner, and as far as possible to preserve the original material in the best possible condition, in order to extract the maximum data from it. The archaeologist is responsible for the excavation.

- 2.1. Excavating the soil to within 1 cm of the wall painting.
- 2.2. Waiting for the layer of soil covering the painting to dry out at a controlled rate.



A fine layer of soil has been left during excavation to cover the painting and ensure its controlled drying out.

3. Preliminary Cleaning

The purpose of preliminary cleaning of the painting at this stage is to allow a rudimentary understanding of its physical condition and to assess its significance, as a basis for decision making as regards the continued excavation and method of treatment. The rest of the cleaning will take place at a later stage in the laboratory, or on site prior to exhibiting the wall painting. Preliminary *in situ* cleaning will be the responsibility of the conservator, following these stages:

- 3.1. Mechanical cleaning of dry soil residue with brushes and a scalpel.
- 3.2. Chemical cleaning of carbonates and other deposits.
- 3.3. Extraction of salts.



Cleaning remains of dry soil from the panel with a chisel to allow gauze material to be applied to stabilize the panel before lifting it.

4. Initial On-Site Consolidation

In many cases, the physical condition of fragments in debris or of panels to be lifted is fragile and crumbling. Therefore, pre-consolidation with reversible materials and methods is needed to stabilize them before collection and transportation to the laboratory. Pre-consolidation of the painting *in situ* will usually be combined with treatment (Stage 7, below). The conservator is responsible for *in situ* pre-consolidation:

4.1. Pre-consolidation of the paint layers with reversible materials will be carried out in exceptional cases before treating the foundation of the painting or before removing the wall paintings.

4.2. Applying support using “facing” with gauze and reversible consolidates, such as Paraloid B72 diluted in an organic-based agent, enabling future treatment. In certain cases, non-reversible materials may be used, such as lime water or lime-based mortar or nano-lime, which will not interfere with future treatment.

4.3. Protection of the painting before removal from the site and transportation, by building wooden or plastic-mesh supports and boxes filled with polyurethane foam or gypsum, matching the size of the panel or fragments.

4.4. When a wall painting is exposed *in situ*, preventive conservation measures must be provided, including temporary drainage, shelter and cover, as well as pre-consolidation of the walls and plaster (strengthening edges, consolidating lacunae, and micro-grouting).



Applying gauze impregnated with Paraloid to strengthen the edges of the painting before lifting and removing it from the wall.



Fixing wooden supports to lift the panel from the site.

5. Collecting Wall-Painting Fragments and Lifting Panels

Collection of fragments or removal of the painting are required in order to transfer them to the laboratory for continued conservation and research, or in order to reassemble them with the *in situ* wall painting. In principle, it is important to collect all the loose fragments on the site even if initially there seems to be no relationship between them. These fragments could be part of an *in situ* wall painting, and will assist in the architectural understanding and restoration of the painting. The aim is to collect the fragments according to their exact location in relation to the structure and the layers of debris in the destroyed building.

- Collection of all the fragments, without selection, will take place when the fragmented finds are out of context and are not part of the building's stratigraphy, for example if they have been moved from their position in ancient times, or deposited as waste.
- The fragments are laid in boxes with paper shreds between the fragments, while maintaining the proper humidity during transportation and storage.
- The archaeologist may be responsible for collecting the fragments, while the conservator will remove the panels or fragments of painting found in the collapse.



The panel is separated from the wall using metal rulers, and then fixed to an additional support with gauze.

5.1. Loose fragments: collecting all the fragments separately, without sorting, and storing in labeled boxes lined with paper or soil. Cleaning of the back and consolidation will sometimes be required before transportation.

5.2. Fragments connected to collapsed walls: collecting the connected fragments and storing in boxes.

5.3. Removing the wall painting from the site: detaching the painting from the wall after constructing a suitable support, and transporting to the laboratory.



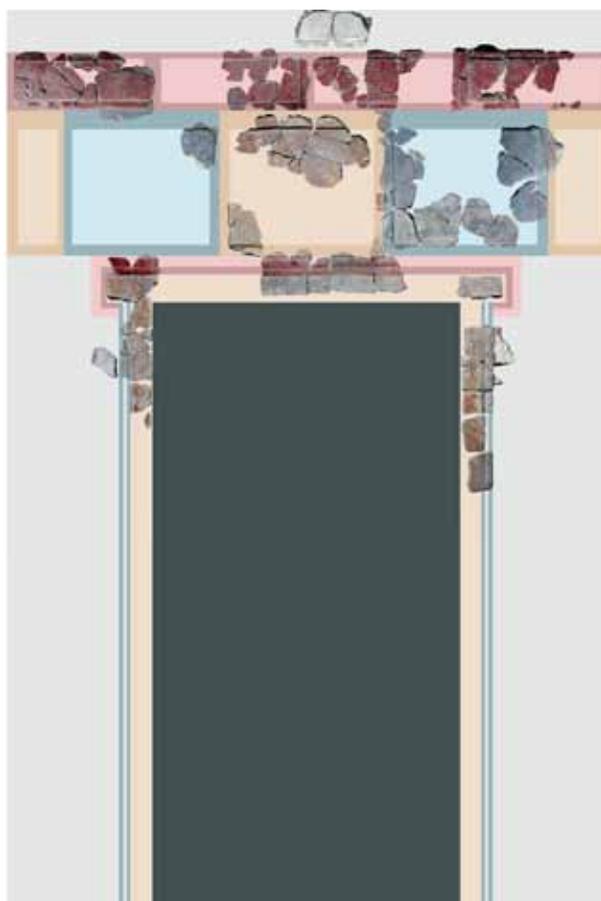
Cleaning the back of the fresco before it can be transported to the laboratory.

6. Reassembly in the Laboratory

The object of reassembling the loose fragments is to permit an understanding of the artistic design, and its relation to the architectural structure and the context of the site. The reassembly is usually undertaken by the conservator in the laboratory.

6.1. Sorting the fragments in each box by color, designs and the different types of mortar used.

6.2. Assembling the fragments according to the documentation and physical evidence: the shape of the fragments, pigments, designs and mortar. In the mortar from ceiling fragments, for example, there may be traces of wooden beams, and it is different from the mortar used in walls.



Reconstruction of the fresco from the rescue excavation at Nahf: the fragments were joined together based on the documentation and physical evidence: the form of the edges, pigments, decorative elements and the different types of mortar.

7. Treatment

The intervention is based on an assessment of the condition of the find after a physical survey and mapping of the effects of destruction and deterioration, and after the value of the finds has been understood and they have been interpreted. The conservator is responsible for the treatment.

7.1. Conservation of loose fragments aligned in preparation for assembly to the wall painting *in situ* or on a panel, or prior to storage.

- The main aim of conserving the loose fragments is to assist in archaeological research. In the case of fragments extracted from collapse, conservation may also aim to enable a restoration of the designs and their reassembly to the wall painting *in situ*, or their exhibition on a panel in a museum.

7.1.1. Dry and wet cleaning, and consolidation of pigments and mortars.

7.1.2. Reassembling the fitting fragments to the wall painting that has been left *in situ*, or to a panel of the painting that has been removed from its site.

7.1.3. Storing the remaining fragments that have been aligned together (without being glued) in suitable boxes.

7.1.4. Monitoring.

7.2. Conservation of a wall painting that has been lifted from its site

- The conservation aims to enable research, restoration and exhibition, either in a museum or on-site.



Cleaning mortar from the back of the painting in the laboratory, and applying a lime-based dividing layer with a permanent support of “aluminum honeycomb.”

7.2.1. Consolidating the mortar of the back of the painting and placing it in a permanent support.

7.2.2. Cleaning and consolidating the layers of paint, integrating lacunae and the surface of the painting, and applying protective layers.

7.2.3. Returning the painting for exhibition *in situ* or in a museum, or transferring for storage.

7.2.4. Monitoring.



Filling in lacunae.



Wet cleaning.



Integration of lacunae.

7.3. Treating a wall painting *in situ*

- The conservation aims to enable research and exhibition within the broad context of the archaeological site. Thus, treatment will include:

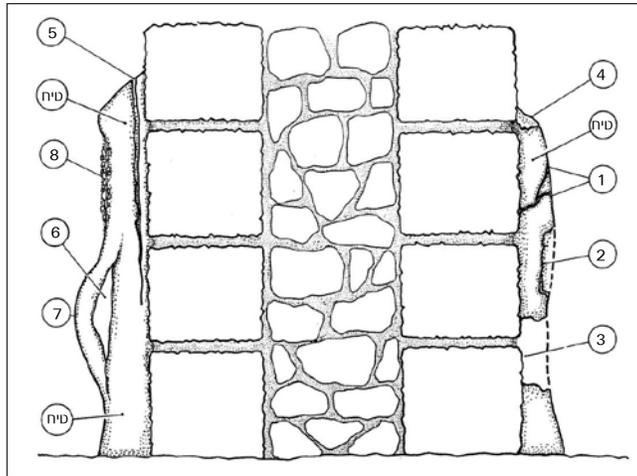
7.3.1. Consolidation of the wall and mortars to support and preserve the wall paintings.

7.3.2. Final cleaning, salt extraction and consolidation of the paint layers.

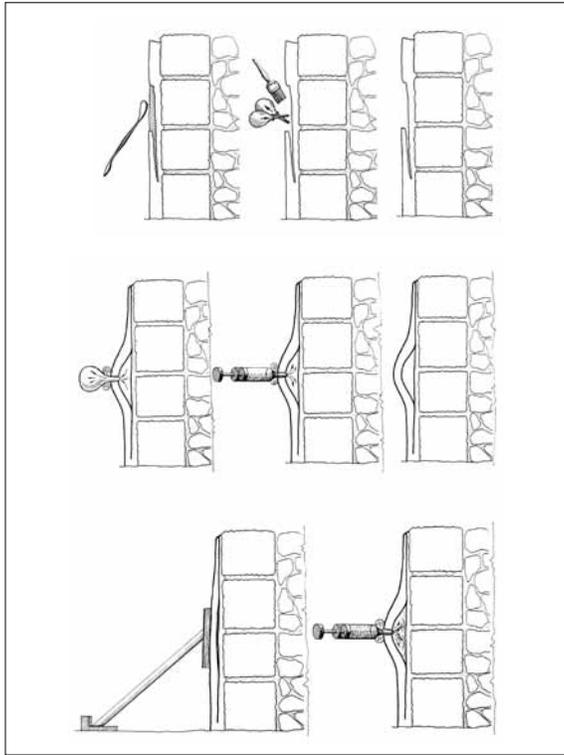
7.3.3. Filling in lacunae, integration of painting and application of protective layers.

7.3.4. Arranging for drainage and temporary protection (roofing or covering) until permanent protective measures are installed.

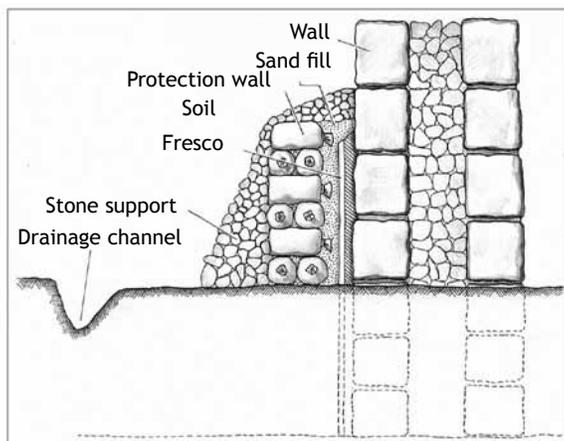
7.3.5. Monitoring and maintenance.



Cross-section showing typical conservation problems encountered with wall paintings exposed in an archaeological excavation: Cracks in the plaster (1); lacunae (gaps) on the surface (2) and on the foundation layer (3); broken plaster edges (4); detachment (5); holes (6); swelling (7); and disintegration of the plaster (8).



Treating plaster to stabilize it, including cleaning and injecting mortar.



Temporary covering and protection of a wall painting from 'En Qobi (for permanent covering, a layer of soil must be added above the stone support).

8. Sampling

Analysis of materials may yield information that will assist in archaeological and artistic research, and also help plan conservation treatment and research (see Appendix 1). The samples may provide data on building techniques, components and characteristics of mortars, pigments and binders in buildings and wall paintings in ancient times, and even contribute to research on the plant environment using tests to identify pollen trapped in plaster. Tests are also used to determine suitable intervention methods: Collection of environmental data, salt testing, erosion patterns and microbiology. Most of the samples will be taken in the laboratory, according to the demands of the experts and research questions posed by the archaeologist or the conservator.

- 8.1. Sampling the mortars from all the foundation layers of the wall painting.
- 8.2. Sampling the pigments and binders from all the paint layers.
- 8.3. Sampling to identify deterioration processes and micro-organisms.
- 8.4. Collecting climatic data from the environs of the *in situ* wall painting.

9. Documenting and Preparing the Final Report

The documentation report provides information on the materials and ancient painting techniques, a graphic report of the physical condition before conservation, and information about the interventions for research, exhibition and further conservation in the future. The conservator is responsible for the documentation.

- 9.1. Photographic records of wall-painting fragments.
- 9.2. Interpretation and graphic reconstruction of the wall painting.
- 9.3. Physical survey report.
- 9.4. Documenting the interventions carried out and the information collected during the conservation work, and mapping them.

The Excavation and Treatment of Wall Paintings in an Archaeological Site

Stage	Description of Tasks	Where	Who	Equipment
1. Measurement	<p>1.1 Measuring and mapping the location of the painting in relation to the structure and the site on a 1:25–1:50 scale.</p> <p>1.2 Measuring and recording all the sections (including detached fragments or sections attached to collapsed walls) on a 1:1 scale.</p> <p>1.3 General photography of the site and the find.</p>	Site	Archaeologist or conservator Surveyor Photographer	<ul style="list-style-type: none"> • Writing implements, transparent paper, site plan • Cameras • Measuring tools such as GPS, theodolite, in rare cases laser scanning or photogrammetry
2. Exposure	<p>2.1 Excavating the soil to within 1 cm of the wall painting and leaving the painting covered with a layer of soil.</p> <p>2.2 Waiting for controlled drying out of the layer of soil.</p> <p>2.3 Arranging for preventive treatment as first aid: drainage, temporary roofing or covering.</p>	Site	Archaeologist	<ul style="list-style-type: none"> • Spatulas, brushes, scalpel • Boxes, shredded paper (for packing), labels • Sand bags, geotextiles, sand, sieved soil from the excavation
3. Primary cleaning	<p>3.1 Mechanical cleaning of dry soil residue with brushes and a scalpel.</p> <p>3.2 Chemical cleaning of carbonates and other deposits.</p> <p>3.3 Extraction of salts.</p>	Site	Conservator	<ul style="list-style-type: none"> • Brush and scalpel • Cleaning deposits: Paper pulp with NH_4HCO_3, EDTA extraction of salts: paper pulp or Japanese paper with distilled water

The Excavation and Treatment of Wall Paintings in an Archaeological Site (cont.)

Stage	Description of Tasks		Where	Who	Equipment
4. Primary stabilization	Loose fragments	Extracting a Panel or Fragments from a Collapse	Conserving the Find In Situ		
	4.1 Pre-consolidating with reversible materials (in rare cases).	4.2 Pre-consolidating the paint layers with reversible materials (in rare instances). 4.3 Applying gauze "facing" and structural consolidation to support the wall painting prior to lifting.	4.4 Preventive conservation measures, including temporary drainage, shelter and temporary cover. 4.5 Pre-consolidating the paint layers with reversible materials, to be carried out in rare cases prior to injection and consolidation. 4.6 Primary consolidation of the walls and plaster (strengthening edges, consolidating lacunae and micro-grouting).	Site	Conservator
	5.1 Loose fragments: Collecting all the fragments separately, without sorting, and storing in padded boxes. 5.2 Fragments connected to collapsed walls: collecting the loose fragments and storing in boxes.	5.3 Protection prior to lifting and transportation, by building wooden boxes or a plastic mesh with polyurethane or gypsum filling tailored to the panel or collapse. 5.4 Detaching the painting from the wall or collapse and transferring it to the laboratory.	Not relevant	Site	Conservator
					<ul style="list-style-type: none"> • Use of reversible consolidants, such as Paraloid B72 diluted with an organic base or Cyclohexane • Materials for detachment after pre-consolidation: covering the surface of the painting with gauze "facing" impregnated with Paraloid B72 diluted with an organic base. • Materials for transfers: supports or wooden boxes filled with polyurethane or gypsum

The Excavation and Treatment of Wall Paintings in an Archaeological Site (cont.)

Stage	Description of Tasks	Conserving the Find <i>In Situ</i>	Where	Who	Equipment
	<p>Loose fragments</p> <p>6.1 Cleaning each box and sorting by colors, designs and different types of mortar.</p> <p>6.2 Assembling the fragments according to the documentation and physical evidence: fragment shape, colors, designs and mortar.</p>	<p>Extracting a Panel or Fragments from a Collapse</p> <p>It may be possible to combine pieces detached from the wall painting in ancient times or during the excavation in the conserved panel.</p>	Laboratory	Conservator	<ul style="list-style-type: none"> • Reversible adhesives • Materials to build a new support or boxes suited to storage
	<p>7.1 Final cleaning and consolidation of paint layers and mortar.</p> <p>7.2 Reassembling the matching fragments to the wall painting remaining <i>in situ</i>, or to the painting panel removed from the site.</p> <p>7.3 Storing the remaining pieced-together fragments (without gluing) in suitable boxes.</p>	<p>7.4 Stabilizing the mortar of the back of the painting and transferring it to a permanent support.</p> <p>7.5 Cleaning the layers of paint and mortars and consolidating them, integrating lacunae and the surface of the painting and applying protective layers.</p> <p>7.6 Returning the painting for presentation <i>in situ</i> or in a museum, or depositing it in storage.</p>	Site/ laboratory	Conservator	<ul style="list-style-type: none"> • Cleaning materials and poultices • Consolidants for mortars and paint layers • Lime- or acrylic-based mortars • Pigments • Protective materials, such as Paraloid and acrylic resin emulsion
	<p>8.1 Sampling the mortars from all the layers making up the wall painting.</p> <p>8.2 Sampling the pigments and binders from all the layers of the painting.</p> <p>8.3 Sampling to identify deterioration processes and micro-organisms that may exist in the wall painting.</p> <p>8.4 Collecting climatic data from the environs of the <i>in situ</i> wall painting.</p>	<p>7.7 Consolidation of the wall and mortars to support and preserve the wall paintings.</p> <p>7.8 Cleaning the layers of paint and mortar and stabilizing them, filling in lacunae, integration and application of protective layers.</p> <p>7.9 Arranging for drainage and temporary protection (roofing or covering) until permanent protective measures are in place.</p> <p>7.10 Monitoring and maintenance.</p>	Site/ laboratory	Archaeologist, conservator or specialists	
	<p>9.1 Recording wall-painting fragments in photographs.</p> <p>9.2 Interpretation and graphic reconstruction of the wall painting.</p> <p>9.3 Documentation of the interventions carried out and the information collected during the conservation work and mapping them.</p>		Office	Archaeologist or conservator	<ul style="list-style-type: none"> • Materials and equipment for producing digital and hard-copy reports

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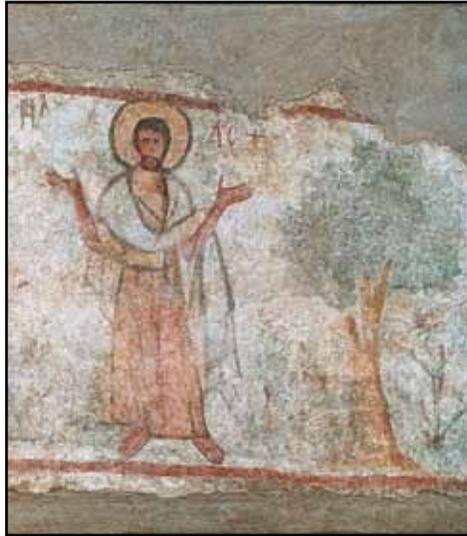
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Appendix 1: Instructions for Taking Samples from Archaeological Sites for Laboratory Analysis

The sample is tested in the laboratory to provide information about the majority of the material from which the sample was taken. It is therefore important to ensure that all information regarding records of the sample is documented and reaches the laboratory together with the sample. The detailed instructions for the kinds of samples that may be taken will be provided by the laboratory where the analysis will be conducted: The amount or size of material required for the analysis; the method of sample collection; the means of packaging and storing the sample; as well as environmental data, such as relative humidity and temperature. The following information is usually required with the sample:

1. Date;
2. Name of the person responsible for collecting the samples;
3. A description of the research goal; for example, a comparison between the characteristics of mortars from different periods at the site, or analysis of wall-painting materials and methods at the site;
4. Name of the site or area sampled at the site, e.g., Caesarea—Aqueduct, or Caesarea—Hippodrome;
5. An indication of the general area sampled on a map of the site;
6. Photograph with an overview of the sampling area;
7. The precise location where the sample was taken marked on a site plan (or rectified Photograph), with a number matching the number of the sample packaging;
8. Photograph of each sample with its number;
9. A description of the data in a table, in the following manner (example):

Sample number	Typology	Number of sample photograph	Description	Location	Period	Remarks	Type of Test
	Wall plaster, mortar from foundations		Strong white plaster, or gray disintegrating mortar	Caesarea—port vaults	First century CE		Mineralogical composition or strength



Wall painting, Ashqelon.