

## TECHNICAL EXAMINATION AND RESTORATION OF THE STUCCO DECORATIONS OF AL HASAWATY MIHRĀB, FATIMID PERIOD, CAIRO, EGYPT

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### *Abstract*

*Stucco mihrābs in Islamic buildings suffer from many causes of deterioration, mainly ground water and salt weathering, which have caused complete loss of the decorations of some stucco mihrābs and have left others in need of restoration and conservation, so finding a solution for this problem becomes ever more urgent. Al Hasawaty stucco mihrāb is an important monument, and is in serious need of restoration and conservation, which should be done in the light of examination and chemical analysis of the stucco material, support and degree of deterioration. The conservation and restoration of the stucco decoration involves the historical documentation of the Al Hasawaty Mausoleum, a condition survey, a measured survey, examination of the stucco decoration, the support and deterioration aspects. In addition the following are needed: mechanical and chemical cleaning, adhesion of detached parts of decorations, grout injection, replacement of the Portland cement plaster with porous lime plaster (disposable layer), mechanical strengthening with mortar and chemical treatment with a consolidant.*

**Keywords:** *Cleaning; Consolidation; Gypsum; Lime; Stucco; Deterioration; Mihrab*

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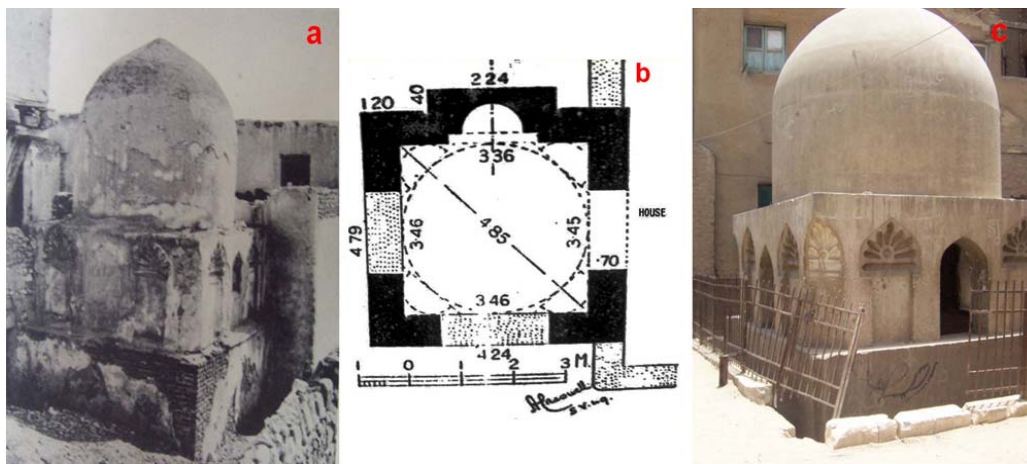
### **Introduction**

The Muhammad El Hasawaty Mausoleum is located just 60 yards south-west of the mausoleum of Imām Ash-Shāfī. Like most mausoleums, it consists of a cubical base averaging 3.41 m on each side internally, a zone of transition, and a dome, in this case without a drum. The whole structure is brick coated with stucco; the walls are 66 cm. thick. A large arched opening occupies the center of each face, except on the side of the mihrāb. The ground having risen considerably, only the upper part of the lower mausoleum is visible from the street (Fig.1).

On entering the interior and glancing at the mihrāb, it is obvious that the present floor is far above the original level. Taking the proportion of the height of mihrābs with their width as roughly 2:1, we get  $2.48 \times 2 = 4.96\text{m}$  as the original height, against its present height of 2.78m. (Now the height is 3.32m), and we may, therefore, conclude that the original floor was about 2m lower. The Committee de Conservation, in the hope of finding important traces of ornaments below the present floor, excavated here but without result; they did not even find remains of the original pavement.

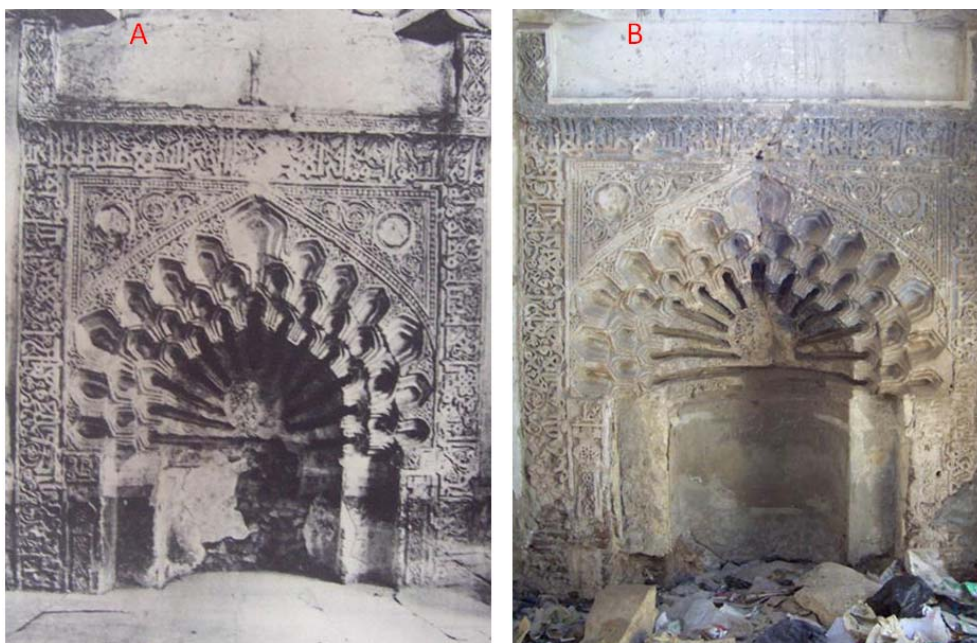
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**Fig. 1.** Al-Hasawati mausoleum: a - before restoration (Creswell, 1952), b - the plan of Al-Hasawati mausoleum, scale 1:100 (Creswell, 1952), c - up to date picture of the mausoleum.

The mihrāb bears the closest possible relationship to that of Sayyida Ruqayya. We have the same fluted conch with a large medallion in the centre, a triple scalloped edge, the same almost keeled arches, the same traces of bosses in the spandrels, etc. According to the features of the mihrāb and comparison of this mihrāb with other stucco monuments, Creswell suggested many dating times (first half of the twelfth century or 478H (1094 A.D.), 527 H (1133), or 519H (1125), etc. (Fig. 2) [1].



**Fig. 2.** The condition of the mihrāb of Muhammad Al Hasawaty: a – image taken in 1952 by Creswell, b – actual image of the mihrāb’s condition

### State of preservation and problems of conservation

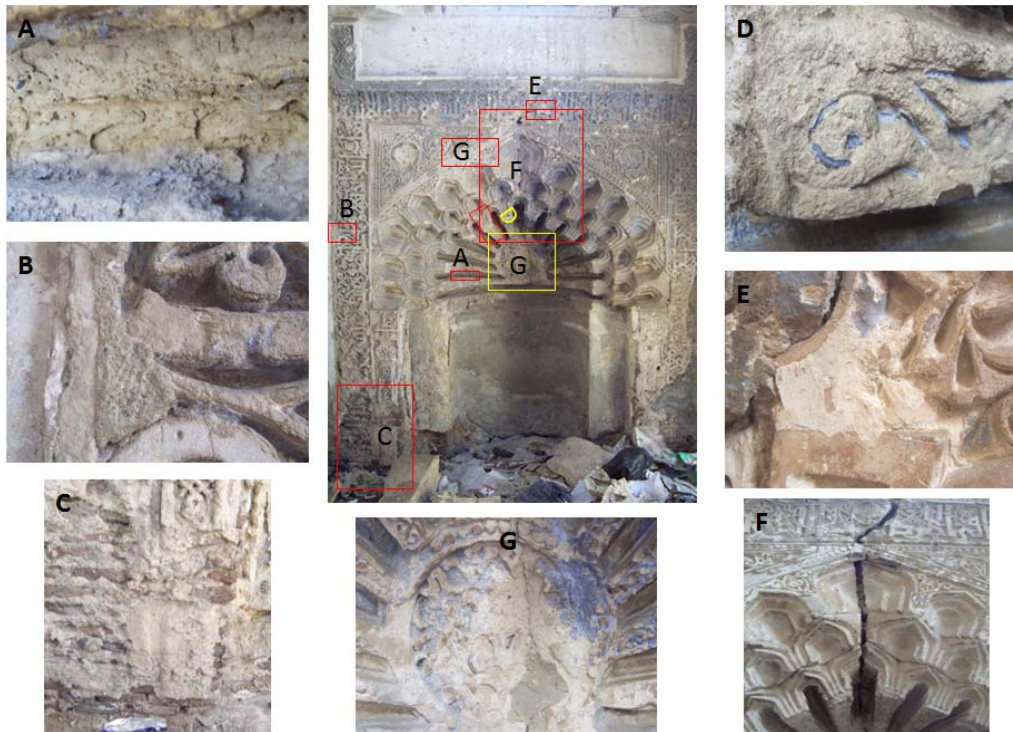
Close up visual inspection helps in characterizing the deterioration and expected execution methods for the Muhammad Al Hasawaty stucco mihrāb, as the presented on next paragraphs.

#### *White and blue layers of lime paint*

These layers of lime paint were found on most parts of the mihrāb, especially at the upper part of the mihrāb as the lower parts were much deteriorated. The lime paint consists of two layers: blue and white, these layers are a recent painting and they have not any archaeological value, and they are man made deterioration (a well known phenomenon in the mausoleum area) (Fig. 2b).

#### *Efflorescence and layers of salt*

Salt layers were found in many places and at many depths of the stucco layer. In some places the salt was considered to be the binding material for the stucco layer with the red brick substrate. The salt layer in some parts was stronger than the stucco layer, which will help in abstracting the salt layer without affecting the fragile stucco layers. The X.R.D analysis results showed that this salt layer consists of sodium chloride (water soluble salt) (Fig. 3a). As indicated in the literature, soluble salts are considered to be among the most important causes of decay. Salts cause damage by the growth of salt crystals within the pores, which can generate stresses that are sufficient to overcome the tensile strength of the material and turn it to powder [2].



**Fig. 3.** The condition of the surface layers of the mihrāb: a - layers of hard salt layers and their effects, b - usage of Portland cement mortar on the surface of stucco, c and d - loss and degradation of stucco layer, e - bad usage of lime and gypsum mortars on the surface of stucco, f and g- presence of cracks and fissures on the surface of stucco

### ***Loss of stucco decorations***

The loss of mihrāb stucco can be divided into three: complete loss of the stucco layer, loss of the surface layer of stucco decoration and degradation of the surface of stucco decoration (Fig. 3c and d).

### ***The use of Portland cement plaster***

The old restoration of the lower part of the mihrāb was done by using strong Portland cement mortar; also, strong Portland cement mortar patches were noted among the fragile stucco motives and as splashes on the surface of the stucco (Fig. 3b and g).

### ***Bad use of lime and gypsum mortars***

These mortars were used in filling the large crack at the center of the mihrāb, many decorations disappeared because of these mortars, also, gypsum mortar was used in completing the missing upper parts of the mihrāb, and there was spreading of gypsum spots on the stucco decoration of the mihrāb (Fig. 3e).

### ***The presence of cracks and fissures***

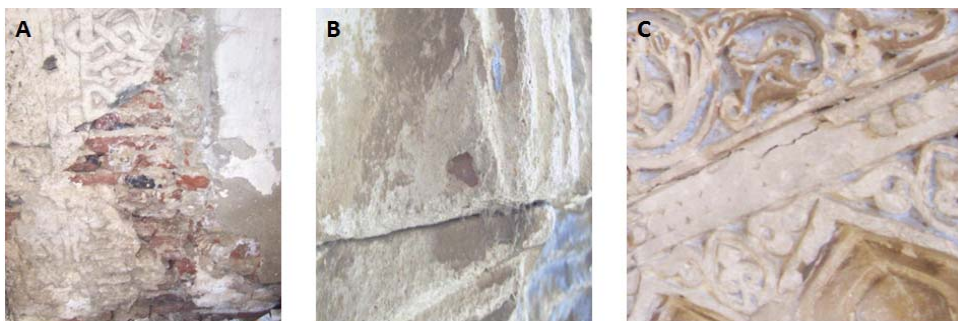
Cracks and fissures were found in many parts of the mihrāb, they ranged from small fissures to large cracks (Fig. 3f and g), these cracks may relate to substrate movement and the heterogeneity of wall materials differing both in porosity and thermal conductivity [3-8].

### ***Touch examination of the stucco surface in the mihrāb***

That examination was done to make an approximate map of the unseen voids behind the stucco layer and will help in the injection procedures.

### ***Characterization of the execution methods of stucco decorations on the Muhammad Al Hasawaty mihrāb***

The following pictures show that the decoration of the Al Hasawaty mihrāb was executed by direct application of stucco mortar on the red brick substrate after which the stucco motives were engraved onsite. In the spandrels two layers of stucco were applied on the substrate; the first layer is flat plaster and the other layer bears the engraved motives (Fig.4).



**Fig. 4.** The application of different treatments: a & b - direct application of stucco mortar and engraving, c - application of two stucco layers on the substrate

## **Technical examination: methods and results**

With the aim of deepening our knowledge of the original techniques of execution and materials used in the mihrāb of Al Hasawaty mausoleum, numerous investigations and analyses were conducted on the stucco material, deterioration and substrate materials. The technical analyses also proved that they are very useful for solving problems of cleaning and restoration, here we were tracking the methodology used by Lazarini and Schwartzbaum [9], and Cotrim et al. [10].

The research used investigation and analytical methods such as; SEM, XRD analysis, XRF analysis and IR analysis (all of these were covered in other papers for the project). The final results of examination and analysis methods helped in the following items:

- The reconstruction of stucco material with the help of XRD analysis after converting the final products (gypsum and calcite) into the binders that will be used in the stucco mix (hemihydrate and calcium hydroxide), the approximate results are: 3.5 parts of calcium hydroxide, 3.5 parts of hemihydrates, and 1.5 parts of fine sand (according to the test of sand grain size grading)
- The determination of some aspects of deterioration such as; the conversion of some gypsum to anhydrite and proof that sodium chloride was the main factor in deterioration.
- The solution for abstracting of salt deterioration as the XRD analysis proved that sodium chloride was the dominant salt that meant use of distilled water in cotton or paper poultices was a suitable method for abstraction of this soluble salt.

### Conservation

The conservation treatments carried out on the stucco mihrāb of Al Hasawaty mausoleum consisted of the following:

- Cleaning and removal of previous restoration and deterioration.
- The adhesion of detached pieces of stucco decoration, injection and strengthening of decorations using a suitable mortar.
- Replacement of Portland cement plaster with a disposable layer of lime plaster.
- Chemical consolidation of fragile parts and an assessment of reintegration for the whole mihrāb.

#### ***Cleaning and removal of previous restoration and deterioration***

##### ***(a) Dusting***

Dusting with soft wide or narrow brushes and blowing tools; this was done from the upper to the lower parts of the mihrāb after the cracks and gaps had been filled with cotton packs. Then a paper poultice with ethyl alcohol was applied to the surface of the stucco surface to remove the residue of dust (Fig. 5a and b) [11].

##### ***(b) Removal of lime paint layer***

Removal of the lime paint layer was done by mechanical cleaning after taking experimental samples, but many parts of the blue layer could not be cleaned mechanically so we used an AB 57 poultice to remove the residue of the lime paint layer (Fig. 5.c and d). Some parts of the stucco motives had disappeared completely because of the new bad restoration with mortar, these motives were revealed step by step by mechanical cleaning (Fig. 6).

##### ***(c) Removal and abstraction of salt from the surface of the stucco***

Most of the salt layers were removed by mechanical cleaning after taking experimental samples, salt coagulations that were found between the stucco layers and the substrate were removed bit by bit and the gaps was filled with stucco mortar to strengthen and make a bond between the stucco layer and the substrate. The residue of salt that could not be removed by mechanical cleaning was abstracted using a paper poultice with water (our aim here was to remove or abstract a reasonable amount of salt, not the whole amount, which was to protect the strength of the stucco material), three rounds of application of the paper poultice was sufficient to arrive at our goal (Fig.7).

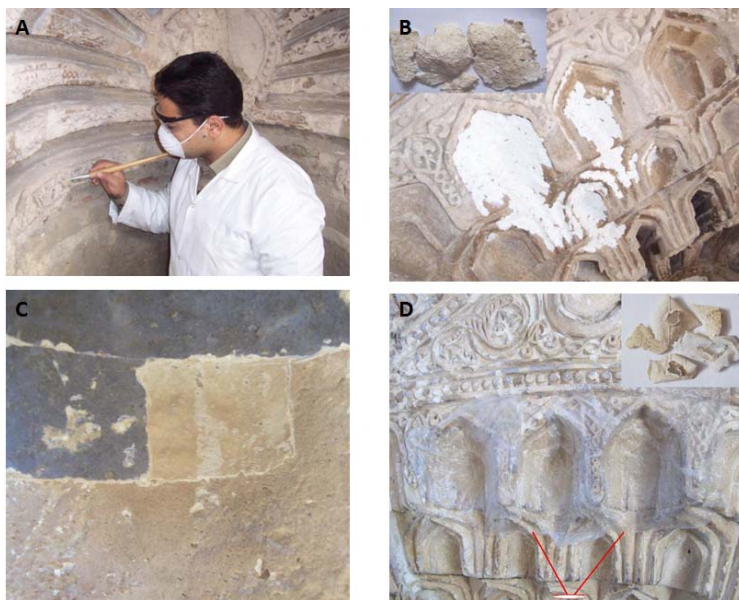


Fig. 5. Photographs during cleaning: a and b - the dusting and application of paper poultice with ethyl alcohol, c and d - the removal of lime layers by mechanical cleaning



Fig. 6. Stages of revealing of the disappeared motives by mechanical cleaning

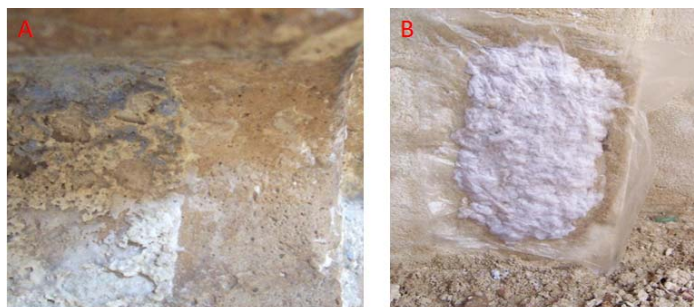


Fig. 7. Stages of cleaning and abstraction of sodium chloride salt from the stucco surface of the mihrab

***The adhesion of detached pieces of stucco decoration***

After cleaning away the dust by brushing and blowing to avoid the harmful effects of dust on the ability to adhere, 50% Primal AC 33 in water was used in reattaching the detached pieces of stucco decoration with the aid of a piece of cotton with the syringe to avoid the flow

down of Primal AC. If any of the Primal AC 33 flowed, we left it until it hardened, and then removed it mechanically with wood sticks (Fig. 8a).

#### ***The injection of stucco decorations***

After preparing the voids by dusting and blowing, an injection of aqueous alcohol (50:50) was applied; this lowered surface tension and thoroughly moistened the inner surfaces of both stucco and wall in the detached area. Then we applied an emulsion of Primal AC 33 (1:1) as that may have a consolidating effect; after this a mix of gypsum and lime in an emulsion of Primal AC 33 was injected. At first the grout was very liquid, then it became more viscous, finally the outer parts of the cracks were finished with mortar that had the same components without the Primal AC 33 (Fig. 8b) [12].



**Fig. 8.** Images during treatment: a - adhesion of detached pieces of stucco decorations, b - the injection of stucco decorations, c - the mechanical strengthening of stucco decorations by mortar.

#### ***The mechanical strengthening of stucco decorations with mortar***

This was done by cleaning and wetting the void surfaces between the stucco decorations and the substrate after which the voids were filled with a mortar consisting of 3.5 parts of calcium hydroxide, 3.5 parts of hemihydrates, and 1.5 parts of fine sand (these approximate ratios were according to analysis of the stucco). After finishing we patinated the new parts (Fig. 8c).

#### ***The filling and completion of the large crack***

This crack was cleaned of dust and the old bad restoration, then we moistened all sides of the crack with water as a preparatory step to applying an amount of mortar, which we used as a pad to support the stainless steel bars for bonding the two sides of the crack. After the mortar hardened we applied many layers of mortar up to the finishing of the outer surface. After that, the surrounding parts affected by mortar were cleaned immediately with mechanical cleaning and a wet sponge (Fig. 9).

#### ***The replacement of Portland cement plaster by porous lime plaster (disposable layer).***

##### ***a. Mechanical removal of Portland cement plaster***

This was done gently by the conservator himself to avoid the deleterious mechanical effects which may harm fragile parts of the stucco (Fig. 10A).

##### ***b. Cleaning mortar and dust from the red brick joints***

Deteriorated mortar and dust in brick joints were cleaned mechanically with a metal spatula and different kinds of brushes to avoid failure of adhesion of the new mortar.

##### ***c. The completion of the missing parts of red brick***

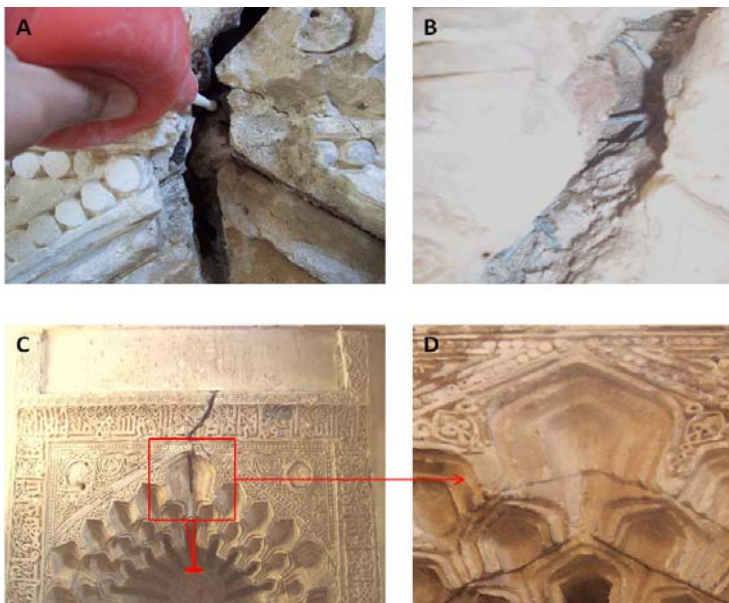
Here we used old bricks found in the site as they may have the same mechanical and physical properties.

##### ***d. Pointing of brick joints with mortar***

Joints were filled with the proposed mortar by spatula, the surface of the mortar used in the pointing process should be 2:3mm lower than the surface of the brick; after this the joints were finished with a wet sponge to open their pores (Fig. 10B), pointing was done at the light of directions of van Balen et al. [13].

**e. Application of the porous lime plaster (sacrificial or disposable layer).**

After drying and hardening of the mortar joints, the lower parts of the mihrāb were washed three times with water to abstract more salt, then a layer of porous lime mortar consisting of 3.5 parts of rough sand, 1.5 parts of lime and quarter part of white Portland cement was applied. The excess of the rough sand ratio and use of ordinary lime were used to form a tenuous and porous plaster which helps to abstract soluble salt without affecting the historic layer of stucco. This sacrificial disposable layer can be replaced after it deteriorates (from about 6 months to one year according to the sequential examination of the specialist) (Fig. 10C) [14]. We selected this solution until the government provide suitable budgets for establishing a suitable Sanitary drainage water system which can prevent or reduce the effects of salts solutions.



**Fig. 9.** Stages of filling and completion of the big crack:  
 a – cleaning stage; b – after cleaning; c - area ready for filling;  
 d – Detail of c after restoration.



**Fig. 10.** The stages of removing of Portland cement layer cleaning of brick joints (a),  
 b - the pointing of brick joints, c - the application of porous lime plaster (disposable layer)

**Chemical consolidation**

After application of a fungicide (Eminent, 10 p.p.m.) [13] we applied Eucosil by spraying and by brush according to the condition of the surface (Eucosil is a protective coating made by Swiss Chem. Company; its solution is a clear water repellent material which prevents



water-chloride ion intrusion (salts) form deteriorating the concrete. It penetrates deep into the substrate, hydrolyses in the pores and capillaries, condenses and forms a hydrophobic zone. It is used as masonry impregnation, strengthener (e.g. for weathered plaster surfaces and pointing mortars), protection against moisture induced damage, prevention of soluble salt blooming and etc. Through an experimental study made by the authors on Eucosil and three other consolidants, Eucosil achieved the best results, so we selected to be used as consolidant for the stucco decorations of El Hasawaty mihrāb) (Fig. 11).



Fig. 11. The application of the solutions: a – fungicide, b - Eucosil consolidant

In figure 12 is presented the image of the Al-Hasawati stucco mihrāb after the consolidation treatments.



Fig. 12. Al-Hasawati stucco mihrāb after the consolidation

## Conclusions

The technical examination and chemical analysis of the stucco material, support, and deterioration played an important role in understanding the construction of the stucco material, and determining execution methods and conservation procedures.

Constant monitoring is very important for any conservation procedures, and conservators should play their role at appropriate times. In Egypt, sometimes we cannot provide suitable

budgets for restoration and conservation of all historic building and their decorations; however, we should do our best to conserve these monuments until the budgets can be provided.

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