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Conservation Study of Traditional Glass - Panels from Siatista, Macedonia - Greece

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Abstract

The mansions of Siatista are dated to the beginning of the 18th century. Part of their architectural design is the use of colourful glass windows. These windows have their origin in the Islamic world and are made of small pieces of coloured glass, which are held together with gypsum plaster.
The weathering and corrosion phenomena of these traditional glass panels, known as "Macedoniki Feggites" (Macedonian Skylights) are closely related to the composition of the construction materials, as well as to the environmental conditions of the area (West Macedonia, Greece).
Compositional analysis of the construction materials and weathering layers was carried out by means of X-rays fluorescence (XRF) and X-ray diffraction (XRD).
Finally, a preliminary conservation study of glass panels took place, testing different conservation methods.

1. Introduction

This project concerns the conservation study of a group of traditional glass skylights from the Hantzigiannidis Mansion (Neratzopoulou) in Siatista.

The village of Siatista, West Macedonia, Greece, was founded at the beginning of the 15th century. Between 1740 and 1780 a number of remarkable mansions were built. The ground floor windows were very small for security, while the first and second floor windows were decorated with colourful glass-panels (Fig. 1.) [1].

Fig. 1. *A Siatista mansion decorated with traditional colourful glass windows (Macedonian Skylights).*

The dimensions of the panels are about 100 cm high and 60 cm wide. They are constructed on a decorative perforated gypsum grid, which holds together the small pieces of colour glasses. In some cases, two pieces of glass are sandwiched around an internal dark layer with engraved decoration. The gypsum grid forms geometrical, vegetable and animal patterns [2]. These types of window panels are well known as "Macedoniki Feggites" (Macedonian Skylights).

The technique of Siatista glass-panels had been used previously at the Temple of Jerusalem, the Temple of Damascus and at the Temples of Asia Minor based on the Byzantine style. In Greece, there are some other similar glass-panels in Kastoria, Veria and Ambelakia, all cities in Macedonia [3].

Gypsum (plaster of Paris) was one of the most commonly used plasters in the Islamic World both as binding and decorative material. Glass was an expensive material and probably was imported from other places. The weathering of the Macedonian Skylights is due to endogenous and exogenous factors, such as the chemical composition of the construction materials and the environmental conditions.

2. Deterioration of Macedonian Skylights

Glass panels are preserved generally in good condition, although, some parts are missing and some of the glass pieces are broken. Their deterioration is due to the weathering of the binding material (gypsum) and that of the glass. Furthermore, previous restoration treatments caused further deterioration of the panels.

In the past, lost parts of glass panels have been filled with lime plaster, bricks and wood. In some other cases, decayed parts of the original gypsum grid have been replaced with new plaster and destroyed glass pieces have also been replaced with new ones (Fig. 2.).

Fig. 2. *Detail of weathered glass window.*

Some of the glass panels have been covered with paper using an greasy organic material as adhesive.

The main deterioration agents affecting the panels are the alterations in the relative humidity and the temperature, as well as biological growth and mechanical forces.

Water in all physical phases causes deterioration both to glass and gypsum.

It is known that the glass surface forms a silicate rich layer caused by the reaction between alkali and water [4]. The durability of glass depends on the type and content of alkali and calcium [5].

This weathering layer is apparent on all external glass surfaces and partly on the internal surfaces of the sandwich glass.

The high levels of humidity have also caused the deterioration of the gypsum plaster. Gypsum is soluble in water and this action is described in the following reaction:

$$CaSO_4.2H_2O \longrightarrow Ca^{+2} + SO_4^{-2} + 2H_2O$$

The solubility of gypsum at 20 °C is 0,24gr/100ml H_2O [6]. The dissolution of gypsum caused an increase in the porosity and a decrease in the mechanical strength of the gypsum grid. Another important deterioration agent of gypsum has been the very low temperature during the winter season, which causes frost action. The high levels of relative humidity have enhanced biological growth thus forming biological crusts on the glass surface [7].

Previous restoration treatments provoked, in some cases, additional deterioration of the windows. The new plaster was applied above the old. deteriorated parts the extra weight of which contributed more mechanical stress, leading in some cases to the collapse of the original grid. The paper application with the organic adhesive caused accelerated deterioration of the gypsum and provoked biological growth.

In some cases, the internal dark decorative layer has deteriorated due to the high levels of the environmental humidity and to cracks in the sandwich-covering glasses [8]. Finally, a thin dark opaque layer of soot has formed on the internal surface of most of the glass panels.

3. Analytical results

In order to understand and estimate the decay agents and mechanisms of deterioration of glass panels it was necessary to consider the microclimatic conditions of the above area. Environmental data about temperature and humidity were provided by the National Meteorological Service of Greece (EMY). These data provided both maximum and minimum temperatures, as well as average relative humidity levels for each month, from 1955 to 1993 (Fig. 3).

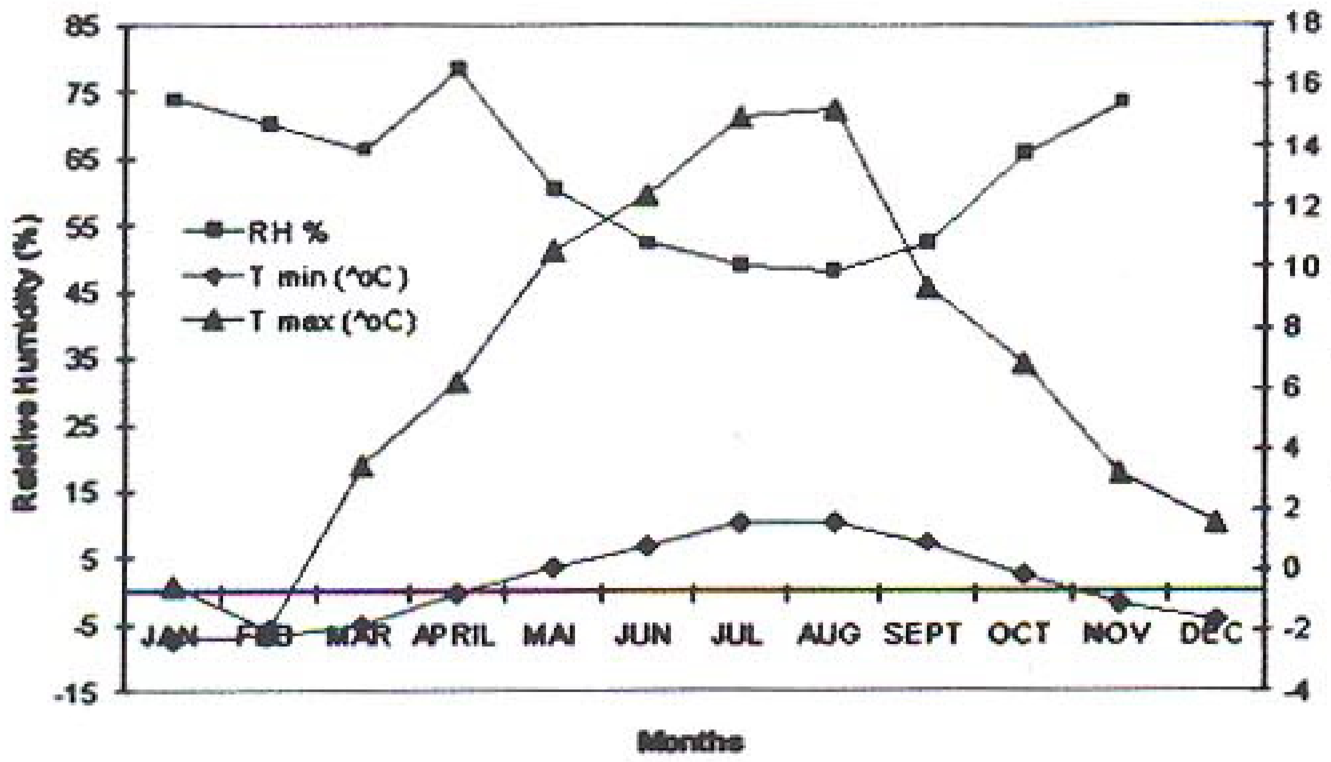

Fig. 3. *Average values of relative humidity, maximum and minimum temperatures at Siatista, for each month, from 1955 to 1993.*

Compositional analysis was performed by means of X-rays fluorescence of some representative glass samples. The analytical results are presented in table 1. Analytical data showed that all glass samples were characterized by a high potassium and calcium concentration.

Elements	SPI-01	SPI-02	SPI-03	SPI-04	SPI-05	SPI-06
Si	30.25	32.41	29.95	33.29	32.74	31.25
Fe	7.54	7.24	6.95	7.58	8.02	6.83
Ca	6.54	6.22	6.25	6.95	7.02	6.4
Mn	3.42	3.59	3.44	3.65	2.98	3.7
Cu	6.82	7.05	7.25	6.35	7.68	6.95
Zn	1.22	1.55	1.04	1.25	1.54	1.44
Sr	0.08	0.05	0.08	0.09	0.03	0.08
Pb	9.88	9.55	9.84	9.84	9.26	9.54
Rb	0.19	0.15	0.22	0.15	0.3	0.14
K	14.98	15.02	14.56	14.55	14.25	14.75
P	1.98	1.05	1.84	1.64	1.78	1.24
As	0.08	0.05	0.11	0.12	0.09	0.08
S	17.25	16.54	18.85	14.3	14.52	17.65

Table 1. *Chemical analysis of a Siatista glass sample by XRF. Compositional data are expressed by means of elements wt %.*

The internal decoration layer was also analyzed by means of X-rays diffraction (XRD) and X-rays fluorescence (XRF). From the XRF analysis, sulphur (S), calcium (Ca) and iron (Fe) were detected in the following concentrations: S 44.32 wt%, Ca 28.91 wt% and Fe 17.79 wt%.

XRD analysis of the weathered layers indicates the presence of calcium carbonate in the external surface of glasses. The thickness of this layer varies between 1 to 1,5 mm and causes the opacifacation of the glass. Furthermore, mineralogical analysis of the plaster by means of XRD showed that it is consisted of high quality gypsum ($CaSO_4.2H_2O$).

4. Conservation Treatments

Conservation study of the glass panels consisted of the consolidation and the restoration of the gypsum grid, as well as the cleaning and the protection of the glass surface. The aim of the cleaning process was the removal of the biological crusts, soot and of any other surface depositions, with respect to the original glass surface and all the weathering layers (Fig. 4).

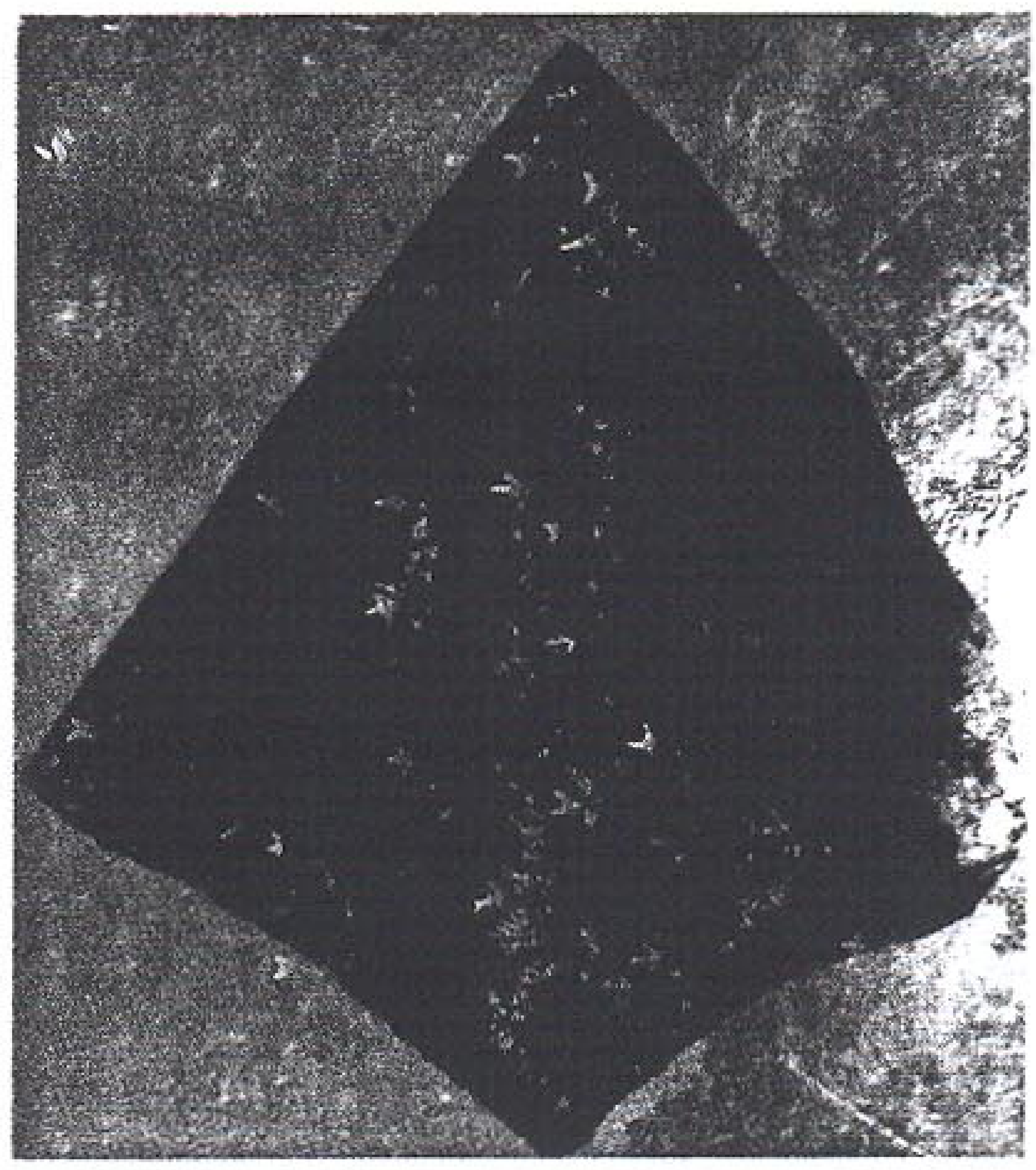

Fig. 4. *Original glass surface before cleaning.*

The materials chosen to be tested for cleaning were:

- De-ionised water;
- Neutral soap (Texapon); and
- 10% Solution (v/v) Hydrogen peroxide in water for the removal of the biological crusts.

The above treatments were carried out by applying the cleaning agents in poultices of sepiolite in order to increase and control the active specific surface area covered and in other cases with the aid of cotton swabs [11].

The consolidation of gypsum was carried out using a saturated solution of Barium Hydroxide in water.

5. Conclusions - Discussion

Hydrogen peroxide solutions aided in the removal of biological crusts without affecting the original surface (Fig. 5). The glass surface was examined microscopically using a stereomicroscope after each application. Calcareous depositions were softened after the application of the sepiolite poultice containing de-ionised water. Finally, calcareous and soil deposits were removed by using cotton swabs.

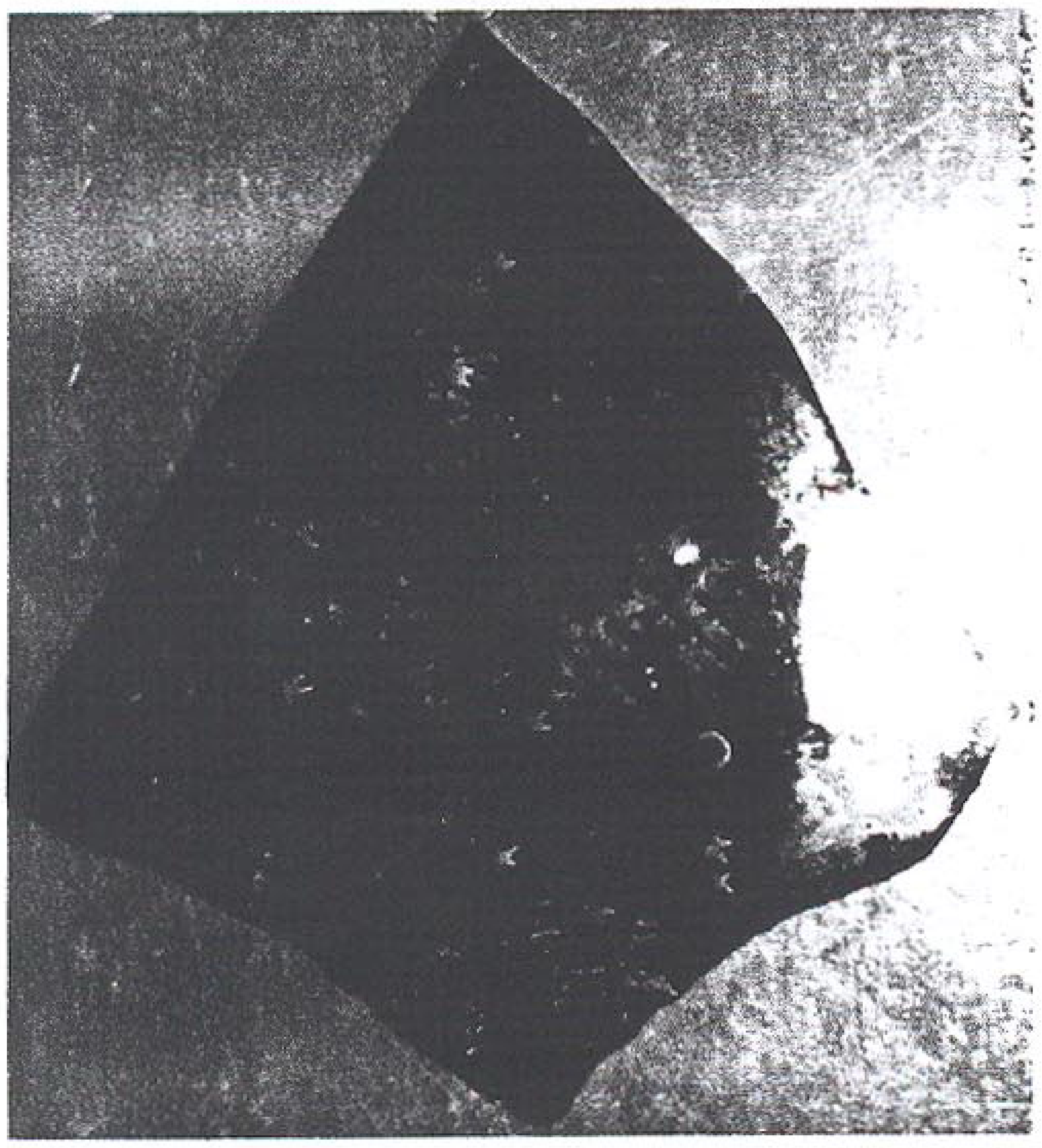

Fig. 5. *Original glass surface after cleaning process.*

The gypsum surface was cleaned with an aqueous solution of Texapon foam before its consolidation.

A 35% solution (w/v) of Paraloid in acetone was used as adhesive for the broken glass and gypsum pieces.

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