The crazing effect in post-Byzantine icons of the 19th century. Study of the effect – The restoration treatment of icons

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1. Introduction

By the term 'crazing', is determined the appearance of a network of thin, dense and irregularly arranged cracks on the surface of the varnish as well as the loss of its visible characteristics (i.e. loss of its transparency and acquisition of a milky appearance). The occurrence of this phenomenon depends on the age of the varnish as well as on the environmental conditions to which the artifact is exposed. It may appear in a very short time on old varnishes, if their surface is saturated with water.

When the general characteristics of this phenomenon were identified on two 19th century icons, the methodology of their study and the strategy for their treatment was organized.

The study that was carried out aimed in determining the following: 1) the reasons that caused the deteriorations on the icons, 2) the extend of the phenomenon. The deteriorations of the varnish might also extend

to the paint layer (‘blancing’) or could be limited to the varnish layer

Figure 1: Christ Pantocrator, 1832, before conservation treatments.

only (‘crazing’). In both cases the causes are the same: very high rates of relevant humidity or contact of the surface with water. The similarity of the two phenomena makes it difficult to distinguish them from each other. 3. the existence of microorganisms in the structural materials of the icons.

By understanding the reasons and the mechanisms of the deterioration, it was possible to organize both the interventional and the preventive conservation methodologies.

2. The Icons under study

The restoration treatment concerned two portable icons by the painter

Figure 2: St. Nicolas, 1833, before conservation treatments.

Athanasios, from the church of Saint Nicolas in Galatista. The first icon, that of Christ Pantocrator, is dated since 1832, and is currently under conservation, whereas the second, the icon of Saint Nicolas, dated since 1833, that adorns one of the icon stand of the iconastasis, has been restored. Both were painted with the egg tempera technique, each on a single-panel wooden carrier (figures 1, 2).

The structural materials of the icons (panel, preparatory and paint layers) have been preserved in satisfactory condition. There are no deteriorations that could affect their structural stability (such as,

extensive cracks on the carrier and activity of wood-eating insects, swelling and separation of the paint layers, etc.).

The study and conservation of the icons focus on the treatment of the same deterioration phenomenon that appears in the varnish.

The thorough research regarding the state of preservation of the icons, which was carried out during their preliminary examination, consisted of their stereomicroscopic and macroscopic observation in the visible and the ultraviolet radiation. The research revealed similar deteriorations; the findings in the front side of the icons were almost identical and consisted of the following forms:

1. Changes of the visible characteristics of the front side of the icons and loss of transparency together with the acquisition of a milky appearance, result in partial concealment of the theme of the icon. In the icon of Saint Nicolas this deterioration spreads over a considerable part in the center of the icon (figure 1), whereas in the icon of Christ Pantocrator the same effect appears in many parts of its surface (figure 2).

Figure 3: St. Nicolas. Photograph under stereomicroscope. The milky appearance of the crazing is more apparent in the edges of the cracks.

The observation of the affected areas under a stereomicroscope also revealed that the surface of the varnish has developed a fine network of cracks, in the form of irregularly arranged hairs, as the result of aging. The phenomenon of discoloration and milky appearance becomes more apparent in the edges of the cracks (figure 3). In areas where extensive cracks of the varnish are observed, the underlying paint layer appears to have been preserved in satisfactory condition (figure 4).

2. Flaking of the varnish in certain areas, are generally of limited extend. The varnish, apart from the fine and irregularly shaped cracks that it has developed, has become fragile in certain areas and is detached from the paint layers. This phenomenon was mainly observed in the icon of Christ Pantocrator.

3. Later local treatments in very few areas in the icon of Christ Pantocrator, generally of poor artistic value, have been detected.

4. A considerably thick deposit of airborne pollutants, mixed with other waxy and oily residue, can be seen. In certain areas different

Figure 4: St. Nicolas. Photograph under stereomicroscope. Between the cracks of the varnish the underlying paint layer has been preserved in satisfactory condition.

Figure 5: Head of St. Nicolas. A considerably thick deposit of airborne pollutants, mixed with other waxy and oily residue can be discerned.

kinds of residue have mixed together, forming a sticky layer. This phenomenon is more evident in the lower part of the icon of Saint Nicolas, as well as in the area of the halo, which was originally covered with metallic plates (figure 5).

From the visual preliminary examination, the determination of the degree of all deteriorations and the area which they cover, as well as the degradation processes, as listed in the previous section, are related with the acute environmental conditions that have developed inside the church. Questions are raised regarding the extend of the deteriorations, caused by microorganisms, in the front part of the icons, i.e. the degree in which they have affected the varnish as well as the underlying paint layers.

It is essential to research: a) the case history of each icon, b) the information coming from physicochemical analysis and c) the environmental conditions of preservation, in order to understand the present state of the artifacts and to determine the proper method of conservation treatment.

3. Case History of the Artifacts

The purpose of this research is to find any relevant bibliography, reports, conservation records, and even oral testimonies which may reveal any information concerning the date and the place where the artifact was painted.

Many researchers have studied the work of the Galatistan icon painters, and have provided information mainly about historical details [1-5]. The Galatistans' icon painting style was heavily influenced by that of Mount Athos, in the Karyes, where they established their icon painting workshop. The first company was constituted of Athonite monks, all coming from Galatista. The founder of this team was the monk Makarios of Galatista, whose work is dated from 1778 to 1814.

The icon painters of this company produced works for approximately one century (1778-1870).

Secular icon painters, also originating in Galatista, worked along with the Galatistan monks of Mount Athos. Among those we come across the name of *Athanasios of Galatista* (whose works are dated from 11 December 1823 to 1 March 1839). Both icons of the present study are attributed to him, based on the dated signatures found in their lower part (figures 6,7).

The main source of well-documented information regarding the construction technique of the icons has been the extensive study of the know-how and technology used in the construction of portable icons by Galatistan artists, which took place in "Ormylia" Art Diagnosis Centre [6].

According to this study, fine quality wood was selected to make the carriers (which were made of one or more panels fastened together), especially for icons of large dimensions, the back side of which was

Figure 6: Christ Pantocrator. The painter's inscription «αωλβ δ(ε)κ(εμβ)ρίου ε χηρ Αθανασίου» [1832 December 5 by the hand of Athanasios].

Figure 7: St. Nicolas. The painter's inscription «αωλγ νοε(μβρίου) κη χειρ Αθανασίου» [1833 November 28 by the hand of Athanasios].

enhanced with the use of transverses.

The painters avoided adhering textile on the carrier; instead, they applied the preparatory layer directly on it. The back side of the panel and the sides around its perimeter were also covered with a thin preparatory layer (gesso and animal glue), whereas on the surface of the ground they applied a thin layer of animal glue.

The Galatistans painted their works using the egg tempera technique and a large number of synthetic pigments, like Prussian blue, ultramarine blue, indigo, copper greens (copper resinate and emerald), cinnabar, cochineal lake, haematite, minium, yellow ochre, orpiment, chromium yellow, Naples yellow, carbon black, lead white, barite and gold powder.

Figure 8: Athanasios from Galatista, Christ Pantocrator, 1834. St Nicolas Church, Galatista Chalkidiki. Sample locations.

4. Investigation by Means of Optical Microscopy and Infrared Spectroscopy

Physicochemical analysis was employed for the study of the 'crazing' phenomenon on a 19th century icon of Christ Pantocrator aiming at evaluating (a) the state of preservation of varnish coatings; (b) the effect of the varnish type and the number of varnish layers to the extent of 'crazing'; (c) the state of preservation of the paint layers below the crazed varnish coatings, which were carried out in the "Ormylia" Art Diagnosis Centre.

4.1. Sampling

Sampling was carried out in two stages (figure 8). Firstly, two samples were obtained: adu1 from Christ's blue cloak and adu3 from His red tunic, which were examined under an optical microscope. Observations were made on the preservation state of the varnishes and the paint layers.

After identifying the presence of two varnish coatings, three more varnish samples were collected from different parts of the painting. The intention here was to investigate varnish aging by means of infrared spectroscopy (FTIR). Two of the samples – adu4 and adu5 – originated from icon sections that were free from 'crazing' defects; the former from Christ's right hand, where two layers of oxidised varnishes (the original and a subsequent one) were detected, and the latter from a recently restored area of the silver frame on which only the second varnish was preserved. The third sample (adu6), acquired from the icon's blue background, exhibited severe crazing.

4.2. Methodology

In order to prepare the cross-sections, a device for grinding and polishing the embedded microsamples (Struers Planopol–V) was employed. A polarising microscope (Zeiss Axiotech 100 HD), equipped with a complete system of white reflected and ultraviolet source of light, and a Spot 2 1.4 digital cooled camera (res.: 1315x1033 pixels, 12 bits per colour) was used for the examination of the cross-sections allowing for a detailed description of the stratigraphy from the preparation and paint layers to the varnish coatings.

Varnish identification was achieved with a Biorad FTS 175 FTIR spectrophotometer. The samples were mixed with anhydrous KBr and then pressed into pellets. Spectra were acquired at 4 cm^{-1} resolution representing averages of 64 scans [7].

4.3. Results and Discussion

4.3.1 Examination of the cross-sections under optical microscope

The stratigraphy of the sample collected from Christ's blue cloak (adu1) consisted of two paint layers (a mixture of indigo and lead white) and two varnish coatings (the original and a subsequent one), each with distinct shades of fluorescence (pale yellow and greyish, respectively) (figure 9). Both varnish layers exhibited vertical and horizontal cracks of 15mm width. In the original varnish, holes appeared along the horizontal cracks as a result of water penetration causing not only the detachment of varnish from the paint layers, but also flaking and loss of the upper varnish layer. It is quite likely that the water collected in the holes facilitated the growth of fungus, which in turn (according to bibliography) accelerated the degradation of the varnish and in general the binding media and the support materials [8,9]. Noteworthy is the fact that the substantial damage caused on the varnishes, did not affect the underlying paint layers.

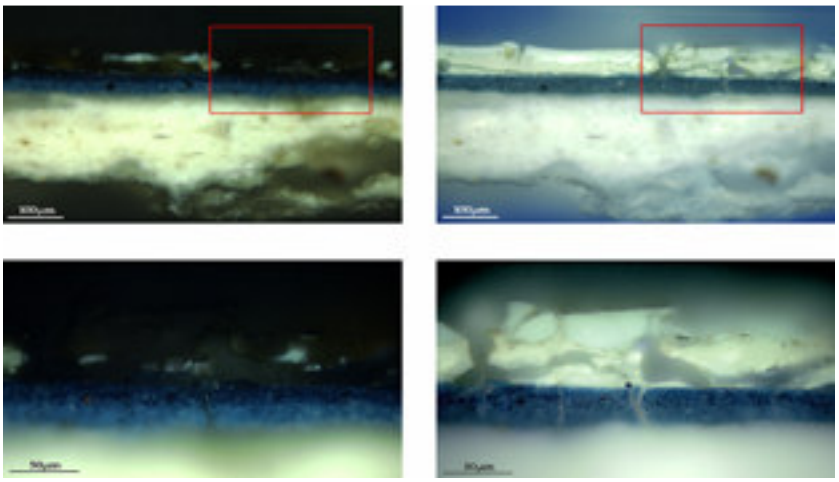

Figure 9: Cross-section of the sample from Christ's blue cloak in white reflected (left) and under ultraviolet (right) light.

In the cross-section of the sample from Christ's red tunic (adu3, figure 10) it is possible to distinguish – due to the location of the sample in the borderline between the tunic and the cloak – two paint layers in the blue cloak (a: a mixture of indigo and led white; b: indigo and grains of lead white) and two in the red tunic itself (a: cinnabar; b: a mixture of haematite and cinnabar). On the surface, the original varnish of the icon could be distinguished. It had undergone more intense degradation (due to the presence of water) than the varnish of the sample adu1 (figure 9). As a consequence of water penetration from the fine horizontal cracks in the original varnish, numerous holes with diameters up to 50 mm were generated. These large holes caused mechanical pressure on adjacent layers resulting in the formation of hollows on the underlying paint layers. The extent of deterioration in the upper varnish layer as well as the pigments' resistance to mechanical pressures affected the degree of damage.

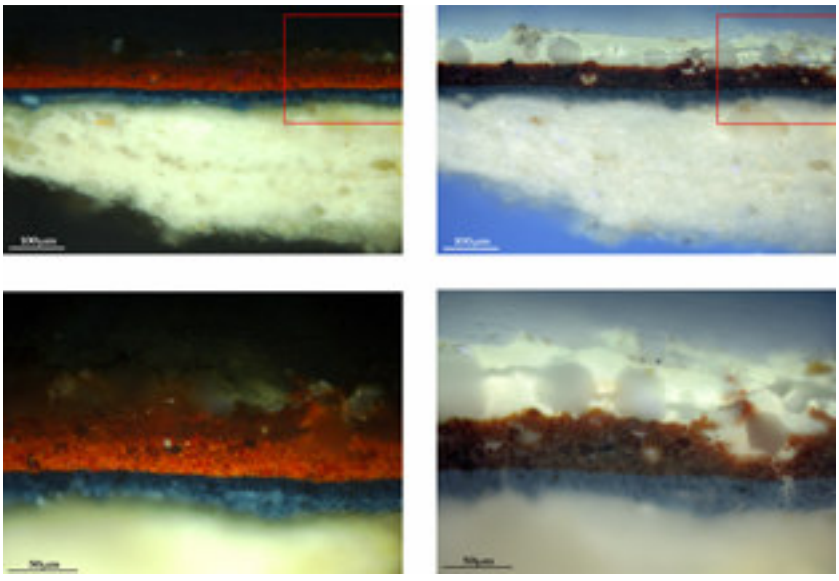

Figure 10: Cross-section of the sample from Christ's red tunic in white reflected (left) and under ultraviolet (right) light.

The absence of the subsequent protective varnish in this cross-section was, most probably, a consequence of the total detachment that took place due to the action of water on the icon's surface. It was clear that its absence accelerated the degradation of the original varnish.

Comparative analysis of the state of varnish preservation in both samples allowed for the following observations:

(a) Water flow on the icon's surface caused swelling and detachment only of the varnish layers due to the horizontal cracks and the numerous holes. Water retention in the holes contributed to the growth of fungus which also accelerated the disintegration of the varnish;

(b) The extent and depth of crazing was the product not only of the time water remained on the icon, but also of the composition and number of varnish layers. Later varnish application on the icon played a protective role by increasing the durability of the underlying earlier varnish;

(c) The state of varnish preservation did not significantly affect the paint layers (figure 9). However, mechanical pressure, caused by the large holes (the result of water penetration), did produce minor damages on the paint layers, depending on the pigments' resistance (figure 10).

4.3.2 Application of Infrared Spectroscopy

By means of infrared spectroscopy it was possible to identify the varnish of the samples adu4, 5 and 6 as resins (figure 11). The few differences one can notice in the spectra of fresh resins generally disappear in aged ones. Therefore, it is very difficult to differentiate samples belonging to the same class. Detailed compositional information could be achieved by means of other analytical

techniques, in particular gas chromatography coupled with mass spectrometry.

FTIR spectra of samples adu4, 5 and 6 consisted of similar features. Microscopy results indicated the presence of two resin varnishes in samples 4 and 6 (a: original, b: subsequent) and one resin varnish (b: subsequent) in sample 5.

During aging, the chemical composition of varnishes changed qualitatively and quantitatively because of oxidation, polymerisation, isomerisation and cleavage reactions. Interactions with other painting materials, especially pigments, also influenced their behaviour and degradation mechanisms [10].

From spectral comparison (figure 11), some details on varnish degradation could be advanced for samples adu4, 5 and 6. The increased absorption of hydroxyl (O-H) groups in adu6 (intense 'crazing' phenomenon) at ~ 3450 cm^{-1} (νO-H) and ~1653 cm^{-1} (δO-H), due to higher water concentration, denoted a greater oxidation

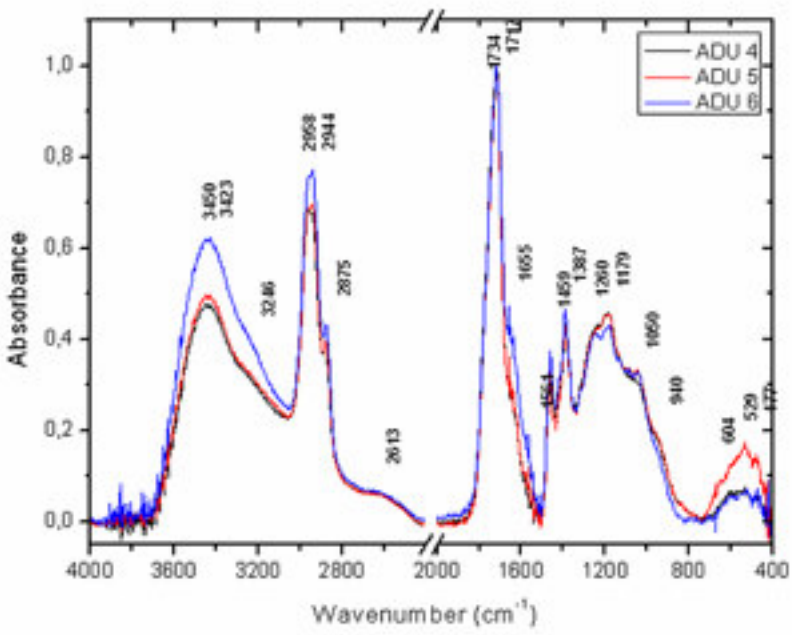

Figure 11: FTIR spectra of samples adu4, 5 and 6.

degree in this sample which resulted in more bond scissions, evidenced by the decrease in C-O and C=C bonds (lower absorption in the region 1260-550 cm^{-1}) [11-13].

In the case of adu5 (subsequent varnish), the higher absorption in the 730-400 cm^{-1} region designated the presence of more CC bonds as a consequence of less fragmentation. This varnish sample has undergone less degradation.

FTIR evaluation of samples adu4, 5 and 6 has demonstrated that varnish degradation in the three sites proceeded at different rates depending upon water concentration as well as varnish type.

5. Environmental Conditions of Preservation

It is important to examine the environmental parameters that affect a constantly damp church. The humidity problems in the church were worsened by the leak of rainwater through the roof.

The purpose of this examination is to acquaint in the best possible detail the affecting conditions to which the icons where exposed, in order to determine the causes and the deteriorations, with the aim to provide useful background for their future monitoring, limitation, and even effacement.

In the interior of churches, warehouses, exhibition rooms etc., the main parameters that affect the preservation conditions of artifacts are relevant humidity, temperature, ventilation, light and airborne atmospheric pollutants.

In relation to examine the aforementioned conditions inside the church of Saint Nicolas in Galatista, additional information have to be collected regarding its construction, the climatic conditions, the heating and air conditioning installations and the number of visitors it attracts regularly.

5.1. Construction of the Church

The church of Saint Nicolas is a three-aisle basilica of the later period of the Turkish occupation and was reconstructed along with its bell tower in 1842 and 1868 (respectively), according to a walled-in marble plate on its southern wall. Some indications regarding the construction of the church and its roof were collected by the oral testimonies of workers that took part in the restoration works in the church in July 2004. The materials used and the following restoration were similar to the construction materials originally used in 1842.

During the works for the restoration of the roof (2004), rainwater leaked in the interior of the church. Although the roof immediately repaired, the area of the bema, where the two icons were kept, was particularly affected. After this event, and within only a few days, the phenomenon discussed here appeared.

5.2. Climatic conditions

In old churches systematic measuring and recording of relevant humidity and temperature take place very rarely. According to oral testimonies and to conclusions reached from studying the construction of the building, the climatic conditions in the interior of the church are characterized by high percentages of humidity throughout the year, and this phenomenon becomes very intense during the winter months. It was also reported that the works for the restoration of the roof and the windows considerably improved the increased humidity problem in certain parts of the walls.

Very few people visit the church regularly, since it only opens on the day Saint Nicolas is commemorated and for private ceremonies. Consequently, no great climatic changes occur in the interior, nor does the people that visit the church carry any pollutants.

From what has been mentioned we can conclude that there are high rates of humidity and low temperatures during the winter. As a result, accumulated moisture is observed on the glass surfaces that cover some of the icons due to the fact that the place is inadequately ventilated. During the summer months the place is never very hot and the relevant humidity remains high.

6. State of Preservation and Methodology of Conservation Treatment

It is deemed necessary to commence restoration treatments due to the preservation condition of the front side of the icons, which includes extensive and deep cracks of the varnish, flaking, intense visual deteriorations, fungi and mechanical pressures that affect the underlying paint layers. The treatments are distinguished into interventional and preventive.

1. interventional: restoration works include the removal of superficial pollutants from the surface of the varnish as well as removal of the aging varnish and of restorations of low aesthetic standards.

2. preventive: the fungi are very resistant to any change of the environmental conditions, as well as to restoration treatments such as cleaning, or even applying fungicides. Nevertheless, they are not kept under control of climatic conditions, careful cleaning and proper ventilation [14- 16].

The purpose of restoration treatments is the treatment of the damaged areas and, where possible, the reversal of the deterioration parameters with improvement measures such as changing the environmental conditions and effacing the nutriments that sustain microorganisms from the substances used in works of art. It is possible, though, to decrease nutriments by removing pollutants from the surface and to avoid selecting conservation materials that can be the source of

nutriments for microorganisms (especially organic substances), in order not to further facilitate the development of the latter.

7. Restoration Treatments

7.1. Interventional

The interventions to be carried out are:

1. removal of superficial pollutants (waxy and oily pollutants, dust and soot),
2. cleaning of the deteriorated varnish,
3. removal of the colouring interventions of low aesthetic standards found in certain areas, and aesthetic restoration.

7.1.1 Cleaning of the surface

The selection of the cleaning method and the materials to be used was based on the preliminary examination of the icons in the visible and the ultraviolet spectrum, informed us about the presence or absence of protective varnish, the endurance of the underlying paint layers and the nature of the pollutants.

The deposits of dust and soot were removed with the help of soft brushes, whereas the more firmly attached pollutants were removed with the use of enzymes. The decomposition of the waxy and oily dirt was achieved with mild solvents (white spirit), whereas their residue was removed with mechanical means (scalpel) under stereomicroscopic observation.

Meticulous cleaning of the surface is deemed imperative, since the remaining pollutants and their direct contact with the paint layers is a fundamental parameter for the reappearance of microorganisms or the attraction of fungi spores, even after the surface has been cleaned.

7.1.2 Removal of deteriorated varnish

One method of treating the 'crazing' phenomenon is the application of solvent vapour on the affected surface (Pettenkofer process), during which the varnish reacquires its transparency (regeneration). Nevertheless, this method is very likely to affect the underlying paint layers, and it has no long-lasting results [17]. Removing the varnish was deemed to be the most effective method for dealing with this problem.

The examination of the cross-sections revealed the existence of hollows in certain parts of the paint layer, caused by mechanical pressures as crazing progressed. In case the varnish was cleaned down to the paint layer it is dangerous for its stability.

The selection of solvents was based on the results of tests that measured the resistance of the paint layers to them, as well as on tests on the solubility of the varnishes. The removal of resins was achieved layer by layer, with parallel stereomicroscopic observation of areas of high sensitivity (figure 12). The icons were examined during the treatment by exposure to ultraviolet light, in order to control and mark the treated areas.

Figure 12: St. Nicolas. Partial cleaning of varnish.

A solution of ethanol-white spirit (1:1) was decided as the most appropriate for removing the varnish and its neutralization was achieved with white spirit.

7.1.3 Removal of later colour intervention

Later colour intervention was originally traced in the icon of Christ Pantocrator in the mid of its upper frame. The original intervention aimed at covering a mechanic damage of that area. The removal of the overpaint and the aesthetic restoration of this area are currently under way (figure 13).

7.2. Preventive Conservation

The preventive conservation procedures were carried out in accordance with the special conditions inside the church.

The first step to be taken is the systematic recording of the climatic conditions in the church and the creation of a case history archive of the environmental parameters.

Due to the lack of previous measurements, a mechanical thermo hydrograph has been placed in a central part of the church for a weekly measuring of the relevant humidity and temperature inside the church. The measuring will last for at least one year. The comparative study of

Figure 13: St. Nicolas. After conservation treatments.

the results will demonstrate the fluctuations of relevant humidity and temperature rates, on a seasonal as well as on a daily basis.

To avoid the reappearance of 'crazing' phenomenon the following measures must be controlled:

1. preservation of the hygiene conditions in the church in an adequate level and perform regular soft cleanings of the surface of the icons. At this point it should be pointed out that the use of wet pieces of cloth must be avoided, as the moisture that will be transferred on the icons will facilitate the appearance of microorganisms.
2. ventilation of the church adequately.
3. exhibition or storing of the icons in appropriate conditions, according to which the former should not hang on moist walls, and, if they are put in frames as is customary in churches, to make sure that mainly the back side, and all sides of the icon are ventilated adequately.
4. carefully controlling of icons' surface with a photographic documentation of the affected areas.

8. Conclusions

The results of the study revealed that the intensity of 'crazing' on the surface of the icons is related to their position inside the church, the direct contact of their front side with the rainwater from the roof of the church, and with the length of time that this contact lasted.

The extensive research during the preliminary examinations and the physicochemical methods of analysis revealed the following: a) the painted surface is covered with two coats of protective varnish (the original and latter one), b) the varnish (both the original and the later) has cracked after coming directly in contact with water; its structure has suffered the opening of hollows, detachments and flaking off in some areas, c) the degree of deterioration of the varnishes depends on

the amount of water that it came in contact with, as well as on the composition of the varnishes, d) the paint layers were not affected, although they have suffered mechanical damage in certain areas due to the hollows that were created on the varnish, and e) the phenomenon is accompanied by the development of fungi.

The absence of either discoloration or spots on the paint layer indicates that the icons have not suffered any chemical or aesthetic deterioration from the affect of the water and the organic waste produced by the metabolism of the fungi, thus the 'crazing' has been limited only to the surface of the varnish. The treatment of the deterioration of the icons due to biological effects, the precaution measures, and the proper method for remedying the fungi activity remains a subject under consideration as regards future interventions.

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