

RESEARCHES REGARDING THE SOURCES AND IMPACT OF THE ATMOSPHERIC POLLUTION AND BIODEGRADATION ON THE TREI IERARHI MONASTERY OF IASI

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ABSTRACT

In the paper, we present the results of the researches regarding the influence of atmospheric pollution and biodegradation on the stone of Trei Ierarhi (Three Hierarchs) Monastery of Iasi. The correlation of microclimatic factors (precipitations, humidity, temperature, frequency and wind speed) with the physical-chemical measurements of environment pollution (powders, gases) has a special importance in the evaluation of the impact against the monuments degradation.

The phenomenon degradation of the site analyzed is emphasized by its position within the city where the degree of pollution and the nature of pollutants are high.

The church is exposed in the exterior to the physical-chemical attack of the atmospheric exhaust gas correlated with the microclimatic factors. The effects of this physical-chemical attack but also of the biological attack are seen on the exterior walls, on the stone lacery (Albesti calcite) of the monument.

In addition, we present the sources and diversity of the biodegradation (lichens, fungi) of the exterior stone of the historic site, and the attenuation means.

INTRODUCTION

In 1634, after a long succession of unfortunate reigns and dramatic events for this tried region of Romania, on the throne of Moldavia reached the great vornic **Vasile Lupu**. a wise enlightened boyar, a lover of beauty and most of all a lover of the faith. The years of his reign (1634-1553) were to represent the first great epoch of culture in Moldavia. In the spirit of the tradition of the great Voivodes of the Musat family of yore. Vasile Lupu inaugurated his reign by building a church, which the ambitious Moldavian voivode desired to be an unparalleled one: the church of the **Three Saint Hierarchy** of Iasi. Conceived as a traditional monastic ensemble, the monastery of the Three Saint Hierarchs has remained up to this day one of the most renowned complexes of feudal Romanian art, an architectural masterpiece that has become a legend which has not ceased to astonish the visitors from all over the world. Between 1882-1887. the complex was completely restored, under the supervision of **Lecomte de Noüy**. The restoration works have brought major modifications to the church and to the adjacent buildings, modifications which have not affected though the initial architectural conception nor the stone ornamentations of the facades. From this same period of the last restoration dates the painting of the house of worship, as well as its entire internal decoration. The pieces of furniture were designed by the French architect and made in Vienna, the payment being undertaken by King Carol I and Queen Elisabeta, the new founders of the church. In the pronaos there are the tombs of Vasile Lupu's family and those of the Princes Dimitrie Cantemir and Alexandru Ioan Cuza.

Although the plan of "Three Hierarchs" is typical for the Moldavian churches of the XVIIth century (vestibule, pronaos, naos and altar), it is the magnificent embroidery in stone adorning the walls from top to base that makes this building more than an ordinary church. The various ornamental patterns of Oriental inspiration intermingled with autochthonous Romanian elements lie in a harmonious succession from one level to the other, completing each other in an amazing unmatched synthesis. The name of the main architect who co-ordinated the construction of "Three Hierarchs" has remained unknown until today. What is significant though is the fact that, according to all evidence, masters from the East and West worked together, accomplishing a flawless synthesis of different traditions and styles, summing them up into a real *universal masterpiece*.



Figures 1 General view

AROUND INFLUENCE CLIMAT

The correlation of microclimatic factors (precipitations, humidity, temperature, frequency and wind speed) with the physical-chemical measurements of environment pollution (powders, gases) has a special importance in the evaluation of the impact against the monuments degradation. The phenomenon degradation of the site analyzed is emphasized by its position within the city where the degree of pollution and the nature of pollutants are high.

The church is exposed in the exterior to the physical-chemical attack of the atmospheric exhaust gas correlated with the climatic factors.

According to the performed measurements, CO and SO₂ correlated with the action of NO₂, NH₄, hydrocarbons, etc have been identified as the main gas pollutant sources. The CO level (CO=8.4mg/m³) is higher in winter than during summer. The daily and weekly CO variations are connected to the intensity and nature of the city traffic while the seasonal variations depend on the atmospheric conditions.

The values of NO₂ (in concentration NO₂=0.25mg/m³) lead to corroding effects at the level of calcite during the periods with high level of humidity, U_{rel}=83%.

The momentary concentrations of SO₂, measured in the cold season on the exterior of the monument exceed the admissible values, having a strong destructive action on the stone wall.

The outer walls of Trei Ierarhi church are not equally affected by the action of the climatic factors. Thus the Northern and Western walls are exposed to the action of the dominant winds from North-West that are full of humidity and whose increased annual frequency (19.55%) explains the high degree of humidity of the walls (Figure 2)

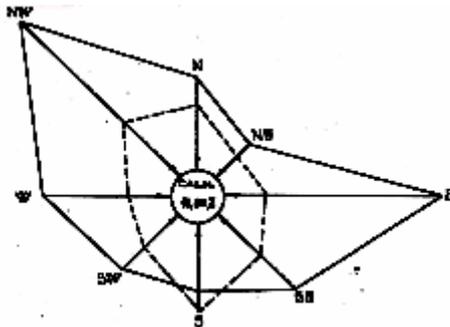


Figure 2

Because there is no higher building in this direction to protect it, the Western flank is exposed to the permanent action of the Western winds that have an average speed of 2.7 m/s. The consequence is a more intensified discoloration of the threshold in comparison to the rest of the building (Figure 3).



Figure 3

The Southern flank is protected by the monastery annex buildings against the action of warm and dry winds that blow from South-South-West. The Northern flank is exposed to swirling currents with permanent character that act abrasively over the walls when these are covered with dust.

Effects degradation of the torsade band that surrounds the church, separating the lower range from the superior one, bordered by black marble plates carved in the baroque style (Figure 4)

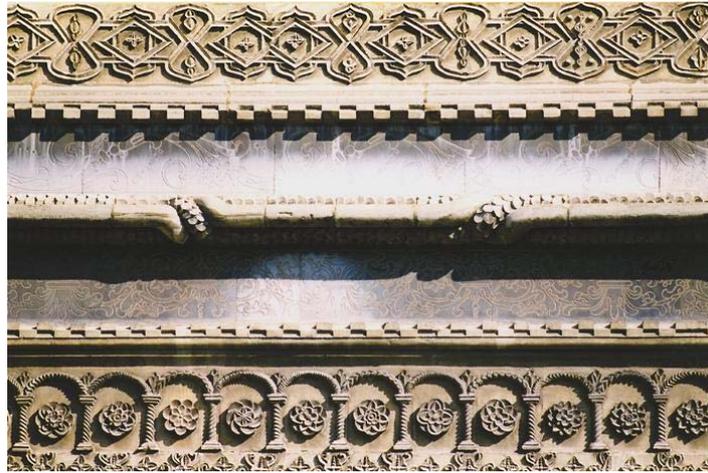


Figure 4

BIODEGRADATION OF THE EXTERIOR STONE OF THE HISTORIC SITE

The biological alteration of the stone cannot be seen as an isolated phenomenon because it is accompanied by the processes of physical, chemical and physical-chemical degradation to which they are connected.

The effects of this physical-chemical attack as well as of the biological attack are visible on the outer walls, on the stone lacery (Albesti calcite) of the monument.

Analyzing the monument's walls we established extended areas with fragile calcite, with stained, disintegrated salts crystallizations. The solvable salts reach the surface where they are crystallized, forming hard deposits and filamentous crystals that seem to be pulled out of pores, producing a tension that determines the fragility and bucking of the surface and the degradation of the ornamental details. Solar disks degradation of the *Clorococcum humile* and *Lecanora muralis* (Figure 5)



Figure 5

The vegetal bioderm on the walls of Trei Ierarhi church comprises bacteria, cynophiceae, green algae, lichens, moss that tend to penetrate rocks' structure, some exceeding in certain areas 8-9 mm and some being maintained in the superficial layer at 2-6 mm. From the depth

of the wall, some dissolved particles and even smaller particles are driven off towards the surface in the capillarity or are even moving along the myceliums, actonomycete and fungi.

The types of organisms that develop on the monument's stone have been identified by means of standards methodologies of sampling, analysis and identification, using techniques of SEM microscopy and optics.

In the first table are illustrated the identified species of microorganisms from the lytical structures and vegetal bioderm from the stone walls of the site.

Procariot	Eucariot
Nostoc sp.	Clorococcum humile
Gloeocapsa nigricans	Aspergillus niger
Bacillus Gram +	Penicillium ssp.
Chemolitotrophe bacteria	Cladasporium ssp.
Actinomycetes	Alternaria alternata
	Mucor sp.
	Candelariella ssp.
	Lecanora muralis
	Bryum intermedium

Table 1

As a result of the 60-day laboratory studies we identified the presence of some bacteria, actonomycete and fungi in the analyzed samples. We considered that the actonomycete contribute to the degradation and mineralization processes of the organic substances, using organic and mineral N. Their presence in the usual culture environments of the samples indicates the fact that they are coupling their action with the other species from the vegetal bioderm both for achieving a favorable environment and for degrading the mineral substrata.

CONCLUSION

- The action of the bioderm is advanced due to the fact that some species penetrated in depth and this action being favoured by the polluting agents.
- The acid rains favour the stone's dislocation and breakage; the solvable salts are crystallized, forming calcite hard deposits and filamentous crystals at the surface of Albesti.
- The monument is exposed to pollution even if we take into consideration only the exhaust gases from the traffic of the nearby street, Ștefan cel Mare și Sfânt, against which it could be protected by means of a high hedge that would hinder the gas diffusion found at the street's marginal level.

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