

COALITION

CSIC Thematic Network on Cultural Heritage. Electronic Newsletter

**Newsletter No. 7
January 2004**

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Edited by

Red Temática de Patrimonio Histórico y Cultural del CSIC

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A NEW STEP FOR COALITION

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Since September 2000 you received six issues of COALITION (two of them as a double issue), produced under the umbrella of the European Commission project EVK4-CT-1999-20001. This project concluded on 31 March 2003. However the publication of COALITION will continue, now under the umbrella of the Spanish CSIC Thematic Network on Cultural Heritage, a network that includes 26 research teams actively involved in cultural heritage research located at 16 different Institutes. The main difference between the previous initiative and this one is that from now the newsletter will be devoted to Cultural Heritage in a wide sense, and not only to biodeterioration problems.

The CSIC Thematic Network on Cultural Heritage was launched in October 2001 to coordinate cultural heritage activities of several research groups working at the Spanish Scientific Research Council (CSIC), the largest public research organisation in Spain. The initiative is part of the CSIC programme for coordinating selected innovative and socially-interesting areas. It was set out to provide coordination between CSIC research institutes working in many different topics, from archaeology to industrially-relevant research and technological development.

The main objective of the network is to support research on cultural heritage and to promote cooperation between European research centres, professional associations and technological companies. This new organisation aims to participate in relevant areas of the 6th Framework Programme of the European Commission, National Research and Technological programmes, and to promote exchanges of ideas, techniques and collaborations in the field.

Advanced and comprehensive instrumentation and knowledge exist within this consortium for the different

involved fields. The network is a platform of access to these resources that can more easily be approached by other researchers. The necessary mechanisms of exchange and collaboration are being created to ensure the critical mass needed for multidisciplinary research projects on cultural heritage and best practices. Additionally the network contributes to dissemination of its activities and capabilities to end users, including local and national culture administrations, foundations, companies, etc.

Network activities are included in five areas of research activity. Table 1 lists specific activities included in each area.

Table 1. Research activity at the CSIC network

Area	Research activity
Archaeology and Architectonic Heritage	Architectural Archaeology Landscape Archaeology Architectonic photogrammetry Research and restoration of architectonic and archaeological heritage
Biology	Molecular biology applied to biodeterioration Characterisation, ecology and physiology of organisms involved in biodeterioration Paleobotany Electron Microscopies
Physics	Physical techniques applied to the study of cultural heritage Laser techniques applied to the restoration and conservation of cultural heritage
Geology	Rock Art: geochemistry, hydrochemistry and microclimatology in karstic environments Characterisation of stone building materials Diagnosis of the state of conservation of architectonic heritage Geoarchaeology and geochronology Building and ornamental stone: characterisation, durability and localisation of quarries Conservation and restoration treatments for the architectonic heritage and sculptures
Material Science	Conservation of mortars and concrete Design of new mortars for restoration Conservation of historic glass heritage New materials for surface treatments Study of ceramics, stone materials and painting techniques Metal corrosion and protection

This international electronic newsletter is intended to disseminate activities of the CSIC Thematic Network and to serve as a forum for scientists, conservators, restorers, and students who share an interest in cultural heritage studies. The goal is to foster an interdisciplinary communication as the scope of the newsletter encompasses humanities,

science and technology. Contributions include short communications, technical notes, description of activities in specialised centres, announcements of jobs and conferences, forthcoming publication of conference proceedings, special issues, dissertations, etc., as a way to share news and information. The newsletter will be published on January and July and is open to anyone who has an interest in cultural heritage. It will last as far as we receive inputs and contributions for the subscribers.

consolidated with a resin to preserve the altered surface. Polymer analysis showed that the resin used was a polyester resin, prepared from polyfunctional aromatic acids and fatty acids, as denoted the recovery of different esters of benzene(poly)carboxylic acids and C₁₆ fatty acids. Although there is some data on the susceptibility to biodeterioration of resins (Salvadori and Nugari, 1988; Koestler and Santoro, 1988; Koestler et al., 1988) this phenomenon was never reported for lichens.

Finally CSIC Thematic Network of Cultural Heritage acknowledges the Spain's Scientific Research Council (CSIC) and Ministry of Science and Technology (MAT2002-10132-E) for the support on this newsletter.

During a visit to Baelo Claudia to study the deterioration processes of stuccoed walls and pavements, a considerable lichen colonization of several consolidated stuccoed capitals was observed (Figure 1a). Five species of lichens were identified growing on the consolidated stuccos: *Caloplaca lactea* (Massal.) Zahlbr., *Caloplaca citrina* (Hoffm.) Th. Fr., *Sarcogyne regularis* Körber, *Verrucaria muralis* Ach. and *Lecania turicensis* (Hepp) Müll. Arg. (Figure 1b-f). All species were growing beneath the resin layer and, in addition, *C. citrina* was growing on the outer surface of the deteriorated resin. These species are very common on the sandstone of this archaeological area (Ariño et al., 1995) and frequently occur on stone monuments and man-made substrata (Deruelle et al., 1979; Nimis et al., 1987; 1992).

For SEM study, samples were fixed with glutaraldehyde (2 %), dried at room temperature and gold coated. To obtain cross sections some samples were submerged in liquid nitrogen and fractured with forceps.

Cross section through the resin-lichen-mortar shows that the lichens are placed between these two materials (Figure 2a,b), forming a dense network of hyphae and algae, with fruiting bodies emerging through the resin layer (Figure 1b). The hyphae network invaded the resin revealing damages due to extensive perforation, pits having a diameter of 2-4 μm (Figure 2c). Observations with fluorescence microscope showed undamaged chlorophyll proving that the photobiont cells were alive. The lichens were active rather than being preserved



LICHEN DETERIORATION OF CONSOLIDANTS USED IN THE CONSERVATION OF STONE MONUMENTS

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Lichens are widespread in Baelo Claudia, a Roman city founded in the second century B.C., and near present-day Tarifa, Cádiz, Southern Spain (Ariño et al., 1995; Ariño and Saiz-Jimenez, 1996). Baelo Claudia is representative of a small industrial city with an economy that was based on fishing, especially tuna from the Straits of Gibraltar, and its trade made it one of the wealthiest cities in the Mediterranean.

The Roman city was discovered in the second decade of the XXth century. The forum and the temples of the city, after excavation in 1971, appeared relatively well preserved. The climate of the area is dry but mild, with relatively heavy rainfall in winter, although in summer there are long periods of aridity.

Since exhumation there has been a gradual deterioration of the stuccoed walls and column capitals. More than twenty years ago, some stuccoed capitals showing heavy decaying processes were

specimens of lichens that were coated by the resin as demonstrated the extensive holes caused in the resin.

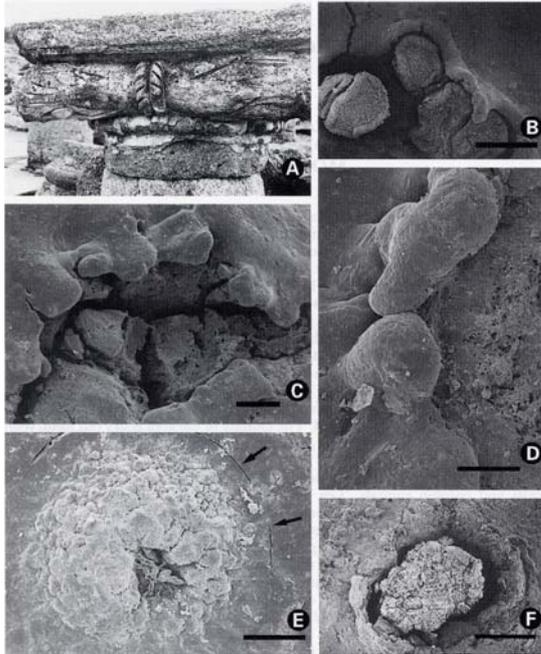


Figure 1. a) Stuccoed capital consolidated with resin. b) Apothecia of *Sarcogyne regularis* Körber emerging from the resin. Scale = 500 μm c) Resin deterioration produced by *Verrucaria muralis* Ach. growth. Scale = 100 μm d) Detail of the interface resin-*V. muralis*. Scale = 50 μm e) Emerging fruiting body of *V. muralis*. Dissolution of the resin apparently accompanied by mechanical action due to pressure from the fruiting body, shown by the fracture line (arrows). Scale = 100 μm f) Development of a fruiting body of *S. regularis* in a resin pit. Scale = 200 μm

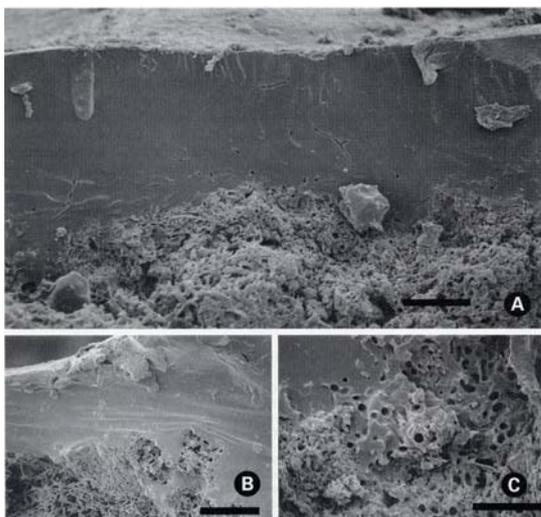


Figure 2. a, b) Cross section of the interface resin-lichen (*Verrucaria muralis* Ach.). The resin is perforated by the lichen. Scales a = 25 μm , b = 50 μm c) Detail of the perforations. Scale = 20 μm

No report book or data could be obtained for the restoration works accomplished

years ago and to whether the stuccoed capitals were cleaned before resin treatment. However, the evidence of living lichens causing resin destruction and survival beneath a layer of resin points to the development of a cryptoendolithic strategy, as only the soredia, apothecia and perithecia were in contact with the exterior. It could be speculated that lichen penetration occurs through the fissures and cracks of the resin layer, invading the interface resin-mortar which could be considered as a protective niche for lichen growth by retaining humidity in an extremely windy and, to some extent, xeric environment, and permitting sufficient light to pass through it. It was observed that lichen structures emerge by exerting pressure on the resin until it is ruptured (Figure 1e). Together with this mechanical action, a chemical effect is clear, as the margins of the resin around the reproductive structures were rounded and showed signs of apparent chemical dissolution (Figures 1c, 1d and 1f). Also the holes produced in the resins (Figure 2c) add further evidence for a chemical effect. In samples of the resin layer without lichen colonization, these types of deterioration were not observed. The fact that deterioration of the resin layer took place only in these definite areas suggests that living lichens cause resin destruction. Survival of lichens beneath a layer of this polymeric resin is clearly supported by Figures 1 and 2 and confirms the high colonization capacity of many lichens for different materials.

Acknowledgements

This study was a contribution from the Cooperation Agreement between the Consejería de Cultura, Junta de Andalucía and the C.S.I.C. The technical assistance of the Electron Microscopy Service of the University of Barcelona is gratefully acknowledged.

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Design and preparation

Thin films prepared by the sol-gel method (Mackenzie and Bercher, 2000) are suitable for the encapsulation of organic dyes (OD), capable of changing their optical absorption (colour) when acidity varies (Shahriari and Ding, 1994). These ODs can be used as environmental pH indicators when encapsulated into a partially densified glassy coating (Villegas et al., 2002). The experimental procedure for obtaining the coatings was as follows: a silica based sol (colloidal suspension) is firstly prepared, starting from a silicon alkoxide that undergoes hydrolysis and slow polycondensation. When hydrolysis is achieved the sol is doped with the OD, in such a way that OD molecules are entrapped in the inner surface of the silica network pores during further polycondensation and partial densification of the glass-like network. Thin coatings were applied upon common glass slides by dipping the slides in the doped sol, and then withdrawing them at a constant rate (5 to 30 cm min⁻¹). The coatings thickness varied between 150 and 500 nm. Once obtained, the coatings were submitted to a soft thermal treatment (60°C for 3 days), in order to polymerise the silica network and densify the system formed by the coating and the glass substrate. After that, the coatings were thin, transparent, coloured films capable of behaving like acidity sensors under wet gaseous conditions, i. e. they are sensitive to acid/basic chemical species combined with the atmospheric water (even below 40% relative humidity). This method for sensor production is versatile enough to allow the use of ODs of very different sensitivities in a given zone of the pH range. Hence, the possibilities for obtaining sensitive materials applicable in preventive conservation strategies are, in fact, promising.

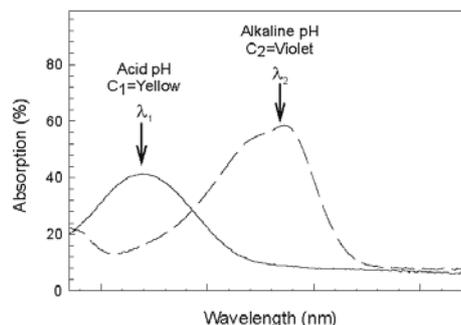


Figure 1. Absorption spectra of a sensor at acid and basic pH

NEW OPTICAL SENSORS FOR MONITORING ACID ENVIRONMENTS IN PREVENTIVE CONSERVATION

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Introduction

Environmental acidity causes deterioration (Leissner, 1996) in inorganic materials (metals, alloys, ceramics, glasses, enamels, etc.); as well as in organic materials (paper, tissue, leather, wood, bones, etc.). The measurement and control of environmental acidity is not always a simple task. Preventive evaluation of environmental pH should involve a brief, reversible, reliable and reproducible procedure. Our objective was to design, produce and evaluate a family of pH sensors with optical response based on thin glassy films. Such sensors will be sensitive to acid chemical species present in the air, especially in polluted environments.



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Physical and chemical properties

The optical absorption of the sensor (Figure 1) under acid conditions (pH_1) in the visible range of the spectrum showed a characteristic band at λ_1 nm (which corresponds to the acid colour C_1); while the band under basic conditions (pH_2) was centred at λ_2 nm (which corresponds to the basic or less acid colour C_2). This means that the OD tautomeric form responsible for the characteristic acid band (λ_1) becomes, via a neutralization reaction, the OD tautomeric form in which a characteristic band appears at λ_2 . It is thus possible to plot the evolution of the intensity of both the λ_1 and the λ_2 bands versus pH (Figure 2) and use them as a calibration curve. The pH range for which the slope is maximum, corresponds to the pH of the sensor maximum sensitivity. For pH values between pH_1 and pH_2 , the colour of the sensor will be the corresponding mixture of colours C_1 and C_2 .

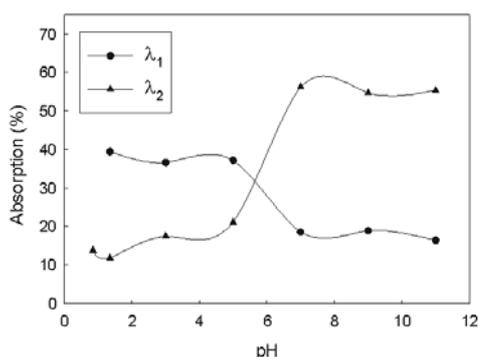


Figure 2. Evolution of absorption bands (λ_1 and λ_2) of fig. 1 versus pH

Chemical fundamentals of OD entrapped into the coatings are related to the changes in the tautomeric forms of the OD molecule due to pH variation. Such changes occur in a few seconds (short time response). The acid species (H^+), once combined with an aqueous medium (H_3O^+), diffuse into the porous coating microstructure where molecules of OD were entrapped. The reaction between H_3O^+ and the OD in the tautomeric form of colour C_2 yields the other tautomeric form (responsible for colour C_1). The purity of the colour C_1 and C_2 depends on the saturation level of both tautomeric forms. The sensors can interact with acid/basic environments, changing their absorption spectrum from the characteristic acid band towards the basic one and vice-versa. In other words, optical acidity

sensors behave as a reversible transducer that can be used many times showing neither signs of fatigue nor delay in their response time.

The chemical stability of the sensors was tested by dipping them into aqueous buffered solutions with pH throughout the pH range. Doped coatings resisted well to hydrolytic attack, both in acid and basic media, up to $\text{pH} \leq 12$. Neither delamination nor surface alteration was detected by scanning electron microscopy. For $\text{pH} > 12$, the coating surface developed small pits that could grow up after long dipping periods. The sensors photostability against UV-VIS radiation was isothermally proved (35°C) by exposing them to a 300 W lamp. After long treatment times (16 h), the characteristic absorbance of the sensor diminished (15%) as a consequence of the photodegradation of the OD and/or the partial densification (curation) of the coating. UV-VIS radiation favoured the polycondensation of the coating silica matrix, while adsorbed solvents are released. This fact affects the further accessibility of the analytes to the encapsulated OD. The mechanical behaviour of sensors was confirmed to be good enough for handling in current works both in laboratories and outdoors (museums, cathedrals, statues, soils, façades, etc.). The sensors can be cleaned with water and/or alcohols and dried with soft neutral paper or tissue. Moreover, they are resistant to ultrasonic treatment (up to 60 min) when immersed into a common cleaner solution at $\text{pH} = 8$. After sonication treatment, optical absorption did not change, and neither cracks nor pits were observed. This indicates good adhesion to the glass substrate. Resistance against peeling and cracking was evaluated by means of sliding friction tests, using up to 294 N of load. Glass substrates were broken even before the coatings were taken off.

Measurement procedure

Both qualitative and quantitative evaluation of environmental acidity are possible by using this kind of sensors. For qualitative evaluation, the sensors can be sensitised when installed as near as desired to the object to be monitored (Figure 3).

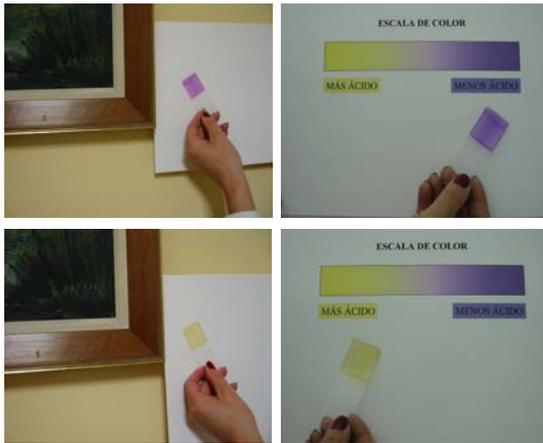


Figure 3. Qualitative evaluation of environmental acidity: the sensor is located near the art work whose environmental acidity will be evaluated and then comparison with a colour scale will indicate the acidity level

Once the sensor is exposed to the environment, it quickly reacts with acid/basic air species, showing the colour of the OD corresponding to the environmental pH detected, which can be evaluated by comparing with a colour scale. A few minutes, or even seconds are sufficient to sensitise the sensor. Parameters such as the air relative humidity and the sensor hydration level have to be taken into account to obtain good response time. We have confirmed that these acidity sensors work well for relative humidity below 40 %, detecting acid species concentrations of a few tens of parts per million and pH's within the accuracy range of 0.1 (Carmona, 2002). Figure 4 shows one example of quantitative detection of SO₂ in the air under low humidity conditions (35.5 %) at 22.7°C and 1100 m of altitude, under continental climate. Sensors have been also tested for a wide range of temperatures (-5 to 60°C) with the aim of checking their continuous (4 months) outdoor behaviour. Neither loss of optical properties nor loss of sensitivity were detected. Figure 4a represents the increase of the characteristic absorption band at λ_1 when the sensor is exposed to different SO₂ concentrations. Figure 4b correlates relative absorbance intensities of the sensor sensitised in buffered liquid media versus the pH of that media. Finally, Figure 4c shows the variation of SO₂ concentration in the air monitored against the pH measured by the sensor.

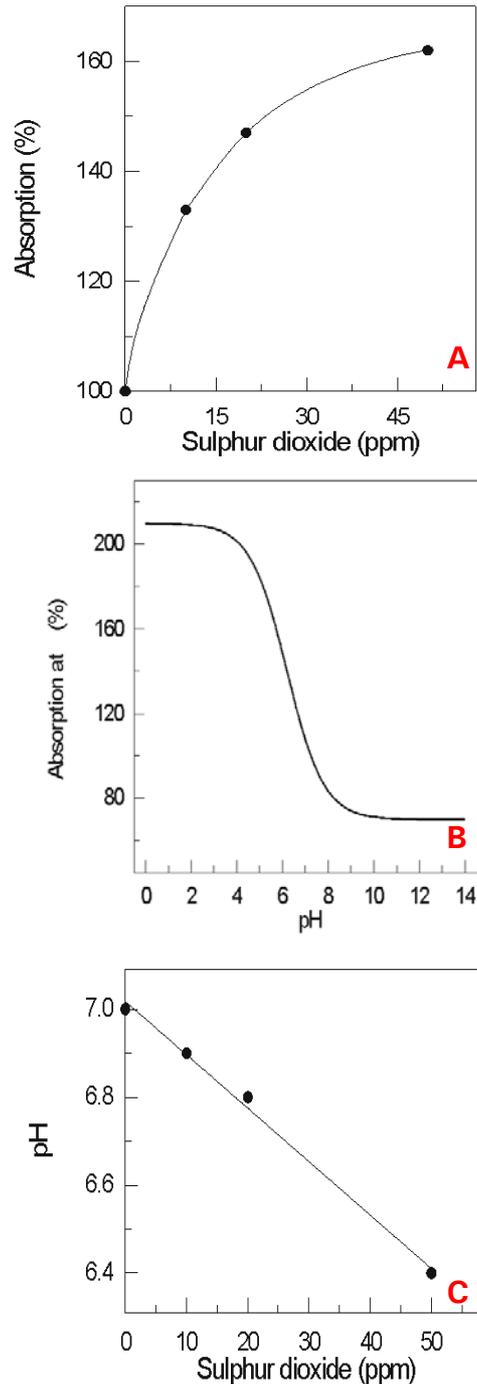


Figure 4. a) Evolution of the sensor absorption intensity against environmental SO₂ concentration. b) Relative variation of the sensor absorption at λ_1 versus pH. Data correspond to tests performed by immersion into liquid buffered media. c) Relationship between pH and SO₂ concentration as measured by the sensor

Conclusions

The doping of glassy silica sol-gel coatings with OD arises as a suitable process for obtaining coatings optically sensitive to acidity changes, both in liquid and gaseous media. The stability of doped coatings

against chemical agents, UV-VIS radiation and easy handling have proved to be good enough for their use as environmental acidity sensors. Moreover, such sensors show reversible behaviour, i.e. reusing is warranted. The quantitative measurement method with the optical sensors prepared is simple, reliable and reproducible. An accuracy of a few tens of parts per million for SO₂ and 0.1 pH units has been obtained, even in relatively dry environments.

Nowadays the research concerning these optical acidity sensors is accomplished and a further development need to be faced.

Acknowledgements

The authors gratefully acknowledge professional support provided by the Historical and Cultural Heritage Thematic Network of CSIC. Dr M.G.-H. is grateful for financial support of an I3P (CSIC-ESF) postdoctoral contract. Dr. N. C. is grateful for financial support of a Marie Curie postdoctoral grant.

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EFFECT OF CHEMICAL ADMIXTURES ON LIME-METAKAOLIN MORTARS CHARACTERISTICS

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Introduction

A mortar is a material resulting from the intimate mixture of sand grains, a binder (lime, cement, etc.) and water. Since a long time ago mortars, have had a double mission in the constructive process: on one hand to act as a link between other materials (stones, bricks etc.); and on the other hand to cover and protect the surfaces of columns, walls, facades, etc. They have been, at a certain extent, the skin of the building. It is obvious that these functions are vital for the conservation of the "monument", and they reveal the importance of these materials in the Historical Heritage.

Lime and lime-pozzolan mortars are the most widespread types used in the archaeological and historic Heritage in spite of having very slow setting and hardening processes and a scarce durability when exposed to the open air (Wisser et al., 1988; Masazza and Pezzuoli, 1981; Atzeni et al., 1993; Sabbioni et al., 1999; Furlan, 1990; Martinez-Ramirez et al., 1995). The high porosity of lime mortars results not only in low mechanical strength but also marked weakness against leaching, ice-thaw, salt crystallization and biological colonization. Lime-pozzolan mortars are stronger and less permeable to water than the lime ones, but they are also weak materials.

At this time, different types of repair mortars are available in the market. These modern materials have notably improved some particular characteristics like setting time, mechanical strengths, durability, etc., compared to the traditional mortars (lime and lime-pozzolan). The current technology concerning repair mortars based on Portland cement materials has a lot of detractors, because of the soluble



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salts the systems may incorporate and the mechanical incompatibility the structures may experience.

Development of new repair mortars to be used in buildings and monuments of Cultural Heritage involves fulfil the following requirements: white colour (susceptible of being coloured), compatible with natural stones, exempt of alkalis, higher mechanical strengths than lime mortars, better bonding and shear strength than lime mortars, pore size distribution adequate to achieve high permeability to vapour but not very permeable to water etc.

Pozzolanic materials are natural substances or industrial by-products having an amorphous or partially crystalline structure formed by silica, silico-aluminium compounds or a combination of both compositions. Pozzolans do not harden when mixed with water, but when they are finely powdered and in presence of water, they are able to react with the calcium hydroxide at ambient temperature to form hydrated calcium silicates and developing suitable mechanical strengths.

In fact the pozzolan-lime reaction is a hydraulic reaction which main hydration product is C-S-H gel (like in Portland cement).

Metakaolin is a white colour artificial pozzolan obtained by thermal treatment of kaolin, it is almost completely amorphous, compatible with natural stones, exempt of alkalis, with very high specific surface which implies a very high reactivity with lime and not very long setting time. However said high specific surface could act as a negative factor because of the high amount of water necessary during the mix. In such case a water reducer or a plasticizer could be used.

The objective of this paper is to study the influence of a chemical admixture (plasticizer) on the behaviour of lime-pozzolan mortars made of lime, metakaolin, and siliceous sand.

Experimental

Starting materials were analysed from the mineralogical (XRD) and chemical

standpoint (UNE 80320:199): Lime was mainly constituted by Ca(OH)_2 (86%) and was slightly carbonated having 12.5% of CaCO_3 . Sand contained 99% of quartz. Metakaolin was an amorphous material, containing a small amount of quartz (wt12%), 42.9 and 54.9 wt % of Al_2O_3 and SiO_2 respectively. The BET specific surface of metakaolin was $7.7 \text{ m}^2/\text{g}$.

Four type of mortars were elaborated mixing lime, metakaolin, sand and water. Details on dosages are given in Table 1.

Lime+ metakaolin/sand ratio was 1:2 in the whole mortars. Mortar I and II contain 2% of a plasticizer added with the mixing water while no admixture was used in Mortars III and IV. The amount of water necessary to the mixing was determined according to UNE Standard (UNE 83-811-92).

Prismatic specimens (1x1x6 cm) of the four type of mortars were made. Specimens were kept in the mould at 21°C and 100% RH for 1 day and after demoulding they were cured at the same conditions for another 15 days.

After this time compressive and flexural strengths, porosity and size pore distribution were determined (UNE-EN 196-1).

Results and Discussion

Table 1 shows, lime: metakaolin ratios and water proportion used for the mortar mixtures as well as total porosity and mechanical strengths exhibited by mortars after 15 days of curing.

The use of the admixture reduces the amount of water necessary to maintain a normal consistency. This water reduction results in a descent of total porosity of mortars and in a mechanical strengths increase. The effect of the admixture on water demand and porosity is more intense in those mortars having high content of metakaolin; while mechanical strength is negatively affected when the mortar is enriched with metakaolin.

The lime/metakaolin ratio affects the water demand and properties of mortars in different way depending on whether admixture is used or not.

Table 1: Porosity, mechanical strength and dosage in mortars

Mortar Type	Lime : Metakaolin	Admixture (2%)	Lime + Metakaolin : water	Porosity (cc/g)	Flexural (MPa)	Compress. (MPa)
I.	1:1	Yes	0.553	29.15	23.63	82.5
II.	1:2	Yes	0.509	27.77	19.01	60.6
III	1:1	No	0.975	34,72	10.36	29.9
IV	1:2	No	1.00	37,51	10.22	29.28

Mortar IV has double metakaolin and is more porous than mortar III, however mechanical behaviour is similar in both mortars. Mortar II also has double metakaolin but it is less porous and weaker than mortar I. In this type of mortars mechanical strength are mainly due to CSH gel produced in the pozzolanic reaction. It seems that the augment of metakaolin in mortars do not favour the raise of mechanical strengths, probably because of there is not lime enough when we put lime:metakaolin ratio of 1:2.

The admixture also affects to the pore size distribution, being porous fractions with diameter from 10 to 1 μm and from 1 to 0.1 μm , the most intensively modified, (Figure 1).

Figure 2 represents the volume of the different fractions of pores versus compressive strength of mortars. No correlation has been found between volumes of porous with diameter lower than 1 μm and mechanical strength. However an inverse correlation between the volume of porous in the 10-1 μm range and the compressive strength was found.

A treatment of the data by adjusting them to a straight line by square minimums gives us an equation showing the

good correlation obtained.

$$Y = -0.2306 X_{10-1\mu\text{m}} + 18.66 \text{ corr. coef.} = 0.9839$$

Conclusions

Chemical admixtures (plasticizer) modify the mechanical behaviour of lime-metakaolin mortars as well as their porosity and microstructure. In general they reduce the water necessary for the mortar mixture, increasing its mechanical strength and diminishing its porosity.

The more metakaolin contains the mortar, the more water is required for the mixing and the higher the mortar porosity is.

Chemical admixture effectiveness is higher (in reference with those two parameters) when specific surface rises, and consequently when more metakaolin is added; however mechanical strengths are not improved, being smaller as metakaolin proportion in the mortar increases.

The use of admixture also affects to the pore size distribution in mortars, being pores with diameter between 10 and 1 μm the fraction more intensively reduced. A good correlation between volumes of porous in the 10-1 μm diameter range with the compressive strengths of mortars has been found.

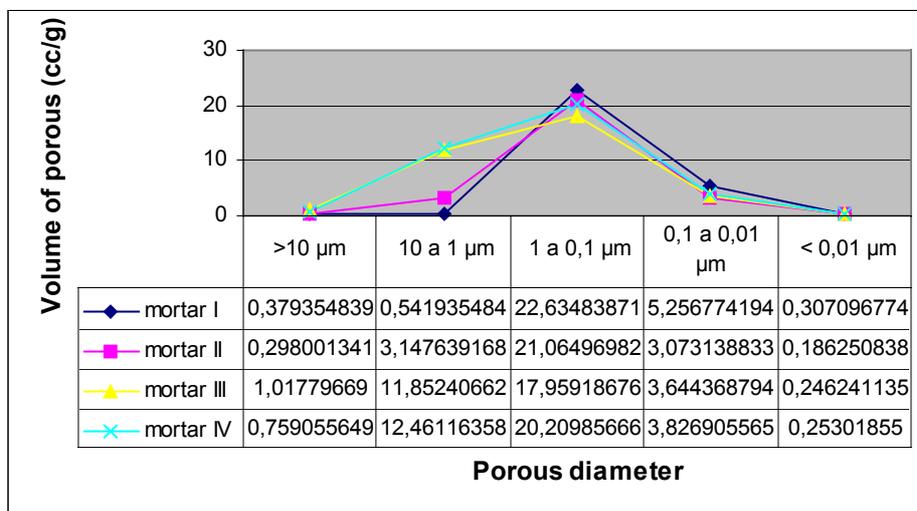


Figure 1. Pore size distribution in mortars

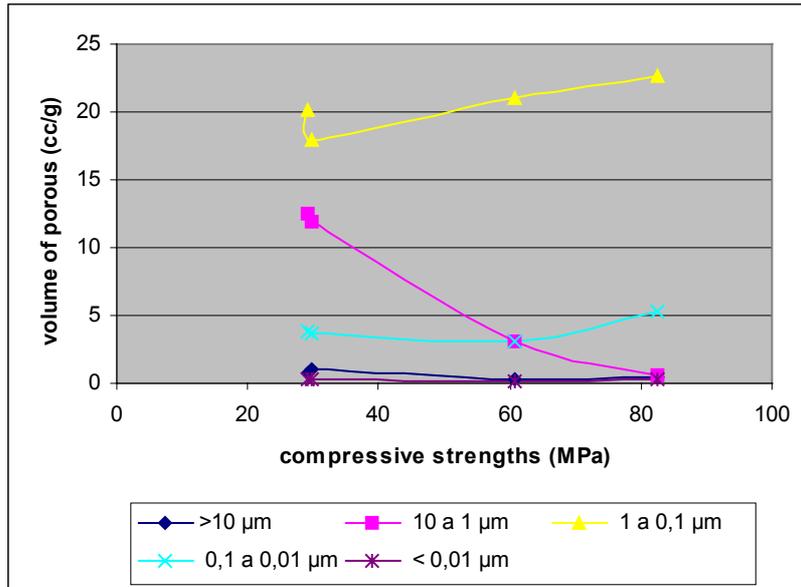


Figure 2. Volume of porous having different diameter ranges versus compressive strengths of mortars

Acknowledgement

Authors wish to thank the Ministerio de Ciencia y Tecnología (MCyT) for their support in the project MAT2002-04200-CO3-03.

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CULTURAL HERITAGE RESEARCH IN "THE MICRO AND TRACE ANALYSIS CENTER" OF THE UNIVERSITY OF ANTWERP

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A.F.L. Godoi, L. Bencs, Z.
Spolnik, K. Janssens & R. Van
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The Micro & Trace Analysis Centre (MiTAC) is part of the University of Antwerp, and has been engaged in a number of areas of research in analytical sciences. One of the current topics is related to the applications of micro- and trace analysis applications concerning Cultural Heritage. MiTAC has been aware that continuous research in this area is of a high priority. Not only for scientific reasons, but also in order to find practical solutions and set up guidelines to take care of cultural property everyday. In this field, MiTAC has two groups, led by Prof. René Van Grieken and Prof. Koen Janssens.

The research group of Prof. René Van Grieken works in several EU projects on preventive cultural heritage conservation. The main topics are the evaluation and analysis of several environmental parameters which influence the deterioration and the weathering of monuments and works of art, in museums, and churches throughout Europe, i.e. preventive conservation. In each case, the best combination of analytical techniques (electron probe X-ray micro analysis, ion chromatography, X-ray fluorescence analysis, gas chromatography-mass spectrometry) are applied to characterize the surrounding atmospheric particles and gases with respect to composition, origin and potential harmful effects on Cultural Heritage items.

The influence of gaseous compounds and particles in museum showcases is of particular interest. Often works of art are exhibited in enclosed showcases to protect them against air pollutants. However, there is some concern about the microclimate conditions inside the showcases and about the gaseous (mostly organic acids) and particulate emissions from leaks and glues and the works of art themselves. At present, a fast, efficient and solvent-free method for extraction and concentration of acetic acid in showcases using solid phase micro-extraction (SPME) is being used and applied for the GC-MS analysis of samples collected in the showcase of a human Egyptian mummy (dating from the 21st dynasty, 1070-945 B.C.), exposed in the Vleeshuis Museum in Antwerp, Belgium.



Figure 1. Egyptian mummy dating from the 21st dynasty, 1070-945 B.C.

The VIDRIO project, sponsored by the EU, has the aim to provide a better understanding of e.g. the environmental effects on the glass surface and paint (grisaille) and to identify the best practice to preserve medieval stained glass windows in their original context, taking into account their exploitation as a result of mass tourism. For the first time, the deterioration process of stained glass and the efficiency of protective glazings (interspace) are analysed simultaneously from a physical, chemical and biological point of view, without neglecting aesthetic and artistic aspects. The study is focused on three monuments: the Saint Urbain Church of Troyes, the Sainte Chapelle of Paris, France, and the Cologne Cathedral, Germany. The last two are included in UNESCO's World List of Cultural Heritage sites.

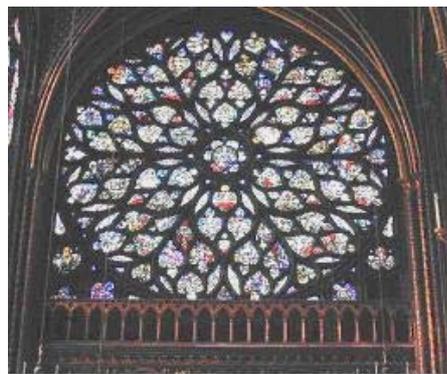


Figure 2. Ancient stained glass window in Sainte Chapelle, Paris

Atmospheric aerosols have recently been studied inside and outside the Correr Museum in Venice, the Art History Museum in Vienna, the Royal Museum of Fine Arts in Antwerp and the Sainsbury Center for Visual Arts in Norwich. In the specific case of the Royal Museum of Fine Arts, for example, it was found that although none of the art works was directly threatened by particulate pollution, more could be done to improve the storage conditions.

The probable damaging influence of conventional air heating systems in historical churches on objects of arts and construction materials is also studied within an EU project called "Friendly Heating". The small church investigated in this regard is in the Italian Dolomites and

contains valuable Cultural Heritage items. A novel electrical bench heating system is being installed to replace the conventional hot air delivery system, and the effects on air circulation, pollution deposition and people comfort are being studied. This study will soon be expanded to wooden churches in the mountains of Poland.

In the EU-funded project PRAXIS (short for 'Portable Raman-X-ray Instrument'), coordinated by Prof. K. Janssens, a prototype of a compact spectrometer is constructed which allows to perform both microscopic X-ray fluorescence analysis (μ -XRF) and microscopic Raman spectroscopy (μ -RS) on the same location on the sample. μ -XRF can provide information on local concentration levels of major and minor constituents in a completely non-destructive manner, while μ -RS allows molecular fingerprinting of the material under investigation. Once the instrument will be finished, its practical use will be evaluated in the context of the (fingerprinting) analysis of historic and modern inks and colorants. For this purpose, the PRAXIS project consortium includes partners from several European cultural heritage and forensic institutions.

Another topic of interest is the provenance analysis of historic glasses. As a function of time, the raw materials, techniques and procedures for glass making have undergone considerable changes, which are reflected in the composition of the glass at the major, minor and trace level. By systematic analysis of large numbers of glass fragments from the Roman period up to the 19 century, from different sites in Europe, more information on trade and technology transfer in different periods between different geographical areas of Europe is obtained.

AN APPROACH TO THE EVALUATION OF THE PUBLIC RESPONSE TOWARDS NEW CONSERVATION STRATEGIES IN ARCHAEOLOGICAL HYPOGEA

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Between April and September 2003 a short and simple questionnaire, available in Italian, English, French, German, Spanish and Polish language, was distributed to the visitors of the Christian Catacomb of St. Callistus in Rome (Fiocchi Nicolai et al., 1998). The research was a part of the triennial European Project CATS, focusing on control, prevention and monitoring of cyanobacteria and the damage they cause to archaeological lithic and painted surfaces (Albertano et al, 2003). The study was aimed to collect public opinion about a new illumination system adopted inside one cubiculum of the catacomb, the so called "Ocean's Cubiculum", a small burial chamber decorated with frescoes that were seriously attacked by the growth of phototrophic biofilms (Sánchez-Moral et al., 2003).

One monochromatic blue lamp, was, in fact, switched on in the cubiculum between February and September 2003, to check its effectiveness in reducing microbial development on lithic faces (Albertano and Bruno, 2003). This type of lamp, however, did not allow the full colour vision of the frescoes. Therefore, an interviewing approach was developed to collect the citizen answers to the initiative. Main goal was to evaluate the visitor response to the adoption of innovative conservation strategies. Integral part of the questionnaire was a set of explanatory posters on show at the catacomb entrance, from which visitors could gain information on the aims of the CATS project, main deterioration causes in hypogean environment and experimental methods applied to reduce biological attack due to cyanobacteria.

Profile of respondents

The filled questionnaires, whose reliability



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was good, let have for the first time information on the profile of the public of the Catacomb of St. Callistus. Unfortunately, the possibility to compare these results to pre-existing data was hampered by the absence of similar researches in archaeological sites.

A total of 1500 questionnaires was collected on site and gave information about visitor cultural interest (Section I), visit to the catacombs (Section II) and knowledge of problems in conservation of catacombs (Section III). At the bottom of the second page a specific section was devoted to demographic information, that were necessary for statistical evaluations.

The whole dataset was organised in Excel files and processed using the Frequency and Descriptive procedures of SPSS package for Windows (1999). The data were first analysed as a whole, then the answers to each question were evaluated according to demographic information.

On the total number of questionnaires collected, 44.9% of respondents were men and 45.7% women.

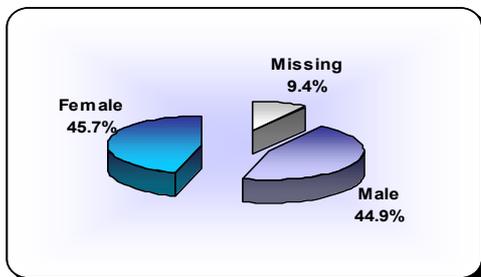


Chart 1. Visitor sample according to gender

A 44.1% of respondents were European, coming mostly from Germany, Spain and France. Extra-European came chiefly from North America. Only one third of visitors were Italian.

These data and those concerning the place of residence of the interviewed people (only 32.7% lived in Italy) clearly confirmed that the Catacomb of St. Callistus is one of the most touristic sites in Rome because of its religious importance as the first official burial place of the Roman Church, the good topographical position along the ancient Roman road Via Appia, the extension and the deepness of the cemetery, the great

number of tombs and burial chambers, the richness and variety of the inscriptions and paintings that it contains.

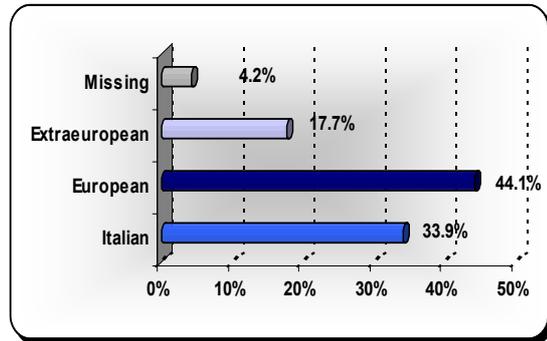


Chart 2. The highest proportion of respondents were from Europe

Visitors of the Catacomb of St. Callistus were mainly adults between 25 and 54 years old. The number of older visitors was rather low.

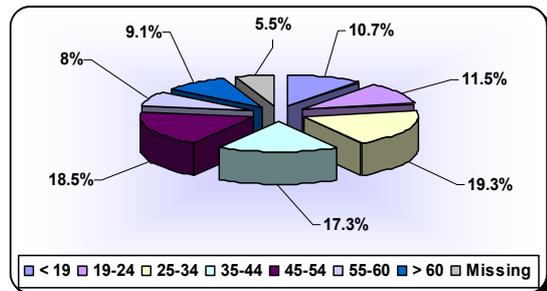


Chart 3. Distribution of visitors on the basis of age

The educational level of respondents was medium-high. In fact, 473 out of 1500 were qualified and 648 graduated. This result showed that there is a precise relationship between high cultural level and interest in visiting archaeological sites.

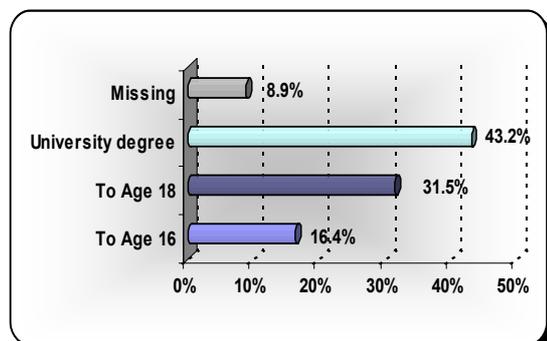


Chart 4. Most of respondents had a high educational profile

Regarding profession, the percentage of employed people (32.3%) and professionals (22.1%) prevailed in the sample, whilst housewife number was

low, despite of the great number of female respondent.

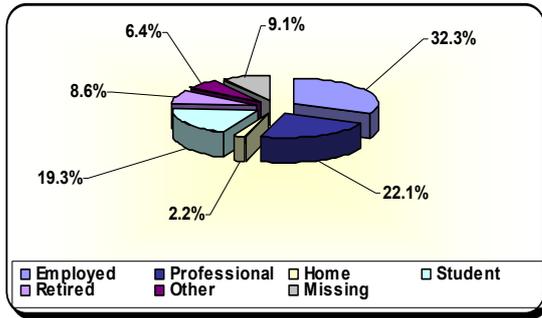


Chart 5. Employed and professionals prevailed among respondents

Response to the new lighting system

Section III of the questionnaire sought public knowledge about the problems in conservation of catacombs. However to evaluate the answer to questions contained in this section, it should be remembered that it followed the reading of the explanatory posters with the description of physical, chemical and biological environment (high air humidity, water percolation, visitor influx, artificial lighting and development of microorganisms). The answers to specific questions, concerning the hazard connected to the conservation of wall paintings, evidenced a certain knowledge of the main deterioration causes in hypogea. Damages to all kind of stone surface are, in fact, the 'everyday problems' faced by conservators and restorers of the "Pontificia Commissione di Archeologia Sacra" of Vatican, who are continuously engaged in restoration intervention (Giuliani, 2002; Bisconti et al., 2002).

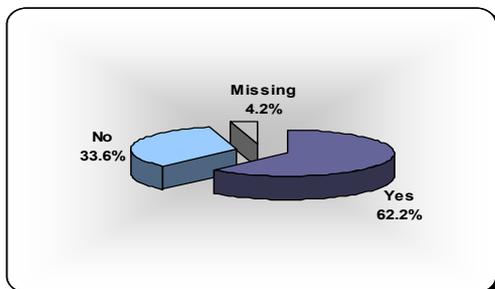


Chart 6. About two third of the respondents were informed of the problems of deterioration in hypogean sites

A 62.2% of respondents knew that catacombs and especially their frescoes could deteriorate, mostly because of the

air humidity, water infiltration and presence of visitors.

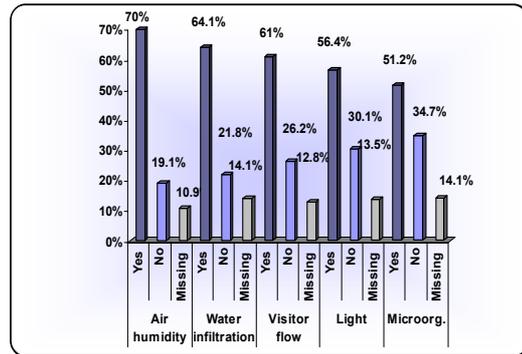


Chart 7. Answer to these 5 questions evidenced that at least half of respondents knew microbial deterioration in catacombs

Concerning the best conservation practice for ancient monuments, to be evaluated on a scale from 1 (minimum) to 5 (maximum), it is interesting to observe that visitors considered restoration and reconstruction less important than conservation; restructuring of buildings less important than monitoring of monuments and, above all, prevention of damage.

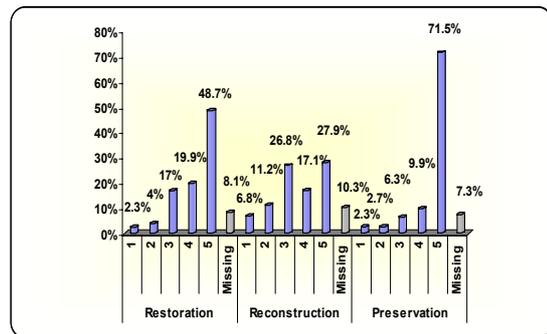


Chart 8. Answer to each question were given to express opinion about preservation, restoration and reconstruction of monuments

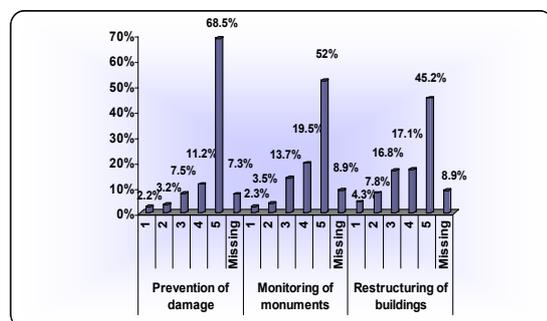


Chart 9. Visitors felt that prevention of the damage was very important in monument conservation

To determine public opinion about the most common means to reduce deterioration problems inside the catacombs, visitors were provided with a

list of different solutions. Most of them agreed on continuous maintenance and application of new strategies, but obviously not on decreasing the visitor number. At present, more and more people visit everyday Christian cemeteries and other cultural sites, but they do not realise that themselves represent one of the most important agents of deterioration. In fact, people not only voluntarily cause damages to archaeological sites, but unintentionally, contribute to the indoor increase of air temperature, carbon dioxide and organic pollutant concentration.

The final question posed by the questionnaire aimed to determine visitor response to the adoption of the blue monochromatic lamp installed inside the Ocean's Cubiculum. This lamp, previously tested in laboratory experiments, was selected because of the positive results obtained in suppressing the growth of those cyanobacteria and associated microorganisms that grew in the cubiculum.

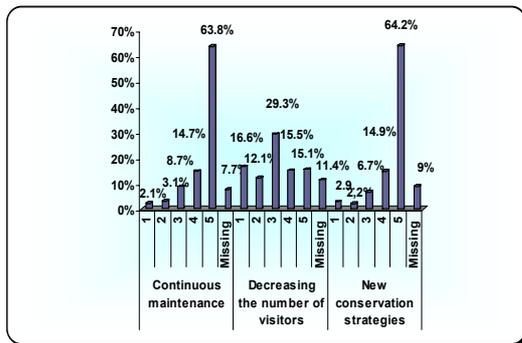


Chart 10. High percentages of respondents agreed on continuous maintenance and development of new conservation strategies

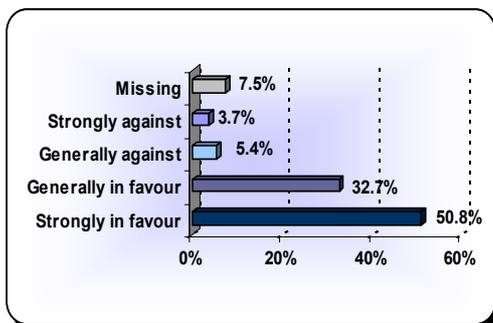


Chart 11. The response of interviewed people to the new lighting system was absolutely in favour

Unfortunately, the use of any monochromatic light sources implies the loss of full colour vision, and people visiting hypogea could have refused this

type of safeguard of the frescoes. Nevertheless, 50.8% of respondents were strongly in favour of the initiative, 32.7% generally in favour, and only 5.4% and 3.7% were respectively against and strongly against it. 7.5% of respondents did not answer the question.

Discussion

The questionnaire results provided for the first time information not only on the profile of the public of the Catacomb of St. Callistus, but also on visitor knowledge about problems in preservation and conservation of monuments. A remarkably high percentage of respondents indicated they were in favour of new conservation technologies, such as the "blue light" installed inside the Ocean's Cubiculum. However, a small percentage refused this type of illumination strategy and this datum, together with the general tendency of people to give the best image of themselves when interviewed, should be considered in the evaluation of the benefit achievable with the adoption of a monochromatic illumination system in ancient hypogea.

The lack of comparable researches in archaeological areas restricted comparison of the present results to data collected in museums (Solima 1999, 2000). Nevertheless, strong similarities were observed between the profile of respondents who visited St. Callistus catacomb and those frequenting museums all over the world, mainly concerning the educational level and a common interest in cultural sites.

Certainly, an extension of this kind of approach to other catacombs and archaeological sites should provide sufficient knowledge on the feeling of citizens towards the application of innovative instruments in the safeguard of cultural heritage. Moreover, improved communication between conservation managers and end-users can provide the way to reconcile the needs of conservators with the interest in visiting monuments of an increasing number of people.

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INVITATION TO CONTRIBUTE

Dear colleagues,

This is the first issue of the electronic newsletter COALITION under the sponsorship of the CSIC Thematic Network on Cultural Heritage. In this new step COALITION Newsletter will cover all Cultural Heritage topics and I invite you to contribute.

Contributions should be short communications, brief reports and case studies (maximum 3 pages), letters and/or comments to letters (1 page), etc. We will accept your contribution prepared in the standard way used in most journals. Then, your manuscript will be adapted to the newsletter format by us. Colour pictures are allowed and encouraged. Only electronic submission is accepted.

We intend to publish two issues per year, depending on the number of manuscripts received. Therefore, there is not deadline and your contribution will be included in the next issue.

Cesareo Saiz-Jimenez
Editor