NTUA University
Athens

CNR – Institute
of Chemical
Methodologies

Association
Investing
in Culture

6th International Congress on

"Science and Technology for the Safeguard of Cultural Heritage in the Mediterranean Basin"

PROCEEDINGS

VOL. II - Session B

Diagnostics, restoration and conservation

CONGRESS
CULTURAL
HERITAGE
ATHENS 2013
Science
&
Technology

Athens, Greece

22 – 25 October 2013

Printed by Centro Copie l'Istantanea, Roma, 2014
ISBN 978-88-97987-04-8

Publishing coordination, revision and realization: Angelo Ferrari - CNR, Inst. of Chemical Methodologies, Italy;

Digital Editing and Data Processing: Stefano Tardiola and Gianni Pingue - CNR, Inst. of Chemical Methodologies, Italy;

Secretariat: Enza Sirugo - CNR, Inst. of Chemical Methodologies, Italy; Manuela Manfredi, A.I.C. Secretariat, Italy.

SILICA THIN FILM SYNTHETIZED BY SOL-GEL PROCESS FOR THE PROTECTION OF OUTDOOR ARTISTIC CERAMIC IN ARCHITECTURE

Renzo Bertoncello[1*], Claudia Bortolussi[2], Michele Cecchin[2], Daniela Lattanzi[3]

[1]Dipartimento di Scienze Chimiche, Università degli Studi di Padova, Via Marzolo 1, 35131 Padova, Italy; e-mail: renzo.bertoncello@unipd.it
[2]SILTEA srl, Via della Croce Rossa 112, Padova 35129, Italy; e-mail: info@siltea.euinfo@siltea.eu
[3]MIBAC- Direzione regionale per i beni culturali e paesaggistici della Lombardia, corso Magenta 24, 20123 Milano, Italy;daniela.lattanzi@beniculturali.it

Keywords: sol-gel, silica coating, outdoor ceramic

Abstract

A coating treatment with a silica thin film synthesized by sol-gel process was performed during the restoration of the Gio Ponti's Church of Santa Maria Annunciata in Milan (Italy). Despite its recent construction (1964-67) the external façades made of porcelain stoneware tiles presented degradation phenomena caused either by exposure to weathering and by the fabrication characteristics of the material. A careful analysis of the deterioration of ceramic elements by optical microscopy and ESEM-EDS was performed in order to characterize the material and to project a proper intervention. A silica thin protective film was synthesized by sol-gel process, according to the method developed by the research group of Chemistry for Cultural Heritage of the University of Padua, and adapted to the specific application by the spin-off company Siltea srl. The method involves the neutral pH catalysis of the *sol* and the room temperature condensation of the film. The coating was applied by means of conventional air-spray gun. Optical microscopy and ESEM-EDS analysis before and after accelerated ageing on several samples were performed to evaluate the protective efficiency of the coating. The treatment was realized on a surface of 300 square meters with good results, encouraging the application of this new technology as an efficient alternative to the traditional methods, often based on the use of synthetic organic polymers.

INTRODUCTION

The Church of *Santa Maria Annunciata* at the *San Carlo Borromeo* Hospital in Milan was built between 1964 and 1967 on the architectural project of GioPonti. (Milan, 1891-1979) who was a very important Italian architect but also an industrial and furniture designer.

The church is considered a prime example of the XX century Italian architecture. Despite its recent construction, a poor state of preservation was observed. For this reason the Italian Ministry of Cultural Heritage (MiBAC Ministero per i Beni e le Attività Culturali) promoted the restoration and conservation of the building. Particular attention was paid for the external façades which were studied in depth [1]. The diagnostic analyses on the outdoor ceramic revealed a complex situation, identifying surface alteration processes caused by exposure to weathering and by the characteristics of the material itself. This kind of degradationis not usually recognized in historical buildings and it is considered a particular issue of contemporary art conservation. It is important to note that the tiles were designed by GioPonti and produced for this church, thus their conservation is of primary interest. The application of a silica sol-gel synthesized coating for the protection of the ceramic tiles was considered particularly suitable for this case, where physical and chemical stress conditions on the surfaces are relevant, and where the stability to direct solar irradiation is necessary.These requirements are not satisfied by the traditional protective systems, often based on organic polymers which tend to turn yellow and to become a substrate for biological attack. Moreover, the formation of cross-linking in aged polymers, changes their solubility with the consequence of a complicate and even damaging removal [2] [3] [4]. The thin film is chemically bonded to the substrate and the compatibility is guaranteed since the coating and the substrate have the same silicates chemical nature.

A specific sol-gel synthesis for the application on surfaces of artistic value was developed by the group of Chemistry for Cultural Heritage of the University of Padua. The innovative method of silica thin film deposition allows obtaining inorganic, pure and highly compatible protective layers for silicates substrates without heating treatments and in neutral environment, in accordance with the requirements of an intervention on cultural heritage material. The method was successfully appliedto the surface of ceramic tiles of the church. The treatment was performed at the end of the restoration of the façades and involved the original and the replaced tiles which were both subjected to laboratory and *in situ* tests before and after the protective coating treatment.

MATERIALS AND METHODS

A specific protocol for the definition of the more suitable treatment was elaborated. It involved the synthesis and the choice of a proper method of application.

Three different situationswere identified among the material and taken into account:

1. well preserved original tiles
2. degraded original tiles
3. tiles of new production for the replacement of missing and unrecoverable elements.

The material was previously studied with particular attention to the degradation processes and their consequences on the ceramic tiles. Samples and cross-sections optical microscopy analysis, together with morphological and chemical analysis using ESEM-EDS technique (Environmental Scanning Electron Microscopy with Energy Dispersive Microprobe, FEI Quanta 200) allowed a complete characterization of the ceramic material.

On the basis of the results, a specific formulation of the sol-gel coating was adopted using Tetraethoxysilane (TEOS) as a precursor and a specific catalyst to avoid migration of lead ions and iridescence effects [5]. The sol-gel method is based on chemical reactions in liquid phase and not on the high temperature treatment of raw materials as sand and clay, thus the resulting material is characterized by high purity, being composed only by silicon and oxygen atoms. The potential application of the sol-gel coatings for the protection of surfaces in the cultural heritage field was limited by the pH of the solution and the thermal treatment for the densification of the film. The innovative formulation developed at the department of Chemical Sciences of the Padua University overcomes these problems.

In neutral environment the kinetic reactions is very slow, thus the synthesis is usually accelerated by means of acid or basic catalysts. For example, an acid catalyst is able to promote the hydrolysis, the first step of the sol-gel process in which the resolution of the molecules of the precursor is observed when reacting

with water.The modified method is characterized by the substitution of the acid catalysts with aqueous solutions with Lewis acids, thus realizing a film deposition in neutral conditions.During the next phase of condensation, the polymerization occurs with the elimination of water or alcohol molecules and the formation of ≡Si-O-Si≡ bonds. The viscosity increases forming a network which progressively entraps the remaining solution (gelation). An ageing is required in order to allow the structural evolution by the formation of covalent bonds. After this period, the deposition can be performed. The drying starts immediately after the application, with the loss of water and the evaporation of volatile compounds. The phenomenon involves first the surface and then the evaporation of liquid from within the pores due to the capillarity. This is a critical step of the sol-gel process, since stress produced by contraction may lead to cracking. The formation of the solid material is possible by the densification which is usually realized by a thermal treatment between 500°and 600°C [6]. With the new formulation the densification occurs at room temperature avoiding substrate damaging and impurity incorporation making possible also *in situ* applications. The film is formed instantly and reaches the total stability in few days [7] [8] [9]. The thin layer formed on the surface of the treated material has a thickness between 150 and 250 nanometers (depending on the method of application) with a composition of amorphous SiO_2 (purity >99.99%). The film is transparent, colorless and isotropic.
Two methods of application were tested: paint brush and airbrush with compressed air. The treatment was tested*in situ* and in laboratory. After a period of natural ageing for *in situ* tiles and climatic chamber cycles for laboratory samples, the morphological and chemical analysis were performed again, in order to evaluate the effect of the protective treatment. Artificial ageing was performed by means of an Atlas Sunset CPS+ climatic chamber.

RESULTS

The ceramic tiles show two different shapes: rectangular with planar surface and diamond-shaped with a central cusp. The morphological analysis of the ceramic samples and their stratigraphy revealed similar features for all the tiles. The ceramic fabric is compact, white with pink hues. Ocher and black inclusions are dispersed in the white matrix. The glaze is grey and it is characterized by a diffuse porosity with bubbles.
The polished section allowed observingtwo well distinct cohesive strata. The glaze has a thickness of about 350 microns with inclusion of the mean diameter of 10 microns and porosity of 100 microns (Fig.1). A silicate composition of the glaze was found trough ESEM-EDS semiquantitative analysis expressed in weight %: Silicon (35 %), Aluminum (3%), Sodium (2%), Calcium (3%), Magnesium (0.8%), Zinc (2%), Potassium (2%) Lead (4%).
The silica thin film synthesized by sol-gel method was considered suitable for this kind of material, since the protective layer does not contain significant amount of alkali ions which may be subjected to leaching. This is important since the persistence of basic solution formed by the weathering of the glaze could be responsible of further damage of the surfaces.
Once characterized the surface to be protected the sol-gel treatment was formulated and tested.
An essential preliminary step was the cleaning of the surfaces, which is necessary in order to ensure the formation of the chemical bonds between the thin film and the glaze. Two methods of application were tested, by means of paintbrush and by spray coating.

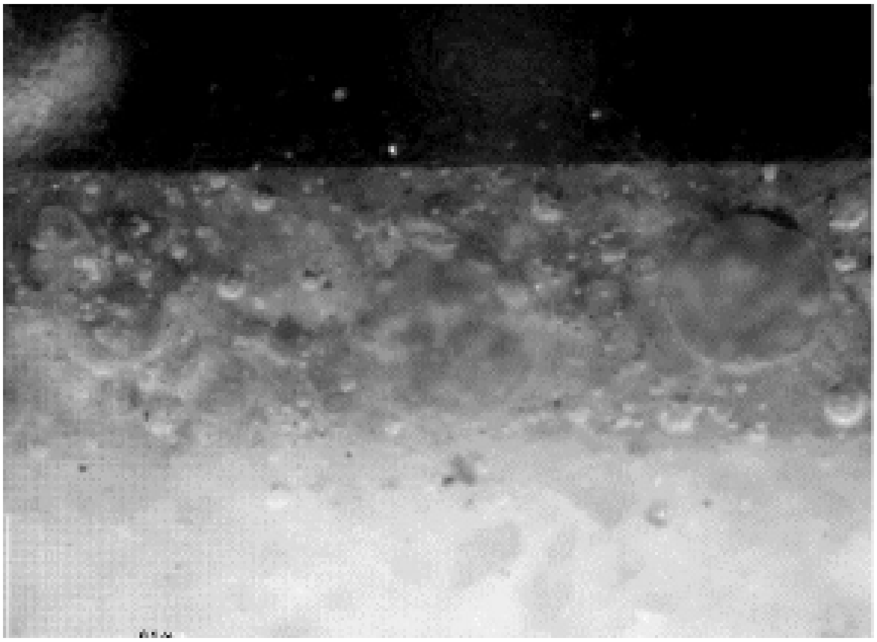

Figure 1. Digital microscope image of the polished section of the ceramic tile. The glaze (upper layer) has a thickness of about 350 microns and it is characterized by a gray color, diffuse porosity and bubbles. The ceramic body is white, compact with ocher and black inclusions.

The deposition performed with the paintbrush was not satisfactory even if the resulting film was homogeneous and covered the entire surface.
Excellent results were obtained by applying the product with an airbrush, ensuring a uniform deposition and an adequate homogeneous thickness thanks to the rapid evaporation of the solvent. The method was also thought to be suitable for the *in situ*application.
Since the two main problems of the glaze were the pitting corrosion and the cracks, particular attention was paid for these phenomena. In order to verify the capability of the protective treatmentto repair and to stop this kind of degradation, two original samples affected by pitting and cracks and two samples of the replacing material were analyzed before and after the treatment. The ESEM-EDS analysis in the crack showed siliceous deposits along the discontinuity of the glaze and Cu, Fe and P presence inside of the fracture.
In the ESEM images it is also possible to distinguish different phases of the pitting formation and development. The phenomenon starts with concentric fractureswhose evolution leads to the loss of the material and the formation of the alveolus reaching in some cases the diameter of 2 millimeters. Inside this area it is possible to recognize a hole. The deposition tests on the tiles of new production show an excellent compatibility of the film with the glazing. Considering the good results obtained in the laboratory tests, a deposition was performed also*in situ.*
In order to evaluate the behavior of the treated tiles in the environment and under specific stress conditions, the samples were undergone to artificial ageing. The first step was the simulation of the solar irradiation with cycles of 12 hours of lighting and dark. The aim was to test the resistance of the film to the daily temperature range and to the UV irradiation. The second and the last steps allowed verifying the interaction of the coating with water, simulating the water condensation on the surface and the effect of rainfalls.
Moreover, the *in situ* coated tiles were analyzed after 60 days, in order to check the interaction of the film with the environment in which it will be applied.

Alterations were not observed after either the natural and artificial ageing. The optical microscopy and ESEM images showed the stability of the film which is not affected by lifting or gaps.
Once tested the conservation conditions of the ceramic and the compatibility of the thin film, the treatment was considered suitable for the application on the outdoor tiles.
The protective treatment was the last phase of the restoration of the church. The surface was firstly cleaned on the basis of a specific protocol developed for the application of this sol-gel thin film. The pre-treatment removes the organic matter from the surfaces and at the same time facilitates a rapid drying. The cleaning was performed by means of a solution of deionized water and surfactant (10:1) which was then washed with deionized water. At the endisopropyl alcohol was used to eliminate organic carbon residues. The cleaning must be realized immediately before the application of the silica coating in order to avoid contamination from the environment. This is fundamental especially when working on outdoor surfaces.
The procedures of the treatment involved contiguous portions of the façade, spacing out cleaning and film deposition according to the scaffolding. In this way the overlapping of different layers of film was prevented. The spray deposition was realized for a total area of 300 mq.

DISCUSSION

The chemical composition of the glazing and its morphology are the results of the traditional production techniques based on the use of sodium chloride salts and alkali lead compounds. Similar results were obtained for the tiles of new production but no lead was recognized in the glazing layer as expected on the basis of the present production methods.
Even if the surfaces appeared in general smooth, the ESEM images show an irregular surface of the tile, due to efflorescence, deposits and alveoli. At a microscopic scale, the glaze is affected by micro cracking, pitting corrosion and scattered alveoli. The phenomena are much more diffuse in tiles from the southern façade, which is exposed to direct solar irradiation and thus to a temperature range larger than the others. The degradation occurs especially on the cusps. The discontinuities of the glaze weaken the whole material thus being more subjected to degradation with respect to the intact material. The micro cracks may evolve in fractures involving not only the glaze but also the ceramic body (Fig.2). Chemical elements not belonging to the chemical composition of the ceramic were transported by polluted meteoric water which flows preferentially along the discontinuities. In particular, Cu and Fe are attributed to the drainpipes and to the metallic roofing, while P is associated to organic residues.
The pitting corrosion was observed in the original and in the new material, supporting the hypothesis that the phenomenon is not related to weathering processes but it is an intrinsic feature of the ceramic. The shape and the distribution of the alveoli which are characterized by a central hole are related to the expulsion of air bubbles during the firing process.
Once tested the chemical compatibility of the sol-gel silica coating, the deposition method was chosen on the basis of the application tests. The paintbrush was excluded due to the thickness of the resulting film, which was considered excessive, compromising the elasticity of the film. Moreover, the traces of the bristles were perceptible, altering the aesthetic features of the glaze. The method was thus considered not suitable for the application on the ceramic tiles.Macroscopic and microscopic observations of spray coated samples confirm that the material after the deposition maintains its aesthetic and chromatic features

since the protective film is homogeneous and does not reveal iridescence effects. Moreover, this method allows a better exploitation of the product, without residues and it is also suitable for the treatment of large surfaces.

Figure 2. The degradation processes affect especially the cusps of the tiles. The cracking of the glaze evolves in the fracture of the ceramic body with loss of tiles. It is possible to recognize the efflorescences along the path of flow of water.

After natural and artificial ageing, any change in the aesthetic and chromatic aspect of the tiles was observed. The function of filler of the treatment for micro cracking is still preserved and the film is also able to contain the phenomenon of pitting corrosion.In the coated samples the degradation process does not develop even in presence of stress conditions while the untreated reference samples show the diffusion of the alveolar areas (Fig.3).

The images referred to the same areas observed after the coating treatment confirm that the film is able to flatten the surface roughness of the glaze, stopping the evolution of the underway degradation processes. As expected, the protective film is not able to restore the deep cracks, since their micrometric dimensions are not comparable with the nanometric thickness of the coating. The tiles showing this kind of damage were substituted before the treatment.

After the restoration and the protective treatment the immediate efficacy of the coating was observed as an increasing of the waterproofing, due to the considerable decrease of the surface roughness. The less specific surface exposed to the environment results in smaller amount of OH groups interacting with water. This is an important feature, since in most cases the degradation processes are linked to the presence of water on the surfaces.

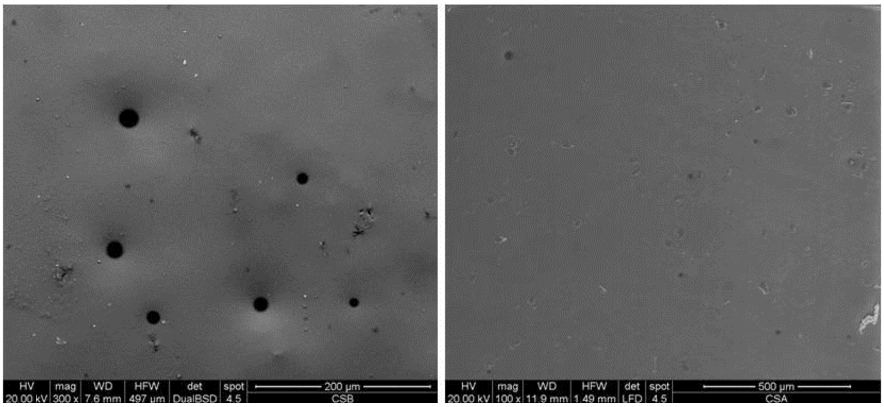

Figure 3. ESEM images of the pitting corrosion in untreated (left) and treated (right) samples after the artificial ageing. The corrosion phenomenon is diffused in the reference sample while in the coated surface the degradation process is stopped.

CONCLUSIONS

The protective silica thin films synthesized by the sol gel method have been successfully applied in the restoration of the outdoor ceramic of the S. Maria Annunciata church in Milan. The treatment was performed after a careful analysis of the material and of the degradation processes. The tests performed *in situ* and in laboratory allow the definition of the protocol of intervention. The coating has proven to be compatible, able to stop the degradation processes and to protect the substrate from further damages. It was verified an increasing of the waterproofing, which gives a better resistance to the material from the atmospheric agents and to pollution. The treatment will be also useful to extend the time between the intervention of maintenance and restoration. From the conservation point of view it was possible to preserve the original material.

REFERENCES

[1] C. Di Francesco, D. Lattanzi, M. Mapelli,L'avvio di un cantiere sperimentale alla chiesa dell'ospedale San Carlo Borromeo, Gio Ponti. Meravigliosa ventura di costruire chiese. La chiesa della Santa Maria Annunciata per l'ospedale San Carlo Borromeo, Milano (2006) 112-140.

[2] M. Favaro, R. Mendichi, F.Ossola, U. Russo, S.Simon, P.Tomasin, P.A. Vigato,Polym. Degrad. Stab.91 (2006) 3083-3096.

[3] M. Favaro, R. Mendichi, F.Ossola, S. Simon, P. Tomasin, P.A.Vigato, Polym. Degrad. Stab. 97 (2007) 335-351.

[4] M. Favaro, F.Ossola, P. Tomasin, P.A.Vigato, Conservation science(2007) 65-72.

[5] R. Bertoncello, L. Milanese, A. Bouquillon, J.C. Dran, B. Mille, J.Salomon, Appl. Phys. A Mater. Sci. Process. 79(2004)193-198.

[6] J.D.Wright, N.A.J.M Sommerdijk,. Sol-gel materials. Chemistry and applications, CRC Advanced Chemistry Text, 2000.

[7] R. Bertoncello, L. Milanese, J.C. Dran, A. Bouquillon, C. Sada, J. Non Cryst. Solids 352(2006) 315-321.

[8]B. Dal Bianco, R. Bertoncello, A. Bouquillon, J.C. Dran, L. Milanese, S. Roehrs, C. Sada, J.Salomon, S. Voltolina,J. Non Cryst. Solids 354 (2008) 2983-2992.

[9] B. Dal Bianco, R. Bertoncello, Nucl. Inst. and Meth.in Physics Research B, 2008,266 , 2358-2362.

INDEX OF PAPERS

VOLUME I – SESSION A: RESOURCES OF THE TERRITORY

INSTRUMENTS, METHODS, RESEARCH AND PROFESSIONAL TRAINING INITIATIVES FOR CULTURAL HERITAGE TRANSMISSION TO THE FUTURE 1

THE ARCHAEOLOGICAL ENSEMBLE OF MÉRIDA AND THE COMPREHENSIVE MANAGEMENT STRATEGY: TOOLS AND METHODS OF CONSERVATION, MAINTENANCE AND VALORIZATION OF A UNESCO SITE 13

INDOOR MICROCLIMATE AND PRESERVATION OF HISTORIC ARCHITECTURE: THE MALATESTIANA LIBRARY IN CESENA 23

INTEGRATED STRATEGIES REGARDING THE REVITALIZATION AND RE-USE OF HISTORICAL CENTRES - CASE STUDY IOSEFIN NEIGHBOURHOOD, TIMISOARA, ROMANIA 31

THE REHABILITATION AND RE-FUNCTIONALIZATION OF FORTIFIED CITADELS AS PART OF THE REVITALIZATION STRATEGY OF HISTORICAL CENTERS–CASE STUDY ARAD FORTRESS, ROMANIA 40

THE USE OF WROUGHT IRON IN THE STRUCTURAL SYSTEM OF OTTOMAN BUILDINGS IN TURKEY 51

REHABILITATION THROUGH A HOLISTIC CONSERVATION AND REVITALIZATION STRATEGIES FOR THE CITIES: CUMALIKIZIK VILLAGE AS A CASE 57

RESTORATION STUDIES AND THE RE-USE OF ORHANELI STONE SCHOOL, BURSA-TURKEY 62

STRATEGY FOR THE INTEGRAL REGENERATION OF A HISTORICAL CENTER. THE CASE OF BEN M'HIDI NEIGHBORHOOD IN ALGIERS. 69

PLANNING TOOLS FOR HISTORIC CENTERS CONSERVATION IN ITALY, CASE STUDY OF "ORTYGIA" SYRACUSE, ITALY. 78

INTANGIBLE SMART CITY INSIDE TANGIBLE HISTORIC CITY: SMART HERITAGE AS REGENERATION OF EURO-MEDITERRANEAN REALITIES 91

TANGIBLE AND INTANGIBLE HERITAGE IN THE MEDITERRANEAN SUSTAINABLE CITY 101

CULTURAL HERITAGE THROUGH HISTORY AND NATURE CONSERVATION AND RE-USE. THE SCICLI CASE STUDY 112

GPR INVESTIGATIONS OF GEOTECHNICAL CONDITIONS AT METEKHI CATHEDRAL AREA 126

WORLD HERITAGE SITES IN SOUTH-EASTERN SICILY 132

REUSE OF URBAN RAILWAY SPACES AND ITS HERITAGE: SPANISH CASE IN THE INTEGRATION OF THE HIGH SPEED TRAIN 142

EXPERIMENTAL AND NUMERICAL ANALYSIS OF THE ST. GIULIANO CHURCH IN POGGIO PICENZE (AQ) 150

THE SAFEGUARD IN THE HEART OF THE CITY. SEVEN PARADIGMATIC EXAMPLES OF URBAN REHABILITATION IN EUROPE 161

REHABILITATION OF THEATRES IN SICILY 171

ARCHAEOLOGICAL PARK "MEDIANA" BY NIŠ (NAISSUS)-OPPORTUNITIES OF REUSE AND PRESENTATION 180

MAJOLICA TILED SPIRES IN SICILY. SHAPE, STRUCTURE AND PROBLEMS 188

URBAN MORPHOLOGY AND ARCHITECTURAL DESIGN IN MEDIEVAL SMALL TOWNS: SAN VITO ROMANO 197

ARCHITECTURAL DOCUMENTATION, ANALYSIS AND REUSE PROPOSAL OF THE HISTORIC VILLA KLONARIDES BUILDING IN PATISSIA, ATHENS 208

GIS MODELLING FOR INTEGRATED DOCUMENTATION OF THE HISTORIC BUILDING OF VILLA KLONARIDI IN ATHENS, GREECE 217

'FRINGSCAPE': A MEDITERRANEAN CITY IN-BETWEEN URBAN LANDSCAPES AND RURAL LANDMARKS 227

THE ROCK-CUT TOMBS OF NORCHIA (VT): THE STATE OF RESEARCH 235

THE MATERIAL PROPERTIES OF HORASAN MORTARS IN SOME OTTOMAN PUBLIC BATHS IN BURSA-TURKEY 244

THE STRUCTURAL FAILURES OF THE FRIGIDARIUM PART OF THE HISTORICAL OTTOMAN BATHS IN BURSA-TURKEY 250

EXAMINATION OF THE MATERIAL PROPERTIES AND THE CONSTRUCTION TECHNIQUES OF TRADITIONAL OTTOMAN TIMBER HOUSES IN THE CUMALIKIZIK VILLAGE, BURSA-TURKEY........ 257

THE EFFECTS OF SOLAR RADIATION IN ARCHAEOLOGICAL SITES 263

ROBOARCH: AN AUTONOMOUS ROBOT FOR ANALYSIS AND DOCUMENTATION OF HISTORICAL ARCHITECTURES 270

ROBOTIC TOOLS AND SYSTEMS FOR MAN/MACHINE COOPERATION IN UNDERWATER ARCHAEOLOGY 279

ARCHAEOLOGICAL TEXT AND URBAN CONTEXTS: STRATEGIES FOR PROMOTION 284

THE ARCHAEOLOGICAL SITE OF BADIA IN TERRA D'OTRANTO:CONTRIBUTION OF THE GEOPHYSICAL PROSPECTING TO THE RECONSTRUCTION OF THE LANDSCAPE FROM THE LATE ANTIQUITY TO THE MIDDLE AGE 291

THE AGORA OF SEGESTA IN IMMERSIVE VIRTUAL ENVIRONMENTS 299

OBJECT TRACKING FRAMEWORK FOR UAV-BASED SURVEILLANCE OF CULTURAL HERITAGE SITES 308

HIGH RESOLUTION SUBSURFACE IMAGING WITH A HOLOGRAPHIC RADAR MOUNTED ON A ROBOTIC SCANNER 314

RECONFIGURING ANCIENT ARCHITECTURE: THE VILLA ROMANA IN PIAZZA ARMERINA 321

THE HISTORIC LIGHTHOUSES OF MEDITERRANEAN BASIN 327

VOLUME I – SESSION C: BIOLOGICAL DIVERSITY

STATURE AND BODY SHAPE OF ANCIENT EGYPTIANS FROM THE OLD KINGDOM 337

MAKING PROCESS, CONSERVATION AND HISTORICAL STUDIES OF TEXTILES BY RADIOGRAPHIC ANALYSIS. APPLICATION ON HISTORICAL TEXTILES FROM XV AND XVI CENTURY 345

BIOLOGICAL AND MICROCLIMATIC DIAGNOSIS IN CULTURAL HERITAGE CONSERVATION: INTERDISCIPLINARY RESEARCH AT PALATINA LIBRARY IN PARMA 352

ANTHROPOLOGICAL ARCHIVES AND SOCIO-ECONOMIC HISTORY OF POPULATIONS LACKING WRITTEN SOURCES. SOME CASE STUDIES 359

THE HISTORIC CYPRESSES OF THE VIALE DI BOLGHERI: NEED OF AN ORGANIC AND NON-STOP ACTION TO PRESERVE A LIVING MONUMENT. 367

MOLECULAR TRACING OF THALASSEMIA IN ANCIENT GREEK HUMAN REMAINS 375

HISTORICAL GARDENS OF CATANIA (SICILY) 380

PLANTS OF HISTORICAL GARDENS OF MILAZZO (MESSINA, SICILY) 388

BOTANICAL TRAITS OF CALTAGIRONE'S HISTORICAL GARDENS (CATANIA, SICILY) 395

ADVANCED TECHNICAL STUDIES OF A POLYCHROME GILDED FURNITURE CABINET DATED 19^{TH} CENTURY FROM MANYAL PALACE MUSEUM, CAIRO 403

RE-DESIGNING GARDEN HISTORY: RESEARCH PROGRAM FOR THE UPGRADE OF THE NATIONAL GARDEN OF ATHENS 412

VOLUME II – SESSION B: DIAGNOSTICS, RESTORATION AND CONSERVATION

STRUCTURAL ASSESSMENT AND REHABILITATION OF AN HISTORIC TRADITIONAL MASONRY BUILDING IN ATHENS 1

DEGRADATION AND PRESERVATION OF RAMMED EARTH. CASE STUDY OF SPAIN 8

THE HISTORY OF ARCHITECTURE AND THE CONSERVATION OF THE BUILT HERITAGE OF THE ARCHDIOCESE OF CHIETI 22

REINFORCEMENT OF HISTORIC MULTI STOREY BEARING STRUCTURES WITH BRACED METAL TUBES 33

SURVEY, RESTORATION AND CONSERVATION OF HISTORICAL BUILDINGS AND MONUMENTS BY USING ROBOTIC SYSTEMS 42

NATURAL FIBRES AS REINFORCEMENT OF GYPSUM COMPRESSION LAYERS..... 52

ANASTILOSIS AND RESTORATION OF GUR-DOKHTAR TOMB, TOMB OF ACHAEMENID (IRAN) 60

CONSERVATION PROBLEMS OF AGHJOTS MONASTIC COMPLEX..... 67

THE MASTER OF ACCADEMIA: A POWERFUL TOOL FOR DATING STRINGED MUSICAL INSTRUMENTS 74

WOODEN DOMES, VAULTED AND FLAT CEILINGS, PARTITION WALLS IN THE SICILIAN CONSTRUCTIVE TRADITION KNOWLEDGE FOR THE SAFEGUARD OF ARCHITECTURE AND TECHNIC 78

THE SIROCCO CHAMBERS: PASSIVE COOLING STRUCTURES IN THE XVI CENTURY PALERMO AREA 86

BINDERS FOR RETOUCHING SYSTEMS IN CONSERVATION: AN OVERVIEW AND EXPERIMENTAL TESTS 99

THE USE OF COMBINED CLEANING SYSTEMS FOR THE RESTORATION OF A DETACHED GRAFFITO FROM THE MUSEUM OF PALAZZO BRASCHI IN ROME 108

LACUNA'S TREATMENT RESTORATION AND TECHNOLOGICAL INNOVATION 115

ACOUSTIC IMPROVEMENTS IN A HISTORICAL BUILDING RESTORATION 122

KNOWING THE HISTORY AND THE MODIFICATIONS DURING TIME OF A HISTORICAL BUILDING FOR A CARE FUL ASSESSMENT OF ITS SEISMIC VULNERABILITY 127

RESEARCH ON THE SEISMIC BEHAVIOUR AND THE RETROFITTING OF THE BUILDINGS FROM THE BULGARIAN CULTURAL HERITAGE 137

LOCAL SEISMIC RESPONSE ASSESSMENT FOR THE SAFEGUARD OF ITALIAN HISTORICAL ARCHITECTURAL MONUMENTS: THE SITE OF SAN CLEMENTE AL VOMANO CHURCH (TERAMO- ABRUZZO) 148

RISK MANAGEMENT STRATEGY FOR CULTURAL HERITAGE 156

HISTORICAL PALACES, COMBINED ACTIONS FOR SAFETY EVALUATION AND SEISMIC RETROFITTING. THE ROSATI PALACE AS CASE STUDY FOR RECENTLY DEVELOPED DESIGN SOLUTIONS 161

“COLLAPSE OF PHYSICAL STRUCTURE OF ANCIENT EGYPTIAN ALABASTER”..... 167

INFLUENCE OF THE PETROPHYSICAL CHARACTERISTICS AND STATE OF CONSERVATION OF STONE SUPPORTS IN THE PENETRATION AND EFFICIENCY OF CONSOLIDATION TREATMENTS IN HISTORIC MONUMENTS 173

NONDESTRUCTIVE CHARACTERIZATION OF NANOPARTICLES AND THEIR APPLICATION IN HISTORICAL PAPER PRESERVATION 180

SALT WEATHERING ON STONE: A CHALLENGE TO THE CONSERVATION OF UNDERGROUND MINING HERITAGE ENHANCED FOR TOURIST EXPLOITATION 185

ANALYTICAL STUDY OF ARCHAEOLOGICAL POTTER SARCOPHAGUS FROM GRECO-ROMAN PERIOD, SAQQARA, EGYPT 195

ARCHAEOMETRIC INVESTIGATION ON GEOPOLYMERIC BINDERS OF ROMAN WATER WORKS IN VERONA (ITALY) (I CENTURY A.D.) ... 201

ANCIENT MARBLES FROM IASOS OF CARIA, MINERALOGICAL AND PETROGRAPHIC CHARACTERIZATION AND PROBLEMS OF CONSERVATION ... 210

NEW DIAGNOSTIC THOUGHT FOR THE QUANTITATIVE DEGRADATION DETECTED ON THE ANCIENT STONE MONUMENTS WHICH WERE RESTORED BY PORTLAND CEMENT ... 216

A MULTIDISCIPLINARY APPROACH TO STUDY THE “SKIN” OF BAROQUE BUILDINGS IN SALENTO (PUGLIA,ITALY) ... 221

CHARACTERISTICS OF MORTARS OF MOSAICS FROM A ROMAN VILLA IN ANTANDROS ANCIENT CITY, TURKEY ... 229

BIOMINERALIZATION CONSOLIDATION OF DEGRADED FRESCO WALL PAINTINGS BY BACILLUS SPHAERICUS BACTERIA ... 237

RESTORATION AND EXHIBITION OF WALL PAINTINGS OF THE EARLY CHRISTIAN BASILICA “THE RED CHURCH” ... 247

EVALUATION OF A ROOF CHANGE IN THE ARIADNE'S HOUSE (POMPEII, ITALY): MICROCLIMATIC MONITORING ... 253

OIL OVERPAINTINGS REMOVAL USING ATMOSPHERIC PRESSURE PLASMA ... 258

HIGH RESOLUTION LASER IMAGING REMOTELY COLLECTED FROM PAINTED SURFACES: INFORMATION FROM REFLECTANCE AND FLUORESCENCE DATA ... 264

ANALYTICAL STUDY OF TWO LACQUER OBJECTS FROM MUSEUM OF FACULTY OF APPLIED ARTS, HELWAN UNIVERSITY, GIZA - EGYPT ... 275

THE EFFECTIVENESS OF LIMONENE EMULSIONS TO REMOVE TERPENOID VARNISHES IN PAINTINGS. EVALUATION BY GAS CHROMATOGRAPHY MASS SPECTROMETRY ... 284

OIL WORKS ON PAPER: INVESTIGATING THE EFFECT OF OIL MEDIUM ON THE PAPER SUPPORTS OF WORKS OF ART VIA VOC EMISSION ANALYSIS ... 294

SEARCHING FOR A PROTECTIVE AGENT TO BE USED ON SURFACES OF ACRYLIC PAINTINGS 301

APPLICATION OF MULTISPECTRAL IMAGING TO THE RECOVERY OF THE ORIGINAL ILLUMINATION CONDITIONS OF ANCIENT PAINTINGS IN CLOSED ENVIRONMENT ‘THE LIGHT RESTORATION’ ... 310

APPLICATION OF HYPERSPECTRAL IMAGING FOR THE STUDY OF PIGMENTS IN PAINTINGS ... 317

DETERIORATION FACTORS INFLUENCING ARCHAEOLOGICAL GLASS WHICH USED FOR MEDICAL PURPOSES APPLIED ON A CASE STUDY FROM ISLAMIC ART MUSEUM- CAIRO-EGYPT ... 324

ANALYTICAL STUDY OF SOME UNPUBLISHED LANTERNS OF THE ISLAMIC ART MUSEUM IN CAIRO “HISTORICAL, ARCHAEOLOGICAL AND ARTISTIC STUDY” ... 330

SILICA THIN FILM SYNTHETIZED BY SOL-GEL PROCESS FOR THE PROTECTION OF OUTDOOR ARTISTIC CERAMIC IN ARCHITECTURE ... 340

AN OVERVIEW ON APULIAN RED FIGURED POTTERY: FROM MANUFACTURING PROCESSES TO PROVENANCE ISSUES ... 347

CHEMICAL-PHYSICAL AND MORPHO-MINERALOGICAL METHODOLOGIES AS TOOLS FOR A FRESH VIEWPOINT ON MEDIEVAL GRAFFITA POTTERY ... 353

MULTI-TECHNIQUE APPROACH FOR THE INVESTIGATION OF OPAQUE GLASS FROM POMPEII ... 359

SPETTROSCOPIC STUDIES ON ETRUSCAN ARCHAEOLOGICAL FINDINGS ... 367

A CONSULTING/PRESERVING MACHINE FOR MANUSCRIPTS: THE MALATESTIANA LIBRARY IN CESENA ... 374

LIF DIAGNOSTIC ON WOODEN ARTWORKS: MEASUREMENTS OF PAINTED WOOD CORNERS OF GRAN PODER CANOPY ... 382

TREATMENT AND RESTORATION OF ANTIQUE SWORD FROM OTTOMAN PERIOD (13^{TH} AH/19^{TH} AD CENTURY) AT THE NATIONAL MILITARY MUSEUM SALADIN CITADEL IN EGYPT ... 391

ARCHAEOMETRIC INVESTIGATION OF ROMAN RAMS AND HELMETS FROM LEVANZO ISLAND, SICILY - ITALY 397

USE OF LASERS FOR CLEANING OF PAPER DOCUMENTS AND COINS 403

NANOSTRUCTURED MATERIALS FOR PROTECTION AND CONSOLIDATION OF ANCIENT STRUCTURES 411

DURABILITY OF SELF-CLEANING TIO_2-BASED NANOCOATINGS ON HISTORICAL STONE SURFACES 418

CLEANING OF VARNISH ON 18TH CENTURY RUSSIAN ICON 'SAINT NICHOLAS' BY MEANS OF ATMOSPHERIC PRESSURE PLASMA 427

CHALK STONE CONSERVATION WITH HYDROXYAPATITE -A STUDY CASE- 436

SYNTHESIS AND CHARACTERIZATION OF A BIO-INSPIRED CALCIUM OXALATE-SILICA NANOCOMPOSITE FOR STONE CONSERVATION 442

USING NANOTECHNOLOGY FOR UPGRADING TRADITIONAL BINDING SYSTEMS 450

VOLUME III – SESSION D: MUSEUMS PROJECTS AND BENEFITS

TAKING ADVANTAGES OF AUGMENTED REALITY TECHNOLOGY IN MUSEUM VISITING EXPERIENCE 1

YOUTH AND CULTURE 10

PLANNING THE PRESERVATION TO ENCREASE THE VALUE. THE SOUT-WESTERN SUBURB OF ROME, RIVER TEVERE DELTA AND OSTIA AND PORTUS ARCHAEOLOGICAL PLACES 17

THE MUSEUM OF LONDON, A CITY MUSEUM AS NARRATIVE EXHIBITION 28

SOFTWARE FOR STORAGE, MANAGEMENT AND ANALYSIS OF PHYSICAL PARAMETERS: CULTURAL HERITAGE MONITORING 35

DEVELOPMENT OF VIRTUAL ENVIRONMENTS FOR THE MUSEUM COMMUNICATION 41

ONLINE CONTENT-BASED RETRIEVAL AND FRUITION WITH MULTIWORDNET: AN EXPERIMENTATION 50

AN ECOMUSEUM ICON OF THE MEDITERRANEAN IN THE ETNA VULCANO AREA 58

RELIGIOUS ITINERARIES IN SICILY: AN EURO-MEDITERRANEAN ROUTE INSPIRED BY THE CULT OF ST. AGATHA 66

ECO-MUSEUMS AND LANDSCAPE PLANNING IN ITALY 74

VOLUME III – SESSION E: CULTURAL HERITAGE IDENTITY

MULTIDISCIPLINARY INTEGRATED STUDY OF SAINT ILDEPHONSE'S COLLEGE, UNIVERSITY OF ALCALÁ (MADRID, SPAIN) 87

R&D FOR THE CULTURAL HERITAGE AS AN INNOVATION POLICY: THE INFORMATION SYSTEM ON THE SKILLS AND SCIENTIFIC RESULTS OF THE NATIONAL RESEARCH COUNCIL OF ITALY 95

ARCHITECTURAL ANALYSIS OF THE ANTEZANA HOSPITAL: A 15^{TH} CENTURY NOBLE HOUSE IN THE HISTORIC CITY OF ALCALÁ DE HENARES (MADRID, SPAIN) 104

INDUSTRIAL HERITAGE IN BASILICATA (SOUTHERN ITALY) 112

3D LASER-COLOURED SCANNING TECHNIQUE FOR AUTOMATIC FRESCOS DEFECTS DETECTION 119

PRESERVE AND VALUE. THE DIGITAL PLATFORM FOR THE ARCHAEOLOGICAL SITE OF OSTIA AND PORTUS 125

FROM HERITAGE BUILDING DIGITIZATION TO COMPUTERIZED EDUCATION 134

FROM "MONUMENT MEDICAL RECORDS" TO 3D GIS FOR HISTORIC ARCHITECTURE DOCUMENTATION 141

CLAN - CULTURAL LOCAL AREA NETWORK; A PROJECT FOR VALORIZATION AND CONSERVATION OF TERRITORY'S WIDESPREAD CULTURAL HERITAGE 150

HISTORICAL PLACE NAMES: FROM ARCHIVES TO LINKED OPEN DATA 158

ADVANCED INFORMATIC METHODOLOGIES APPLIED TO THE CULTURAL HERITAGE: 3D RECONSTRUCTION OF THE ST. ANGELO DI CIVITELLA DI NESCE COMPLEX (RIETI, ITALY) 166

DIASPORA AND SURROUNDINGS-METHODOLOGY FOR RESEARCH REGARDING ISSUES OF IDENTITY AND GLOBALIZATION 175

GIS-BASED ARCHAEOLOGICAL RECORDING IN LEBANON 187

EXTRACTING INFORMATION FROM MULTIMODAL IMAGES OF DOCUMENTS AND ARTWORKS... 196

THE ACTIVITY OF CEN TC 346-CONSERVATION OF CULTURAL HERITAGE 205

ASSESSMENT OF FUNERARY MONUMENTS STONE DECAY IN SAINT ANTHONY BASILICA IN PADOVA 212

'SIRACUSA 3D REBORN'. AN ANCIENT GREEK CITY BROUGHT BACK TO LIFE 220

THE DIGITAL STEREO-ORTHOIMAGE: A TECHNIQUE FOR OPTIMAL GEOMETRIC DOCUMENTATION OF COMPLEX ARCHAEOLOGICAL MONUMENTS 228

MENSALE: MENSE STORICHE ED ARTISTICHE LUCANE. BETWEEN ART AND ALIMENTATION ... 237

HISTORIC CELLARS OF BASILICATA, THE "CINTI" OF GRASSANO 248

RFID TECHNOLOGY FOR THE MANAGEMENT OF NATURAL HISTORY COLLECTIONS 259

BUILDING AN OPEN SOUND ARCHIVE: THE CASE OF THE GRA.FO PROJECT 264

RIO DE JANEIRO, ROME AND THE MEGA EVENTS: COMPARING MODELS OF URBAN DEVELOPMENT 270

THE SERCHIO VALLEY AS A NEW TOURIST DESTINATION IN TUSCANY. A CASE HISTORY 275

INTERDISCIPLINARY STUDY OF THE PRESERVATION STATE AND CONSERVATION PROCEDURES OF THE EARLY CHRISTIAN BASILICA IN THE SANCTUARY OF APOLLO ERETHIMIOS IN THEOLOGOS, RHODES 287

MEDIEVAL HISTORICAL LANDSCAPE AND ARCHITECTURE ALONG THE CULTURAL ROUTES IN THE NORTH-WEST OF ITALY 301

PROBLEM - BASED METHODOLOGY IN BUILT HERITAGE PROTECTION - A PARADIGM FOR BUILDING MATERIALS'DECAY DUE TO ACID RAIN 306

APPLICATION OF INTEGRATED DOCUMENTATION PROTOCOLS IN VILLA KLONARIDIS (HISTORIC BUILDING) 315

"HANDS-ON CULTURAL HERITAGE" EDUCATIONAL APPROACH INTERCONNECTING SECONDARY WITH TERTIARY LEVEL EDUCATION 326

NEW MEDIA AND CULTURAL HERITAGE 335

BEYOND THE FRINGE: A REFLECTION ON AGRO-FOREST SYSTEMS, LANDSCAPE AND SOCIETY IN MEDITERRANEAN PERI-URBAN AREAS 339

VOLUME III – SESSION F: CULTURAL ASSETS AS RESOURCES AND SUSTAINABLE DEVELOPMENT

ITALIAN CULTURAL HERITAGE: REFLECTIONS AND PERSPECTIVES OF THE UNESCO SITES WITHIN THE NATIONAL TOURISM SYSTEM 349

THE NEW MANAGEMENT APPROACH IN PROTECTION AND REACTIVATION OF CULTURAL AND NATURAL HERITAGE IN RESAVA–MLAVA REGION 360

THE SUSTAINABLE DEVELOPMENT OF A TRADITIONAL SETTLEMENT: THE CASE OF DRAKOPOULATA SETTLEMENT AS A MODEL OF CULTURAL, ECONOMICAL & TOURIST VIABLE UNIT 370

INTEGRATED MANAGEMENT OF CULTURAL HERITAGE AND ACTIVITIES IN THE MEDITERRANEAN COUNTRIES: AN INTEGRATED CULTURAL SYSTEM 377

BUILT HERITAGE IN GREEK INSULAR REGIONS: THE CASE OF CASTLES IN THE IONIAN ISLANDS 385

PRINCIPLES OF SPATIAL PLANNING FOR SUSTAINABLE DEVELOPMENT: CREATING AREAS OF OPEN-AIR MUSEUM IN MANI 393

PROPOSAL FOR A TYPOLOGICAL, TOPOGRAPHICAL AND MORPHOLOGICAL ATLAS OF QANAT 405

'MU.S.A. – MUST SEE ADVISOR' PROJECT: A CULTURAL HERITAGE BOOSTER........ 410

TELL TUQAN: GRAPHIC DESIGN, COMMUNICATION AND ENHANCEMENT 420

THE VICUS OF CALVATONE-BEDRIACUM: CULTURAL HERITAGE PROMOTION AND COMMUNICATION 425