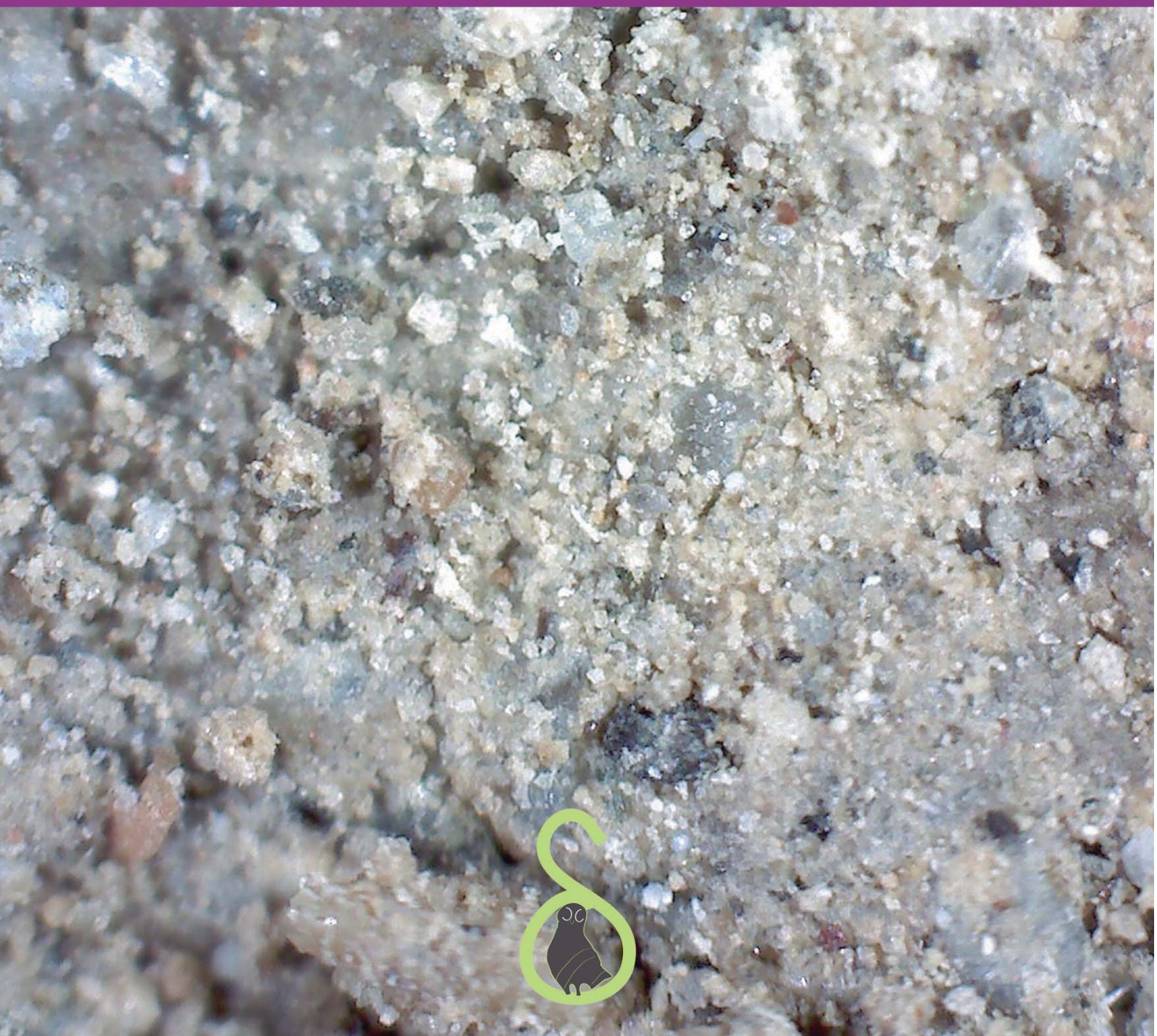
N5 2016 ISSN: 2241-0163

e - δialogos

5 | TAKING ACTION IN CONSERVATION

annual digital journal on research in conservation and cultural heritage



e-δialogos
Annual digital journal on research in
Conservation and Cultural Heritage

Edition: Diadrasis, *Interdisciplinary research on Archaeological & Architectural Conservation*

Vournazou 31
11521 Athens
Greece
ISSN: 2241-0163

Contact: dialogos@diadrasis.org
http://www.diadrasis.org/edialogos.html

Number 5: Taking action in conservation

INDEX

EDITORIAL

Lucía Gómez-Robles
Projects Director, DIADRASIS, SPAIN

e-dialogos is an annual publication, yet this new issue comes out with a five months delay. Other projects and changes in the structure of our NGO are the cause for this delay, and it finally circulates in May 2016. With this 5th issue of the journal we wish to say good bye to our previous editor-in-chief, Valerie Magar Meurs, who was with us for the last five years. But as every end is also a new beginning, we would like to welcome our next head of the editorial board, Nota Pantzou, a regular collaborator of DIADRASIS, who has also participated in several of our projects.

The project which kept us busy till the end of 2015 was Viaduct, a communication tool for scientific analysis in heritage. This research project, funded by the John S. Latsis Public Benefit Foundation, gave us the opportunity to create a handbook and a website on laboratory analysis for architectural restoration. The whole process which led to the publication and the final results are presented in the first article of this issue.

A great contribution has been made by Douglas Porter, from the University of Vermont in the USA and his collaborators, David Broxton, Angelyn Bass, Deborah A. Neher, Thomas R. Weicht, Patrick Longmire, Rebecca Domingue, Michael Spilde, by presenting an interesting research on the role of the biotic and abiotic crusts in the preservation of cultural heritage, specifically, in Long House Pueblo at Bandelier National Monument (USA). By analysing the surface of the tuffs the team discovered that the surfaces created over the tuffs are more erosion resistant than the underlying rock and, therefore, they protect the delicate prehistoric remains.

Moving from micro to macro preservation, AbdelHamid Salah El-Sharief describes the amazing story of the creation of "The Egyptian Heritage Rescue Team". This initiative was the outcome of the frustration, after experiencing the failure of the rescue in the archaeological storerooms at the Giza Plateau. Yet, instead of just complaining, AbdelHamid started a long path towards creating an organization, where members would be properly trained to implement high standard first-aid interventions for cultural heritage. At the moment, this is probably the most skilled group acting on a national level in heritage rescue worldwide.

Longer term actions for heritage protection are however conducted by the Cultural Heritage without Borders. Jonathan Eaton presents their efforts to stop the chain of neglect affecting an Albanian city, Gjirokastra. The organization is trying to recover some of the ruined buildings in the city, through restoration and the introduction of new activities which will keep the structures alive.

Activities for children to keep museums living through dissemination, is the proposal by Jovana Mijatovic from Serbia. She is presenting several dissemination

projects for the city of Belgrade, aiming at the improvement of children's knowledge about the history of the city and at raising awareness for the conservation of the cultural heritage.

Finally, and as a complement to dissemination topics, our journal closes with an article on a multi-layered information system for exhibitions, where traditional and non-technological devices are applied. The article presents two cases of temporary exhibitions, where different coding systems were used in order to organise the information and to help the visitor select the most suitable data according to his/her interest or available time.

Our "favourite" section is this time signed by Líneas Cruzadas, a Spanish cultural association focusing on Contemporary Art, which underlines the importance of public involvement in heritage preservation

This is certainly quite a varied issue but we trust all our readers will find topics of their interest. We hope they will enjoy reading as much as we enjoyed preparing it.

20 May 2016

Lucía Gómez-Robles

Editor

VIADUCT: CREATING BRIDGES FOR COMMUNICATION REGARDING SCIENTIFIC ANALYSIS

Laura-Melpomeni Tapini
Conservator of Antiquities and Historical Buildings, DIADRASIS Managing Director, GREECE
lmt@diadrasis.org

Lucía Gómez-Robles
Architect and Art Historian, DIADRASIS Projects' Director, SPAIN
luciagomezrobles@gmail.com

1. INTRODUCTION

Going back to DIADRASIS' last year's key activity one will see *"a long high bridge, usually with arches, that carries a road or a railroad across a river or a valley"*[1] or, simply, a VIADUCT! We designed a research project for scientific analysis in heritage and the name was selected symbolically, implying the need for a communication bridge between heritage professionals and scientists. "VIADUCT, a communication tool for scientific analysis in heritage" (Fig. 1), funded by the John S. Latsis Public Benefit Foundation Funding Programme, gave fruits in all four fields of DIADRASIS' actions of, namely research, non-formal education, awareness and publications.

The main aim of this research was the creation of comprehension tools for bridging communication gaps of different heritage professionals regarding 21 scientific analyses for the Built Heritage. For this specific purpose DIADRASIS created a research team involving an Archaeometrist: Dr. Sophie Blain, a Chemist: Ariadni Dimitrakopoulou, an Architect and Art Historian: Dr. Lucía Gómez-Robles and a Conservator of Antiquities: Laura-Melpomeni Tapini. The project was also based on the collaboration with the Coordinación Nacional de Conservación del Patrimonio Histórico (CNCPC) of the Instituto Nacional de Antropología e Historia (INAH), Mexico, the FRS-F.N.R.S. and Université de Liège (ULg), Belgium.

The communication tools initially proposed were a handbook and a website. However, in the course of the research, we realized the necessity of adding a summative poster, a two days seminar for heritage specialists and finally a workshop for the wider public.

2. THE METHODOLOGY

The main aim of this research was communication. Communication requires clarity and simplicity. For this reason we designed a step by step methodology, beginning with analyzing our own limits and challenges in communication and understanding, followed by designing practical communication tools of various formats.

Step 1: Map the needs of the different professionals

The first barrier related to the scientific analyses in question and which each research team member had to overcome was that of the proper professional conviction. It became evident already from the first discussions that each one of us was taking for granted terms and realities that were unknown to others. This helped us set the basis of the entire research, since we faced and mapped the main «dark areas» of communication. With a list of precise questions we proceeded with the second step, that of defining the context and structure of the communication tools.

[1] *Oxford dictionary definition of Viaduct.*

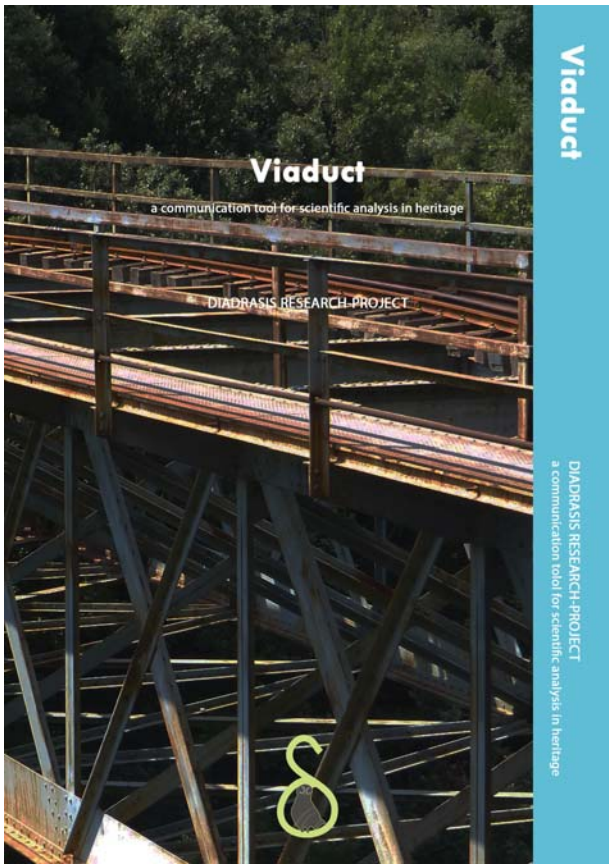


Fig. 1. Handbook cover. Image by DIADRASIS.

Step 2: Handbook context and structure

Scientific analyses in Heritage are a wide and evolving field. We therefore needed to delimit the research by defining parameters for inclusion in a method towards «Viaduct». The parameters were:

Applicabity to the Built Heritage

Dating and/or Characterization Techniques

Applicability on building materials, namely stone, CBM (Ceramic Building Materials), mortar, wood, metal (iron and lead) and the pigments

Most frequently used

As the main aim of VIADUCT was "tools for communication" we wished to make a handbook with a structure handy for the user. The core of the handbook are the 21 analyses, for which one chapter is dedicated to each. In addition, tables, diagrams, summative tables and diagrams lead the reader to search for answers according to the desired depth of information.

Tables & diagrams have been designed to help the reader with a panoramic view of the contents of this handbook so as to easily identify where one can find more detailed information:

Analyses' type diagram, summarizing all the methods according to the type of results provided by each analysis

Material-Question table (contingency table), summarizing all the methods applicable to each material, grouped by type of question (when, what, how, where from, why [why is it altered?])

Analysis summative table for each analysis, summarizing the main information: materials, accuracy, time, cost, sampling, advantages, limitations and some quick tips. The colour reference of the table is then repeated in the following pages, where each analysis is expounded indepentendly.

In the case of the text of the chapters the book presents 21 scientific analyses description. A detailed presentation of each analysis was prepared for its main points as to: how does it work, applicable materials, sampling process, suitable(or not) for in situ analysis, advantages, limitations, cost, duration, tips, brief example and references. For dating analysis, the in situ analysis description is missing, as it is not applicable; instead there are dated events and applicability periods.

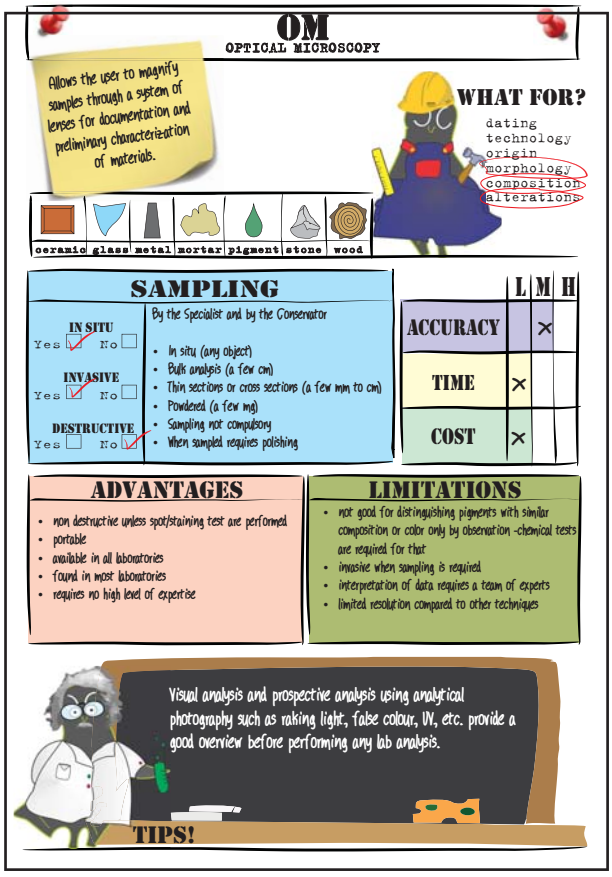


Fig.2. Example of summative table. Image by DIADRASIS.

In addition and for quick enquiries, some appendices are included at the end of the book: abbreviations, a visual glossary (with all the different results, i.e. spectra, images, graphics and a simple explanation-interpretation), a glossary (all terms marked with * in the texts), the periodic table and the electromagnetic spectrum.

Step 3: Definition of terminology

The last step in the structural organization of the research was the definition and clarification of the exact meaning of the termonology used for characterizing and categorizing each one of the analyses. These definitions are an addition to the general glossary and due to their importance they appear at the beginning of all the deliverables (introduction of the book, first box of the poster, first page of the website).

The terms analyzed and clarified are: in situ, invasive analysis, non-invasive analysis, destructive analysis, non-destructive analysis, accuracy, time and cost.

This step was of crucial importance as these eight terms have been the reference point for the researchers and will be the core reference for the user. Having clarified these terms we could move on to the bibliographic research for each analysis.

Step 4: Bibliographic research and chapters creation

The bibliographic research was made through the use of all available resources, bibliographic and web. Due to the international profile of the research team we had the possibility of consulting scientific articles from Grece, Italy, UK, France, Belgium, Germany, et. al.

The chapters were written by the specialists of the team, 17 on characterization methods by Ariadni Dimitrakopoulou and 4 on dating by Dr. Sophie Blain. They were then peer-reviewed by more than 20 international colleagues (see acknowledgments). Following the peer review, all chapters have been elaborated to ensure that the texts would be comprehesible also for non-experts. The latter, the final edition as well as the drafting of the introduction and the conclusions were made by the other two members of the research team, Dr. Lucía Gómez -Robles and Laura-Melpomeni Tapini.

This handbook being only a brief presentation of the methods, it was deemed necessary to add something more for those interested in more specific data. Therefore, a reference list with both bibliographic and web resources is provided at the end of every analysis in the hard copy and at the end of each chapter as well as in the website.

Step 5: Summative tables and diagrams design

Alongside with writing and editing of the texts we worked on designing and finalizing the structure and content of the tables and the diagrams.

The summative tables (Fig. 2) were designed as a brief identity card for each analysis, containing the basic information of the extended texts. Each card is divided into three levels:

General information containing one phrase description of each method, check box on applicable materials and a check box on the type of results.

Practical information containing checkboxes on sampling (in situ, invasive, destructive) together with a short text on practicalities of sampling and metrics on time, cost and accuracy (high- medium- low).

Finally overall considerations namely bullet points of advantages and limitations and of main characteristics and tips.

The colour reference of the summative table is then repeated in the following pages, where each analysis is explained.

On the other hand the idea of the diagrams is to help the reader formulate a clear question and make the first selection of applicable methods. There are two initial diagrams:

The Analyses' type diagram, in black and white, dividing the methods in a tree according to the type of results in different levels.

The contingency table, combining material with the core question. For easier reference the column of each material has the color of the material's icon. For non-applicable methods the box is left white, with a red x.

Another tool of the book is the image glossary which is designed as a columns table, following the order of the analysis type diagram and chapters. Each column provides brief information on:

Analysis (type and method).

Fig. 3. Screenshot of the website. "Find your analysis by material & questions". Image by DIADRASIS.

Result, with an example in image or diagram of the results of each analysis.

Interpretation, a one sentence explanation of the type of data that can be read in the result.

Step 6: Web design

The actual format of the web dissemination was modified from the original proposals, after consultation with the web developer. After careful analysis of the created material, the users and their requirements, the web developer suggested that the initial idea of a wiki based site be expanded with an extension for smart phones. He proposed that we rather focus on a high standard website for the data base, designed from the beginning as a responsive site for all mobile devices, as required by contemporary search engines.

The website includes all the basic data of the analysis grouped as follows:

The project section includes a description of the project, brief information on other deliverables, instructions about how to use the site, quick access button towards analyses search and glossary, terminology used, a presentation of the team members and the partner institutions.

The finding an analysis sections allows searching by name, by material/question (Fig. 3) and alphabetically.

The analysis cards are the 21 types of analysis including its name, what is it for, applicable materials, a brief description, metrics, sampling type, tips from the expert, advantages/Limitations, how does it work and references.

The glossary section contains the terminology and the image glossary.

Finally the bibliography section includes the bibliographic resources and the web resources.

The contact page offer basic information about DIADRASIS.

Overall, the website follows the structure of the book but the order and the size of information have been adapted to be more user friendly.

Step 7: Dissemination strategy

In conclusion, more importance was given to the dissemination methodology. The real success of the project will be the wide use of the deliverables, the poster, the book and the website around the world.

Until now DIADRASIS has organsed three public activities, a two days seminar called "Viaduct: do we make the best out of our analysis?" for 20 heritage and laboratory experts, an open event, for the presentation of the book and the website to the wider scientific community and a public awarness workshop called "Inspector Clouseau and the abandoned building".

The "Viaduct seminar: do we make the best out of our analysis?" was a two-days seminar, dealing with how characterization and dating analysis can be successfully integrated into any conservation project of the Built Heritage. The main aim of this seminar was to help scholars of different disciplines understand in practice the importance of the effective use of scientific analysis, the necessity of integrating it with all context analyses and finally the crucial role of interdisciplinary dialogue, which makes the best out of each analysis. The seminar was developed with brief lectures but mainly with team exercises, round tables and discussions. It was organized by DIADRASIS in collaboration with CNCPC-INAH of Mexico and the Directorate of Conservation of Ancient & Modern Monuments of the Hellenic Ministry of Culture and Sports. Twenty participants from Greece, Germany, Bulgaria and Egypt attended the seminar.

The Workshop "Inspector Clouseau and the abandoned building" was an interactive workshop, based on the context of learning while playing, for the 1st Mediterranean science festival, held in 6/12/2015 in Limassol, Cyprus. It was desidned as a tool for introducing to the wider audience the nature of the conservators' and the conservation scientists' work and for raising awareness on the complexity of threats which affect the maintenance of the built heritage.

3. LIMITS/CHALLENGES

The viaduct on the front cover is not just an image symbolizing connection or the effort to bring together all those struggling for the survival of our patrimony, our cultural heritage. It is mainly the bridge which brought us from the past, from that exciting summer seminar in the Pelion Mountains, to the future, to the interdisciplinarity where we may all speak a common language. Nevertheless the research team faced some challenges in conducting this research, mainly due to the nature of the team itself.

Researchers in different countries

The internationality of the team, which had several advantages, like the aforementioned access to

Fig. 4. Seminar participants taking samples from mosaics replica. Image by DIADRASIS.

Fig. 5. Seminar participants analysing the historical information of the case study. Image by DIADRASIS.

Multilanguage bibliographic resources, at times creates some practical issues. The team had the possibility of meeting three times and the rest of the communication was conducted online. In the internal evaluation of the project we all agreed that at least one more physical meeting in the early stages of the research would have facilitated the execution of the project.

Language barriers

The language selected for the entire project was English. Nevertheless, as none of the four team members were native speakers of the language, we often had to rely on external consultation for the selection of the proper terminology. The clarification of the terminology was one of the working steps that required much more time than we predicted when planning the project.

Overload

All those involved in the research were getting more and more excited while developing these communication tools. Expectations grew and we all wished to add that extra 'little more' on the project, like the poster, the seminar and the workshop. In this spirit we discussed the prospect of translating the website in Spanish, as reported in the interim report. However, in a second review, we realized that that was not feasible within our time and budget limits. Yet although we withdrew this ambitious plan, we are still looking forward to a funding that will give us the opportunity to translate both the website and the book at a later time.

4. CONCLUSIONS

Science reflects continuous evolution. Therefore, as we are dealing with scientific analysis, it is expected that what is innovative today can easily be substituted in a near future. The methods presented in the book and the website are the ones more commonly used at the moment, yet some are already evolving. New scientific discoveries are continuously offering novel tools to Archaeometry and, although the distant future might reserve extremely innovative options, current research focuses on improving already existing scientific methods. These improvements are mainly related to portability, non-invasive analysis and direct dating.

VIADUCT aimed at building bridges between laboratory scientists and heritage professionals, in order to provide the latter with basic knowledge on the potentials of dating and characterization methods applied on building materials. DIADRASIS research team hopes that this work will facilitate the work of professionals of heritage conservation, and it holds high expectations that this is a viaduct between the builders of the past and the actors of the future.

5. ACKNOWLEDGMENTS

We are deeply grateful to the John S. Latsis Public Benefit Foundation for believing in our project and trusting a team of young researchers. Thanks to their generous support, VIADUCT grew from a vague idea into a true project with tangible results.

We are also very grateful to the international experts that embraced our project and contributed in multiple ways: general information and observations, reviews, suggestions and much more. Without them all, this handbook would not have been realized. So, special thanks go:

to Dr Edgar Casanova, nuclear chemist and researcher at the CODICE (Conservación, Diagnóstico y Caracterización Espectroscópica de Materiales) laboratory at the National Coordination of Conservation of Cultural Heritage in Mexico, who was of substantial help by sharing his experience for tips and practical information on characterization methods;

to Dr Helena Calvo Del Castillo, Council Administrator and teacher at the Belgian School of Gemmology, Delegate and Examination Committee of the Federation for European Education in Gemmology and postdoctoral researcher at the European Centre of Archaeometry at the University of Liège, for her review on the characterization methods;

to Dr Anne-Christine Da Silva, assistant professor at the University of Liège, for her comments on Optical microscopy;

to Dr Ziad El Morr, lecturer at the University of Beirut, Lebanon, for his review of the SEM method;

to Alessandra Fiasco, Conservation scientist, for her support in the illustration.

to Dr Gwenaël Hervé, postdoctoral researcher at the Department of Earth and Environmental Sciences (Geophysics) at the University of Munich, for his review on the archaeomagnetism method;

to Dr Maxime L'Héritier, lecturer at the University of Paris 8, to Dr Stéphane Büttner, researcher at the Centre d'Etudes Médiévales d'Auxerre, France, to Guido Buonfiglio, Master student at the Università degli Studi di Catania, Italy, to Nadia Cantin, Engineer at the Centre of Archaeometry at the University of Bordeaux, France and to Dr Gaspard Pagès, researcher at the French National Centre for Scientific Research, ArScAn - Archéologies et Sciences de l'Antiquité (UMR7041) for their bibliographical advices;

to Maria Mertzani, Head of the Directorate of Conservation of Ancient & Modern Monuments of the Hellenic Ministry of Culture and Sports, to Dr Polytimi Loukopoulou & Dr Christina Margariti of the department of applied research of the Directorate, for warmly supporting this project by participating in the relative seminar;

to Tasos Protopapas, for being an extraordinary collaborator in designing a very practical but also beautiful website, coping with all the last minute ideas that kept pouring from our heads;

to Nora Ariadna Pérez Castellanos, Master in Materials Science and Engineering and Head researcher of the CODICE (Conservación, Diagnóstico y Caracterización Espectroscópica de Materiales) laboratory at the National Coordination of Conservation of Cultural Heritage in Mexico for the pictures of results of characterization methods;

to Dr Isabel Villaseñor Alonso, Deputy Director of Research at the National Coordination of Conservation of Cultural Heritage in Mexico, for tips and practical information on characterization methods;

... and last but not least to Eftychia Tapini, for her patient multiple editing of all texts and tables.

Fig. 1. Thin section of canyon-wall tuff. Image by the authors.

THE ROLE OF BIOFILMS AND LICHENS IN THE PRESERVATION OF ARCHAEOLOGICAL FEATURES IN THE BANDELIER TUFF, BANDELIER NATIONAL MONUMENT

Douglas Porter
School of Engineering, University of Vermont, USA
Douglas.Porter@uvm.edu
David Broxton
Computational Earth Science, Los Alamos National Laboratory, USA
Angelyn Bass
Department of Anthropology, University of New Mexico, USA
Deborah A. Neher
Department of Plant and Soil Science, University of Vermont, USA
Thomas R. Weicht
Department of Plant and Soil Science, University of Vermont, USA
Patrick Longmire
Department of Energy Oversight Bureau, New Mexico Environment Department, USA
Rebecca Domingue
1200 Architectural Engineers, USA
Michael Spilde
Institute of Meteoritics, Earth and Planetary Sciences, University of New Mexico, USA

Case hardened surfaces that develop over tuff outcrops in Frijoles Canyon (Bandelier National Monument, New Mexico, USA) are a combination of biotic and abiotic crusts that contribute to the preservation of ancient anthropogenic features carved in the cliffs. This study shows that in the initial stages of crust development, lichens and other surface biota cement wind-blown and water-transported particles to the rock face and reinforce and stabilize the accumulated clay / silt coatings. Abiotic crusts form on canyon walls by the partial dissolution of the tuff in the near-surface zone, followed by precipitation of secondary minerals that form a durable cement. We conclude that acid excretions from cyanobacteria and lichens colonizing the surface act to catalyze tuff dissolution. The resulting case hardened surfaces are more erosion resistant than the underlying rock, and protect the fragile prehistoric rock-cut dwellings (cavates), features, and petroglyphs left by the ancient Pueblo people. In conducting the study, researchers have considered whether lichen/biofilm cover may improve bulk mechanical properties of the tuff that outweigh biodeteriorative effects and provide some degree of protection to the material below. These are the initial results of an ongoing project. We hope that better understanding of case hardening / crust formation will lead to the development of low-impact interventions that promote, or at least do not inhibit, natural colonization of the partially hardened surface by lichens and other biota.

Keywords:
tuff – biofilm – lichens – archaeological site – crust – preservation

1. INTRODUCTION

The deeply dissected Pajarito Plateau, located on the eastern flank of the Jemez Mountains of northern New Mexico, is characterized by numerous fingerlike mesas and deep sheer-walled canyons formed from erosion of two thick ignimbrite sheets deposited by separate eruptions approximately 1.6 and 1.2 million years ago (Fig. 2). Ancestral Pueblo people and others have used the plateau for thousands of years, with peaks in population occurring from the 12th to the mid-16th century. Among the most extraordinary of the archaeological sites are the rock-cut caves called cavates (derived from the words "cave" and "excavate"), which were used as dwelling, storage, and special-purpose rooms. They are the ancestral dwellings of the Native American Pueblos that still live in the region (Fig. 3).

The cavates were carved directly into the soft rhyolitic tuff, along a weakly cemented zone where the two ash flows meet. There are a few thousand of these dwellings on the Plateau in an area of about 620 square kilometers. Many of these have intact earthen wall plasters and floors, some with polychrome and incised decoration, as well as numerous built-in features to produce and store food and to weave fabric (Fig. 4). The landscape surrounding the cavates is full of architectural and agricultural artifacts, including multi-story masonry community houses, foot trails worn in

Fig. 2. Frijoles Canyon in Bandelier National Monument, where there are over 1000 cavates in a 2 km-long section of the canyon. The mountains in the background give the general location of the Toledo and Valles calderas that spewed ash forming the Bandelier Tuff approximately 1.6 and 1.2 million years ago. Over 300,000 people a year visit this canyon to explore the cavates.

the tuff, water collection and transport systems, stone shrines, and painted incised symbols (also known as petroglyphs) on the cliff faces and plastered walls. Bandelier National Monument is located in Frijoles Canyon, one of the longest and deepest canyons on the plateau, and has been a National Monument since 1916.

One challenge of conserving the cavates is how to preserve their physical integrity despite constant landscape-level change and erosion of the cliffs (Fig. 5). Deterioration processes affecting cavate condition include mass wasting of the cliff face through losses of fracture-bound boulders, mechanical damage of outcrop surfaces, the interaction of the tuff with wind and water, and the presence (or not) of a weather rind or case hardened surface on the tuff outcrops. Case hardening appears to protect the glassy ash of the Qbt1g unit (the cooling unit in which most of the cavates are carved) from erosion and loss, at least partially as the result of secondary minerals deposited in near-surface pore spaces. Weather rind formation begins with the deposition of dissolved solutes and suspended particulates on rock surfaces by surface water flowing over canyon walls, followed by the colonization of the rock surface by surface-stabilizing

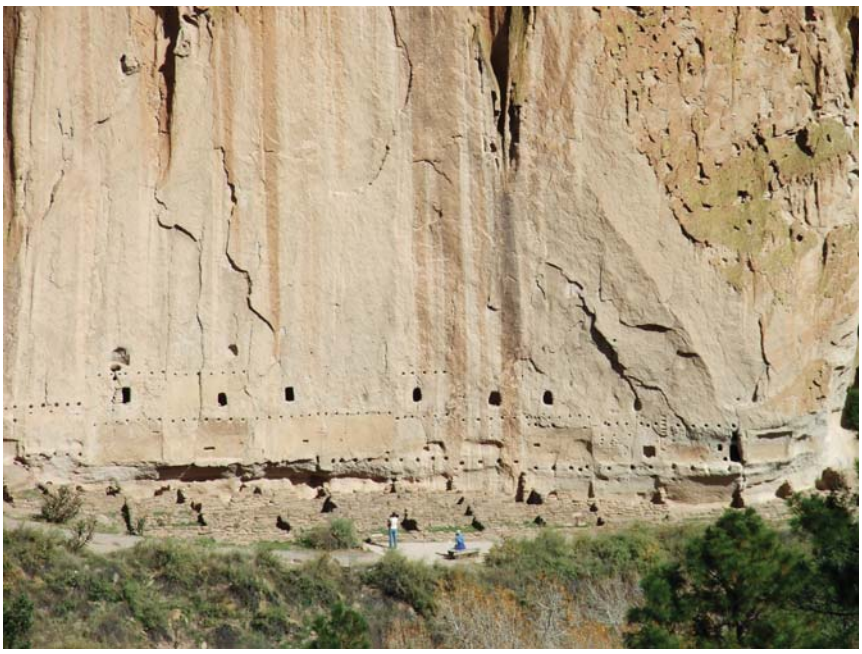


Fig. 3. Long House Pueblo at Bandelier National Monument. From the visitor trail one can see cavates carved into the poorly consolidated Qbt1g subunit of the Bandelier Tuff, along with viga sockets that supported wood roof members in the masonry rooms that formed the front of the pueblo. These rooms are in ruins (photo foreground), and earthen plasters that finished the room interiors is visible on the outcrop surface (below the viga sockets). Note the case-hardened surfaces, especially on the upper right; this research is focused on the processes of their formation. Photo credit: Western Mapping Co.

Fig. 4. Inside the cavates are numerous built-in features to produce and store food and to weave fabric. This is the only place where the domestic details of the lives of the prehistoric Pueblo people are still visible. Cavate interiors are often sooted and plastered with up to 30 layers earthen plaster, some of them decorated with painted and incised designs.

biota that include cyanobacteria and lichens. The growth of lichens and other biotic crust constituents on exposed surfaces is especially important for promoting development of case hardening by catalyzing bio-geochemical reactions that lead to dissolution of the volcanic glass and precipitation of secondary minerals in the near-surface zone.

Biodeteriorative effects of lichens and other biota on rock surfaces, and particularly on rock art and monuments of rock or stone, are well documented (e.g., COOKS & FOURIE, 1990; STRETCH & VILES, 2002; SOUZA-EGIPSY et al., 2004; GORDON & DORN, 2005). As a consequence, design responses from the heritage community are typically focused on removal (CANEVA et al., 2008; SCHEERER et al., 2009). Lichens and biofilm constituents absorb water and produce weak acids that increase the solubility of rock surfaces and result in modifications of the mineral substrata. Lichen hyphae and rhizines exploit naturally occurring fractures in the rock, lichen thalli expand and contract with changes in temperature and humidity, causing exfoliation of the substrate surface in the process, and produce organic salts that are also expansive.

Fig. 5. Cavate B002 with its surviving masonry wall (bottom center). Note the broad range of case hardened surfaces of the surrounding tuff, and the "swiss-cheese" texture that develops where the durable case hardened surface is breached, exposing the soft underlying tuffs to erosion. The extensively altered surfaces (upper half) are types 6 and 7 (see Table 1); on the far right a more recently exposed surface, slightly recessed and having a smoother texture, has developed another rind. Areas of recent erosion appear as white or grey patches (Type 1); erosion at the lower right edge of the cavate threatens to undermine the prehistoric wall. Some of the freshly exposed tuff has begun to acquire silt-clay coatings (Type 2) that constitute one of the initial stages of case hardening. At bottom left, moderately well indurated surfaces have silt-clay layers colonized by lichens and other microflora (which appear yellow, green and black in the photo). Note the partially detached boulder above the wall, the column of cantilevered stones at the east end of the surviving wall, and the erosion of the tuff just below this column.

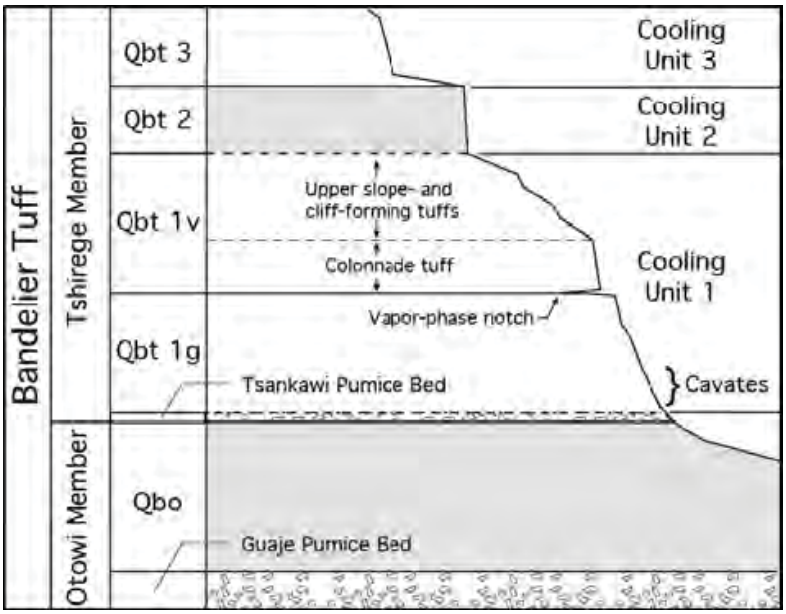


Fig. 6. Schematic stratigraphic column for the Bandelier Tuff showing subunits of the Tshirege Member in the ruins area of Frijoles Canyon.

Damage associated with these processes, which include depletion of structural cations, fragmentation and dissolution of small grains, surface staining, disintegration, and exfoliation was once thought to occur very slowly, but recent research indicates that some rocks and building stones are significantly impacted in a decade or less.

However, under some circumstances lichens may provide a level of weather protection to relatively porous and unconsolidated rock substrata. This appears to be particularly true of the Bandelier Tuff, where lichen cover actually seems to improve the weather resistance of the tuff and provide some degree of protection to archaeological resources carved in the rock. In this case the lichen cover seems to function more like a biological soil crust, forming a barrier layer shielding rock surfaces from water flow, wind abrasion, and temperature variation, resulting in reduced weathering rates.

2. TUFF STRATIGRAPHY AND CHARACTERIZATION

The Bandelier Tuff consists of two regional rhyolitic ignimbrite sheets, the Otowi and Tshirege Members. These tuffs were erupted 1.61 and 1.22 Ma ago, respectively, from the Valles caldera complex in the central part of the Jemez Mountains volcanic field (SMITH & BAILEY, 1966; SMITH et al., 1970; IZETT & OBRADOVICH, 1994; SPELL et al., 1996). The Otowi Member consists of poorly indurated non-welded tuffs that form talus-covered slopes at the base of Frijoles Canyon. The Tshirege Member is a multiple-flow ignimbrite that forms the prominent canyon walls in Frijoles Canyon. The Tshirege Member has a complex welding profile that results in dramatic cliffs separated by narrow benches, and is subdivided into mappable cooling units that reflect the complex emplacement and cooling history of the tuff (SMITH, 1960a and 1960b, SMITH & BAILEY, 1966; CROWE et al., 1978, BROXTON & RENEAU, 1995). In the study area, three cooling units are recognized based on welding compaction and crystallization zones (Fig. 6). The zonal patterns of welding and crystallization produce vertical variations in density, porosity, hardness, and color that are reflected in the canyon wall profile, particularly on arid south- and southwest-facing canyon walls that receive daily sun exposure year-round.

The Tshirege Member is approximately 134 m thick near the park's visitor center. Approximately 95% of the Pueblo archaeological fabric occurs in the non-welded vitric tuffs that make up the lower 21 m of the Tshirege Member. These tuffs are shown as unit Qbt 1g in Fig. 5. Although tuffs of unit Qbt 1g are generally soft, they commonly form near-vertical cliffs because they are capped by strongly indurated welded tuffs higher on the canyon walls. Unaltered tuffs near the base of unit Qbt 1g are white but gradually become light pinkish-orange and slightly more indurated up section. Qbt 1g tuffs consist of pumice lapilli >2 mm in size in a poorly sorted matrix of ash, crystals, and rock fragments (BROXTON & RENEAU, 1995).

The mineralogy of unit Qbt 1g is dominated by 60- to 70 wt. % volcanic glass that occurs as pumices,

Fig. 7. Edge of an erosional remnant of a Type 7 case hardened surface showing a more recently exposed adjacent surface (left) that is less altered.

Fig. 8. Case hardened surfaces in unit Qbt 1g of the Tshirege Member of the Bandlier Tuff. 'Swiss-cheese' texture is characteristic where holes develop in the durable case hardened surface, exposing the soft underlying tuffs to preferential erosion by wind and water.

shards, and ash[1] (BROXTON et al., 1995). The absence of significant secondary minerals in the glass, such as clays and zeolites, strongly suggests that these tuffs have had limited contact with groundwater since their deposition. Crystalline components of the tuff are primarily sanidine and quartz phenocrysts; subordinate clinopyroxene, hornblende, and fayalite phenocrysts; and trace magnetite, zircon, and chevkinite microphenocrysts. Crystalline lithic clasts of reddish-brown-to-black porphyritic dacite and crystal-poor devitrified welded tuff are generally sparse (<1%). Unaltered tuffs in unit Qbt 1g have an average matrix porosity of 46% and an average dry bulk density of 1.26 gm/cm3 (ROGERS & GALLAHER, 1995). Porosity in these tuffs includes intergrannular pore spaces between particles and vesicles in pumice clasts. Pumice vesicles include highly inflated equant varieties and bundles of stretched tubes.

Many Qbt 1 canyon wall exposures are covered by pale-orange case hardened surfaces that are 0.25 to 1.3 cm thick. These surfaces are resistant to erosion and form a protective layer over the underlying softer tuffs (Fig. 7). Some of the anthropogenic features, like petroglyphs and hand-and-toe-hold trails carved into the outcrops 500-1000 years ago, have case hardened surfaces. The case hardened surfaces commonly have a distinctive "swiss cheese" appearance where round to elliptical cavernous hollows penetrate the hard surface layer, exposing underlying softer tuffs to selective erosion by wind and water (Fig. 8; cf. Fig. 5). The degree of case hardening varies from location to location, resulting in differential weathering patterns on cliff faces. For this study, a scale was developed to describe the progressive development of case hardening on cliff faces (Table 1). The scale includes seven categories of case hardened surfaces with Type 1 representing the least altered surfaces (fresh tuff)

[1] *This paper differentiates between fine (0.001-0.01 mm) and coarse volcanic ash (0.01-2 mm) because of the different behaviors associated with these particle sizes during alteration. We call coarse ash particles shards. Shards are large enough to contain vesicles and preserve delicate cuspate forms that are the junctions of two or more vesicles.*

Type 1		• Freshly exposed, apparently unaltered tuff • White to light gray in color • Rough texture with prominent pumices • Little to no sedimentation of silt-clay or calcite visible on surface • Easily abraded with light pressure • Fine glassy ash in the tuff matrix is abundant and unaltered • Matrix porosity is high (40-50%) • Secondary minerals are absent to rare
Type 2		• Sedimented silt-clay coating over freshly exposed tuff • Coating is very thin, resembling a wash, and is often in runnels down the tuff surface • Filamentous cyanobacteria frequently found to have colonized this surface coating • Fine glassy ash in the tuff matrix is abundant and unaltered • Matrix porosity is high (40-50%) • Secondary minerals are absent to rare
Type 3		• Black biofilm layer overlaying exposed tuff • Silt-clay coating / lichen cover are less prominent surface features • Moderately indurated and resistant to erosion • Alteration is sporadic and generally limited to a zone 0.1 to 0.5 cm thick • Porosity remains high where the tuff is little altered, but in heavily mineralized areas is reduced to 20 to 30%
Type 4		• Lichens and other biogrowth appear over a prominent silt-clay coating • Crustose lichens are more plentiful than in other surface types • Moderately indurated and resistant to erosion • Alteration is sporadic and generally limited to a zone 0.1 to 0.5 cm thick • Porosity remains high where the tuff is little altered, but in heavily mineralized areas is reduced to 20 to 30%
Type 5		• Generous lichen distribution, often accompanying a thick silt-clay coating • Comparatively smooth texture, lacking the large surface asperities that are typical of Types 6 and 7 • Moderately indurated and resistant to erosion • Alteration is sporadic and generally limited to a zone 0.1 to 0.5 cm thick • Porosity remains high where the tuff is little altered, but in heavily mineralized areas is reduced to 20 to 30%

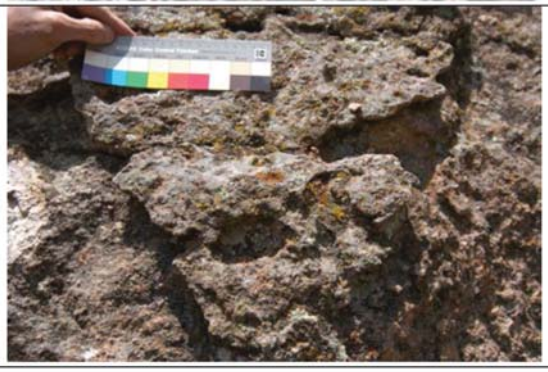
Type 6		• Well developed lichen growth • Surface is rough, with asperities in the range of 1-3cm • Abrupt changes in surface level at losses, with crust thickness of up to 4 cm • Strongly indurated, with crusts that are generally 1 to 1.3 cm thick • Case hardened zone is commonly made up of two parallel bands of alteration • Porosity for the inner alteration band commonly <5%
Type 7		• Well developed lichen growth, with greater biocommunity diversity • Severely eroded, with surface asperities in the range of 1-6cm • Examples have prominent edges with crust thickness of up to 6 cm • Strongly indurated, with crusts that are generally 1 to 1.3 cm thick • Case hardened zone is commonly made up of two parallel bands of alteration • Porosity for the inner alteration band commonly <5%

Table 1. Tuff surface types.

and Type 7 representing the most altered surfaces. Classification of case hardened surfaces is based on observations about the thicknesses and hardness of altered surfaces, color, surface roughness, and the abundance and diversity of surface biota (mostly lichens). Samples for this study were selected to represent the various stages of development of these surfaces.

Canyon walls are continually modified by cliff retreat processes such as rock falls and large-block failures. These gravity-driven processes, which play a major role in canyon widening over time, occur when the lithostatic forces acting on a portion of the canyon wall overcome the tensile strength of the tuff, causing it to collapse outward into the unconfined space of the canyon. High-angle fractures in the tuff often act as failure planes, particularly in the tuff units that overlie unit Qbt 1g. These tuff units are strongly welded and contain a dense network of cooling fractures along with some tectonic fractures. Unit Qbt 1g has fewer fractures because it was emplaced at lower temperatures and did not develop cooling fractures. Despite having relatively few fractures, there are locations where Qbt 1g rock falls or large block failures were controlled by high-angle fractures (RENEAU, 2000).

Fig. 9. The case hardened tuff surface (left) includes a silt-clay layer colonized by lichens. Note the similarities in surface topography and patina to the biological soil crust on the right.

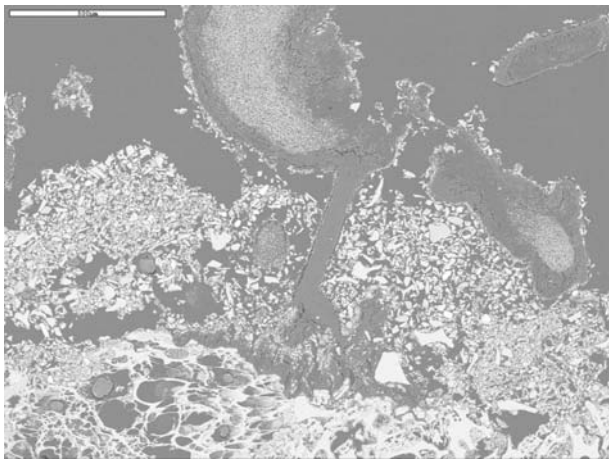


Fig. 10. SEM backscatter image showing a lichen thallus on sedimented volcanic ash adhering to the canyon wall. The lichen is the dark mass at the top. The sedimented layer (middle zone) is over 500 µm thick and includes shards, ash, and crystal fragments embedded in a clay matrix. Lichen rhizines / hyphae (microfilaments) pervade the sedimented layer and help stabilize it. The canyon wall bedrock is the area with the large pumice at the bottom.

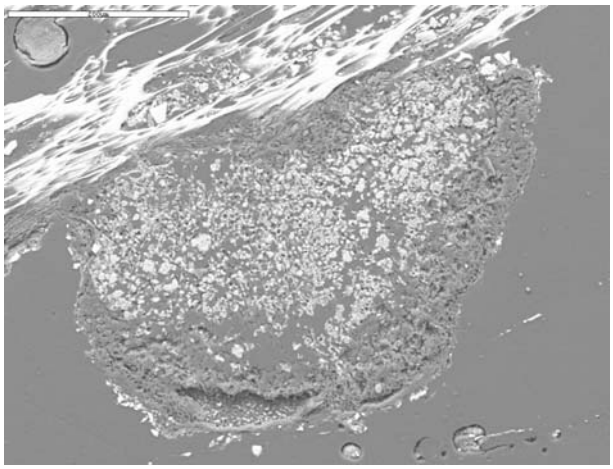


Fig. 11. SEM backscatter image showing a lichen thallus growing directly on tuff on the canyon wall. The lichen is the dark mass with the cellular structure. Light gray crystals of weddellite (calcium oxalate) fill the thallus. Microfilaments invade the long-tube pumice vesicles of the bedrock tuff at the top of the photograph.

In addition to cliff retreat processes, canyon walls are modified by water and wind erosion. Runoff from mesa tops periodically cascades down canyon walls, particularly during monsoonal rainstorms that are common during the summer months. Sheet flow of surface water over exposed cliff faces dislodges and transports loose particles. Drainages on mesa tops often funnel runoff to particular areas of the canyon wall, eroding deeply recessed slots and alcoves that contain pour-offs. Discharge of large volumes of sediment-laden water in these canyon wall drainages greatly accelerates erosion at these locations. During cold-weather months, near-surface tuffs and fractures periodically become saturated locally due to imbibition of snowmelt and runoff; these tuffs are susceptible to mechanical disaggregation by freeze/thaw cycles. Wind erosion also plays a role in modifying canyon walls, forming erosional features on cliff surfaces. Wind-driven particulates sandblast tuff surfaces and contribute to their mechanical disintegration by dislodging and removing the fine ash. Non-welded vitric tuffs are particularly susceptible to erosion because of their low degree of consolidation. Where the case hardened surface is breached, air currents excavate cavernous hollows in the underlying soft tuffs.

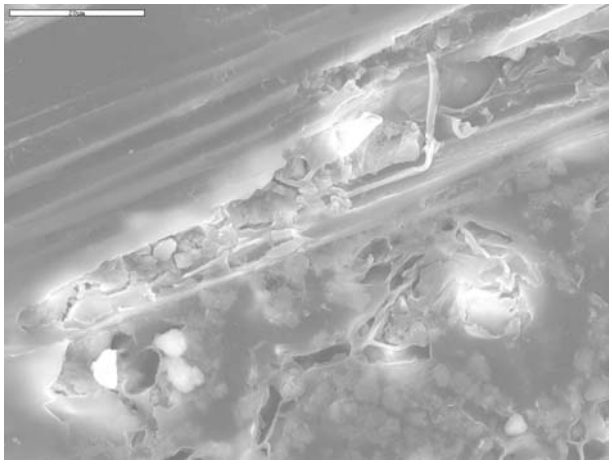


Fig. 12. SEM secondary electron image showing dissolution of pumice vesicle walls in contact with lichen hyphae. The tubular pumice (extending from lower left to upper right) has scalloped edges. Lichen (lower right) is in contact with the pumice and hyphal filaments invade the large open vesicle (upper right).

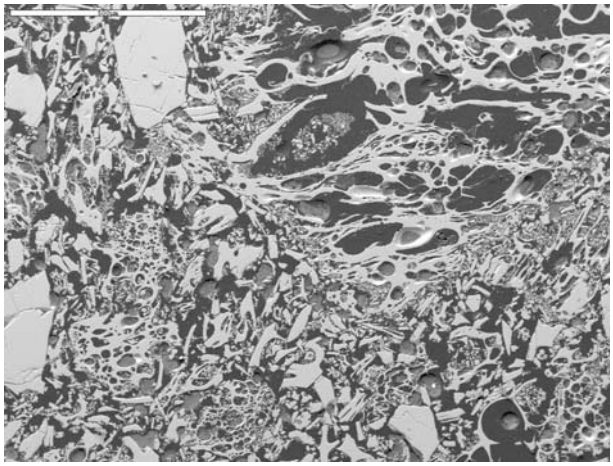


Fig. 13. SEM backscatter image of canyon wall tuff bedrock with Type 1 to 2 alteration. The tuff has undergone minimal alteration and lacks cementation by secondary minerals. The tuff contains abundant vitric ash in the groundmass, and delicate shard and pumice lapilli structures are well preserved. The porosity of the tuff is 40 to 50%.

3. COATINGS AND RINDS

Modification of canyon wall surfaces and development of a hard surface coating or rind (case hardening) involves three main components. 1) deposition of sedimented particulates on exposed tuff surfaces; 2) growth of lichens and microflora on (and in) exposed tuff surfaces and on the sedimented layers that coat them; and 3) bio-geochemical reactions that lead to the dissolution of volcanic glass and precipitation of secondary minerals (Fig. 9).

Thin discontinuous coatings of sedimented particles occur on tuff bedrock surfaces in all seven types of surfaces described in Table 1. Sediment, soil, and tuff particles from mesa tops and canyon walls are mobilized by surface runoff during storm events; as surface-water flow diminishes, a thin coating of clay and silt is deposited on canyon walls. The sedimented layers (0.05 to 0.5 mm thick) are primarily made up of silt-sized (5-50 µm) pyroclasts of glass shards and pumice fragments, subordinate fragments of sanidine and quartz crystals, and traces of oxides such as magnetite and ilmenite. These constituents are common components of Bandelier Tuff and were derived from local sources. Most silt and clay layers show little sorting or layering, though stratified layers in a few samples indicate multiple episodes of deposition. The pyroclasts and crystals are embedded in a matrix of clay-sized particles that cement and stabilize these deposits. SEM EDS analyses indicate the clay minerals are likely smectite and lesser amounts of illite. In some of the more highly altered samples, opal ± clay is the cementing agent for these deposits, with opal cement occasionally concentrated at the interface between the clay-silt layer and the tuff bedrock. Except where cemented by opal, the thin layers of silt and clay adhering to the tuff are too thin, discontinuous, and poorly cemented to significantly impede erosion processes. However, these layers provide a suitable substrate for microflora to colonize canyon walls[2].

Lichens are found on most tuff surfaces[3] and their abundance and diversity appear to increase along with the degree of case hardening. SEM images show that lichens grow on top of the sedimented layers (Fig. 10) as well as on bare bedrock surfaces (Fig. 11). In the Qbt 1g subunit, lichens and other biotic crust constituents help stabilize canyon walls by acting as a protective buffer between the tuffs and wind and surface water erosion and they trap wind-blown and water-transported silt particles within their overlapping lobes. Secretions of sticky polysaccharides enhance cementation of the friable materials found at the substrate surface[4]. Lichen rhizines form a dense network of filaments that invade, reinforce, and stabilize the sedimented layers and the open intergranular pores and pumice vesicles of the bedrock tuff (Fig. 12); in the samples examined for this study, microfungal filaments were found to extend up to 1 mm into the tuff bedrock. Oxalic acid excreted by biotic constituents plays a role in the dissolution of volcanic glass. The role of lichens as a source of oxalic acid is demonstrated by dense accumulations of 1 to 3 µm oxalate crystals in lichen thalli. These crystals are identified as weddellite ($CaC_2O_4 \cdot 2H_2O$) based on their tabular form and SEM EDS analyses. Glass dissolution at the thallus-substrate interface is manifested as scalloped and embayed edges on glass shards and pumice lapilli (Fig. 13).

The growth of lichens and other biocommunity constituents on outcrop surfaces seems especially important for promoting development of case hardening by catalyzing biogeochemical reactions that lead to dissolution of the volcanic glass and precipitation of secondary minerals (BROXTON et al 2014). Microbial activity often results in the acidification of the surrounding habitat (NASH, 2008); for example, accumulation and excretion of tricarboxylic acid pathway metabolites is widespread in fungi (GOLDBERG et al., 2006). These byproducts, particularly oxalic and citric acids, are linked to the dissolution of inorganic substrates necessary for fungal growth (DUTTON & EVANS, 1996; SAND, 1996; CHEN et al., 2000; GADD, 2004, 2007; GUGGIARI et al., 2011). Further, the most reactive of these acids, oxalic acid, has been associated positively with carbon accumulation (JACOBS et al., 2002 and 2004; GIBSON & MITCHELL, 2004; MARTIN et al., 2012) and likely plays an important role in the dissolution of volcanic glass and precipitation of secondary minerals. Primary chemical processes by which lichens solubilize minerals are: 1) generation of respiratory CO_2; 2) the excretion

[2] *In collecting samples of the sedimented clay-silt deposits, researchers have recovered large filamentous cyanobacteria from the coatings.*

[3] *Lichens identified by investigators include* Aspicilia *sp.,* Lecanora *sp.,* Acarospora chlorophana, Staurothele *sp.* Pleopsidium chlorophana, Candellariella rosulans, *and* Toninnia *sp. The development of biotic crusts on anthropogenic features like hand- and toe-holds and petroglyphs indicates that fairly well developed crusts can appear within a few hundred years of exposure.*

[4] *Polysaccharides secreted by soil crust constituents are successful in trapping aeolian material, creating a thin layer of silt and clay on the crust surface that is a nearly ubiquitous feature of the crusts (DANIN & GANOR, 1991; DAVEY & CLARKE, 1992; VERRECCHIA et al., 1995).*

of oxalic acid; and 3) the production of biochemical compounds with complexing ability (CHEN et al., 2000; PINNA, 2014). Secondary processes include citric acid as a chelator and phenolic compounds which act as antimicrobials for self-defense.

Progressive alteration of the glassy components of the tuffs at the canyon wall interface leads to case hardened surfaces that are more durable and less porous over time. The seven surface types described in Table 1 represent a continuum of alteration, and there is considerable overlap between each of the identified types. The least altered canyon surfaces (e.g. Types 1 and 2) are associated with recent rock falls and other fresh exposures of tuff; these are interpreted as the youngest canyon wall surfaces. The most highly-altered surfaces (e.g. Types 6 and 7) are erosional remnants of surfaces that once covered larger areas; these surfaces stand in bas-relief 1 to 6 cm higher than adjacent wall surfaces that are significantly less altered. These characteristics suggest Type 6 and 7 surfaces are the oldest and most stable parts of the canyon wall. Removal of Type 6 and 7 surfaces by rock falls and other mechanisms exposes fresh tuff that begins the process of case hardening anew. The walls of Frijoles Canyon undergo continual modification by erosion and cliff retreat, but these processes do not occur uniformly at all locations. As a result, present-day canyon walls are a mosaic of surfaces that represent various exposure periods and stages of weathering.

Canyon walls with Type 1 and 2 surfaces (Table 1) are the least altered and least durable. Pyroclasts in these tuffs show little or no evidence for glass dissolution and secondary minerals cementing the soft tuff matrix are rare to absent (Fig. 13). In one sample, small amounts of intergrown opal ($SiO_2 \bullet nH_2O$) and smectite group minerals ($(Na,Ca)_{0.33}(Al,Mg)_2(Si_4O_{10})(OH)_2 \bullet 4H_2O$) are deposited in pores near the outer wall surface, but most of the sample is free of alteration. Important characteristics of Type 1 and 2 surfaces are: 1) fine glassy ash in the tuff matrix is abundant and unaltered; 2) the matrix porosity is high (40-50%); 3) secondary minerals are absent to rare; and 4) exposed tuff surfaces are soft and friable because of the lack of cementation.

Canyon walls with Type 3 through 5 surfaces (Table 1) are moderately indurated and resistant to erosion. Lichens and other biota are abundant on these surfaces and their root systems extend up to 1 mm into the tuff. Dissolution of volcanic glass and deposition of secondary minerals generally occurs in a zone 0.1 to 0.5 cm thick adjacent to the canyon wall. Beyond this zone, secondary minerals are absent and the tuffs show little evidence of alteration. Thin sections examined by optical microscope and SEM show that alteration of the tuff is not uniformly distributed throughout the case hardened zone, and there is significant heterogeneity in the distribution of secondary minerals. This results in enclaves of tuff with few or no secondary minerals interspersed with areas that are thoroughly mineralized. Alteration is largely concentrated in the fine ashy matrix of the tuff where glassy pyroclasts in contact with pore water underwent hydrolysis. Pore water in this near surface environment is recharged by infiltrated surface water, and near-saturation

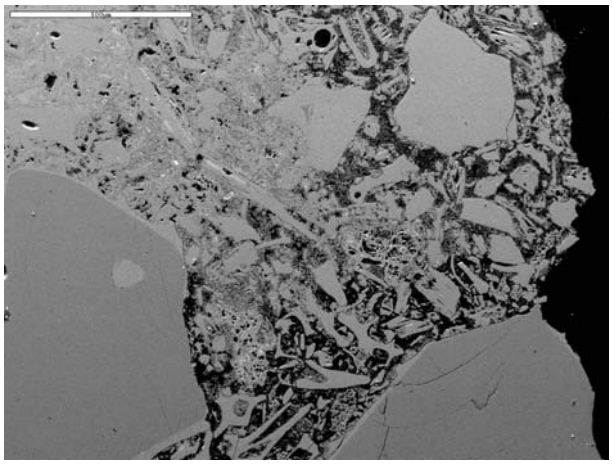


Fig. 14. SEM backscatter image of case hardened tuff with Type 3 to 5 alteration. At the sample surface (right), the larger glass shards are moderately scalloped and unfilled pore spaces still account for 30-40% of the sample volume. Moving left, there is more dissolution and replacement of the original material and pore space is reduced to < 20%. Opal is the dominant filling material; other filling materials include sepiolite and intergrown calcite and opal (4-4). At the far left, open pore space is less than 5% at a depth of approx. 1.30mm.

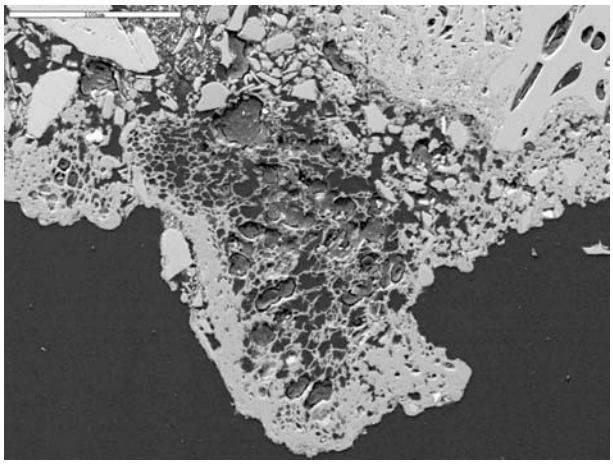


Fig. 15. SEM backscatter image showing pseudomorph of a lichen replaced by opal in a case-hardened surface; delicate cellular structure of lichen is preserved by the mineralization. The lichen is attached to tuff bedrock where most of the fine ash in the matrix is replaced by intergrown opal and clay. Small bright white areas are trace barite.

Fig. 16. Canyon-wall tuff with Type 7 alteration. The image is a thin section butt 2.5 cm wide cut perpendicular to the canyon wall. The canyon wall is on the right side of the image. The case hardened zone is made up of two parallel bands of alteration. The outer alteration band, next to the canyon wall, is mostly white in color. The inner alteration band ranges is medium to dark brown in color. Both bands are extensively altered, but the inner band is more highly mineralized. The tuff left of the inner band of alteration is slightly altered and contains abundant volcanic glass. Porosity is 20 to 30% in the outer band, 1 to 15% in the inner band, and 30 to 40% in the slightly altered tuff.

conditions occurred in some pore spaces for at least short periods of time. Organic acids released by the lichens are almost certainly an important catalyst for hydrolysis reactions by reducing the pH of pore water. Following dissolution, secondary minerals were deposited in open pores, cementing the tuff matrix. Secondary minerals are largely concentrated in the fine-grain groundmass of the tuff and largely replaced fine ash particles (Fig. 14). Larger pyroclasts such as shards and pumice lapilli remain abundant in the alteration zone, but many show moderate to severe dissolution along their margins. Except for oxidation halos around magnetite, crystalline components of the tuff such as phenocrysts and lithic fragments show no apparent alteration. Optical petrography and analyses by microprobe and SEM EDS identify the primary secondary minerals as opal ($SiO_2 \cdot nH_2O$) and sepiolite ($Mg_4(Si_6O_{15})(OH)_2 \cdot 6H_2O$). Calcite ($CaCO_3$) and smectite-group minerals are subordinate secondary minerals and barite ($BaSO_4$) is relatively rare. Texturally, the secondary minerals are intergrown and were apparently co-precipitated. Opal not only

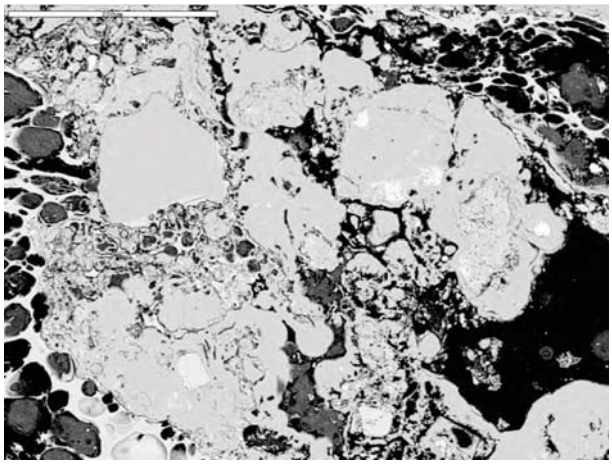


Fig. 17. SEM backscatter image for the outer band of alteration in Type 7 case hardened tuff. Volcanic ash in the tuff matrix is replaced by thick, massive bands of opal (medium gray) and finely intergrown opal and clays (mottled appearance). Some larger glassy pyroclasts (vesicular pumice and 100-μm-wide equant clast in the upper left quadrant) survived alteration, but show moderate to severe effects of dissolution at their margins. There are thin rinds of opal pseudomorphs replacing pumice vesicles in the center left part of the image.

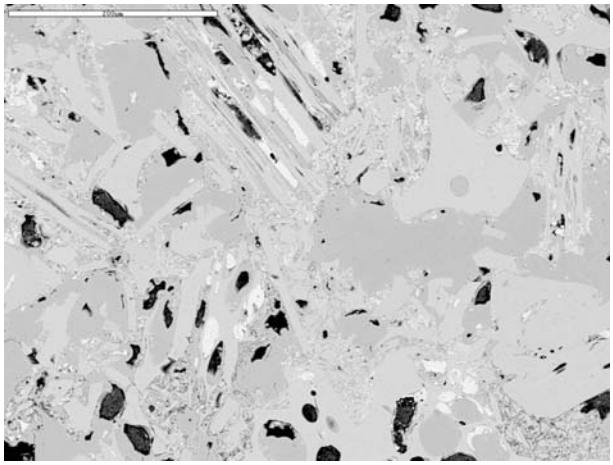


Fig. 18. SEM backscatter image for the inner band of alteration in Type 7 case hardened tuff. Large glassy shards (light gray) show few delicate cuspate structures due to dissolution. The shards are thoroughly cemented by massive opal (medium gray), calcite (white), and sepiolite (small mottled dark gray areas). All of the fine matrix ash and most of the original pore space have been replaced by mineralization. The few remaining pores are shown in black. Image analysis of this image yields the following proportions: 49.2% glass shards, 43% opal, 4.3% calcite, trace sepiolite, and 3.5% porosity.

co-precipitated with other secondary minerals, it also formed thick, optically continuous deposits in pores as a late stage mineral. Botryoidal and rhythmically layered opal lining open vugs suggest that mineralization occurred under saturated conditions. In some samples, lichen thalli adhering to the tuff surface are silicified to opal, preserving delicate structures as pseudomorphs (Fig. 15). Similarly, lichen rhizines / rhyzoids that penetrate the tuff are sometimes replaced by opal, preserving their delicate structures. The porosity of Type 3 through 5 surfaces decreases as the abundance of secondary mineral cements increases. Porosity remains high where the tuff is little altered, but in heavily mineralized areas the porosity is reduced to 20 to 30%.

Canyon walls with Type 6 and 7 surfaces (Table 1 and Fig. 6) are strongly indurated and form the most erosion-resistant cliff faces in unit Qbt 1g. These surfaces are extremely rough and support extensive biocommunities. Case hardened surfaces form crusts that are generally 1 to 1.3 cm thick, but pockets of alteration extend as much as 2.5 cm from the canyon wall. The case hardened zone is commonly made up of two parallel bands of alteration (Fig. 15). The outer alteration band, next to the canyon wall, is 3.5-6.7 mm thick and is mostly white in color. The inner alteration band ranges 5 to 8.5 mm thick and is medium to dark brown in color. The transition between the two zones is abrupt, occurring over a distance of 0.1 mm or less. The outer band is extensively altered, and is characterized by replacement of the ashy tuff matrix by opal that envelops glass shards and pumice lapilli (Fig. 17). The edges of shards and pumice lapilli show moderate to severe dissolution effects. Some of the opal shows rhythmic growth layering. Subordinate to trace amounts of aluminum-rich clay minerals and calcite are intergrown with opal. These secondary minerals form a durable cement that fills a significant amount of the available pore space. Porosity estimates for the outer band of alteration ranges from 20 to 30%. The inner band of alteration is more strongly mineralized than the outer band. Secondary minerals in the inner band of alteration consist of massive opal with intergrown calcite ± sepiolite. Locally, sepiolite and calcite are the dominant secondary minerals. All of the fine ash in the tuff matrix is replaced by massive deposits of secondary minerals that envelop the surviving glass shards and pumice lapilli (Fig. 18). Many of the surviving shards and pumice lapilli are extensively modified by dissolution, but some delicate cuspate shards are surprisingly well preserved. Porosity for the inner alteration band was estimated by image analysis of SEM backscatter images, and ranges from 1 to 15% and was commonly <5%. The transition from the inner alteration band to deeper tuffs (i.e. more than about 1.3 cm from the canyon wall) is marked by a gradual decline in mineralization. As the alteration diminishes, glassy ash in the tuff matrix becomes more prevalent. Porosities in these slightly altered tuffs range from 30 to 40%.

4. WATER ABSORPTION, EROSION RESISTANCE, AND ENZYMATIC ACTIVITY

To characterize the effects of case hardening on the weather resistance of tuff surfaces, a series of tests for

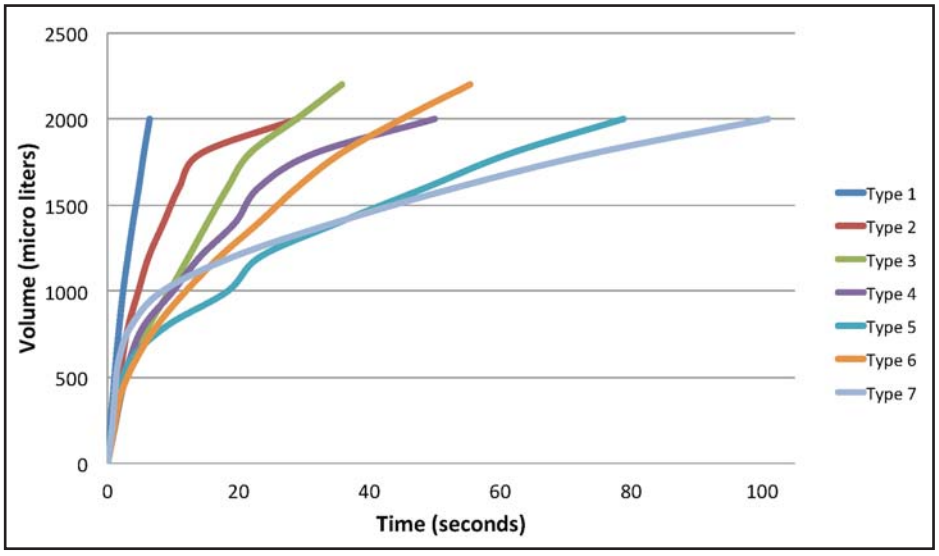


Table 2. Absorption values for each surface type are plotted against time. For Type 1 surfaces the average rate is essentially linear, while for Types 2-7 rates slowed significantly as the experiment progressed.

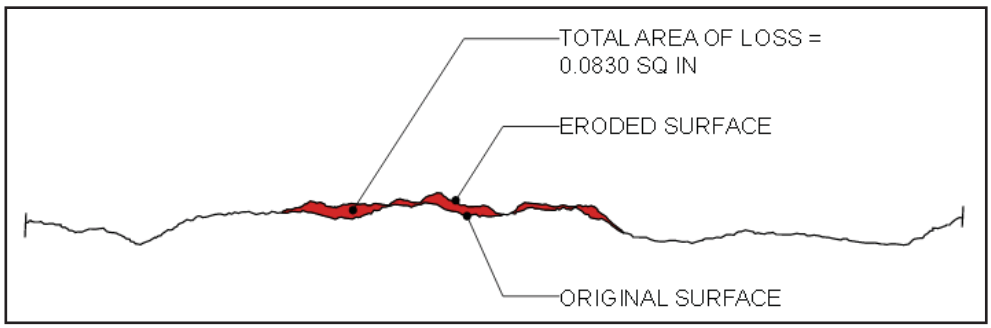


Fig. 19. Sample profile. Image by the authors.

in situ measurement of absorption, erosion resistance to wind and water erosion, and gas permeability were developed and carried out in a pilot project (involving a limited number of samples) conducted in 2013. In addition, a series of enzyme assays, intended to correlate these properties to enzymatic activity, were conducted in the laboratory. As has been noted, alteration of the tuff in the near-surface zone is discontinuous, especially for case hardened surfaces that are less well developed, so measurements display a broad range of values.

To test the hypothesis that pore filling minerals and mucilaginous cyanobacteria in crusts that develop on the rock surface reduce the water uptake of the porous rock, investigators collected measurements using a prototype device developed by the Institute for Theoretical and Applied Mechanics (Czech Republic) that quantifies the volume of water absorbed by the rock in situ through time. Among the advantages associated with the device is that water is applied only to the surface (this is important because case hardening is a surface / near surface phenomenon), and the instrument is graduated specifically for imbibition rates typical of porous rocks[5]. In trial runs of this test, absorption rates of recently exposed tuff surfaces were greater than for samples having more highly developed crusts. Rates for unaltered surfaces (Type 1) were essentially linear. For altered surfaces, absorption rates slowed as the experiment progressed; this suggests that the swelling of clays or mucilaginous films may play a role in reducing absorption for crusts in initial stages of development (Types 2-4), while for well-developed crusts with occluded pores, there appears to be initial filling of the available porosity followed by leveling off of the absorption rate (Table 2).

To evaluate comparative erosion resistance, investigators developed an in situ erosion test adapted from ASTM G76: Standard Test Method for Conducting Erosion Tests by Solid Particle Impingement Using Gas Jets. The method was adapted to the poorly consolidated tuff in terms of gas delivery pressures and blast media selected. The ASTM standard quantifies erosion in terms of mass loss, and measurements are made by weighing samples before and after each test run. Because tests at Bandelier were conducted in situ, the adapted test protocol includes a technique for collecting surface profiles before and after the test and calculating the areas between the profiles. Pilot test results indicate that sedimented silt / clay coatings

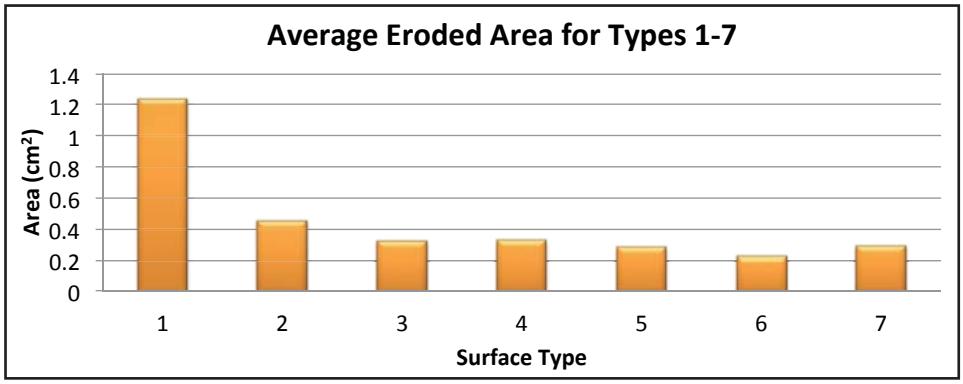


Table 3. Erosion was measured as the area between surface profiles collected before and after each test (Fig. 19), and average erosion areas were plotted for each surface type.

[5] *Sources of error include: 1) differences in surface temperature at each of the sample sites, perhaps resulting in significantly different rates of evaporation; and 2) there is currently no way to distinguish between the volume of water absorbed by surface biota and the volume absorbed by the rock. It is possible that a significant proportion of the water absorbed by surface biota is lost in transpiration.*

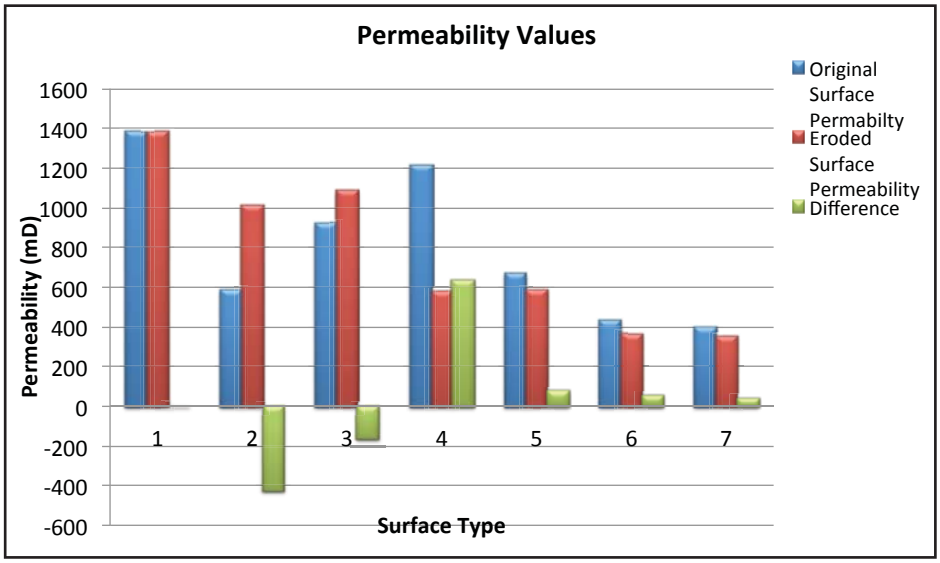


Table 4. Surface permeability values were collected for each sample with the sample surface intact. A second set of values was collected after eroding sample surfaces to remove sediments and biological material.

and the presence of even intermittent lichen cover enhance the erosion resistance of the tuff. There was frequently no measurable erosion of surfaces with highly developed case hardened crusts (Types 6 and 7) apart from the loss of surface sediments and biological material (Table 3). Since tests were run once at each test site, results document changes in surface profile regardless of the type of material (tuff vs. sedimented coatings/surface biota) lost. Running additional tests at each test site would tend to highlight the role of sedimented surface materials in the erosion resistance of the surface. For crusts in initial stages of development, it is expected that the rate of erosion would increase abruptly following the loss of the surface material; for well-developed crusts, erosion resistance is largely a function of hard secondary minerals precipitated in the near-surface zone, and it is expected that losses would tend toward 0 once sedimented and biotic surface crusts were removed.

In situ measurement of surface gas permeability is likely to be a useful measure of resistance to weather. It is expected that permeability decreases with increases in surface strength, and decreases proportionally with absorption rate. In pilot tests, surface gas permeability measurements were made using a handheld permeameter, the Tinyperm II, made by NER.[6] Measured permeability values for unaltered surfaces (Type 1) were greater than for surfaces with crusts, though the correlation to absorption and erosion resistance data is not very direct. Obtaining good coupling to the rock was not always possible, due to the fragility of some of the surface coatings, and testing of these fragile surfaces is likely to require adaptation of a dual-durometer coupler. For surfaces in the initial stages of crust development (Types 2 & 3), reductions in permeability are apparently largely a function of the materials accumulated on the surface (sedimented silt/ clay, biotic crusts), and permeability values for these samples were similar to Type 1 values once the surface coatings were removed. With more highly altered surfaces (Types 5-7), reductions in permeability seem more closely related to reductions in porosity in the near-surface zone, and removal of sediments / biological material from the surfaces of these samples had little impact on the measured values. The performance of surface Type 4 seemed clearly to mark a transition between the two groups, where removal of surface coatings resulted in a substantial reduction in surface permeability (Table 4).

A series of enzyme assays conducted in the laboratory correlate microbial activity to crust development. Activity of photosynthetic microbes, measured as chlorophyll content extracted by acetone, increased progressively with type, reaching an asymptote by tuff surface Type 6 or 7. Chlorophyll may represent activity by cyanobacteria as independent entities or as symbionts of lichens or actinobacteria. In contrast, saprophytic activity was greatest for intermediate Types 4 and 5. General saprophytic activity was measured as a maximum rate of β-glucosidase and general biological activity as phosphatase activity across a gradient of substrate concentrations.

[6] *Tinyperm II is a hand-held version of the Autoscan II, a surface gas permeameter that allows for spatially integrated measurements of gas permeability on specimen surfaces; the range of measurements is 0.01 to 10 darcys, and spatial coordinates on an x/y grid can be as small as 0.1mm (NER 2010).*

Collectively, these data support the hypothesis that there is a succession in microbial community on these surfaces. The greatest diversity of activity occurs at an intermediate stage that corresponds with a porous habitat and a balance between autotrophs and saprotrophs. Autotrophs colonize recently exposed rock surfaces. Exudation of oxalic acid dissolves glass in the near-surface zone, creating pore space for saprophytes. As autotrophs die, they are decomposed by saprophytes. However, eventually opal and other precipitated minerals occlude available pore space, reducing habitat for saprophytes and resulting in reduced microbial activity.

5. CONCLUSIONS

In the literature, lichens and other biota on culturally significant surfaces are typically discussed in terms of their biodeteriorative effects. Lichens, algae, and associated microflora excrete inorganic and organic acids that are effective chelating agents, and play a primary role in the biocorrosion of rock substrata (JONES & Wilson 1985; ADAMO et al., 1993; CHEN et al., 2000; ST. CLAIR & SEAWARD, 2004). Insoluble metal oxalate compounds, formed from cations released from substrate minerals and oxalic acid excreted by lichen mycobiants, frequently accompany colonization of rock surfaces and their occurrence is routinely interpreted as a measure of the biodeteriorative potential of a particular biocommunity (SEAWARD, 2004). The close relationship between substrate composition and the oxalate minerals that accumulate in lichen thalli is well documented (PURVIS et al. 1985; PURVIS 1996; WILSON et al. 1981). In addition, the dissolution of respiratory CO_2 contained in water held by lichen thalli can lower the pH at the substrate-thallus interface, accelerating the chemical weathering of the rock (SEAWARD et al., 1989; WIERZCHOS & ASCASO, 1996; JACKSON & KELLER, 1970).

For the Bandelier Tuff, however, improvements in bulk mechanical properties of the surfaces provide significant resistance to the erosional processes that threaten the archaeological resources of Frijoles Canyon. Even the presence of poorly indurated silt / clay coatings and intermittent lichen cover enhance erosion resistance and reduce absorption rates. Surface improvements occur as the result of two different processes: 1) colonization of outcrop surfaces by cyanobacteria, lichens and other biota cement wind-blown and water-transported particles to the rock face through secretion of sticky polysaccharides. The formation of dense networks of filaments infiltrate, reinforce, and stabilize the accumulated clay / silt coatings, and shield the loose ash in the bedrock tuff from wind- and water-driven actions that accelerate erosion, and; 2) excretion of organic acids by biotic crust constituents catalyze biogeochemical reactions that lead to dissolution of fine volcanic glass and cementation of the tuff surface by precipitation of secondary minerals in the network of interconnected pores. Both processes result in occlusion of pores at the surface, initially by the accumulation of clay / silt coatings and the presence of mucilaginous cyanobacteria in the surface crust, and eventually by the precipitation of secondary minerals (principally opal, calcite, and clay) in the near-surface pore space of the tuff. As crusts develop, imbibition rates at the surface gradually decrease, limiting the potential for additional hydrolytic reactions. At the same time resistance to erosion increases, initially due to the protective buffer provided by sedimented coatings and the surface biota that colonize them, but eventually as the result of deposition of secondary minerals that are much harder than the poorly consolidated glass.

The impacts of biological activity on the rock surface are paradoxical in the sense that both deteriorative and protective effects are produced. However, the protective effects appear to outweigh the biodeteriorative effects in terms of surface durability[7]. Where the crusts are damaged, erosion occurs at accelerated rates, resulting in losses of many cubic centimeters over the course of a few decades (based on comparative analysis of images produced in the early years of archaeological documentation of the canyon with more recent images of the same features / sites). The most well developed crusts, by comparison, are thousands of years old. Furthermore, the hydrolytic processes catalyzed by biotic crust constituents are self-limiting in a sense. Microbial populations initially thrive as they derive essential nutrients from the dissolution reactions they catalyze in the volcanic ash, but biological activity eventually declines as precipitation of secondary minerals

[7] *Other researchers report similar benefits conferred by lichen / microbe cover on other types of rocks (Mottershead and Lucas, 2000; Viles and Pentecost, 1994; Arino et al., 1995). Algal layers on sandstone formations in Western Australia are thought to perform a consolidating function, for example. Cryptoendolithic lichen growths have been identified as weathering rinds on some sandstones. With relatively soluble rocks, like Spanish gypsum, lichen cover results in reduced rates of erosion and a distinct surface morphology resulting from the development patterns of the lichen cover.*

decreases porosity in the near-surface zone and limits access to new sources of nutrients. Initial experiments suggest that microbial demand for organic and inorganic sources of $PO4^{-3}$ gradually exceeds supply as succession progresses. This is correlated positively with the concentration of chlorophyll. A $PO4^{-3}$ deficit develops in older surfaces with well-developed crusts where the pore space has been occluded by secondary minerals. As pore space and phosphorus become less available, colonization by additional cyanobacteria and lichens is limited.

In the initial stages of development, the crusts that form on vertical and subvertical outcrop surfaces of the Qbt1g function analogously to biological soil crusts on non-cohesive soils in arid and semi-arid climates. Soil crusts are almost universally effective in reducing surface erosion associated with wind and water. Well-developed crusts, with lichens and mosses, offer 2 to 130 times greater resistance to erosion than soils with less well developed crusts (BELNAP et al., 2001). With respect to water erosion, lichen cover prevents direct impact of raindrops on soil surfaces, and microfilamental reinforcement of the upper soil layers and the cementing action of extracellular polysaccharide compounds exuded by fungi, algae, and cyanobacteria help to contain soil particles at the surface (SCHULTEN, 1985; BELNAP & GARDNER, 1993; TISDALE & OADES, 1982). Additionally, rough surface microtopographies reduce the energy of runoff and the transport of sediment (BELNAP, 1995; BLACKBURN, 1975). By binding soil particles together, crusts effectively increase the threshold friction velocities of soils, making them more resistant to wind erosion (BELNAP & GILLETTE, 1997, 1998; LEYS & ELDRIDGE, 1998; BELNAP & GARDNER, 1993; ELDRIDGE & GREENE, 1994).

Like biological soil crusts, the biotic crusts that form on the Bandelier Tuff are easily disturbed; cyanobacterial and microfungal filaments become brittle when dry, and are easily crushed (BELNAP & LANGE 2001: 342). South-facing canyon walls (where the cavates are excavated) are pockmarked with damage sites resulting from loss of the crusts (as the result of falling debris, for example) and the effects of wind and water erosion on these unprotected surfaces. Many of these, because of their proximity to archaeological resources carved in the rock, result in the loss of cultural material. Soil crust recovery can, in some cases, be accelerated by inoculation (FAUST, 1970 & 1971; see also, LEWIN, 1977; TIEDEMANN et al., 1980; ASHLEY & RUSHFORTH, 1984; ST, CLAIR et al., 1986; BELNAP, 1993; BUTTARS et al., 1998), and it seems possible that minimal stabilization of eroding tuff surfaces may be promoted by the application of silt/clay washes to the bare tuff. Given the prevalence of surface biota on the rock face, inoculation may occur without additional intervention once the surface has been minimally stabilized in this way. Our hope is that better understanding of case hardening will at least provide a counterpoint to design responses from the heritage community that are primarily focused on lichen removal, and may lead to the development of such low-impact interventions for stabilization of rapidly eroding areas that currently threaten these resources. This research represents a departure from traditional studies that explore the biodeteriorative effects of biotic crusts on rock surfaces, and may provide a new model for understanding the interaction of microflora with poorly consolidated rocks. A better understanding of the complex interaction between biotic crusts and these landscape-scale monuments, including the role of biotic crusts in improving the competence of porous and unconsolidated rock, is likely to be useful in the preservation and management of other troglodytic and rock art sites.

Received: 1 July 2015
Published: 31 May 2016

REFERENCES

Adamo, P., A. Marchetiello, and P. Violante (1993) "The weathering of mafic rocks by lichens", Lichenologist, Volume 25, Number 3, pp. 285-297.

Arino, X., J. J. Ortega-Calvo, A. Gomez-Bolea, and C. Saiz-Jimenez (1995) "Lichen colonization of the Roman pavement at Baelo Claudia, Cadiz, Spain, Biodeterioration vs. bioprotection", Sci. Total Environ, Number 167, pp. 353-363.

Arino, X., A. Gomez-Bolea and C. Saiz-Jimenez (1997) "Lichens on ancient mortars", Int. Biodeterior. Biodegrad, Number 40, pp. 217-224.

Ascaso, A., J. Wierzchos and A. de los Rios (1995) "Cytological investigations of lithobiontic microorganisms in granitic rocks", Bot. Acta, Number 108, pp. 474-481.

Ashley, J. and S. R. Rushforth (1984) "Growth of soil algae on top soil and processed oil shale from the Uintah Basin, Utah, U.S.A.", Reclamation and Revegetation Research, Number 3, pp. 49-63.

Belnap, J. (1995) "Surface disturbances: their role in accelerating desertification", Environmental Monitoring and Assessment, Number 37, pp. 39-57.

Belnap, J. and J. S. Gardner (1993) "Soil microstructure in soils of the Colorado Plateau: the role of the cyanobacterium Microcoleus vaginatus", Great Basin Naturalist, Volume 53, Number 1, pp. 40-47.

Belnap, J. and D. A. Gillette (1997) "Disturbance of biological soil crusts: impacts on potential wind erodibility of sandy desert soils in southeastern Utah", Land Degradation and Development, Number 8, pp. 355-362.

Belnap, J. and D. A. Gillette, 1998. Vulnerability of desert biological soil crusts to wind erosion: the influences of crust development, soil texture, and disturbance. Journal of Arid Environments 39: 133-142.

Belnap, J. and O. L. Lange (eds.) (2001) Biological Soil Crusts: Structure, Function, and Management, Springer, New York.

Belnap, J., R. Rosentreter, S. Leonard, J.H. Kaltenecker, J. Williams and D. Eldridge (2001) Biological Soil Crusts: Ecology and Management, Technical Reference 1730-2; BLM/ID/ST-01/001+1730.

Blackburn, W. H. (1975) "Factors influencing infiltration rate and sediment production of semiarid rangelands in Nevada", Water Resources Research, Volume 11, Number 6, pp. 929-937.

Broxton, D., D. Porter, A. Bass and R. Domingue (2014) "Case Hardening and the Weather Resistance of Rhyolitic Tuff: Preservation of the Cavates and Petroglyphs of Bandelier National Monument", Proceedings, 9th International Masonry Conference 2014, Guimaraes, Portugal.

Broxton, D. E. and S. L. Reneau (1995) Stratigraphic Nomenclature of the Bandelier Tuff for the Environmental Restoration Project at Los Alamos National Laboratory (LA-13010-MS UC-903), Los Alamos National Laboratory, Los Alamos.

Buttars, S. M., L. L. St. Clair, et al. (1998) "Pelletized cyanobacterial soil amendments: laboratory testing for survival, escapability, and nitrogen fixation", Arid Soil Research and Rehabilitation, Number 12, pp. 165-178.

Campbell, S. E. (1979) "Soil stabilization by a prokaryotic desert crust: implications for Precambrian land biota", Origins of Life, Number 9, pp. 335-348.

Caneva, G. M. P. Nugari, and Ornella S. (2008) "Control of biodeterioration and bioremediation techniques", In: Plant Biology for Cultural Heritage: Biodeterioration and Conservation, Getty Conservation Institute, Los Angeles, pp. 309-346.

Chen J., H. P. Blume, and L. Beyer (2000) "Weathering of rocks induced by lichen colonization – a review", Catena, Number 39, p. 121-146.

Crowe, B. M., G. W. Linn, G. Heiken, and M. L. Bevier (1978) Stratigraphy of the Bandelier Tuff in the Pajarito Plateau (LA-7225-MS, 57), Los Alamos Science Laboratory, Los Alamos.

Danin, A. and E. Ganor (1991) "Trapping of airborne dust by mosses in the Negev Desert, Israel", Earth Surface Processes and Landforms, Number 16, pp. 153-162.

Davey, M. C. and K. J. Clarke (1992) "Fine structure of a terrestrial cyanobacterial mat from Antarctica", Journal of Phycology, Number 28, pp. 199-202.

Del Monte, M., C. Sabbioni, and G. Zappia (1987) "The origin of calcium oxalates on historical buildings, monuments and natural outcrops", Science of the Total Environment, Number 67, pp. 17–39.

Eldridge, D. J. and R. S. B. Greene (1994) "Microbiotic soil crusts: a review of their roles in soil and ecological processes in the rangelands of Australia", Australian Journal of Soil Research, Volume 32, Number 3, pp. 389-415.

Eldridge, D. J. and R. S. B. Greene (1995) "The roles of biological crusts in soil and ecological processes in Rangelands", Working Papers of the Eighth Biennial Conference of the Australian Rangeland Society (June), pp. 133-135.

Faust, W. F. (1970) The effect of algal-mold crusts on the hydrologic processes of infiltration, runoff, and soil erosion under simulated conditions, University of Arizona, Department of Watershed Management, 60.

Harper, K. T. and J. R. Marble (1988) "A role for nonvascular plants in management of arid and semiarid Rangelands", In: Vegetation Science Applications for Rangeland Analysis and Management. P.T. Tueller, Kluwer Academic Publishers, Dordrecht, pp. 135-169.

Izett, G. A., and J. D. Obradovich (1994) "40Ar/39Ar age constraints for the Jaramillo normal subchron and the Matuyama-Brunhes geomagnetic boundary", Jour. Geophy. Res., Number 99, pp. 2925-2934.

Jackson, T. A., and W. D. Keller (1970) "A comparative study of the role of lichens and "inorganic" processes in the chemical weathering of recent Hawaiian lava flows", Am. J. Sci., Number 269, pp. 446-466.

Johansen, J. R. (1993) "Cryptogamic crusts of semiarid and arid lands of North America", Journal of Phycology, Number 29, pp. 140-147.

Jones, D. and M. J. Wilson (1985) "Chemical activity of lichens on mineral surfaces-a review", International Biodeterioration, Number 21, pp. 99-104.

Lewin, R. A. (1977) "The use of algae as soil conditioners", Transactions, Centros de Investigacion de Baja California and Scripps Institution of Oceanography, Number 3, pp. 31-35.

Leys, J. F. and D. J. Eldridge (1998) "Influence of cryptogamic crust disturbance to wind erosion on sand and loam rangeland soils", Earth Surface Processes and Landforms, Number 23, pp. 963-974.

Moses, C. A. and B. J. Smith (1993) "A note on the role of the lichen Collema auriforma in solution basin development on a carboniferous limestone substrate", Earth Surf. Processes Landforms, Number 18, pp. 363-368.

Mottershead, D. and G. Lucas (2000) "The role of lichens in inhibiting erosion of a soluble rock", The Lichenologist, Number 32, pp. 601-609.

Prieto Lamas, B., M. T. Rivas Brae and B. M. Silva Hermo (1995) "Colonization by lichens of granite churches in Galicia-northwest Spain", Sci. Total Environ., Number 167, pp. 343-351.

Purvis, O. W. (1984) "The occurrence of copper oxalate in lichens growing on copper sulphide-bearing rocks in Scandinavia", Lichenologist, Number 16, pp. 197-204.

Purvis O. W. (1996) "Interactions of lichens with metals", Science Progress, Number 79, pp. 283-309.

Purvis, O. W., O. L. Gilbert and P. W. James (1985) "The influence of copper mineralization on Acarospora smaragdula", Lichenologist, Number 17, pp. 111-116.

Reneau, S. L. (2000) "Stream incision and terrace development in Frijoles Canyon, Bandelier National Monument, New Mexico, and the influence of lithology and climate", Geomorphology, Number 32, pp. 171-193.

Rogers, D. B. and B. M. Gallaher (1995) The Unsaturated Hydraulic Characteristics of the Bandelier Tuff. LA-12968-MS, Los Alamos National Laboratory, Los Alamos.

Scheerer, S., O. Ortega-Morales and C. Gaylarde (2009) "Microbial deterioration of stone monuments—an updated overview", Advances in applied microbiology, Number 66, pp. 97-139.

Schulten, J. A. (1985) "Soil aggregation by cryptogams of a sand prairie", American Journal of Botany, Volume 72, Number 11, pp. 1657-1661.

Seaward M. R. D. (2004) "Lichens as subversive agents of biodeterioration", In: Larry St. Clair and Mark Seaward (eds.), Biodeterioration of Stone Surfaces, Kluwer, Dordrecht.

Seaward, M. R. D., C. Diacobini, M. R. Giuliani and A. Roccardi (1989) "The role of lichens in the biodeterioration of ancient monuments with particular reference to Central Italy", Int. Biodeterior., Number 25, pp. 49-55.

Shields, L. M. and L. W. Durrell (1964) "Algae in relation to soil fertility", Botanical Review, Number 30, pp. 92-128.

Smith, R. L. (1960) "Ash Flows", Geol. Soc. Amer. Bull., Number 71, pp. 795-842.

Smith, R. L. (1960) "Zones and zonal variations in welded ash flows", Prof. Paper 354-F, U.S. Geological Survey, Washington, pp. 149-159.

Smith, R. L. and R. A. Bailey (1966) "The Bandelier Tuff: a study of ash-flow eruption cycles from zoned magma Chambers", Bulletin of Volcanology, Number 29, pp. 83-104.

Smith, R. L., R. A. Bailey and C. S., Ross (1970) Geologic map of the Jemez Mountains, New Mexico. U.S. Geological Survey Misc. Geol. Inv. Map I-571, Map scale 1:125,000.

Spell, T. L., I. McDougall and A. P. Doulgeris (1996) "Cerro Toledo Rhyolite, Jemez volcanic field, New Mexico: 40Ar/39Ar geochronology of eruptions between two caldera-forming events", Geol. Soc. Amer. Bull., Number 108, pp. 1549-1566.

St. Clair, L. L., J. R. Johansen, et al. (1986) "Rapid stabilization of fire-disturbed sites using a soil crust slurry: inoculation studies", Reclamation and Revegetation Research, Number 4, pp. 261-269.

St. Clair, L. and M. Seaward (2004) "Biodeterioration of rock substrata by lichens: progress and problems", In: L. St. Clair and M. Seaward (eds.), Biodeterioration of Stone Surfaces: Lichens and biofilms as weathering agents of rocks and cultural heritage, 1-8, Kluwer, Dordrecht.

Tiedemann, A. R., W. Lopushinsky, et al. (1980) "Plant and soil responses to a commercial blue-green algae Inoculant", Soil Biology and Biochemistry, Number 12, pp. 471-475.

Tisdall, J. M. and J. M. Oades (1982) "Organic matter and water-stable aggregates in soils", Journal of Soil Science, Number 33, pp. 141-163.

Verrecchia, E., A. Yair, et al. (1995) "Physical properties of the psammophile cryptogamic crust and their consequences to the water regime of sandy soils, north-western Negev Desert, Israel", Journal of Arid Environments, Number 29, pp. 427-437.

Viles, H. and A. Pentecost (1994) "Problems in assessing the weathering action of lichens, with an example of endoliths on sandstone", In: Robinson and Williams (eds.), Rock Weathering and Landform Evolution, Wiley, Chichester, pp. 99-116.

Wessels, D. C. J. and B. Schoeman (1988) "Mechanism and rate of weathering of Clarens sandstone by an endolithic lichen", South African Journal of Science, Number 84, pp. 274-277.

Wierzchos, J. and C. Ascaso (1996) "Morphological and chemical features of bioweathered granitic biotite induced by lichen activity", Clays and Clay Minerals, Number 44, pp. 652-657.

Wilson, M. J., D. Jones and W.J. McHardy (1981) "The weathering of serpentinite by Lecanora atra", Lichenologist, Number 13, pp. 167-176.

Fig. 1. Pyramid of Cheops, El Giza, Egypt. Image by DIADRASIS.

FROM A DREAM TO A TEAM: THE EGYPTIAN HERITAGE RESCUE TEAM (EHRF)

AbdelHamid Salah El-Sharief
Chairperson Egyptian Heritage Rescue Foundation, EGYPT
a.hamid.salah@gmail.com

Egypt's Heritage is at risk. The prevailing instability and the recent social and economic problems have created dangerous conditions in areas with heritage collections, which might suffer damages or even be irrevocably destroyed. The author of this article presents the story of the creation of "The Egyptian Heritage Rescue Foundation", a non-profit organisation dedicated to the protection of cultural heritage by training professionals on first-aid actions following disasters as well as conducting rescue activities such as the intervention at the Museum of Islamic Art after the car-bomb explosion on January 24th 2014.

Keywords:
Egypt – rescue – heritage – disaster – risk – emergency

1. THE STORY

Egypt, with its unparalleled rich history, has a huge and diverse heritage to be protected and preserved. It includes vestiges of a civilization going back to the late prehistoric era (5000 BC), moving through to the Pharaonic, Greco-Roman, Coptic and Islamic periods.
Egypt's Heritage has always been at risk. Due to the unpredictable security conditions and the drastic social and economic developments that followed the January 25th Revolution (2011), the protection of heritage receded as a priority. The absence of vigilant supervision made things worse. During the last four years tombs have been pillaged and many historical sites looted. In February 2011 25 artifacts were stolen from the Egyptian Museum on Tahrir Square in Cairo, to be followed some months after by several other institutions vandalized, among them The Institut d'Egypte, the Archeological Museum of Mallawi in southern Egypt and several others.

During a live TV program on March 4th 2011, a high ranking official openly declared that the archeological storerooms of the Giza Plateau were about to be looted within a couple of days. This was the strangest declaration to ever be heard by a decision maker, who completely dissociated himself from any responsibility, bluntly announcing the "news", not even showing intentions of trying to take preventive measures! Utterly shocked, the TV presenter asked in complete dismay: "where are the security forces commissioned to protect our antiquities?" to which the high official answered: "there is no more police in Egypt"…

The next day a group of concerned and strongly alarmed young citizens, including myself, met for the first time in the back stage offices of this government official. We were all thinking of just one thing, how to fight for our heritage. However, to meet with such a high ranking official was not an easy matter, as he would only see "important" persons. But after the January 25th the atmosphere had changed and civil servants became more sensitive to the demands of the youth of Egypt. So finally, after three hours we were taken to see him in his spacious office. While waiting we had decided to recommend moving the endangered artifacts to a secure location. It took us one hour to convince him. He finally accepted and referred us to the inspectors in charge of the Giza Plateau, who should plan and coordinate our rescue mission. We were happy to work under their instructions as, other than our noble intentions, we were completely inexperienced in such matters..

The next day we joined them on the plateau, where the packing material had been prepared. The storage areas were actually the pharaonic caves under the great Pyramid (Fig. 2 & 3). When going down we noticed, next to the pyramid, some army armored cars. I was so delighted that I went up again to thank them for guarding us. To my great surprise though, I found out they were to leave soon!

Fig. 2. Storage areas in the pharaonic caves under the great Pyramid. Image by Sarah Marei.

Shocked and scared, I ran down into the caves, where the evacuation of the artifacts had already begun, only to find out that the brick walls blocking the entrance of the caves had been demolished, disclosing a second protective device, sealed steel doors. These of course had also to be unsoldered… Once done, we worked frantically to pack all the objects as quickly as possible, because we felt scared and feared attacks. It took us a whole day, at the end of which we managed, with great relief, to deliver our precious cargo to the new safe location provided by the authorities. At that moment my colleagues and I felt so gratified, as we felt we had been useful in saving some of our heritage! Already at the time I had second thoughts about the way this transfer was effected. True we had worked under the orders of the experts of the SCA; but I felt that the job had not be done according to scientific criteria. For one, I could not remember handing any detailed inventory of the artifacts to the warden in the new location…

My concerns grew more when one day, about two months later, I read in an Interpol communication that the storerooms of the Giza plateau had been burgled. I immediately contacted the official who had supervised the move, only to hear that unfortunately it was the new location that had been plundered!

I was stunned and awoke to the painful realization that good intentions are never enough; without proper knowledge one might damage instead of protecting… This is how I decided to look for this knowledge. I found out that ICCROM in Rome provided a course on "First Aid to Culture Heritage in Conflict times", applied and was accepted.

While studying I realized that this course was not simply a matter of gaining knowledge; it also implied my responsibility to convey it to my superiors back home; I dreamt of founding an Egyptian Heritage Rescue Team (EHRT).

Fig. 3. Storage areas located in the pharaonic caves. Image by Sarah Marei.

Fig. 4. First National course on First Aid to Culture Heritage in Emergency Times held in Cairo. Image by AbdelHamid Salah El-Sharief.

I could not wait for my return to Egypt and discussed the idea with my professors at ICCROM. The course director, Aparna Tandon immediately agreed to support me: "we will not leave you alone" she said.

When the course finished, my responsibilities started... The Egyptian context, with its different resources, challenges and opportunities, should be considered so as to tailor the ICCROM program to our needs. After a primary survey, I came up with a first draft that was discussed and finalized with ICCROM.

Our second step was to select the course participants, making sure that their capacities matched the course purposes and objectives. We aimed at regrouping government employees and NGO members, to ensure future cooperation between public and private sectors. After two months' work and numerous meetings and interviews, thirty three participants were selected. What remained was the most important step, obtaining financial support. It had been brought to our attention at the end of the course that Prince Clause Fund (PCF) usually supported such ventures; I applied and they promptly responded, accepting to subsidize our project.

The course methodology involves theoretical studies as well as planned practical in-situ visits and simulated sessions; it therefore creates an integrated response towards risks linked to conflict situations. It is meant to increase capacity in dealing with circumstances that create a direct hazard to cultural heritage during natural disaster, political instability, civil unrest and conflict. It develops a museum and site managing ability to assess risk preparedness, provides knowledge for planning and develops skills for disaster mitigation and emergency interventions. Apart from addressing natural disasters, it provides a most effective tool for the efficient prevention of looting, theft and illicit traffic of cultural heritage.

This course does not rely only on conveying theoretical knowledge but includes, at the end of the program, a final simulation which will allow participants to put

Fig. 5. First National course on First Aid to Culture Heritage in Emergency Times held in Cairo. Image by AbdelHamid Salah El-Sharief.

Fig. 6. Training program "Disaster Preparedness and Risk Mitigation for Museums in the event of Disaster or Conflict". Image by AbdelHamid Salah El-Sharief.

Fig. 7. Training program "Disaster Preparedness and Risk Mitigation for Museums in the event of Disaster or Conflict". Image by Waleed Yossef.

into practice what they have learned. It ends up with a practical exercise in salvaging and providing first aid to collections. Trainees will have to demonstrate their skills in documentation as well as professional management capacities: developing team work, respecting the chain of command and learning to communicate with the authorities and deal with the press…

By June 2012, the first National course on First Aid to Culture Heritage in Emergency Times was held in Cairo (Figs. 4 & 5) through a cooperation between the newly formed Egyptian Heritage Rescue Team (EHRT), ICCROM and the Ministry of Antiquities. It lasted three weeks, during which twenty nine Egyptians, out of a class of thirty three, graduated as qualified First Aiders to Culture Heritage.

Upon completion of this course the EHRT team gathered to plan its future. It was decided to organize it as an official NGO, "The Egyptian Heritage Rescue Foundation" (EHRF), which could eventually become the nucleus for a Department for Disaster Risk Management and Emergency Response, within the Ministry of Antiquities. Our NGO was officially registered in November 2013.

Also in 2013 the EHRF, together with UNESCO, ICCROM, ICOM and the Ministry of Antiquities, launched a training program: "Disaster Preparedness and Risk Mitigation for Museums in the event of Disaster or Conflict". In December 2013 seventeen trainees from eleven MoA museums and six from four museums of the Ministry of Culture graduated (Figs. 6 & 7).

Unfortunately, while we were still planning, the Mallawi Museum was vandalized and looted. We were terribly distressed by this unfortunate event which however, instead of discouraging us, strengthened our conviction to organize and to better prepare the protection of our heritage.

Fig. 8. Training of Trainers course held in 2014. Image by Waleed Yossef.

Fig. 9. Training of Trainers course held in 2014. Image by AbdelHamid Salah El-Sharief.

Fig. 10. First National course delivered by Egyptian Trainers. Image by Waleed Yossef.

It became clear that we needed a qualified first aid team in each city and museum; this was quite a challenge as we had to convince national as well as international authorities that the EHRF was capable of implementing a training of that scale, in a reasonable time period.

We proposed a Training of Trainers (ToT) program (Figs. 8 & 9) in three phases: a first course taught by trainers from ICCROM, ICOMOS, ICORP and available Egyptian experts; a second stage, where eleven trainees who had attended this first course would be given one month to prepare the modules, collect the data and adapt the international methodology to develop a training program matching the needs of targeted Egyptian institutions. In the third and final phase these eleven individuals, in order to qualify as trainers, would have to confirm their ability in training: they would be required to deliver on their own, under the supervision of ICCROM and the Ministry of Antiquities, a national course for training fifteen participants from five cities located in Upper Egypt. Through this program, at the end of a three month period we had managed to produce eleven ToT and fifteen qualified First Aiders, this time entirely trained by Egyptian experts (Fig. 10).

On January 24th 2014, a car bomb exploded in front of the Cairo Security headquarters, opposite the Museum of Islamic Art and the National Archive Library. Both of these cultural institutions were heavily damaged by the blast. Apart from the direct impact, the hanging ceiling of the museum collapsed and its debris smashed the display cases, further destroying invaluable artifacts. To add to our misery, water tanks related to fire extinguishing systems exploded, causing irreparable additional damage. The Minister of Antiquities called on the Egyptian Heritage Rescue

Fig. 11. Members of the Egyptian Heritage Rescue Team working at the Museum of Islamic Art after a car bomb explosion in 2014. Image by Essam Khattab and HebatAllah AbdelHamid.

Fig. 12. Members of the Egyptian Heritage Rescue Team working at the Museum of Islamic Art after a car bomb explosion in 2014. Image by AbdelHamid Salah El-Sharief.

Team to lead the rescue mission. Together with the staff of the museum, the 11 EHRF ToT and all of the trained first aiders it managed to organize a salvage operation according to international standards, not only recovering the minutest fragments of destroyed artifacts, but also photographing, documenting and providing proper storage for whatever was left of the museum collection. The Egyptian Heritage Rescue Team was also involved in saving the collections of the National Archive and transferring manuscripts to the modern concrete building in Boulaq (Figs. 11 to 13).

In December 2014 the Egyptian Heritage Rescue Foundation, with the technical support of ICCROM and funds from HSBC, organized a second course on Disaster Risk Management and First Aid to Cultural Heritage in Emergency Times. Five new teams from five different cities in the Delta graduated, thus raising to eleven the number of teams trained from towns in both Upper and Lower Egypt (Figs. 14).

The dramatic events following the January 24th blast alerted the Egyptian Authorities as to the importance of the Egyptian Heritage Rescue Foundation in protecting Egyptian Heritage and confirmed the need for collaboration and cooperation between public and private institutions. As a result, in 2015, a new department of Disaster Risk Management was officially established at the Ministry of Antiquities and has since worked in collaboration with the EHRF.

Fig. 13. Members of the Egyptian Heritage Rescue Team working at the Museum of Islamic Art after a car bomb explosion in 2014. Image by AbdelHamid Salah El-Sharief.

Fig. 14. Members of the Egyptian Heritage Rescue Team working at the Museum of Islamic Art after a car bomb explosion in 2014. Image by AbdelHamid Salah El-Sharief.

The EHRF involvement in the Egyptian scene did not make them forget their obligations towards our Arab region. In November 2014 the EHRF participated in training Syrian Antiquity personnel in Lebanon and in January 2015, in cooperation with UNESCO, ICCROM-ATHAR, ALECSO and the Ministry of Antiquities, it organized the first Regional course on "Building National Capacities for Managing Risks to Cultural heritage in Case of Emergency". Participants from Iraq, Yemen, Palestine, Sudan, Libya and Egypt were trained.

From 2012 to date, all the staff trained by the EHRF, whether as TOT or as First aiders to Cultural Heritage, are volunteering in a very important endeavor, that of developing a risk map of the Egyptian Cultural Heritage… Apart from that, all ninety seven of them are ready to voluntarily assist whenever and wherever our legacy is endangered.
Our story started with a dream, this dream became our goal and the goal became a plan… This plan, Rescuing Egyptian Heritage, has become our life.

2. ANNEX: THE COURSE

The Main course modules that we delivered in our abovementioned courses are based on ICCROM modules. They are:

2.1. MODULE OUTLINES

Module 1. the concept of Culture Heritage

The module focuses on Heritage, which is our legacy from the past, what we live with today and what we pass on to future generations. Our cultural and natural heritage is both inspiration and irreplaceable sources of life.

Module 2. Disaster Risk Management

The main objective of the module is to provide an overview of the various aspects of disaster risk management of cultural heritage. In particular, the Module provides interdisciplinary training to:

Undertake an integrated risk assessment by analyzing the vulnerability of cultural heritage to disaster risks;

Build an integrated system for disaster risk management of cultural heritage, incorporating mitigation, preparedness, response and recovery measures;

Formulate risk management plans for cultural heritage that correspond to the urban and regional disaster management plans and policies; and

Establish an international scientific support network for risk management of cultural heritage in order to build the institutional capacity needed to formulate comprehensive risk management plans that are based on the characteristics of cultural heritage and the nature of hazards in the regional context.

Module 3. Documentation Techniques of culture property

Participants will be presented with the fields of documentation, so as to get more out of the tools for documentation, such as digital cameras, hand held devices such as smartphones and tablets, measuring tape and other tools as well as:

Making an inventory

Collecting data

Collecting maps

Collecting photo.

Specifying themes and subthemes

Creating information sheets

In his Module the importance of documentation in an emergency will also be discussed. Quite often, in case of an emergency, collections will have to be (temporarily) moved. In order to keep track of where objects are, simple and effective documentation is vital. This session will discuss methods of such documentation.

Module 4. Emergency planning and response

A Framework for First Aid Actions: this module will present an open framework of action for providing first aid to cultural heritage since emergencies are highly influenced by the context.

It starts with Context analysis and goes through on-site survey, security and stabilization actions, triage, salvage and first aid to cultural heritage. Practical sessions are included in each topic, to ensure understanding and efficient performance, should any of the trainees be involved in an emergency situation.

Module 5. First Aid applied to structures and buildings

This module deals with the stabilization of heavy objects, archaeological remains or building parts that face the imminent threat of a collapse or could be damaged by another unavoidable source. Examples include shoring of walls, temporary structural supports, erecting temporary shelters, covering exposed surface etc.

A systematic triage, condition assessment and documentation should accompany first aid for buildings.

Understanding of the main architectural and constructional attributes of Egyptian Museums.

Module 6. Emergency Evacuation and storage

Comprises packing, transportation and relocation of cultural objects to another temporary location. It involves systematic documentation and safe handling of objects/items during transfer from one location to another. Through this topic the participants will be able to prioritize culture materials for evacuation. They are required to think critically and develop efficient tools for documentation, plan workflows for evacuation and create temporary storage. The training emphasizes on making the best use of available resources as most of the museums and storage areas in Egypt lack efficient tools and resources for this kind of work.

Storage in Emergencies

Both evacuation and salvage can involve setting up a temporary storage, as the original location might not be safe. Setting up such a space includes a documentation plan for locating objects and a configuration for appropriate fixtures and furniture in order to diminish future risks.

Using the materials provided, participants will suggest a layout for the collection within a specific space and justify their choices for the location chosen for the objects, the use of floor space, room height and location system, the choice of storage materials and priorities in the evacuation.

Final Simulation

This exercise will allow participants to implement the theory that was provided in the previous sessions. It focuses on 'teamwork', salvage and first aid to collections, on how to handle documentation, the chain of command, how to communicate with the authorities, how to deal with the press, etc.

Participants should organize themselves and gather as much information as they can about the set up

situation. Participants should think of a strategy for dealing with the situation and should be organized into teams for its practical application at the museum.

The exercise will conclude with a debriefing, the purpose of which is to identify those specific actions or situations that went well, as well as those that might require additional thought and planning, to ensure success in the future. Debriefing is a critical tool in the process of team-building, especially if accurate information is given about the difficulties or issues encountered, leading to applicable responses. A debriefing should also include the emotional reactions people may experience as a result of being involved in a serious emergency.

During the debriefing instructors will encourage participants to reflect upon their previous experiences, if any, in responding to an emergency and to consider how they would react now, should they find themselves in a similar situation.

Received: 29 December 2015
Published: 31 May 2016

Fig. 1. House after a fire in Gjirokastra. Image by CHwB.

THE CONSEQUENCES OF NEGLECT: CONFRONTING NEGLECTED HERITAGE AS AN INTEGRAL PART OF EMERGENCY PREPAREDNESS AND RESPONSE

Jonathan Eaton
Program Officer, Cultural Heritage without Borders (CHwB), ALBANIA
jonathan.eaton@chwb.org

This essay discusses how human neglect of cultural heritage can be both a result of conflict and natural disaster, as well as an exacerbating factor in such cases – compounding the difficulties and resulting in greater damage and loss. I examine the concept of neglected heritage as a long-term crisis that builds over time, often only becoming highly visible in situations of particular stress. Drawing on my own experience living in Albania and working with Cultural Heritage without Borders (CHwB) there, I discuss how the neglect of heritage can be addressed as part of the mission of institutions and organizations working with heritage in situations of conflict or natural disaster. "The Consequences of Neglect" was originally given as a presentation on 4 April 2015 during the course First Aid for Cultural Heritage in Times of Crisis, organized in Amsterdam by ICCROM and UNESCO Netherlands, with support from the Prince Claus Fund.

Keywords:
neglect – built heritage – disaster – conflict – Gjirokastra

1. INTRODUCTION

Gjirokastra is a historic city perched dramatically on a mountainside in southern Albania. It is the kind of city that has inspired travelers for centuries, with its hundreds of towering stone houses — built in a unique architectural style that won Gjirokastra a place on UNESCO's World Heritage List in 2005. At the heart of the city, the massive Hadëri house stands on the peak of a low ridge, dominating the surrounding neighborhoods. The house was once a shining example of Gjirokastra's architectural wealth, but today, it is in ruins. Abandoned for years, then partially consumed by fire, Hadëri house is a symbol of the slow-moving crisis that has gripped Gjirokastra's historic fabric. In early 2014, local authorities took the extraordinary step of demolishing parts of this listed historical building to keep it from collapsing on neighboring houses or passing pedestrians (GAZETA SHQIP, 2014). In the wake of this destruction, the organization Cultural Heritage without Borders (CHwB) decided to take action, proposing an alternative means of temporarily stabilizing the structure, in order to prevent further collapse until funds could be secured for a full restoration. Yet this intervention, critical as it is, could only act as a temporary 'band aid'. How did the building get to this point? In fact, Hadëri house had been doomed since long before it was consumed by fire. It was the building's neglect and abandonment years earlier that made it especially vulnerable to disaster. The following essay is a way to think about neglect and the effects it has on heritage sites such as historic Gjirokastra. It is a reflection on the ways that we approach neglect, and particularly neglected heritage sites, as a crucial factor for long-term disaster preparedness and recovery. At the conclusion of this essay, I offer three proposals for breaking the cycle of neglect: 1) short term measures to halt further decay; 2) full restoration and revitalization; 3) acknowledging the structural causes of neglect, in order to address them in the long term. To illustrate these proposals, I draw on the case of Gjirokastra and the work that CHwB has been conducting there.

2. CONFLICT, NEGLECT AND DISASTERS

CHwB is an organization that sprang up in response to the targeted destruction of historic buildings as a genocidal tactic of the 1992-1995 Bosnian War (RIEDLMAYER, 2002). Following on this, CHwB was founded on the principle that the cultural and ethnic dimensions of conflict must be addressed, and one powerful way to do this is by working directly with the historic sites threatened by conflict. The organization, now in its 20th year of existence, describes itself as "dedicated to rescuing and preserving tangible and intangible cultural heritage affected by conflict, neglect or human and natural disasters" (CHwB, n.d.). In comparison to the founding activities of CHwB — restoring historic structures that were damaged or destroyed during the Bosnian War— this statement

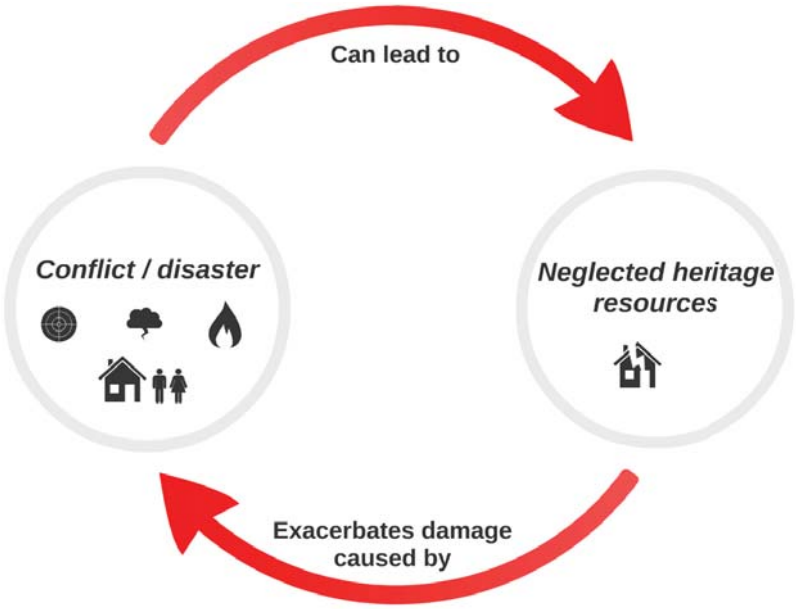


Fig. 2. The cycle of damage between conflict/ disaster and neglect. Source: "The Consequences of Neglect," presentation given during the course First Aid for Cultural Heritage in Times of Crisis, Amsterdam, 4 April 2015. Image by Jonathan Eaton.

reflects a broadening of focus, covering not only the threat of conflict, but also that of neglect or human and natural disasters. At first glance, the sentence "affected by conflict, neglect or human and natural disasters" reads well. It is even a bit poetic. But upon closer inspection, to quote Sesame Street, "one of these things is not like the others." Conflict and disasters evoke situations where heritage is actively threatened, as a direct or indirect consequence of human action or a natural occurrence. ISIS bombs an ancient temple in Palmyra (STACK, 2015); an earthquake levels historic areas in Nepal (BARRY & NAJAR, 2015); developers pave a new highway over the remains of a Byzantine church (STEFANOVIĆ, 2015; NOVOSTI, 2015). These are immediately identifiable crisis situations. Although the appropriate level and character of the response will vary, each of these represents a discernible event that can galvanize the public to take action.

Neglect, however, can be more difficult to pin down. For one, it is harder to assign blame. Is a crumbling historic house the fault of the owners, of governmental heritage agencies, of the disinterest of the general public, of the economic situation in that city or country? Neglect creeps in over time, eating away at a historic building bit by bit, rather than dismembering it with a single bomb blast or a torrent of water. Neglect "is not like the others." But does it belong with them? I argue in the following essay that neglect represents a long-term, slow-moving crisis that builds over time, often becoming highly visible only in situations of particular stress. Cycles of neglect are both caused by and exacerbate the damage wrought by conflict and disaster. Therefore, breaking those cycles must be a crucial component of emergency preparedness and response, as well as post-disaster/post-conflict recovery.

Neglect holds a mutually reinforcing relationship with its more flashy companions, 'conflict' and 'disaster,' each of these playing off of and exacerbating the others (Fig. 2). When conflict or disasters (fires, floods, earthquakes, etc.) occur, people are confronted with a situation that is beyond their control. Preparedness can go a long way toward mitigating the effects of such catastrophes, but in many cases, such situations lead to heritage resources that are neglected or completely abandoned. In some instances, people must flee from fighting or relocate after their homes become uninhabitable from floodwaters or an earthquake. Immediate response resources are limited, and they must rightly go toward alleviating suffering and providing urgently needed food, shelter and medical care. For some people, the task of repairing damage to a historic home is too difficult. Others may decide in the wake of a conflict or disaster to relocate permanently to a new city or a new country. In such cases, heritage resources, particularly privately-owned historic buildings, can be left to decay.

McEntire et al. (2010: 54) point out that there exist many types and causes of vulnerability to crises, depending on both social and physical elements. Neglect bridges the two, bringing the weight of a social situation to bear on the physical integrity of historical

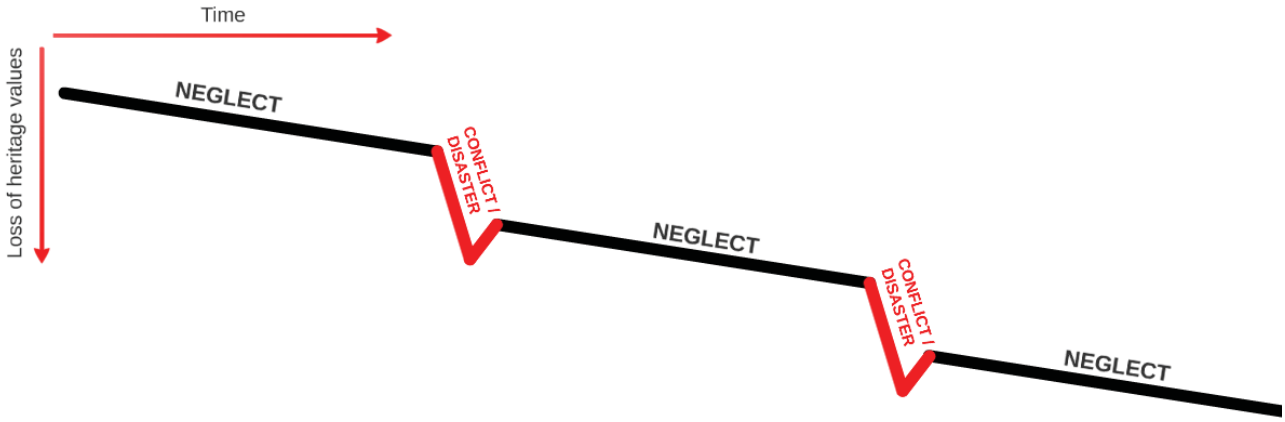


Fig. 3. The loss of heritage values over time, given the relationship between conflict/disaster and neglect. Source: "The Consequences of Neglect," presentation given during the course First Aid for Cultural Heritage in Times of Crisis, Amsterdam, 4 April 2015. Image by Jonathan Eaton.

structures. "Therefore, it is argued that 'natural disasters' are also created by humans by increasing the vulnerability of people towards extreme physical events…" (KULATUNGA, 2010: 305). When a historic building has been neglected, whether due to conflict, disaster, economic migration or any other reason, this abandonment or lack of investment leads to a steady loss of heritage values over time as weather, accidents and vandalism take their toll.[1] In the case of a historic building, neglect causes its structure to weaken, making it more vulnerable to catastrophic damage in the event of conflict or disaster. Perhaps the decay of electrical wiring puts the building at risk of a fire, or a small hole in the roof has allowed water to start entering the walls. In such cases, it is only a matter of time before a heavy rain or a small earthquake causes a wall or part of a roof to collapse. If there has been a major disaster, such as a large earthquake or wide scale flooding, or in the aftermath of a war, then perhaps there would be some recovery-related post-disaster investment, which would go toward stabilizing or repairing some of the damaged heritage resources. However, in general, these investments tend to be short-lived and often do not address the full needs of damaged and neglected heritage (MACKEE, ASKLAND & ASKEW, 2014: 203; MACKEE, 2011; TABOROFF, 2003: 236-7; LOOK & SPENNEMANN, 2000 & 2001). The results of conflict or disaster often cause additional neglect, due to further abandonment or greater lack of resources, leading to more loss of heritage values over time. Without some intervention, the cycle repeats itself, and the heritage site is eventually lost for good (Fig. 3).

3. FALL OF THE STONE CITY?[2]

To illustrate the process outlined above, I would like to return to the example of Gjirokastra, Albania, a historic city and World Heritage Site where I have spent time personally and through my work with CHwB. Gjirokastra's heritage is certainly suffering from neglect. In 2015, CHwB's office in Gjirokastra conducted a detailed condition assessment of 650 listed historical monuments in the city (most of which are privately-owned houses). The assessment report, subsequently adopted by the Institute of Monuments of Culture in Tirana, found that a staggering 169 (26%) of these historic buildings are in poor or very bad condition, while 373 (55%) have been altered illegally. Of these, 122 have lost all or nearly all of their historical/artistic value and 170 have been transformed almost totally. Most troubling, 35 monuments are in ruins while 79 are unoccupied, meaning that 18% of the listed historic monuments in Gjirokastra are abandoned. According to the report, "vacant monuments still represent the biggest threat for monuments" in Gjirokastra (CHwB, 2015b:4). All in all, only a fraction of Gjirokastra's historic buildings have survived in well-maintained condition from the fall of the communist regime to the present day.

Long before Gjirokastra was inscribed on UNESCO's World Heritage List in 2005, it was first declared a 'museum city' by the communist regime. Under communism, private property was abolished. So, having overturned the semi-feudal system that had provided the income necessary to maintain

[1] *"Loss of heritage values" means the loss of any element that gives particular value to a heritage site. This value can be historic, artistic, aesthetic, social, functional, or many others, as judged subjectively by various groups of people who identify with, inhabit or otherwise engage with a heritage site.*
[2] *Gjirokastra is often known as the "City of Stone," and The Fall of the Stone City is the English-language title of a novel by award-winning author Ismail Kadare, who was born in Gjirokastra.*

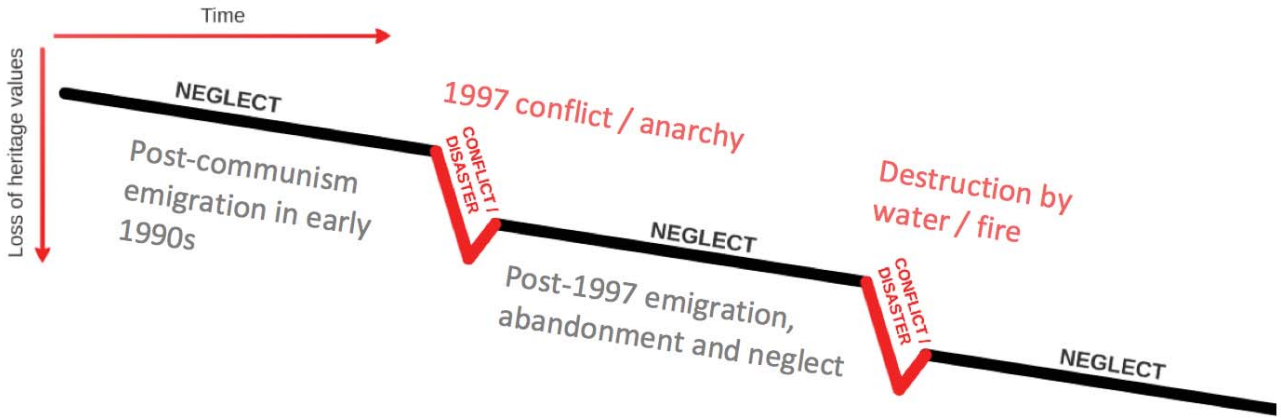


Fig. 4. The loss of heritage values in Gjirokastra, illustrating the cycles of neglect and conflict/disaster over time. Source: "The Consequences of Neglect," presentation given during the course First Aid for Cultural Heritage in Times of Crisis, Amsterdam, 4 April 2015. Image by Jonathan Eaton.

Gjirokastra's large, historic homes, the state took over this role. In order to preserve the hundreds of historic structures in the city, the regime established a large craft workshop, which operated until the fall of communism in Albania in the early 1990s. When the communist state finally collapsed, so did the entire social and economic system of Albania. The borders of the country opened, and people were able to move freely internally and externally for the first time in decades, kicking off a massive migration from rural areas to cities, from small cities to the capital Tirana and from all parts of Albania to Italy, Greece, the United States and elsewhere (VICKERS & PETTIFER, 1997). Many residents of Gjirokastra left for Greece (just 30km away) or Tirana (much further) to find work (VULLNETARI & KING, 2008: 147). This emigration left many of Gjirokastra's towering houses with no one but the elderly of the family to care for them. To make matters worse, many properties face unclear or contested ownership. In many cases, properties were returned to all the descendants of the owner(s) that had held them when they were taken by the former regime. These families, which had expanded and emigrated, often failed to agree on whether to keep these houses or sell them and who had the responsibility to maintain them — a responsibility which was de facto abdicated by the state with the return of the properties and the closing of the craft workshop. To make matters more difficult, many of the houses that were returned to their original owners continued to be inhabited by the families that were placed there by the communist regime. The occupying families often refused to maintain the buildings, since they were not their property. These factors combined to make Gjirokastra's neglected heritage more vulnerable to decay throughout the 1990s and placed it in a weakened position when crisis struck in 1997.

In the free market capitalist frenzy that broke out following the fall of the communist regime, thousands of Albanians had invested their life savings in pyramid/Ponzi schemes. The collapse of these schemes in 1997 sparked a chain of protests and revolts that led to the complete disintegration of government and a period of violent anarchy that lasted several months before order could be restored (THE NEW YORK TIMES, 1997). During this period, heritage sites, including museums, were the focus of widespread damage and looting. In some cases (e.g. the Museum of Bajram Curri), museums that were looted in 1997 have never reopened. In the case of Gjirokastra, the events of 1997 caused damage to the city's already weakened heritage infrastructure, both through indiscriminate acts of violence and targeted looting of heritage (GILKES, 2002). The aftermath of the 1997 anarchy and conflict saw further emigration from Gjirokastra, exacerbating the neglect of the city's historic center, placing even more abandoned homes at risk of destruction by harsh weather, fire or vandalism (Fig. 4).

During the past five or six years, Gjirokastra's historic center has seen a bit of a revival. However, in many cases, particularly outside of the centrally located bazaar neighborhood, the cycle of neglect continues to affect historic houses in the city today — often with dire consequences. In 2012 the palatial Hadëri house (Fig. 5), having been abandoned for years and already crumbling from lack of maintenance, succumbed to a disastrous fire that tore through the remaining wooden interior of the house. The fire destroyed much

of the roof structure, as well as most of the rooms on the building's upper floors—further weakening a building with already precarious structural stability. Gurgai house developed a small hole in its stone roof, allowing water to seep slowly into the structure of the building. A particularly heavy rain in the winter of 2014/2015 caused the exterior face of one of the building's stone walls, already weakened by moisture, to collapse (Fig. 6). These two houses are only some of the latest in a long string of examples where disaster has severely damaged historic structures that were made even more vulnerable due to long-term neglect. And fire and water are not the only hazards facing Gjirokastra's weakened historic fabric. The city lies in an active seismic zone, as well. On the very day this essay was written, Albania experienced three perceptible earthquakes within a 24-hour period, registered by the European-Mediterranean Seismological Centre at 4.0, 3.3 and 4.8 on the Richter scale (EMSC, 2015). Unless neglect of heritage is addressed, heritage resources —from archaeological sites to castles to historic houses to museums— are at an ever-greater risk of being severely damaged and destroyed when disaster strikes.

3. HALTING THE CYCLE OF NEGLECT

Clearly neglect has a detrimental effect on historic structures. However, as the examples above show, the consequences of neglect are even more dire when coupled with the effects of political, social and natural disasters. How can this cycle be interrupted? What actions can counter the cycle of neglect and reintroduce resilience to historic buildings, so that they can better resist and survive when faced with a crisis? I propose a three-part approach, in light of the experience of CHwB in Gjirokastra: 1) a 'band aid' approach to shore up damaged structures and halt further decay; 2) full restoration of derelict historic buildings, combined with revitalization to give them both a function and an occupant to maintain them; 3) addressing the root structural causes of the buildings' abandonment and neglect.

Over the past several years, CHwB has tested out a few methods of halting the neglect-fueled deterioration of heritage in Gjirokastra. In 2014-2015, the organization implemented a program called 'Gjirokastra: Where the Change Begins', which introduced for the first time in Gjirokastra temporary measures to halt the further

Fig. 5 & 6. A portion of the Hadëri house in 2014 (left), two years after a devastating fire. One wall of the Gurgai house (right) collapsed in 2014 after a heavy rain. Images by CHwB.

Fig. 7. A view of Hadëri house (left) shows support structures that shore up the remaining walls. Image by CHwB.

collapse of structures in danger (CHwB, 2015a). For this pilot project, two houses were selected, each at different stages of decay. The Hadëri house, nearly completely ruined, was selected to demonstrate techniques for installing temporary cover and rebuilding or shoring up walls and arches (Fig. 7). Meanwhile, the Gurgai house, which was a few steps away from ruin but still able to be saved, was selected to repair a hole that had recently opened in its stone roof (Fig. 8). These 'band aid' measures are similar to those implemented in places such as Italy following the devastating L'Aquila earthquake in 2009. They are not meant to be a permanent solution; rather they only halt temporarily the buildings' further collapse, helping the building to survive until funding can be secured for a full restoration. However, in cases like the Hadëri house, the building remains in a semi-ruinous state, without an occupant to maintain it and without resolving the underlying causes of its abandonment. These measures address the effects rather than the causes of neglect, but they are a valuable first step in ensuring the survival of heritage resources and signaling the importance of halting their decay.

In the best case, these temporary stopgap measures are meant to be followed up by a full restoration of the building and a revitalization effort that gives the newly restored building a social and economic function to provide for its maintenance. Such a process occurred with two other houses that CHwB restored in

Fig. 8. Two photos of Gurgai house show the hole in the roof and repair works underway to restore it. Images by CHwB.

Fig. 9. View of the Babameto I house before the restoration project conducted by CHwB. Image by CHwB.

Gjirokastra, both owned by the Babameto family. The smaller house, known colloquially as Babameto II, was restored in 2012, while restoration of the larger house, known as Babameto I, was completed in 2013.[3] Both of these houses were abandoned and in a mostly ruined condition when CHwB undertook their full restoration. In each case, however, the goal was not merely to deliver a fully restored, but still abandoned structure. The goal was to revitalize them as living elements of the historic fabric of the community. Babameto II, located in the historic bazaar on the 'Street of the Craftsmen' is currently operated as an artisan center and shop, while Babameto I has become a youth hostel and cultural center (Figs. 9 and 10). In each case, an agreement was reached with the owners that the buildings would be leased rent-free for a period of five years to the local non-profit Gjirokastra Conservation and Development Organization, who would manage and maintain them. Such a process breaks the cycle of neglect by getting people back into the houses, in order to use and care for them. Addressing neglect in such a way makes these buildings much less vulnerable to conflict and/or disaster and more quick to recover afterward (KULATUNGA, 2010). Yet, at the end of the five-year period, their owners will once again take full control, and the future of these houses from that point on is less certain.

Present in this strategy is the hope and the possibility for longer-term community-based revitalization. For this to occur, the owners will need to see the benefit of continuing to use and maintain these buildings, either as income-generators or as family residences. Other owners of historic homes in Gjirokastra will also need to see the benefits of inhabiting/employing their houses and maintaining them using the proper materials and techniques. At its core, this is an attempt to begin to address the root structural causes of the neglect that plagues historic Gjirokastra, some of which include: the cost of maintaining large historic houses, the desire for the conveniences of 'modern city life,' the out-migration of Gjirokastra's citizens, particularly young people, and the lack of opportunities for work in the historic part of the city. In order to improve community resilience and aid recovery from disaster, Kulatunga (2010:308) emphasizes the importance of cultural leaders and knowledge transfer — both of which are interrupted by the long-term neglect of heritage resources. Through its work in Gjirokastra, CHwB has observed the same. In order to change the fate of Gjirokastra, in order to stop the neglect, the city's residents have to see their historic homes as a resource, rather than a burden (CHwB, n.d.). They have to be drawn to live in the historic neighborhoods up on the mountainside, rather than in the newer concrete jungle in the valley below, and to do so without turning the historic part of the city into a concrete jungle itself.

It is understood intuitively that situations of conflict and disaster often lead to the neglect of heritage. However, prior neglect also affects heritage in times of conflict and disaster, exacerbating the damage and hindering recovery. More research is needed on

[3] The appellations 'I' and 'II' refer to the buildings' respective status according to Albanian cultural heritage law, with Babameto I being a 'first-category' monument, which is the highest level, and Babameto II being a 'second-category' monument. These two tiers denote the differences in how listed monuments should be treated, in terms of maintenance and alterations (Albanian Law Nr. 9048, dated 7.4.2003, "For Cultural Heritage").

Fig. 10. View of the Babameto I house after the restoration project conducted by CHwB. Image by CHwB.

how and to what extent this occurs. More research is also needed in terms of understanding the complex and varied structural problems that can lead to heritage being neglected or abandoned, in order to better recognize how to address these problems at their source. The case of Gjirokastra presents some evidence that neglect increases historic buildings' vulnerability to crisis situations, including conflict and disaster. It also provides some possibilities for addressing these vulnerabilities, through a combination of temporary interventions, restoration and revitalization. Implementing these approaches in tandem can help a historic city be more prepared to face disasters and help the communities living there recover more quickly in the aftermath of a disaster. However, the resources to intervene in such ways are limited. Organizations such as CHwB and others around the world are trying to understand how they can most efficiently allocate their resources to fight threats to heritage. Their success will lie not only in how they address the volatile threats of conflict and disaster, but also how well they can mitigate and reverse the cycles of neglect.

Received: 8 November 2015
Published: 31 May 2016

REFERENCES

Barry, E. and N. Najar (2015) "Nepal's Cultural Heritage Becomes Its Scrap as Human Crisis Takes Priority After Earthquake". New York Times. 28 April 2015. [http://www.nytimes.com/2015/04/29/world/asia/as-human-crisis-takes-priority-after-nepal-quake-a-nations-treasures-become-its-scrap.html], [accessed 2 November 2015].

Cultural Heritage without Borders (2015a) Bringing Life to the Ruins. 2 March 2015. [http://chwb.org/albania/news/bringing-life-to-the-ruins/], [accessed 2 November 2015].

Cultural Heritage without Borders (2015b) Condition Assessment and Categorization for Interventions: 650 Declared 1st and 2nd Category Monuments in Historical Core of Gjirokastra for Conservation of Tangible Monuments of Gjirokastra. Tirana: with the Regional Directorate of National Culture—Gjirokastra and Epoka University.

Cultural Heritage without Borders (n.d.) Strategic Plan. [http://chwb.org/albania/who-we-are/strategic-plan/], [accessed 31 October 2015].

European-Mediterranean Seismological Centre (2015) Search for earthquakes. [http://www.emsc-csem.org/Earthquake/?filter=yes], [accessed 2 November 2015].

Gazeta Shqip (2014) Gjirokastër, shembet Shtëpia e Hadërajve (Gjirokastër, Hadëri House demolished), 12 January 2014. [http://www.gazeta-shqip.com/lajme/2014/01/12/gjirokaster-shembet-shtepia-e-haderajve/], [accessed 7 November 2015].

Gilkes, O.J. (2002) "How the goddess lost her head: The myth and reality of the looting of Butrint", Culture without Context 10, [http://www2.mcdonald.cam.ac.uk/projects/iarc/culturewithoutcontext/issue10/gilkes.htm], [accessed 2 November 2015].

Kulatunga, U. (2010) "Impact of culture towards disaster risk reduction", International Journal of Strategic Property Management, Number 14, pp.304-313.

Law No. 9048 (2003) Për trashëgiminë kulturore (For cultural heritage). Fletorja Zyrtare e Republikës së Shqipërisë 2003(33). Qendra e Botimeve Zyrtare. [http://qbz.gov.al/botime/fletore_zyrtare/2003/PDF-2003/33-2003.pdf], [accessed 6 November 2015].

Look, D.W. and D.H.R. Spennemann (2000) "Disaster management for cultural properties", CRM Volume 23, Number 6, pp. 3-5.

Look, D.W. and D.H.R. Spennemann (2001) "Disaster preparedness, planning and mitigation", CRM Volume 24, Number 8, pp. 3-4.

MacKee, J. (2011) "Restoring non-secular cultural heritage in south and Southeast Asia in the aftermath of a natural disaster: Integrating systems theory and indigenous philosophical and cultural traditions to support sustainable conservation approaches", Historic Environment, Volume 23, Number 2, pp. 48-54.

MacKee, J., H.H. Askland and L. Askew (2014) "Recovering cultural built heritage after natural disasters: A resilience perspective", International Journal of Disaster Resilience in the Built Environment, Volume 5, Number 2, pp. 202-212.

McEntire, D., C.G. Crocker and E. Peters (2010) "Addressing vulnerability through an integrated approach", International Journal of Disaster Resilience in the Built Environment, Volume 1, Number 1, pp. 50-64.

Novosti (2015) Nastavljene pripreme za zatrpavanje ranohrišćanske bazilike na Koridoru 10 (Continued preparations for the filling of an early Christian basilica on Corridor 10), 5 July 2015, [http://www.novosti.rs/vesti/srbija.73.html:556060-Nastavljene-pripreme-za-zatrpavanje-ranohriscanske-bazilike-na-Koridoru-10], [accessed 2 November 2015].

Riedlmayer, A. (2002) "From the Ashes: The Pasts and Future of Bosnia's Cultural Heritage", In: M. Shatzmiller (ed.), Islam and Bosnia: Conflict Resolution and Foreign Policy in Multi-Ethnic States, McGill-Queens University Press, Montreal, pp. 98-135.

Stack, L. (2015) "ISIS Blows Up Ancient Temple at Syria's Palmyra Ruins", The New York Times, 23 August 2015, [http://www.nytimes.com/2015/08/24/world/middleeast/islamic-state-blows-up-ancient-temple-at-syrias-palmyra-ruins.html], [accessed 2 November 2015].

Stefanović, S. (2015) "An open letter to the Government of the Republic of Serbia concerning the Early Christian basilica", Laboratory for Bioarchaeology, 22 July 2015, [http://bioarchlab.org/events/137-an-open-letter-to-the-government-of-the-republic-of-serbia-concerning-the-early-christian-basilica], [accessed 2 November 2015].

Taboroff, J. (2003) "Natural disasters and urban cultural heritage: a reassessment", In: A. Kreimer, M. Arnold, A. Carlin (eds.), Building Safer Cities: The Future of Disaster Risk. World Bank, Washington, D.C., pp. 233-240.

The New York Times (1997) "Violent Protests of Pyramid Schemes Spread in Albania", 27 January 1997. [http://www.nytimes.com/1997/01/27/world/violent-protests-of-pyramid-schemes-spread-in-albania.html], [accessed 2 November 2015].

Vickers, M. and J. Pettifer (1997) Albania: From Anarchy to a Balkan Identity, Hurst, London.

Vullnetari, J. and R. King (2008) "'Does Your Granny Eat Grass?' On Mass Migration, Care Drain and the Fate of Older People in Rural Albania", Global Networks, Volume 8, Number 2, pp. 139-171.

Fig. 1. Children creating a mosaic inspired by original Roman floor mosaics at the Residence of Princess Ljubica (Belgrade City Museum). Image by Jovana Mijatovic.

TRAVELING THROUGH TIME WITH CHILDREN IN BELGRADE

Jovana Mijatovic
Archaeologist, MA. on Conservation, Independent Consultant, SERBIA
jjovanam@yahoo.com

The education program Traveling Through Time is a series of creative children workshops including Antique Mosaics, Millefiori, Decoding Hieroglyphic and Glagolitic scripts, Archaeological excavation and conservation, Historical stroll through Belgrade and Zemun, etc. Here non-formal educational methods for children aged from 10 to 14 are used and these correspond to their school program (subjects of history, language, art, etc.).
These workshops take place in the Belgrade City Museum in collaboration with the Museums Kids Club as well as with Center "Duga" – a center that aims at helping in learning focused on orphan, deaf and blind children.

Keywords:
children workshops – non-formal education – creativity – museum – cultural heritage

"A child you should behold
But still let him be free
The sooner you deem him a man
The sooner a man he will be…"
Rsumovic (2015)

1. INTRODUCTION

The *Traveling Through Time* educational program is a series of cultural, educational and creative children workshops with the main aim of developing children's team learning and creativity through amusing games. By using non-formal education methods, children learn about the fields of archaeology, conservation, history, art, significant old scripts and their decoding. The children are encouraged to spark their imagination and create authentic work in a variety of media. In each workshop, children explore ideas and processes behind one ancient craft, as well as modern ways to preserve them. The workshops invite children to question, explore, experiment and solve problems as they create and interact with different crafts and with other pupils. They can express themselves creatively while learning to build their skills in a friendly team-work environment. They are also taught how and why it is important to protect cultural heritage for the next generations.

All workshops consist of Power Point presentation (Fig. 2 & 3) about the main subject and practical work. The work is conducted in small teams so that the workshops are economical and can very easily adapted to different spaces (museum rooms, outdoor spaces, festivals, etc.).

2. ANTIQUE MOSAICS

With the workshop "Antique Mosaics" the children learn basic facts about everyday life within the Roman Empire. They develop craft abilities and creativity and at the same time they learn the basics of mosaics-making. They learn how the Romans decorated their living surroundings, which techniques they used, as well which topics or scenes they were frequently depicting on mosaics.

The Power Point presentation shows a short history of mosaics making. It also demonstrates how the mosaics are treated upon the discovery in archaeological excavations and how are they then preserved and protected. In this way, the children develop awareness about the cultural heritage that surrounds them and that needs to be kept for future generations.

Afterwards, the pupils are divided into small teams and each team makes one mosaic inspired by Roman floor mosaics. Materials used are collage papers glued onto cardboard (Figs. 4 & 5).

Fig. 2. Presentation at the Museum of Ivo Andrić (Belgrade City Museum). Image by Jovana Mijatovic.

Fig. 3. Presentation at the Residence of Princess Ljubica (Belgrade City Museum). Image by Jovana Mijatovic.

3. MILLEFIORI

The goal of this workshop is to teach pupils how and with which materials the glass vessels are made. Also, which glass objects and vessels were used in Roman Empire and what was their purpose in everyday life. The techniques of glass vessel decoration are also presented, e.g. different applications of molten glass, cameo, diatretum technique and especially millefiori, the so called "1000 flowers" technique.

The presentation shows different objects made of glass and the techniques of their making. Simultaneously with the description of techniques, the demonstration is made with the colored modeling clay so the pupils can easily understand the way of production and apply it later on the workshop.

Practical work comprises of the use of modern glass jars and application onto them of Roman decoration techniques. The workshop of glass jars decorating is unusual and interesting for children as they learn to use colored clay for making decorations and figures in entirely new way, different to the one they are used to in conventional school (Figs. 6 to 9).

4. DECODING LETTERS: HIEROGLYPHS AND GLAGOLITIC ALPHABET

The activity is divided according two different types of writting: hieroglyphs and glacolitic.

4.1. DECODING LETTERS - HIEROGLYPHICS - "THE KEYS OF LETTERING"

The starting idea of the workshop is to learn the importance of the invention of writing and its development from pictographic towards phonetic scripts.

Fig. 4. Mosaic made with plastic bags. Image by Jovana Mijatovic.

Fig. 5. Works inspired on antique mosaics made by children at the Residence of Princess Ljubica (Belgrade City Museum). Image by Jovana Mijatovic.

The pupils learn from the initial presentation how many types of writing existed in old Egypt; where the inscriptions and hieroglyphs can be found and seen; who deciphered the Egyptian writing; where they can find elements of Egyptian culture in Belgrade; etc.

After the presentation, the children are divided into teams named after great and important Egyptian rulers or deities. After a short introduction about the life and work of writer Duško Radović and his aphorisms, each team needs to translate a couple of Belgrade aphorisms into hieroglyphic texts. The teams receive the text written on a cardboard and sets of pictorial hieroglyphs. They need to find the matching symbols for letters and to glue them beneath the text (Fig. 10).

Figs. 6, 7 & 8. Millefiori made by children at the Residence of Princess Ljubica (Belgrade City Museum). Image by Jovana Mijatovic.

Fig. 9. Children making millefiori at the Residence of Princess Ljubica (Belgrade City Museum). Image by Jovana Mijatovic.

The idea of this workshop is to teach children about one ancient skill but also to connect it with something more familiar and closer in time (in this case the ancient script combined with the text about Belgrade, their hometown).

4.2. DECODING LETTERS - "GLAGOLITIC"

This workshop is similar to the previous one. It highlights importance of language and literacy but the focus is set more on development of Serbian language and Serbian Cyrillic script.

The workshop begins with a short introduction of the Cyrillic development, from the first script "glagolitic" (glagoljica) and its creators – Ćirilo and Metodije in the 9th century up to the language reforms of Vuk Karadzić in the 18th century. The presentation also includes the story of the Serbian Nobel Prize winner Ivo Andrić.

After the presentation, the children are divided in teams, named after stories or novels written by Andrić. They will be writing his quotes with "glagolitic" letters. Each team has a task to "translate" a small section of chosen from a text by Andrić, which talks about the city of Belgrade. Each member of the team writes

Fig. 10. Children playing the Keys of Lettering at the Residence of Princess Ljubica (Belgrade City Museum).

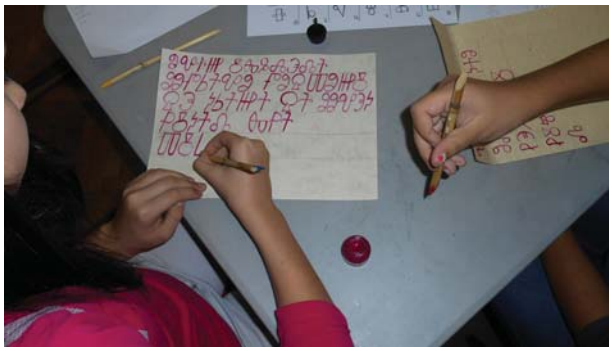


Fig. 11. Activity on glagolitic writing at the Museum of Ivo Andric (Belgrade City Museum). Image by Jovana Mijatovic.

Fig. 12. Final text with glagolitic letters at the Museum of Ivo Andric (Belgrade City Museum). Image by Jovana Mijatovic.

individual words in "glagolitic". The entire team then joins these individual words into sentences and at the end into a whole text. Preparation includes matching of Cyrillic and "glagolitic" letters. All writing is done through the use of quills and colored inks (Fig. 11 & 12).

5. SHARP EYE - CRAFTY HANDS

The goal of this workshop is to highlight the importance of conservation, as one of the ways of preserving cultural heritage. At the same time, it is great opportunity for children to learn and develop their skills and abilities, especially precision and patience.

The workshop starts with a Power Point introduction which shows what is the field of conservation; why we perform it; where it can be applied; why it is important; who are the conservators; where they work and what exactly are their tasks.

The next phase explains the activities at three different points or stations. These stations are:

- archaeological trench – simulation of archaeological excavation in the pool filled with sand and using archaeological tools

- joining the fragments of old photos of Belgrade

- search for ceramic fragments that belong to one same vessel and its reconstruction by gluing the pieces together

The kids move together visiting all of these stations and listening to the instructions for work. The next practical part of the workshop follows by pupils being separated in three teams. Each team works in one station and they exchange between stations in 20 minutes intervals. In that way, each team experiences all three tasks.

Fig. 13. Excavation during the Sharp Eye – Crafty Hands activity at the Residence of Princess Ljubica (Belgrade City Museum). Image by Jovana Mijatovic.

Fig. 14. Joining photographs fragments during the Sharp Eye – Crafty Hands activity at the Residence of Princess Ljubica (Belgrade City Museum). Image by Jovana Mijatovic.

Fig. 15. Ceramic vessels reconstruction during the Sharp Eye – Crafty Hands activity at the Residence of Princess Ljubica (Belgrade City Museum). Image by Jovana Mijatovic.

Fig. 16. Stroll through Belgrade fortress and Zemun at Belgrade fortress with Center "Duga". Image by Jovana Mijatovic.

At the end, all participants get a short explanation about the photos they were reconstructing and small index of terms that were used in the workshop (Figs. 13 to 15).

The Workshop "Sharp Eye – Crafty Hands" was inspired by ICCROM training International Course on "First Aid to Cultural Heritage in Times of Crisis" (Amsterdam) were the author participated in April 2015. The course identifies areas of joint programming between culture and humanitarian sectors to ensure that the affected communities participate in the recovery process. The core component of the course is highly practical with simulations and hands-on exercises on damage assessment, salvage and first aid measure for sites and collections. In this workshop children learn more about first aid, risks, stabilization and restoration.

6. HISTORICAL STROLL THROUGH BELGRADE AND ZEMUN

The tour "Stroll through Belgrade fortress and Zemun" has the goal of teaching children about the history of their town through interesting stories and anecdotes. They can learn where and how the first settlements at Taurunum and Singidunum were built; who were their first inhabitants and which people lived here throughout centuries. The children can learn about important landmarks and monuments which they see every day, as for example Gardoš tower, the "Winner" monument, the gates of Belgrade fortress, and the old foundry in Zemun, among others.

They also discover the importance of certain persons for the history of Belgrade, e.g. Despot Stefan Lazarević, Miloš Obrenović, Ivan Meštrović, Mihailo Obrenović and others (Figs. 16 to 18).

7. CONCLUSIONS

The educational program *Traveling Through Time* is a series of workshops that started in September 2014. All workshops were dedicated to children aged between 10 and 14 years old, coming from 10 schools in Belgrade. From September 2015 a program for children aged

Fig. 17. Stroll through Belgrade fortress and Zemun at Belgrade fortress with Center "Duga". Image by Jovana Mijatovic.

Fig. 18. Stroll through Belgrade fortress and Zemun at Belgrade fortress with Center "Duga". Image by Jovana Mijatovic.

from 14 to 18 years old will also be initiated. The goal of these workshops will be communication between museums and children, how they perceive museums and what would they change in exhibitions. That will be a unique chance for them to create exhibitions and be involved in collections creation and presentation. They will not only be observers but also play an active part in the world of cultural heritage.

The importance of involving children through workshops is invaluable for the future. If they learn now significance of they own history and cultural heritage, in the future they will be better keepers than we are today.

Received: 28 October 2015
Published: 31 May 2016

REFERENCES

Ršumović, Ljubivoje (2015) A Child. [Rsumovic,https://sites.google.com/site/projectgoethe/Home/ljubivoje-rumovi/dete], (accessed 14 February 2015)

Fig. 1. Visitor consulting a raising label. Image by Lucía Gómez-Robles.

MULTI-LAYERED EXHIBITIONS USING TRADITIONAL SYSTEMS. TWO CASES IN MEXICO*

Lucía Gómez-Robles
Architect and Art Historian, Projects' Director, DIADRASIS, SPAIN
luciagomezrobles@gmail.com

Multi-layered and hypertextual systems applied to dissemination allow for the stratification of information for a better understanding. The digital era brought with it many possibilities yet new technologies need maintenance, which might be an issue in regions with low investment on culture. Furthermore, when visitors extensively use display terminals they are isolated from their group. Nevertheless, interactive and stratified information is a communication strategy that may be successfully applied with non-digital devices. This article presents two different cases of temporary exhibitions without technology, organized in Mexico, where codes that clearly distinguish the levels or the categories of the information were used, consequently offering an easy non-technological selection system.

Keywords:
engaging exhibitions – interaction – multi-layered information – museums – dissemination

1. INTRODUCTION

The most important advantage of the digital era applied to dissemination is probably the multi-layered and hypertextual systems, namely the possibility of superimposing different layers of information and connecting them. We all experience the benefits of these systems when using the internet, jumping from one topic to another by a simple click and rapidly reaching different levels of information according to our own interest.

The system offers two main advantages. On the one hand, data are not all displayed at the same time, consequently reducing space and avoiding to confuse the user. On the other hand the same user may choose the information relevant to him, and what is interesting and may be seen in detail as well as what is not so important and should therefore be put aside.

The benefits are very tempting from the dissemination point of view and for this reason many museums have integrated computer terminals with hypermedia information, to improve the visiting experience for people interested in enlarging their knowledge. However, the use of these displays has often not been very successful due to maintenance problems and their individual character. Maintenance is an important issue, especially in regions with low investment on culture, where budgets need to follow other priorities. Furthermore, even when funds and subsequently maintenance are guaranteed, the individual use of display terminals does not suit the common museum visitor, or people in groups, couples, families, schools , etc. For older visitors some special digital displays, even regular terminals, might be intimidating and unfriendly as well. Nevertheless, this issue is decreasing everyday, thanks to the globalization of technologies.

2. NONLINEAR, INTERACTIVE, ENGAGING EXHIBITIONS

From the 18th century on, museums have evolved from being just cabinets for curiosities, where thousands of objects were stacked inside a room without any explanations, to becoming a more modern concept which attempts to create meaningful experiences for visitors. However, this is not easy to achieve and most museums, particularly in Mexico[1] maintain a traditional museography system with plain technical labels or, in the best-cases, a linear narrative on large panels full of non-stratified information that visitors rarely read in full.

Digital devices often help to provide richer discourses that allow visitors to interact with the exhibition and to make selections within the visit. Yet, as mentioned

* *The author was curator and museographer at both exhibitions.*
[1] *Despite the fact that the majority of museums in Mexico keep an old style museography, there are some interesting exceptions such as the MIDE or the Gran Museo del Mundo Maya, that are really noteworthy.*

above, digital resources are not always the best option when designing an exhibition even though the possibility of nonlinear exhibition discourses is however desirable.

Nonetheless multi-layered information and interactivity are not exclusive characteristics of technological exhibitions. As a matter of fact, stratified interactive information is a concept and it can also be applied to physical and traditional ways. Even when designing a hypertextual application for a computer, the first step is the simple organization and classifi cation of the information by topics, relevance, type, etc. The information is then included in a properly organised database, which allows multiple connections (hyperlink). The system however may be developed without technology, by using a code which clearly distinguishes the levels or the categories of the information, that is, offering an easy selection system. The main difference between the digital and the physical system is the amount of data displayed at the same time. While the digital application only shows the selected information, the physical system needs to present all the layers together, for the visitor to choose. This requisite forces the use of a large space to show all the information but this apparent inconvenience becomes an asset, considering that all the visible layers are available for the visitor who does not need to explore the contents searching for specific data, as in the case of a computer application. In addition more than one visitor, with different interests, may also enjoy the display at the same time.

3. MULTI-LAYERED BIG FORMAT LABELS FOR WORKS OF ART. THE CASE OF ATLIXCO, PUEBLA

In 2013, the National Coordination of Conservation of Cultural Heritage (CNCPC) of the National Institute of Anthropology and History (INAH) prepared a semi-temporary exhibition for a collection of twenty one canvas paintings and two polychrome wooden sculptures previously conserved at the CNCPC. These heritage elements belonged to the temple of Santa Clara in Atlixco, a historical town in the state of Puebla, the last remains of the historical monastery of the Clarisses in that city. The collection consisted of an incomplete series of the Life of San Francis by Luis Berrueco, a famous local painter in Puebla during the 18th century, an almost complete cycle of the Life of the Virgin by Bartholomé Alonso de Cazares, an 18th century painter from Seville, Spain, and three anonymous paintings and two sculptures of Saint Clare and Saint Anthony. The paintings had been piled for years in one of the side rooms of the temple, resulting in heavy damage. The purpose of the exhibition was to provide a proper place to safeguard the collection until the temple was conserved, its condition is not suitable for the artefacts. At the same time, it was an opportunity to bring them back to the local community, who can now enjoy them. Additionally the museography also provided a space to describe and explain the conservation processes undertaken at the CNCPC.

The place chosen for the exhibition were three large rooms in the Cultural Centre of the city. Since the building was not a real museum and it lacked trained staff for the maintenance of a complex museography, the goal of the exhibition was to provide the maximum information in the simplest way. The budget for the exhibition was also low. For these reasons the strategy was to make the most out of the descriptive labels. Labels were designed for this occasion as an "object panel" (Fig. 2) including different kinds of information, encoded by colours. The code allows the public to easily select the topics of its interest. Every painting or sculpture had one of these panels with the following information (Table 1):

<table>
<tr><td colspan="2">Tittle
Author
Date</td></tr>
<tr><td rowspan="3">Image of the object
before the conservation processes</td><td>Description of the scene</td></tr>
<tr><td>Information about the author</td></tr>
<tr><td>Curiosities of the representation</td></tr>
<tr><td rowspan="2">Image of
the conservation process</td><td>Conservation processes</td></tr>
<tr><td>Main data on the Iconography of the object</td></tr>
<tr><td colspan="2">Image of the object
(after conservation) with indication
of figures and attributes</td></tr>
</table>

Table 1. Distribution of the information in the panels. Table by Lucía Gómez-Robles.

The description of the scene (in red) includes a detailed explanation of the historical and symbolic context.

The information about the author (in pink) comprises characteristics about the author's style and some additional biographical data. When possible, this information about his life was linked to details shown in the painting.

Curiosities of the representation (in purple) describes anomalies in the scene, distinctive features typical from the original region (Puebla or Seville) or peculiarities of its historical period.

The Conservation process (in orange) explains the main conservation treatments undertaken on the heritage object, using simple terms for visitors to understand the different actions. This topic is also reinforced by the images of the object placed on the left side, before the conservation processes were undertaken.

Iconography main data (in blue) includes the most important information from the iconographical point of view. This topic is supported by the bottom image, where all the figures and attributes are identified as well.

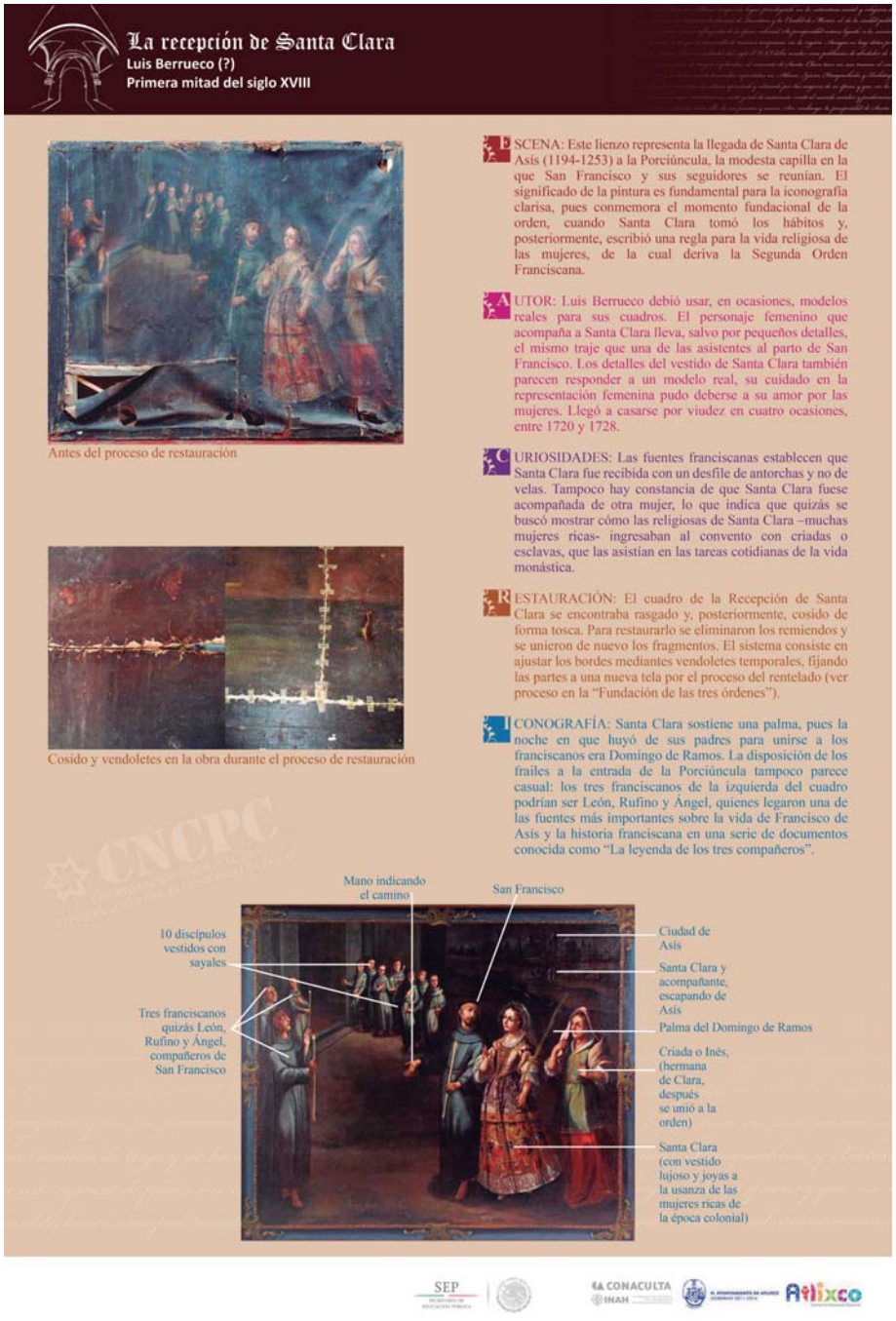


Fig. 2. Example of object panel. Design by Alma Méndez.

Fig. 3. Leaflet with instructions on the colour code. Design by Alma Méndez.

At the beginning of the exhibition a leaflet briefly explains the colour code (Fig. 3) and the contents of the three exhibition spaces and the hall with the introductory information: cycle of the Virgin, San Francis series and sculptures and anonymous paintings (Fig. 4). Every space also includes a section panel with further explanations on the group of objects exhibited there as well as their author, in order to provide a general context. Through this simple system visitors may plan their own visit according to their interests or make five different visits by following one of the topics/colours.

The exhibition museography is extremely simple due to the condition of the space but the experience, as the visitors themselves explained, is very rich thanks to the important amount of information available through a very friendly system.

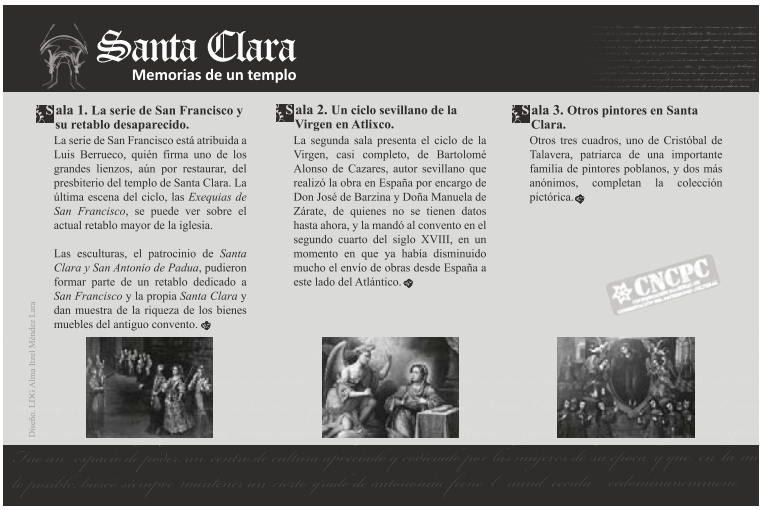


Fig. 4. Leaflet with information on the contents of the rooms. Design by Alma Méndez.

4. STRATIFIED INTERACTIVE INFORMATION FOR CHOIRBOOKS. THE CASE OF TEPOTZOTLÁN

In 2014 the CNCPC produced an exhibition on historic choirbooks in collaboration with the National Museum of the Viceroyalty (MNV) in Tepotzotlán, North of Mexico City. As in the previous example, the origin of the project was the previous conservation project of the museum collection of choirbooks.

On this occasion the place was the museum and the museography team from the Museum worked closely with the CNCPC in the creation of the exhibition. The budget was also higher, which allowed for a more complex solution, based on the same principles: different information layers that were easy to identify by visitors, for an individual selection of which part of the exhibition to visit. This time, and thanks to the budget and the expert team in charge of the

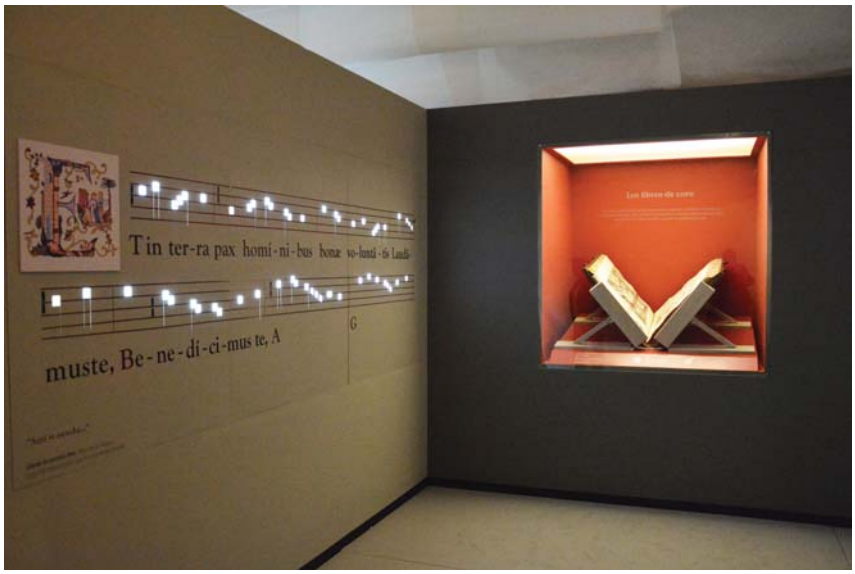


Fig. 5. Room 1. Plainsong. Image by Óscar Gutiérrez.

Fig. 6. Room 2. Polyphony. Image by Óscar Gutiérrez.

Fig. 7. Room 3. Manufacture. Image by Óscar Gutiérrez.

Fig. 8. Room 4. The use (the choir). Image by Óscar Gutiérrez.

Fig. 9. Room 5. The neglect. Image by Óscar Gutiérrez.

Fig. 10. Room 6. The stabilization project. Image by Óscar Gutiérrez.

production, an additional feature could be added: interactivity by handling. Right from the beginning, one of the main design conditions was to use physical solutions in order to reduce maintenance requirements.

The exhibition was divided in six rooms. The first two were dedicated to music, plainsong (Fig. 5) and polyphony (Fig. 6). The other four explained the life of these books, from their creation to the stabilization project: how they were made (Fig. 7), how they were used inside the temple and by whom (Fig. 8), how and when they were abandoned and the damages they suffered during the neglect period (Fig. 9), and finally the stabilization project undertaken at the CNCPC (Fig. 10).

Every book presented a specific topic, up to 19 different pieces were distributed in the six rooms: "what is a choirbook", "plainsong", "polyphony", "the amanuensis", "the illuminator", "the binder", "books for the mass", "books for the canonical hours", "instructions for singing", "factitious", "reparations", "the choir", "choirboys and bad habits", "vandalism", "mutilation", "neglect", "historical reparations", "small interventions", and finally, "what next, after the project". These main topics created the basic story of the exhibition, the life of the choirbooks.

Furthermore, the books also offered a very rich amount of additional information that could impress the public. Sometimes these data were visible on the book itself but in other cases the information was supplementary and not directly observable, which led to a different display system. Three different information levels were designed and distributed in three of the rooms, around the showcases containing the books (Fig. 11), those dedicated to polyphony, the use of the books (the choir) and the neglect (Table 2 & Fig. 11).

Observable information	Main topic [BOOK]			
[Interactive labels with questions and answers]	Technical data	Specific information on conservation	Specific information on art	Specific information on history

Table 2. Distribution of the information in the showcases. Table by Lucía Gómez-Robles.

Fig. 11. Example of book showcase and information distribution. Image by Óscar Gutiérrez.

Fig. 12. Panel of the writer in the manufacture room. It includes the general description of his activity and a step by step explanation of the process illustrated by drawings. Image by Lucía Gómez-Robles.

Fig. 13. Large format photograph in the stabilization project room. Image by Lucía Gómez-Robles.

Fig. 14. Binding system and tools of the binder. Image by Lucía Gómez-Robles.

The other three, instead, were complemented with large format photographs, drawings and replicas (Fig. 12 to 14).

Therefore, the main topic supported the information illustrated by the book containing the central story, while side interactive labels invited the visitor to observe the object according to a specific question. These questions had two different objectives. On one hand, they guided the observation and on the other, they allowed to rapidly decide whether the additional data were interested or not for the reader. After reading the question, the visitor could choose to observe the book to figure out the explanation by himself, to discover the answer by handling the moving label or just leave if he was not interested. Most of the information was hidden by the interactive labels but it was easily identified through the questions.

For example the book to explain "factitious" contained, as the key information, the explanation about this kind of books:

Factitious

Due to their use through the centuries, choirbooks needed to be updated according to changes in the liturgy. Sometimes they were disassembled to introduce new pages or to combine parts from different books. These are called factitious.

The observable data questions in this case were related to the material evidences identifying factitious books (Table 3):

Visible question	Hidden answer
Can you see a jump in the pagination?	*This indicates that the book is a factitious. The page number **28** includes the end by writing "finis", but it continues with the following one, numbered **109**.*
Can you see that pages have different sizes?	*This indicates that the book was made by joining two different ones. The pages on the left are smaller than the ones on the right side.*

Table 3. Scheme of the observable data questions in the case of factitious *book. Table by Lucía Gómez-Robles.*

Fig. 15. Spin labels in the Polyphony room. Image by Óscar Gutiérrez.

Fig. 16. Raising labels in the choir room. Image by Óscar Gutiérrez.

These kinds of questions were always showing observable evidence and they were presented through a mechanical interactive label. They could spin to show the answer behind (Fig. 15), be raised like a tap to discover the solution under (Fig. 16) or be extracted like a horizontal book in a shelf to read the information on the cover. These last ones were constructed as real books (Fig. 17).

Finally, some specialized information was also included in the object label keeping the easy selection strategy. This label was designed as a long band of 130 cm including regular technical information and art, history and conservation data identified through a coloured icon (Fig. 18W). This information was not directly observable but obtained through the specialists' analyses.

5. CONCLUSION

Collections of works of art are often presented without any kind of information except for technical data which commonly includes title, author (when

Fig. 17. Extractable labels in the neglect room. Image by Óscar Gutiérrez.

known), date and material. However, and since the general public is not made of experts, this is clearly insufficient. Sometimes museums solve the problem with long introductory panels full of information that, most of the time, are too extensive and too far from the exhibit objects. Digital terminals have been used as a possible solution to supply further information that can be selected by the user without using a big space, although they are not generally connected to the object.

The solutions explained within this text propose more direct information, linked to the object and designed in a way that allows the visitor to choose levels of information, colors, shapes, mechanical interactivity and design tools that create multi-layered low-cost possibilities. These exhibitions do not presume the previous knowledge of the visitors. Different kinds of information with different depth levels are available for the public to choose.

The absence of technology should not be an obstacle to creating nonlinear discourses in museums. Stratified information is a way of thinking, a showing strategy. We just need to choose the best tool available, apply it and create an unforgettable experience for visitors.

Received: 15 October 2015
Published: 31 May 2016

Fig. 18. Book with object label, in this case: technical information, conservation specific data, art specific data and history specific data. These data are identified through a coloured icon: conservation (scalpel and orange colour), art (paint brush and yellow colour), history (quill pen and red colour). Image by Óscar Gutiérrez.

Fig. 1. A post-modern bridge in Madrid, scenario for the video on 'Postmodernity in art'. Image by Líneas Cruzadas.

MY FAVOURITE WAY OF PRESERVING HERITAGE: GETTING PEOPLE INVOLVED

Líneas Cruzadas*
Cultural Association, SPAIN
www.lineascruzadas.org

The editors of e-Dialogos asked us to write a paper about our favourite piece of heritage and we were quite surprised: How a cultural association focused on Contemporary Art could accept the challenge?

So we decided to go a bit further.

Our association was set up to promote education, respect and enjoyment of Culture, particularly Contemporary Culture. And this is not an easy task. Nowadays it is widely believed that "old things" are valuable, such as monuments, paintings, archaeological sites, etc., and that society must respect and even preserve them. General public appreciates, without hesitation, the importance of the Parthenon or the Prado Museum. However, things get more complex when we face Urban Art or Conceptualism.

Following these ideas we designed a project named Glosario[1] ("glossary"), based on the creation of an audio-visual dictionary of terms of contemporary culture. For this purpose, we invited several art historians, cultural managers and artists to talk about art terms, such as "Fanzine" or "Hiperrealism", to Biologists, Therapists or Engineers. One video, one concept and one conversation, with two very different kinds of participants. It was vital for us to include people not related to the cultural field, so as to provide a non-academic approach to these topics.

We aimed to make different elements of contemporary culture understandable, by just recording a simple conversation of two people in a public space, not in the closed cube of an academic institution such a gallery or a museum. We wanted all these people to have a direct approach to modern art, which is so close by, but at the same time so far too, as it is accepted and valued just like the ancient works of art. Our intention somehow was to help changing the vision and sensitivity of the people a little and to bring them closer to the world of art and modern heritage, thus becoming an essential part of this project.

People would discover contemporary art and learn how to value ancient and contemporary heritage, tangible and intangible, as well as long-lasting and ephemeral creations. We believe that only by being appreciated, will heritage be respected and preserved. So, our favourite way of preserving heritage (antique or modern) is by getting people involved in the projects, as we did in Glosario, and as Diadrasis also does in their heritage projects, in a different way.

* *Ana Javierre (Cultural Manager) and Yolanda García (Art Historian), founders of Líneas Cruzadas.*

[1] *The* Glosario *project is available at https://www.youtube.com/playlist?list=PLmpSI3H5RCzF-a4YYLuTo_pYx3s4moh-R*

Fig. 17. Líneas Cruzadas' team recording the video on 'Art installation'. Image by Líneas Cruzadas.

It was our aim to link this idea to a phrase we read in an article by Salvador Muñoz Viñas (e-Dialogos n. 3), "the notion of heritage is changing". We firmly believe that, society must be increasingly prepared to understand and appreciate all versions of heritage and new artistic creations, thus definitely contributing to the enhancement and preservation of these works through to the future.

Received: 20 May 2016
Published: 31 May 2016