



CHINA AND ITALY:
SHARING CULTURAL HERITAGE EXPERTISE

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SHARING CULTURAL HERITAGE EXPERTISE

EDITED BY
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INTRODUCTION

Riccardo Pozzo

Director of the Department of Human and Social Sciences, Cultural Heritage of the National Research Council of Italy - CNR

Research in the Department Human and Social Sciences, Cultural Heritage of the National Research Council of Italy embraces social sciences as a whole as well as material and immaterial cultural heritage. The activity is focused on four disciplinary macro-areas: cultural studies, law, social sciences, linguistics and cognitive research, that are very different from each other but unified by the common goal of contributing to knowledge, preservation, use of cultural identity and cultural heritage.

Among its lines of investigation we find: information and communication technology, research evaluation and indicators, e-publishing, smart cities, innovation, creativity for knowledge society economics SME, democracy and laws, analysis of European, national, regional and communal institutions, migrations and transmission of culture, multilanguage, teaching technologies, communications security, social cohesion and competitiveness patterns, cognitive science, computational linguistics, history of language and lexicography, history of philosophy and science, history of ancient and modern Mediterranean, cultural heritage preservation, archiving, cataloguing and representation, cultural heritage diagnostic, conservation, and restoration, archaeology; archaeometry; cultural heritage valorization.

"Social and Cultural Innovation" is a syntagm that has become of current usage among researchers in recent years due to the name chosen by European Strategy Forum Research Infrastructures for the working group whose object are the landmarks and projects that are primarily connected with Social Sciences and Humanities.[1] For

1 http://www.esfri.eu/working-groups/social-and-cultural-innovation: "The Social and Cultural Innovation SWG proposes possible solutions (related to RIs) that are able to help tackle the Grand Challenges facing society, such as health or demographic change, or the 'Inclusive, innovative and secure societies' challenge from the third pillar of Horizon 2020, called 'Tackling societal challenges.' It establishes possible methods through which social sciences and humanities could be used as an evaluation criterion for the activity of other RIs in the ESFRI roadmap (e.g. social impact, etc.). It also explores how RIs can contribute to social innovation or better knowledge transfer towards society."

itself, innovation means the creation of new products and services by bringing to the market a new idea. While fundamental research is curiosity driven, it also has a translational impact, because the transfer of knowledge makes innovation possible, which is product driven, in so far as it generates new products and production lines. Innovation is the affair of research councils all over the world, which are quite different from both universities and academies. Research councils were founded about a century ago, at the time of World War I, while universities date back to the Middle Ages, and academies to the Renaissance. They differ because universities are devoted to teaching and professors are free to teach and investigate whatever they like; academies were funded by kings who wanted scholars to live at court, so that they might able to pose questions of their interest and receive answers; while governments funded research councils in order to achieve results of strategic relevance for the country.

Knowledge conservation, protection, and use trigger integration policies; they also promote cultural, economic and social growth. We are talking about areas such as knowledge and in-situ protection of cultural contexts and artifacts, post-war archaeology, virtual reality, and sustainable museography,[2] whose impact implies (a) making Cultural Heritage instrumental for science and cultural diplomacy; (b) protecting and promoting cultural diversity; (c) documenting, conserving, monitoring, using it, and eventually (e) protecting it from environmental and anthropic threats in the Middle East and in North Africa. In Brussels, the strategic approach to cultural diplomacy points to cultural diversity as an integral part of the values of the European Union.

The great challenge is the passage from data science to data humanities. The European Union has recognized the need and urgency to provide advanced facilities for interdisciplinary cutting-edge research in Social and Cultural Innovation. The main goal is to deal with every aspect of science and technology related to the field, offering innovative solutions to the societal challenges of the new millennium. As a matter of fact, also Social and Cultural Innovation researchers are confronted with huge amounts and an increasing complexity of data in highly interdisciplinary settings. Let us only think of enabling technologies such as: NFC-Near Field Communication; CRM-Content Rights Management; contents-aware networks

2 E.g. satellites and topographical techniques, drones and sensors for heritage protection in wide areas; advanced diagnostic systems; nano-materials and nano-technologies for conservation; 3D for the enhancement of cognitive access in historic and archaeological contexts; methodologies and protocols for 3D rendering in hazardous contexts; monitoring artefacts/context interaction; advanced exhibition systems: smart showcases.

(fruition and enjoyment); low-latency networks (warning and security); and huge-bandwidth networks (augmented reality).

Cultures are part of national identities, in which case they are bound to one country's language and history. However, cultures are fundamentally the constituent of transnational ties and identities. Cultures are in themselves more than their means of support. Cultures are immaterial. They are lights, namely the aura of invisible light that the civilized human being attaches to the object as a token of appreciation, veneration, and awe. At the center of all research on cultural heritage are auratic objects, be they material of immaterial (artifacts, books, social findings), but always set by a person, which makes today a repositioning as regards technological development more and more urgent. Persons are not out there only to make sure machines work, they are expected to pose the questions the human being finds it necessary to pose while going on the via humanitatis.

The object of China and Italy Sharing Cultural Heritage Expertise is to provide readers and users with top-rate solutions for data analysis in archeology and cultural heritage, in-situ non-invasive technologies for monuments and artifacts and generally ICT and sensing technologies for cultural heritage. Currently, six research infrastructures for "Social and Cultural Innovation" are up and running, among them, E-RIHS (European Research Infrastructure for Heritage Science) creates synergy for a multidisciplinary approach to heritage interpretation, preservation, documentation, and management. China and Italy Sharing Cultural Heritage Expertise is a substantial contribution towards the implementation of the grand Italian project of establishing the European Research Infrastructure for Heritage Science.

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Chai Xiaoming

Director of the Chinese Academy of Cultural Heritage - CACH

Chinese Academy of Cultural Heritage, formerly the Commission for the Preservation of Cultural Objects of the Old Capital established in 1935, is a knowledge-intensive, research-based and innovative nonprofit public institution directly under the State Administration of Cultural Heritage of China. It is mainly engaged in research on cultural relics, protection and restoration of cultural relics and related trainings. With the basic feature demonstrated by the integration of humanities and social science, natural science and engineering science for application purpose, it is one of the most important professional forces in the field of cultural heritage of China. It has obvious strengths in protection of underwater cultural heritage, world heritage monitoring and research, DYZ conservation, restoration of cultural relics and specialized trainings and education. It has qualification for archaeological excavation, Class-A qualification for design for technical protection of movable cultural relics, Class-1 qualification for restoration of movable cultural relics, Class-A qualification for survey and design for cultural relic protection projects, and Class-1 qualification for implementation of cultural relic protection projects. It serves as a postdoctoral workstation approved by the Ministry of Human Resources and Social Security of the People's Republic of China. In recent years, it has undertaken 12 national significant research projects under the National Social Science Fund and the National Natural Science Fund, and more than 120 research projects under other funds of the central government. It has won a number of awards at national, provincial and ministerial levels. It has published more than 110 kinds of professional works and more than 1,100 academic papers.

Chinese Academy of Cultural Heritage has established good partnership with cultural heritage organizations in more than 20 countries to launch cooperation and communication with each other on science and technologies for cultural relic protection. In November 2014, based on early long-term cooperation, Chinese Academy of Cultural Heritage and National Research Council of Italy entered into the *Agreement on Scientific Cooperation between the Chinese Academy of Cultural Heritage and the National Research Council of Italy* and the *Cooperation Programme of the Agreement on Scientific Cooperation between the Chinese Academy of Cultural Heritage and the National Research Council of Italy*, aiming to launch more strategic and profound academic cooperation and communication between national cultural heritage protection and research institutions of the two countries. Based on the cooperation framework, five selected projects under the cooperation between the Chinese and Italian parties have been initiated and launched in 2016 to carry out cooperation and researches concerning large-scale cultural route protection, utilization and management, archaeological site exhibition and promotion, dehydration and consolidation of waterlogged culture relics, innovative consolidation of earthen sites, photo-electronic techniques and testing of cultural relics of organic texture.

To show and exchange the achievements of cooperation, both sides plan to jointly edit a series of academic publications. This book, as the first collection of papers, includes papers on both sides' achievements in researches of protection, exhibition and utilization of urban archaeological sites in recent years, especially those on different measures adopted to protect Rome and Luoyang and similar significant ancient capitals under current development. It is very inspiring. The collection of papers also covers research achievements on protection and utilization of stone cultural relics, discussions about principles and concepts on protection of such cultural relics, heritage monitoring and protection strategies, application of diagnostic analytical methods in protection of stone cultural relics, application of information technology in protection of stone cultural relics, and studies on application of protection materials, technologies and methods. It is believed that, these papers will provide very good references for improving scientific researches of Dazu Rock Carvings and other similar cultural relics.

It is hoped that both sides will enhance communication on existing cooperation projects, make better research achievements and publish more works. It is also hoped that, the cooperation between Chinese Academy of Cultural Heritage and National Research Council of Italy will be expanded to cover a wider range of fields so that great contributions will be made to the academic development for cultural heritage protection of China and Italy, which have abundant cultural heritage resources and great strengths in cultural heritage protection.

Finally, please allow me to express my sincere appreciation for all the Chinese and Italian organizations and people who have made great efforts for the book.

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I

INNOVATIVE CONSERVATION APPROACHES: METHODOLOGIES, TECHNIQUES AND TOOLS

INHERITANCE AND INNOVATION OF LACQUER AND GOLD FOIL COATING

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"Resplendent, heart-shaking and eye-pleasing" Yang Jialuo sighed with emotion while surveying the Avalokitesvara Bodhisattva Statue (Fig. 1). This is also the reason why Baoding rock carvings are unique and valuable. The "gold coat" of the Avalokitesvara Bodhisattva not only gives dazzling rays of light to pilgrims, but also has very effective protective effect on the rock carving. Buddhism and Chinese traditional gold foil coating techniques are inextricably related. Before Buddhism was spread to China, quite mature gold foil coating techniques had emerged in China. After Buddhism was spread to China, gold foil coating techniques were destined to serve the art of Buddhist sculpture. Because the rare precious metal of gold can not only convey Buddhist statues' solemnity and dignity, its luster can also help convey religious spirit. There are similar cases in Western or other primitive religious statue worshipping.

Chinese traditional gold foil coating techniques are a set of complex techniques and skills instead of the simple working procedure of gilding gold foil. There are certain differences among "gold foil coating" techniques of the Song, Yuan, Ming and Qing dynasties in specific steps, mainly lying in paste materials and skills. *Treatise on Architectural Methods* of the Song Dynasty mentions five modes of gold use: "gold mixing", "gold scraping", "gold foil coating", "gold polishing" and "gold and lacquer coating". All these are methods of gold use in architectural decoration obviously different from gold foil coating for statues. Gold foil coating for Buddhist statues as understood by modern people is the technique of combining gold foil and lacquer prevalent mainly in the Ming dynasty. It is recorded by *On Lacquer Decoration* written by lacquerer Huang Cheng in the Longqing period of the Ming dynasty. In the Qing dynasty, skills of lacquer art developed to some extent on the basis of inheritance of those of the Ming dynasty, and combination of lacquer and gold foil was applied in extensive fields.

Fig. 1 The Avalokitesvara Bodhisattva statue (Thousand hand) in Dazu

The Avalokitesvara Bodhisattva statue underwent four recorded restorations in history, one in the Ming dynasty and three in the Qing dynasty, and gold was added to the statue during every restoration. Therefore, there are several layers of gold foil preserved on the Avalokitesvara Bodhisattva statue. According to analysis, there are basically four to five layers of gold foil preserved on the statue and as many as eight layers of gold foil on the main body. The restoration team originally planned to clear and re-gild such curling gold foil to preserve more historical information (Fig. 2).

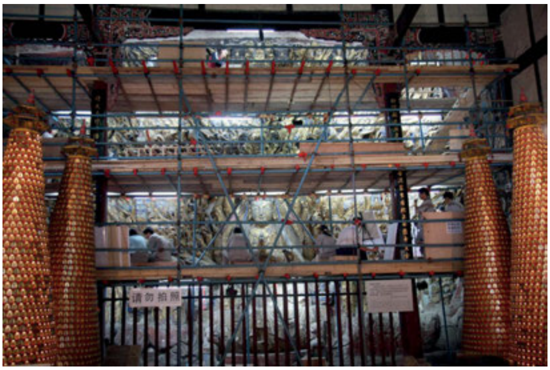
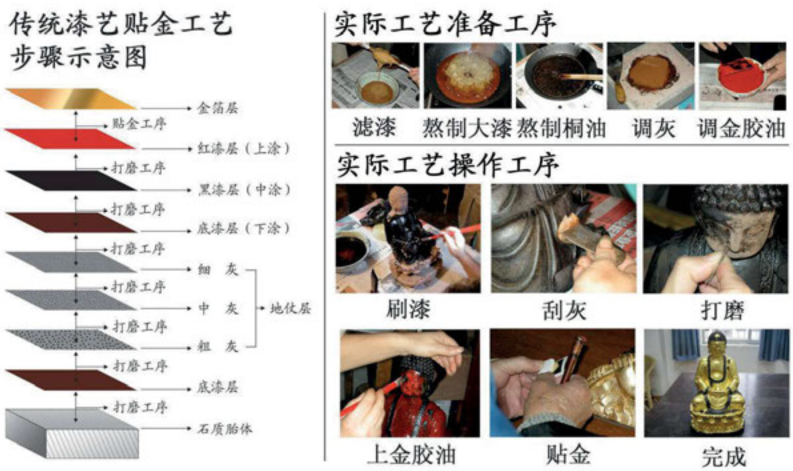


Fig. 2 The Bodhisattva Statue under restoration

However, after screening and cleaning, less than 30% of all the gold foil was usable, and well-preserved gold foil was too little to meet the need of restoration. The project team experimented with combination of different materials and techniques many times. In 2008 and 2009, the repair personnel selected a part of the statue to carry out the first experiment for the statue using modern chemical materials (15%ZB-WB-J-1 and 20%ZB-WB-J-2) as adhesives. After clearing the layers of gold foil on the surface of the statue, they used adhesives to reinforce the weathered rock mass under the statue's layers of gold foil, directly re-affixed the curling gold foil, and sealed the reinforced part for protection. However, this experiment's effect was not satisfactory. Cracking, curling and shedding occurred to the reinforced gold foil before long. Besides, the internal stone body was not well reinforced, and its safety was not effectively enhanced.



贴金工序	Gold foil coating procedure
打磨工序	Polishing procedure
金箔层	Gold foil layer
红漆层（上涂	Red lacquer layer (upper coating)
黑漆层（中涂	Black lacquer layer (middle coating)
底漆层（下涂	Bottom lacquer layer (lower coating)
细灰	Thin grey
中灰	Intermediate grey
粗灰	Thick grey
底漆层	Bottom lacquer laye

Fig. 3 Basic flow of the lacquer and gold foil coating technique for the Avalokitesvara Bodhisattva statue

In 2010, the repair personnel experimented with two different adhesives (improved ZB-WB-J and traditional lacquer) again. Traditional lacquer was chosen as experimental material for the following reasons: first, the gold foil coating technique adopted for the Avalokitesvara Bodhisattva statue is the traditional lacquer and gold foil coating technique; second, Sichuan, Chongqing and Yunnan around Dazu rock carvings are places where lacquer trees are concentrated in China, and use of traditional lacquer has advantages in light of obtainment of local materials; third, adopting the traditional techniques and materials used for the statue originally is of important significance to study and inheritance of traditional techniques for cultural relics at the non-material level (Fig. 3).

In the lacquer and gold foil layer repair experiment between 2010 and 2011, modern material ZB-WB-J suitable for stone reinforcement, addition and repair could not realize stable effect of gold foil repair, while traditional lacquer and the lacquer and gold foil coating technique showed more advantages.[1] Observation of the experiment's effect shows that raw lacquer's characteristics are especially suitable for the hot and humid climatic environment of Sichuan and Chongqing. Use of the traditional lacquer technique not only enhanced the stability of re-affixed old gold foil, but also made it possible to use new supplementary or full colors of gold foil, thus realizing the repair effect of consistency between integrity and the appearance seen from the distance; thanks to raw lacquer's osmotic effect, the combination of the original stone body and its added parts and their strength both improved; besides, lacquer and gold foil with good protective sealing effect can better protect the stone body and reduce external water's adverse influence on the body (Xu, Li, Zuo 2013).

To further study and discuss rational plans on restoration of the Avalokitesvara Bodhisattva statue's gold foil layers, from January to June 2013, the repair personnel implemented a new round of repair effect experiments within the range of 34 hands in the experiment area. After four experiments, the project team finally developed a relatively satisfactory repair technique, and the repair method and effect were also recognized by the expert team and the State Administration of Cultural Heritage. We kept all experiment areas of the body to witness this repair task on the one hand

1 Raw lacquer as a natural and very stable organic material has the characteristics of strong adhesiveness, moth proof, water proof, fire resistance and corrosion resistance. At present, no synthetic finish can surpass its main performance such as solidity and durability. The dried lacquer film structure is a very tight three-dimensional network structure, insoluble by almost any solvent, solid and lustrous with good durability, abrasion resistance, water resistance, corrosion resistance and insulating property. Though raw lacquer has certain toxicity, lacquer film is nontoxic and pollution free. It is an excellent green ecological material.

and to continue observing the state of the experiment areas and provide reference points for future repair operation.

As the restoration of the Avalokitesvara Bodhisattva statue should ensure the safety of the body and achieve the final exhibition effect, different parts must be realized according to different steps. The specific course of implementing the body repair techniques is as follows:

1. Raw lacquer osmosis. Turpentine should be added to raw lacquer for osmosis according to the proportion of 10% to blend and prepare the material for reinforcement through osmosis. It is mainly used to reinforce the small-area empty drums of the body and the parts to be filled with new materials.
2. Lacquer plaster application. The lacquer plaster used to repair the Buddhist statue's body is prepared by grinding grey bricks into fine plaster and fully mixing it with raw lacquer and water. Generally, the proportion among raw lacquer, tile plaster and water is 0.5:1:0.2, depending on weather conditions. Special lacquer plaster knives should be used when lacquer plaster is applied for the first time. The surface of the knife edge should touch the body of the Avalokitesvara Bodhisattva statue to apply lacquer plaster smoothly, press it over the surface of the body and remove the surplus lacquer plaster. When the lacquer plaster is completely dry, plaster application can be carried out on the whole body for the second time.
3. Polishing. When the lacquer plaster is completely dry, polish it with No. 240 abrasive paper, remove the dust on the surface with a vacuum cleaner, and wipe off the particles remaining on the surface of the body with a pure cotton towel wetted with pure water.
4. Raw lacquer coating. After cleaning and drying, brush the whole body with raw lacquer. Turpentine should be added to the raw lacquer to be applied according to the proportion of 10%-15% depending on weather conditions and be evenly blended. Brush the whole body with raw lacquer, leaving no untouched spot and no trace of brushing. When the raw lacquer is completely dry, apply lacquer plaster again. The methods of lacquer plaster preparation and plaster application are the same as above, but this time plaster application knives should be changed to films to make the layer of lacquer plaster thinner and evener.
5. Processed lacquer coating. Processed lacquer is prepared by boiling raw lacquer. The proportion between raw lacquer and processed lacquer is about 50% under general circumstances, about 40% when the temperature is low, and can reach 60% and even higher when the temperature is

high. Brush the whole body with lacquer, leaving no untouched spot and no trace of brushing. The method of lacquer brushing is the same as above. Repeat the procedures to brush the whole body with processed lacquer. The methods of processed lacquer preparation and coating are the same as above.

6. Polishing and dust removal. When the raw lacquer is completely dry, polish it with No. 360 abrasive paper, and carry out cleaning and dust removal with cotton cloth, hair brushes and small vacuum cleaners.
7. Golden priming lacquer. Filter the prepared golden priming lacquer at least two times to remove dregs. Then plan the areas and specific parts to be brushed with golden priming lacquer. Golden priming lacquer is applied to the surface with special oxtail brushes for Chinese lacquer. When the golden priming lacquer is no longer wet, i.e. about 80% dry, gold foil coating can be carried out.
8. Selecting gold foil specifications. Before gold foil coating, select the gold foil size first according to the area of the parts to be coated. The gold foil for body coating is customized with a side length of 45 mm.
9. Affixing gold foil. When applying gold foil, one should hold the breath and should not breathe out much air. Meanwhile, attention should be given to avoiding strong air flow directions and circulation of air flow so as not to affect affixation of gold foil. When mild wind blows, the body should be surrounded by a curtain to form a relatively closed space before gold foil coating. During gold foil coating, attention should be given to avoiding excessive overlapping of gold foil layers, cracks and lacquer exposure.
10. Looking for parts not coated with gold and adding gold. During gold foil coating, attention should be given to looking missed parts and adding gold. If cracks and lacquer exposure are found during gold foil affixation, additional gold foil should be affixed in time. Whether there are parts not coated with gold or golden priming lacquer is exposed at joints during gold foil, affixation should be examined carefully. If there is any such phenomenon, gold foil must be added in time to prevent differences in gold foil luster.
11. Brushing gold, pressing gold and wiping gold. After gold foil is affixed and gold is added, brush the surplus gold particles from the gold foil joints with wool brushes and writing brushes. When the lacquer surface is firmly covered by self-made cotton cloth bags, wipe the gold lightly with cotton again to make the gold foil surface flatter and smoother and ensure the gold's uniform color without any local scattering light and rotating light. When gold is

brushed, attention should be given to proper application of force and avoid excessive application of force, which will cause indentation on the surface of gold foil. Meanwhile, attention should be given to changing cotton. When there are too many gold foil particles attaching to the cotton's surface, abrasion marks will be left by gold foil particles during wiping.

12. Sealing for protection. When all the working procedures of gold foil affixation are completed, apply self-made sealing material for protection to the surface of the gold foil layer with wool brushes to realize the purpose of final sealing for protection.

During this repair of the gold foil layer of the Avalokitesvara Bodhisattva statue, the techniques further studied on the basis of using the traditional lacquer coating techniques used by local lacquerers in Dazu were used after approval by the State Administration of Cultural Heritage. The application of such repair techniques ensured the safety and stability of cultural heritage repair, and at the same time ensured the statue's artistic value and cultural value (Fig. 4). Meanwhile, traditional lacquer and gold foil coating techniques were studied and recorded, providing important reference points for protection of similar statues in Sichuan and Chongqing.

Fig. 4 The Bodhisattva Statue under restoration, detail

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ADVANCED INSTRUMENTAL ANALYSIS TO RECONSTRUCT PAINTING MATERIALS AND TECHNIQUES OF ANCIENT ASIAN STATUES

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Modelling sculptures is a wide-spread technique in Central and South-East Asia particularly in Buddhist sanctuaries. Although there are many preserved sculptures, very little is known about the painting techniques used due to the lack of available technical literature as well as the paucity of scientific investigations. This paper summarizes the results obtained from the multi-analytical characterisation of the organic and inorganic materials in paint micro samples from some polychrome Asian sculptures in clay. Results obtained from the Western and Eastern Buddhas of the Bamiyan valley (6th century, Afghanistan), the Terracotta Army (221 – 210 aC, Shaanxi Province, China), and the clay sculptures from Shuilu'an temple (1563-1567, Shaanxi Province, China) are herein described.

EXPERIMENTAL APPROACH

A combination of techniques, including optical microscopy observation, was used to determine the inorganic composition of the different paint layers. Polarised light microscopy (PLM), X-Ray Fluorescence (XRF) and Scanning Electron Microscopy coupled with Energy Dispersive X–ray Spectroscopy (SEM-EDS) were used for the morphological analysis and inorganic content determination.

The distribution of the materials, both organic and inorganic, was achieved by means of Synchrotron Radiation µFTIR and µXRF analysis carried out at ID21 beamline, ESRF (European Synchrotron Radiation Facility, Grenoble, France). Discussion about the sample preparation methods and the experimental conditions have been provided elsewhere.

The chemical investigation on the organic binders has been performed on micro sub-samples obtained separating the paint layers under the binocular microscope. For this purpose, a Gas Chromatography-Mass Spectroscopy (GC/MS) analytical procedure was used for the characterization of glycerolipids, natural waxes, terpenoid resins, proteinaceous and polysaccharide materials in the same paint micro-samples avoiding interferences from inorganic compounds (Luveras, Bonaduce, Andreotti, et al. 2010). This analytical procedure permits to characterise the organic materials present layer by layer, helping the reconstruction of the painting technique. A database of paint materials compatible with materials available in the area under study has been established, to support the analytical evaluation of the data obtained.

RESULTS AND DISCUSSION

Western and Eastern Buddhas of the Bamiyan valley

The Bamiyan Buddhas where destroyed in 2001 by Taliban. In 2002 an ICOMOS mission started to rescue and store the fragments of the figures, and to safeguard the remains. In this context, scientific investigations were undertaken on a selection of the smallest fragments aimed at investigating the original appearance of the statues and their manufacturing techniques. The results allowed some general conclusions to be drawn. The first preserved pigmented layer was obtained using a mixture of white earth and iron oxides for the sangati and ultramarine for the blue lining. On top of this layer there was a first overpainting made with red lead on the sangati of the Western Buddha and a pink overpainting on the Eastern Buddha; in a second phase both layers were repainted in lead red. A lead white restoration layer was subsequently applied on top of the Buddhas and then the Western Buddha was finally repainted with red lead. The statues before the destruction appeared brownish because of a clay layer applied during a restoration that was carried out at the beginning of the 20th century.

The organic material was investigated in 15 of these fragments. Given the complex stratigraphy of the fragments, in order to reconstruct the original painting technique, and to understand which materials were used in the restorations that followed in the centuries, 50 sub samples were obtained by selectively sampling different layers or group of layers. The samples analysed did not show the presence of lipids, resins or waxes, but polysaccharide and proteinaceous materials were present, as it could be ascertained by the presence of sugars and proteins in the chromatograms. By combining the information obtained with the different techniques it has been possible to gain detailed information on the different fragments analysed and support the reconstruction of the original visual appearance of the giant statues and the artistic techniques used by the artists of the time (Lluveras-Tenorio, Birolo, Blaensdorf et al. 2016; Bonaduce, Cito, Colombini et al. 2009) As an example in Figure 1 the cross-section of a sample collected from the western Buddha is shown, highlighting the sample stratigraphy, with relative inorganic elemental composition and organic materials identified in layer or group of layers.

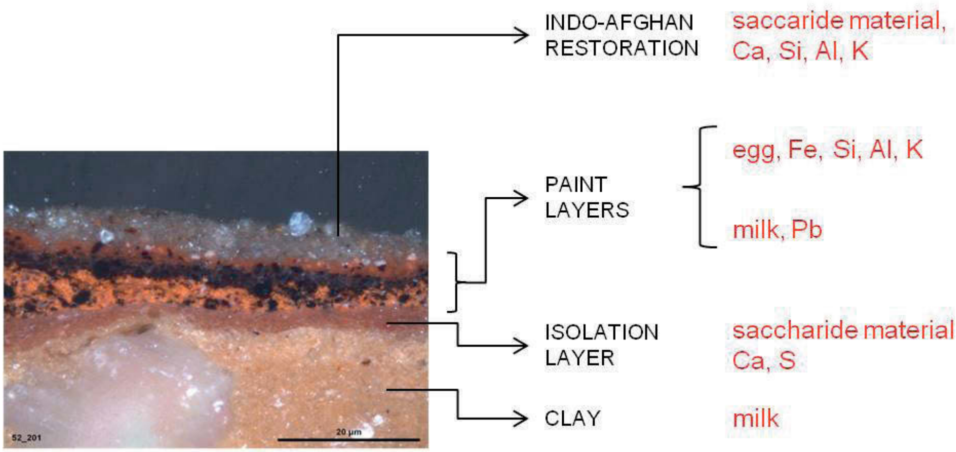

Fig. 1 Cross section of a sample collected from the western Buddha, with description of the sample stratigraphy, elemental composition and organic materials identified in the different paint layers

The Terracotta Army

The identification of the binders of the samples from the Terracotta Army proved to be very challenging when it was undertaken (Bonaduce, Blaensdorf, Dietemann et al. 2008). The samples were collected from the paint layers that were adhering to the soil after the excavation of the statues, as a consequence of the detachment of the qi-lacquer preparation layer. The main reason for this difficulty was due to the very high content of inorganic material present. Inorganic materials can interact with the organic binders, leading to the formation of complexes, promoting cross-linking and hydrolysis. In the case of proteinaceous materials, pigments cause aggregation and cross linking, causing a significant decrease in the protein solubility. As chromatographic methods entail the solubilisation of the binder as a first step, the loss of solubility caused by ageing and the simultaneous presence of inorganic pigments represents a major problem. Moreover pigments can interfere in the derivatisation step, leading to chromatograms with no peaks. This is especially true for some pigments, among which those containing copper are the most troublesome ones.

Proteins are identified by comparing the amino acidic profiles with a database of reference samples by means of a statistical treatment of the data. The results can be visualised in a graph, the loading plot, which is shown in Figure 2, where samples showing similar amino acidic composition appear close to each other. Figure 2 clearly shows that all samples from the Terracotta army are located in the cluster of egg, allowing the identification of the paint binder used for the polychromy.

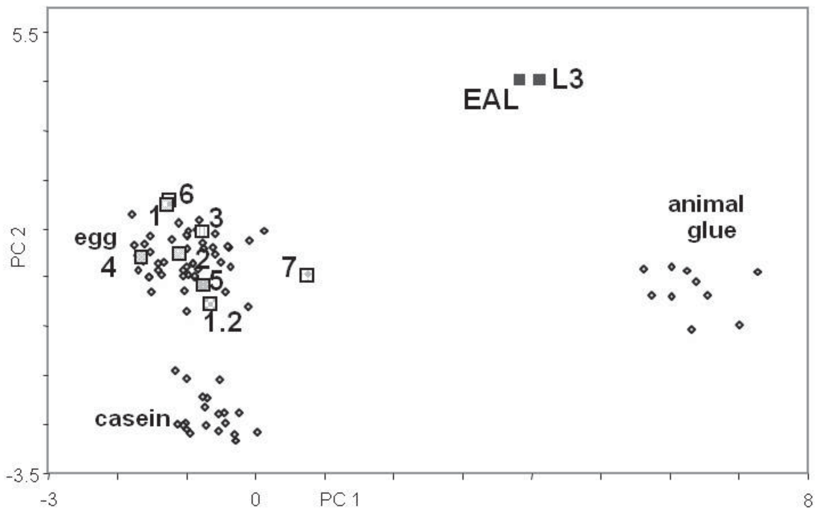

Fig. 2 Loading plot of the samples collected from the Terracotta Army, in comparison with a database of reference samples of egg, animal glue and milk. In the database also the amino acidic profiles of two East Asian lacuqer - qi-lacquer - were included, which were used as paint preparation

The clay sculptures from Shuilu'an temple

The temple of Shuilu'an, near Lantian (60 km southeast of Xi'an), is an important example of a Buddhist sanctuary with clay sculptures in China. The main hall of the rather small temple was decorated with about 1400 clay sculptures in the years of 1563-67. Unlike most of the sanctuaries and most relevant for the analysis is the fact that the sculptures have never been repainted, a situation that is rarely found in China.

The sculptures range from large statues of Buddha incarnations of about 250 m height to tiny figures arranged in vivid scenes. Sculptures and relieves are modelled in clay and brightly painted. In most parts the original paint layers are still very well preserved.

Results show the presence of proteinaceous materials in all the samples analysed: coloured paint layers, priming layers and clay support (Pouyet, Lluveras-Tenorio, Nevin et al. 2014). Animal glue seems to be present in all the samples analysed. A second proteinaceous material seems to be present. In some cases, egg and milk were identified by comparison with the database. However, in other cases a mixture of proteinaceous materials seems to have been used not allowing a better identification.

Saccharide materials were identified mainly in the priming layer in a similar way to the Afghan Buddhas. Only for a gilded with a metal foil (gold), a siccative oil was identified. The source of the drying oil requires further investigation (Pouyet, Lluveras-Tenorio, Nevin et al. 2014).

Special attention was therefore paid to the gilded sample. The distribution of the materials, both organic and inorganic, was achieved by means of Synchrotron Radiation µFTIR and µXRF analysis carried out at the ESRF (European Synchrotron Radiation Facility, Grenoble, France) (Lluveras, Bonaduce, Colombini et al. 2011). From bulk to surface, results showed that (Fig. 3a): the white priming layer (1) is composed of silicates (3624, 1029 cm^{-1}), and of organic material in low quantities. GC/MS showed the presence of a proteinaceous material, probably milk or casein. In layer 2, characteristic carbonyl ester and CH fatty chain bands could indicate the presence of a lipidic material, possible result of the penetration of the oil identified in the above layers. Silicate-based compounds have been identified in this layer as well. This red layer prepared the application of a large mordant (3) layer (Fig. 3b) composed of oil (1740–1710 cm^{-1}), in agreement with the detection of oil by GC/MS analysis (Fig. 3c) and lead white (1410cm^{-1}), more precisely cerussite. Carboxylates were also detected in this layer (1550 cm^{-1}). Further discussion has been provided elsewhere (Lluveras, Bonaduce, Colombini et al. 2011).

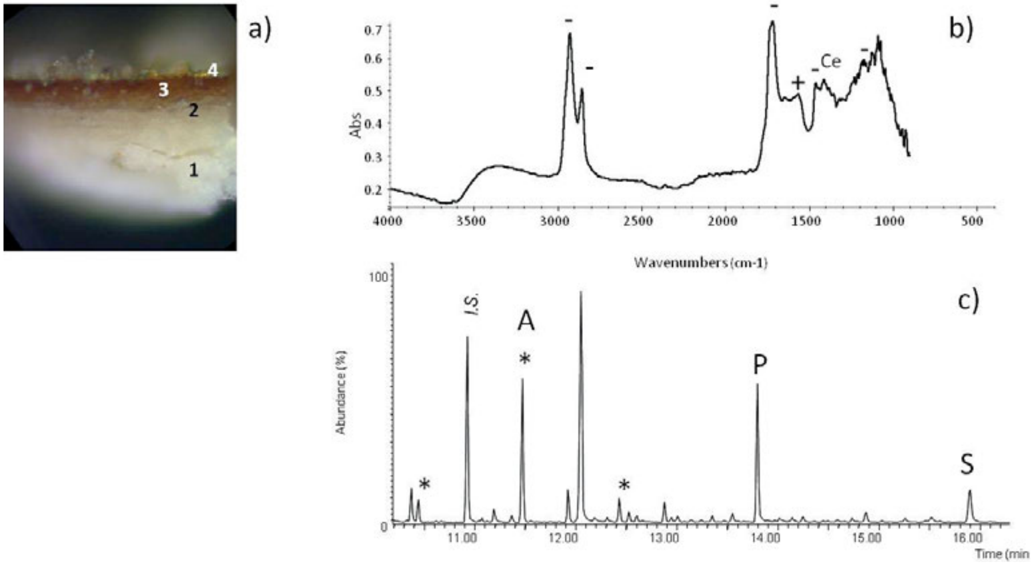

Fig. 3 a) Optical microscope image of the cross-section of the gilded sample from Shuilu'an (the paint layers identified are numerated); b) FTIR spectra of layer 3 (bands attributed to oil (-), cerussite (Ce) and carboxylates (+) are indicated; c) chromatogram of the lipid fraction of layers 2 and 3 (dicarboxylic acids (*), A=azelac acid, P=palmitic acid; S= stearic acid)

CONCLUSION

The combination of the results obtained by the research performed in samples from the Western and the Eastern Buddha of the Bamiyan valley (Afghanistan), from the Terracotta Army and from clay sculptures from Shuilu'an (Shaanxi Province, China) add a piece of information. The obtained data provide the foundations for a reliable understanding of the painting technique of the clay and terracotta sculptures, which represent an ancient and widespread artistic expression of Asian cultures, from the most ancient Chinese dynasties to later Buddhist cultures.

The three sites studied showed the presence of different materials. Proteinaceous materials seem to be widespread: egg, animal glue, milk and mixtures of them were identified. The source of saccharide material, although present, could not be identified in any of the samples. Though a mixture of materials can be hypothesized for one of the samples, little is known about the use of saccharide sources in ancient Asia.

Data highlight that the painting technique of the Asian painters on clay statues was quite complex. Although more investigation is necessary, results show an interesting overall view of the painting techniques of the clay and terracotta sculptures along the Silk Road.

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TUFF ROCKS DETERIORATION MECHANISM AND PRESERVATION MATERIALS SCREEN IN CHENGDE MOUNTAIN RESORT

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INTRODUCTION

Tuff stone relics are extensively distributed in China. Wanfotang grotto in Yi county, Liaoning province and Caomao mountain cultural relic in Aohan Qi, Inner Mongolia are typical tuff relics in North China; Nanshan statue, Taozhu Grand Buddha, Yuhang Cliffside carvings and Keyan statue in Zhejiang province and Quzhou ancient wall which mainly made of tuff rocks are distributed in Southeast China (Li et al. 2014). High porosity, high content of clay and variable environmental conditions lead to poor weathering resistance of tuff rocks as well as susceptible influence of humiture, which result in diseases such as exfoliation, plate crack and surface salt, etc. However, researches on tuff relics are extremely limited domestically and abroad, which achievements are mainly focus on qualitative description of diseases (Reid et al. 2000; Hildreth et al. 1979; Mu et al. 2001), chemical constituents analysis (Hildreth et al. 2007; Peppard et al. 2001), geologic genesis (Qiu et al. 2009) and exploitation and utilization (Mu et al. 2001) of tuff rocks. Neither deterioration mechanisms under unfavorable environment factors nor restoration researches have been found, not to mention reinforcement materials and technologies application studies. Volcanic tuffs, formed by substance erupted from volcano, are the most widely distributed among volcaniclastic rock category. Typical tuff texture, high content of volcano substance (>90%) and small particle size (<2mm) are typical features of tuff rocks (Xu et al. 2009). Pyroclastics in tuff rocks includes cuttings, crystals and vertices, which are existed individually or together. Low crystals content and high vertices content are general distribution in tuff rocks. Accordingly, volcanic tuffs are classified: vertices tuff, cuttings tuff, crystals tuff, compound tuff and ignimbrite tuff (Le 1984).

Inscriptions, stone lions, statues, sumeru pedestals, tower foundations and fences in Chengde Mountain Resort or in surrounding temples are mainly made of tuff stone, which are also called as Parrot rock in local. Extreme temperature reaches minus 20C° in winter, as a result, tuff rock frost heave and shrinkage caused by frequent freeze-thaw action impact not only the integrity and aesthetics of tuff relics but also global stability of tuff relics. Diseases such as exfoliation and deep cracks threats on valuable tuff relics are required to be relieved urgently. However, neither tuff rock durability evaluation under environmental factors nor deterioration micro mechanisms researches have been done yet, which are not conducive to preservation of tuff relics.

Tuff stone relics in Chengde Mountain Resort and surrounding temples are surveyed in this paper, which include disaster types and distribution as well as microanalysis on tuff stone's mineral composition and microstructure. Freeze-thawing and salt injury imitation laboratory test are experimented in order to analyze the environmental impact on tuff stones. Disaster emerges and development evolution rule based on tuff stone features and environment impact are introduced in this paper. Accordingly, reinforcement materials for tuff relics have been tested and screened.

TUFF ROCKS PROPERTIES AND DETERIORATION CHARACTERISTICS

Tuff rocks in Chengde, showing in fresh hoar color, developed micro horizontal bedding and not much graded bedding. Most of tuff rocks have already alternated, which result in surface claylike loose in surface, however, protogenous tuff texture of most tuff rocks have been retained expect few felsitic texture. Classics particles made up by cuttings, crystals and vertices. Vertices have been calcitizated or montmorillonited already which result in quartz, feldspar and biotite alternative mineral. Cuttings with irregular shape and crushing edge shape have been chloritizated.

Tuff rocks sampled from Mountain Resort and surrounding temples, which are under nearly coincident environment, are in basis coherence. X-ray diffraction test was conducted on samples. The result indicates high content of clay and colloidal particles in samples (colloidal particles content are over 10%). Claylike loose were found in samples surface as result of secondary clay minerals, such as illite, montmorillonite and kaolinite.

Mercury injection tests were conducted in order to analyze pore size and distribution of tuff samples. The results indicate that the apparent density is 2.24g/cm³, open porosity is 16.10% and total porosity is 17.70%. Pore size and contents distributions are showed as followed. All pore size over 0.01μm but rarely size over than 100μm were distributed in fresh tuff samples, but most pore size are within the range of 0.1~1μm. According to relevant research (Li et al.2014) , pores size within the range of 0.1~1μm possesses highest absorbability, which result in high water and salt storage capacity of tuff rocks, as well as water-rock interaction correspondingly.

Tuff samples in lama tower of Pule temple and in glaze archway of Xumifu temple were analyzed by polarization microscope. Scanning pictures shows that phenocryst and substrate are main composition of tuff rocks, there into, phenocryst includes feldspar, quartz and biotite. Besides, cracks and concealed joints were developed with limonite filling. Statistically analyzed were conducted on directed cracks and concealed joints, which proportion is 72%.

Minerals like quartz, soda feldspar, common feldspar and kaolinite, as well as cuttings and volcanic ash are contained in tuff rocks. According to X-ray diffraction test result, 10-20% clay minerals which including 10% kaolinite and 2-9% I/S mixed-layer minerals are proved to be existed in tuff rocks. I/S mixed-layer mineral, one kind of expansive clay minerals, are symbols of rock stratum delaminating in sediment logy (Weaver 1956), which are also potential interpretation for directional cracks in tuff rocks. Showing active properties and strong water adsorption capacity, clay minerals and muscovite may lead to 8 times expansion ability of sand rocks (Li 2014). Therefore, 10~20% clay minerals in tuff rocks, especially 2~9% I/S mixed-layer minerals are material source for water-weathering and salt-weathering of tuff rocks.

According to mercury injection tests results, the open porosity is 16.10% while the total porosity is 17.70%; Water absorption rate is 6.22% while saturated water absorption rate is 7.49% and calculated saturation coefficient is 0.831, which are all lager than other volcanic rocks or sedimentary rocks. It follows from it that pores in tuff rocks are mostly open pores, which means that it is conducive to absorb water or saline solution from external environment. Besides, laboratory tests results show that specific gravity of tuff rock is 2.659g/cm³ while apparent density is 2.204g/cm³, which are all less than other volcanic rocks or sedimentary rocks. It also proved that pores are intensely developed in tuff rocks.

According to field investigation, micro joints are widely distributed in tuff rocks of Chengde relics. Meanwhile, most micro joints are existed in group in Chengde tuff rocks. Generally, micro joints are induced structures of crustal stress field or discontinuities (faults), thus micro joints show directional appearance or multi periods, multi groups and multi occurrence features (Zhu 1999). Massive micro joints and concealed joints, filling with carbonate and limonite, were found in tuff rocks under scanning electron microscope. According to statistics, directional cracks and micro joints accounted for 72% of the proportion of total cracks, which is potential interpretation for lath-shaped cracks in tuff rocks of Chengde relics.

Typical deterioration form of Mountain Resort and surrounding temples are cracks, exfoliations and crusts according to field investigation.

Fig. 1 Lath-shaped cracks in Chengde Mountain Resort

1. Crack is a phenomenon that the mechanical crushing or the components pulling apart as result of destroy of stone relic's integrity, which divided into pressing cracks, pulling cracks and tearing cracks according to stress state (Roma 1990). There into, pressing cracks or crush zone are mainly distributed in the bottom of the wall and the top of the pillar which enduring pressure; pulling cracks are mainly distributed in the bottom of the beam; tearing cracks, also showed as faults are usually accompanied by displace-

ment. According to field investigation results, these three cracks are widely distributed in Mountain Resort relics.

Another special crack, lath-shaped cracks are widely developed besides three types above, which are the most severe and representative cracks in Mountain Resort and surrounding temples. Lath-shaped cracks, with plenty of mechanical cracks and much loss quantity as well as large aperture, have been threatened relics integrity and stability.

2. Exfoliation is a phenomenon that surface parts divorced horizontally from matrix rocks as result of smaller external force (Roma 1990). Exfoliations are divided into granular exfoliation, squamous exfoliation and schistose exfoliation according to spall shape. According to field investigation results, exfoliations in Mountain Resort and surrounding temples are mainly granular exfoliations and schistose exfoliations.
3. Crust is a phenomenon that external material crusted in stone's surface (Roma 1990). According to field investigation results, water corrosion crusts are widely present in Mountain Resort. Besides, iron rust crusts developed intensively in censer foundation of Anyuan Temple, which have been gone deep into rock inside. Even though the crusts are stable, the crust color is deeply distributed, producing server impact on aesthetics of tuff relics.

DETERIORATION MECHANISMS

With a certain degree of weathering, tuff rocks were sampled from Mountain Resort. Dimension of the samples are 50×50×50mm. The samples were marked as ND-1, ND-2 and ND-3 with the surface polished and the stripes directions marked. The sample was oven dried at temperature of 70±5C° and the weights were recorded.

The oven dried samples were put in a container with spacing of not less than 15mm between the samples. Water (20±10C°) is poured into the container until half heights of the samples are immersed in water. One hour, water was poured again until 3/4 height of samples are also immersed in water and left for two hours. Finally, after two hours, water is poured in to the container until the whole heights (25±5mm) of the samples were immersed in water.

The samples immersed in water for 48 hours before they were transferred to the freezer. The samples were left in the freezer for six hours and then transferred into room temperature water (20±5C°) for another six hours. Elastic wave velocity and weight of samples were measured during each cycle. Six freeze-thawing cycles were conducted according to test conditions.

With a certain degree of weathering, tuff rocks were sampled from Mountain Resort. Samples were cut as 50×50×50mm and surface smooth have been machined. 9 samples were tested and each 3 samples as one group: identifier N1 corresponds to Na2SO4 solution; identifier N2 corresponds to Na2CO3 solution; identifier N3 corresponds to KNO3 solution. Put samples into saline solution(mass concentration is 14%, temperature is 20±5C°)with the immersion of 8~10mm for two hours after drying, then shifted samples to roaster(105±5C°) for no less than 16 hours. At the end, took out samples from roaster and cooled for 2 hours. Elastic wave velocity and weight of samples were measured during each circle.

Samples in Na2SO4 solution were damaged after 4 cycles; samples in Na2CO3 solution were found with evident erosion after 10 cycle, however, no general failure were found even though with surface roughness; samples in KNO3 solution were found with no evident changes after 10 cycles.

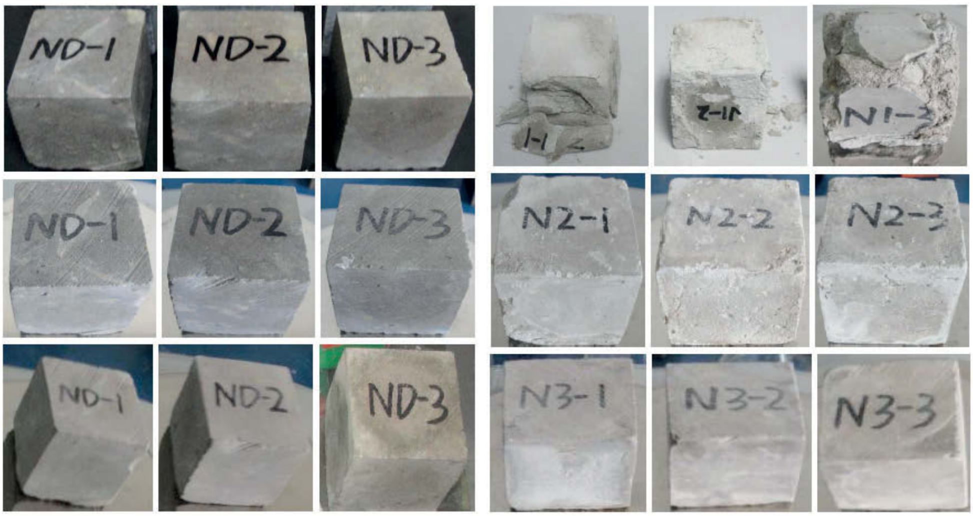

Fig. 2 Pictures of samples obtained from freeze-thawing tests and salt injury imitation tests

In freeze-thawing tests, wave velocities of samples declined with 4.8% in the direction perpendicular to bedding and 2.3% in the direction parallel to bedding. Final, weights of samples were 98.7% of initial weights. Reason analysis: high porosity supplied space for freeze-thaw action so that the water freeze expansion and clay minerals imbibition led to pore destroy, correspondingly, the wave velocities and massive of samples declined. Wave velocities in the direction perpendicular to bedding declined about two times of direction parallel to bedding, which means directional joints developed.

In salt injury tests, samples in Na2SO4 solution destroyed after only 4 cycles as a result of expansibility produced by conversation of Na2SO4 transform into Na2SO4·10H2O, leading volume expansion ratio of 318% (Deng et al. 2009); Samples in Na2CO3 solution are with growth-steady trend in both wave velocities and weights as a result of smaller expansibility of conversation of Na2CO3 transform into Na2CO3·10H2O, which occurrence conditions are rigorous; Samples in KNO3 solution are with no significant damage expect partly exfoliation which corresponding to no water absorption of KNO3, so that the KNO3 were stored in pores of tuff rocks.

REINFORCEMENT MATERIALS SCREEN AND EFFECT

Xu Mi foundation in Shuxiang temple with serious exfoliation was took as tests subject. Test acreage was 20×10cm for each material. Applied materials in Table 3 to the left side and left right side as blank control. 30 days later, reinforcement results were showed as followed.

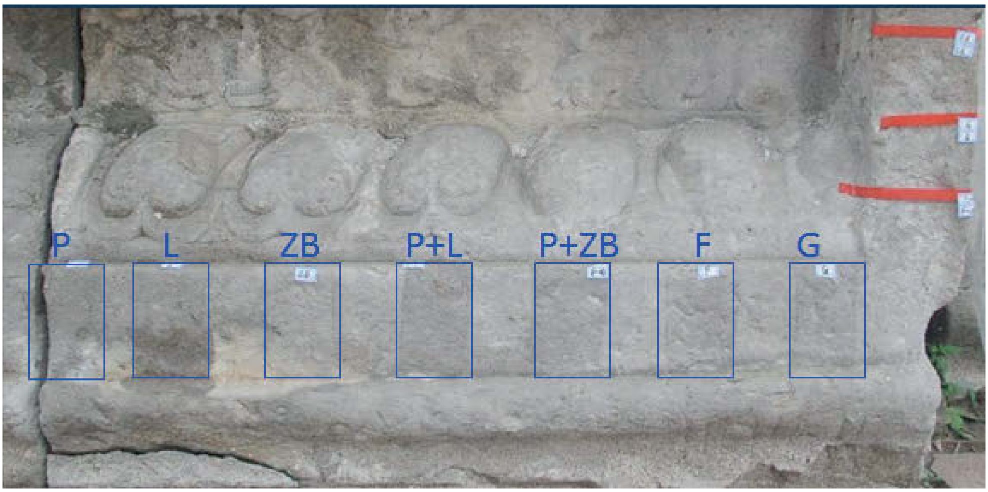

Fig. 3 Reinforcement results after 30 days by different weather proof materials

1. Areas brushed with PS and ZB showed shallow colors, which were similar to tuff rocks color; Areas brushed with L showed deep color; Areas brushed by F appeared with fluorescence; Areas brushed by G showed milk-white color. Comparatively, the color compatibility of materials was sorted as ZB, P, P+ZB, P+L, F, L, G.
2. Permeability was different from each material. PS solution showed strong permeability even in secondary brushing; ZB solution permeability were also considerable however it is lower than PS; with poor permeability of L solution, partial solution flew along the surface; F solution were translated to impermeable layer over tuff rocks.
3. Brushed rock surface with hairbrush when the surface was dried. Fine sand or salt drop were detected in areas brushing with L solution, however, smooth surface was observed in area brushing with F. Comparatively, the weatherproof capacity of materials was sorted as ZB, P, P+ZB, P+L, G, F, L.

All materials above showed their reinforcement potentiality in different aspects. According to the evaluation in combination property, ZB, P and P+ZB solution were suggested. However, specific circumstance of relics and material characteristic should be taken into consideration.

To assure grouting quality, high early strength and shrinkage as little as possible is required during grouting engineering. Slurry stone body is required to be combined with relic body. Accordingly, we conducted material selection tests in laboratory. The results indicated that the metakaolinite in Ginger nut improved early strength of slurry stone body, however, the shrinkage and porosity would be larger due to metakaolinite, as result, and we admixed concrete expansive agent (AEA) to prevent excessive shrinkage of slurry stone body.

Optimum proportion, with the mass ratio of hydraulic lime (Ginger nut): metakaolinite : quartz sand = 1:0.6:0.4, water-cement ratio as 0.6, concrete expansive agent ratio as 10%, were determined by laboratory tests according to the evaluation of fluidity, set time, age strength, shrinkage and porosity.

Fig. 4 Burner stone in Anyuan temple before and after repair

Fig. 5 Danbi stone in Anyuan temple before and after repair

CONCLUSION

According to field investigation results, typical diseases of tuff rocks in Chengde relics are lath-shaped cracks, exfoliations and crusts. According to microanalysis and deterioration, imitation tests results, deterioration mechanism of tuff rocks in Chengde are concluded as: I/S mixed-layer minerals in tuff rocks are easily to react with water or salt solution, which is also interpretation for directional cracks. Besides, rhyolitic structure and micro joints in tuff rocks can be taken as explanation for lath-shaped cracks. Meanwhile, moisture and expansive salt solution are favorable external conditions for deterioration. According to reinforcement materials selection tests results, ZB, P, P+ZB, P+L, G, F and L shows certain reinforcement effect even if with different reinforcement performance. Generally, ZB, P and P+ZB comprehensive performances are better than L. Optimum proportion of grouting materials were obtained as quartz sand = 1:0.6:0.4, water-cement ratio as 0.6, concrete expansive agent ratio as 10%.

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THE STONE MATERIALS IN THE CULTURAL HERITAGE: CAUSES OF DECAY AND ITALIAN EXAMPLES

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Stones are natural materials that man has always used for the realization of monuments, selecting them in function of various characteristics as availability, workability, chromatic aspect. However, the durability of the stone materials, frequently in antithesis with their workability, it is not always considered. A rock is a mono or poly-mineral aggregate formed naturally with long and complex processes which result in the lithification. After its formation, it undergoes further transformations that are part of the so-called geochemical cycle. As a matter of fact, each stone is in equilibrium with the environment in which it is located. If the environmental parameters change in time, this causes a loss of the equilibrium and the need of adaptation.

This happens when a rock goes from burial (high temperature and high pressure) to subaerial conditions (low temperature, atmospheric pressure and circulating fluids with different chemical composition). This adaption is the rock weathering, and it is due to both intrinsic properties of the rock (mineralogical and chemical composition, structure and texture, physical/technical characteristics), and external environment in which it is inserted.

The transformations determine, through physical and chemical phenomena, a partial or complete change of the compositional and structural characteristics of the rock. The development of these two phenomena is related to the climatic environment: in cold and arid regions, weathering is almost exclusively physical, in humid hot regions is maximum the chemical weathering, in temperate climates, the two processes are mixed.

Physical weathering leads to a division of rocks into fragments, more or less large, without any change in the chemistry. We have *thermoclastism phenomena*, due to thermal shock from exposure to sunlight, and *frost weathering*, due to freeze-thaw cycles. The mineralogical composition of the rock, grain and structure influence this weathering (Winkler 1975).

Temperature changes cause expansion and contraction phenomena. Since the coefficient of thermal expansion of minerals is a vector property, an increase in temperature causes, in different crystalline species and for the same mineral, differential expansion in different directions. In a poly-mineral rock, without preferred orientation of minerals, i.e a granite, stresses for expansions among minerals having opposite orientations, can happen. The mechanical disintegration, always connected with expansion and contraction phenomena, is also developed in mono-mineral rocks as calcitic marble.

Calcite is the only mineral that upon heating expands in one direction while contracting in the others; and, upon cooling it will contract along the *c* axis while expanding along the other ones. Therefore, calcite marbles are the most susceptible to thermal cycling that leads to granular decohesion of the stone matrix, i.e., the so called "sugaring" (or *marmo* cotto) deterioration pattern that has been long known. This is mostly the result of the thermal stress induced along grain boundaries that leads to their failure and even to grain fissuring. Grain size, grain shape and lattice preferred orientation in the marbles are the main internal parameters to be considered as responsible of this phenomenon (Cantisani et al. 2009).

Generally, the final effect of physical weathering is always an increase in the porosity which corresponds to an increase of specific surface area, and this promotes a possible subsequent chemical weathering of the rock.

Often physical weathering is not uniform, for example in presence of oriented textures due to elongated (amphiboles etc.) or planar (micas) minerals, with consequent flaking and exfoliation. Exfoliation can be observed also in rocks with homogeneous texture like granites and it can be explained because rocks are poor conductors of heat, therefore the surfaces heat up much more than the underlying layers: this way internal shear stresses are generated that, repeated over time and accentuated by sudden cooling as during storms, determine the exfoliation.

Frost weathering is caused by the increase in volume of water, present in the porosity, in the passage to solid form (ice). This creates, on the wall of the pores, high pressures that can break the rocks due to the low tensile shear strength resistance of these materials. This weathering phenomenon is very efficient in presence of frequent transitions between the liquid-solid states and it is controlled by several factors as porous structure and its degree of water saturation, speed and duration of cooling. Physical weathering is due, also, to salt crystallization when fluids circulating in the porosity are rich in salts and the supersaturation is reached. As a matter of fact repeated cycles of salt crystallization cause high pressures on the wall of the pores, and the rocks will be broken.

Chemical weathering occur via two processes: full dissolution of a mineral in a solvent, and solubilisation of some elements with formation of new minerals and an insoluble residue (hydrolysis of silicates). The first process involves in particular calcite (CaCO3), mineral often found in the rocks used for construction of monumental building both as a principal component (limestone, calcite marbles) and like cement of sandstone.

Dissolution processes are favoured by the presence of carbon dioxide dissolved in the rainwater. A calcium bicarbonate solution is created, from which, by evaporation or CO2 loss, the carbonate can precipitate. Even dolomite undergoes this type of attack while for the silicates the solubility in water is negligible. The hydrolysis is a more complex process and concerns in particular the silicate minerals. The phenomenon can be divided into three phases:

- breakage of the primary minerals structure and consequent release of various cations (Na^+, K^+, $Ca2^+$, Mg^{2+}) and silica (SiO2);
- removal in solution of a part of these constituents;
- recombination of the residue with components of the atmosphere to form new stable minerals in the new environmental conditions, as clay minerals, Fe and Al hydroxides.

In general there is a reduction of Ca^{2+}, Na^+, Mg^{2+}, K^+ and a relative increase of Al, Fe, Si, and H2O.

The speed of attack of silicates is different. Usually, minerals that crystallize first from a silicate melt (pyroxenes, plagioclase calcium, biotite) are more hydrolysable compared to those of the final crystallization stages (sodic plagioclase, K feldspar, muscovite, quartz). Anyway, the attack of aqueous solutions is progressive and marked by the formation of a series of secondary minerals depending on the starting mineral and different environmental conditions. In general, therefore, the dark rocks rich of pyroxenes, biotite, amphiboles suffer a higher weathering than light rocks (rich in K feldspar and quartz) (Winkler 1975).

The weathering history of a stone material used in buildings/statues begins from its extraction in the quarry. In fact, with this operation the latent tensions present in the stone material are released with subsequent cracking and the action of the tools used in the processing of stone causes micro surface cracks that will favour the action of agents responsible for the decay (Lorenzini, Tabasso 1986).

After the laying, the decay proceeds with the chemical and chemical-physical processes previously described, but two facts should be considered:

- the changing of environmental conditions of the last century due to presence in the atmosphere of compounds derived from the combustion of coal and hydrocarbons;
- the incorrect laying of the block or slab.

These two factors can lead to the onset of new decay phenomena. Considering the second point, for example a rock with well-defined oriented texture (plans of sedimentation, schistosity) placed with the planes parallel to compression stresses to which it will be subjected will suffer higher decay. Another example is the coupling between different stones with lack of appropriate expansion joints, or between stones and materials not chemically stable such as plaster, cement, iron pins.

The knowledge of weathering of rocks, so far briefly exposed, is of particular importance when it is transferred to the materials constituting a work of art, since it will help to direct the restoration actions to slow these phenomena. As a matter of fact any effort to slow down the decay process, will determine a response and this response should be foresee in order not to cause, in medium to long-term, higher damage than that we wanted to avoid or slow down.

The stone materials mostly used in Italian architecture will be briefly described regarding their genesis, composition, structure and especially the decay processes. They are sandstones, carbonate, magmatic and metamorphic rocks. The sandstones are formed through a process of diagenesis of sediments accumulated in both marine and lacustrine basins. These rocks are extremely variable in composition and texture depending on their geological history. They usually consist of rocks fragments and minerals held together by a clay mineral matrix and/or a cement that is generally calcitic and, more rarely, in Italy, siliceous. Sandstones consist of layers that often present a laminated texture (laminations) that can be both parallel and convoluted. The texture of these rocks, as well as more specifically the physical characteristics such as porosity (size, distribution, shape), water absorption coefficient and saturation index, are perhaps the most significant parameters as regards the decay processes that may affect them.

The main cause of the sandstones decay is the presence of water that through chemical-physical mechanisms, favours the loss of cohesion among the grains. In particular, water causes the leaching of the clay matrix, dissolution of the carbonate cement, tensions generated by the absorption in the clay minerals lattice. These stones are poorly durable also for the presence of structural discontinuities from which the decay process start (Fratini et al. 2014).

The decay phenomena appear in all their magnitude almost suddenly: in the early stages the exposed surface develops a sort of coherent portion about 1 cm thick below which the material is less coherent. Finally, when the substrate is no longer able to support the exposed layer, this one falls and produces another superficial coherent portion in a continuous cycle (Fig. 1).

Fig. 1 Exfoliation phenomena in a column of Pietra Serena Sandstone

The carbonatic rocks are made at least of 50% of calcite/dolomite. These rocks have a wide range of lithofacies determined by structural, chemical and mineralogical characteristics of the original sediments, and by various modifications incurred during the lithification process. Consequently, the weathering is extremely different. For example in a nodular limestone the weathering occurs around the nodules which are detached almost intact. While, in compact micritic limestones the decay phenomena will be slow and continuous with a consumption of the exposed surface that can be differentiated in zones corresponding to variations of the structure/texture, or zones more exposed to leaching. Again, the organogenic limestones often show alveolar decay phenomena (Fig. 2).

Fig. 2 Alveolar weathering phenomena on a Pietra di Lecce limestone gate

On the contrary, travertine, widely used in many Italian regions shows a very good durability (Fig. 3). This can be explained by two reasons: first the high porosity characterized by rather large pores which do not retain water, second its formation in subaerial conditions, therefore quite similar to the exposure condition of a monument.

Fig. 3 Good conditions of a travertine hold water hole

A separate discussion must be made for the marble, a material that is among the most used in sculpture. With the term "marble" many rocks are often classified independently of their nature and origin. Therefore it is important to give a petrographic classification: marble is a rock resulting from the transformation of a carbonate rock through metamorphic processes of recrystallization in the solid state with mineral reactions and mobilization of chemical elements. The metamorphic transformations occur at variable depths within the earth's crust via structural and paragenetic adaptation of the rock to new temperature and pressure conditions which are intermediate between those of diagenesis and magmatism.

The crystalloblastic structure and the crystal size, depend on the degree of metamorphism. The pure marble, usually made of only calcite, has a white uniform colour. Impurities present in the original limestone or induced by the circulating solutions, make the marble coloured, veined or speckled. For example, the gray-green veins of *Cipollino* are due to the presence of mica. The dark gray coloration of *Bardiglio* is due to the presence of graphitic and carbonaceous impurities. The "Siena yellow marble", owes its colour to diffused iron hydroxides.

As previously reported, even for the marble, the deterioration process begin during the extraction in the quarry. The following sculpting phase determines a further stress. To be noted, in this regard, that in an artwork the most sculptured parts are usually the most decayed. The damage is manifested by an increase of porosity, saturation index and mechanical characteristics of the surface and by the presence of micro-fractures both inter and intra granular.

Previously, we have discussed about the physical and chemical weathering of marble but not about the action of atmospheric pollutants. Currently, the meteoric water is not only acid for the presence of carbon dioxide, but also for the presence of sulphur and nitrogen compounds. In particular, the sulphur compounds are the most aggressive since the sulphuric anhydride combines with water to give sulphuric acid that easily reacts with the calcium carbonate to give gypsum. This is accompanied by a cyclical action of crystallization and dissolution of gypsum which can lead to a structural deterioration of the marble. Gypsum deposits are particularly evident in areas not washed away by the water where they form the so-called black crusts (Fig. 4).

The black crust contribute to the decay in two ways:

- hindering the normal exchange of fluid between the material and the outside, trapping at the crust-marble interface the pollutants present in rainwater;

- their partial dissolution produces the infiltration of water rich in dissolved gypsum which causes tensions inside the marble.

Among the metamorphic rocks the serpentinite is particularly used in central Italy for the decoration of many façades of religious buildings. It is a rock derived from peridotite, a magmatic rock made of olivine and pyroxenes that, for hydrothermal processes occurring along the mid oceanic ranges are completely transformed in serpentine. This mineral, which has a phyllosilicate structure, is quite stable chemically at ambient conditions therefore the rock suffers essentially a physical decay due to its dark colour (Fig. 5).

Fig. 4 Black crust deposits on marble statue

Fig. 5 Weathering phenomena in a serpentinite column

Among the magmatic rocks, the trachytic and leucitic effusive rocks are widely used in Rome and Naples areas. These materials show low durability due to their considerable heterogeneity due to the presence of a large phenocrysts in a glassy groundmass. In particular, the weathering affects the groundmass and thus highlights the crystalline inclusions. The result is a pseudo-alveolar decay. This review of the main decay phenomenologies of lithotypes used in the Italian vernacular and monumental architecture points out that the decay is different not only for the main categories of rocks, but also for each single lithotype: it's necessary a careful petrographic and micro-climatic investigation in order to understand the observed decay phenomenologies, and to suggest appropriate interventions. However, we should remember that the weathering of a rock is an ineluctable phenomenon, because it is the chemical and physical adaptation of minerals and rocks to new environmental conditions, different from those where the rock was formed. The restoration of stone materials can only slow down these processes, reducing the contact with the main decay agents (water, air pollutants).

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DETECTION AND ANALYSIS ABOUT THE BLACK DEPOSITION ON THE SURFACE OF THE ROCK OF FANTIAN TEMPLE PILLARS

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INTRODUCTION

FanTian temple is located on the southeast phoenix mountain, Hangzhou city, Zhejiang province, and it was built by King Qian Hongti of Wuyue in the second year of Qiande, Song dynasty. The pillars of FanTian temple, formerly called Nanbota temple, stand next to the temple gate founded by King Qian Hongti of Wuyue. They have survived thousands of years on earth, known as the gems of Wuyue (Shao 2000). These twin pillars have identical shape and structure and are carved out of limestone. They stand 13 meters apart from each other, their height measures 14.99 meters on the south side and 14.87 meters on the north. There is a harmony of proportion in all parts of the octahedron which makes the FanTian temple pillars look fantastic (Fig. 1).

For more than a millennium, on the rock surface of the FanTian temple pillars have grown a large number of black incrusting substances, due to environmental conditions, which have seriously affected the pillars artistic value as stone cultural relics. Our aim was to find a sound scientific method to clean contaminants off the surface in order to bring back the pillars' original appearance and aesthetic feeling, and to investigate this deterioration process, of black deposition on the limestone surface, in order to protect them also in future.

Fig. 1 FanTian temple pillars

BLACK DEPOSITION AND ITS COMPOSITION ANALYSIS

The deposition is some kind of external substances that are the thick-black greater than 1 mm on the stone surface (Wang 2004). The pathogenesis of diseases can be the result of atmospheric dust and acid rain (Li 2011). The black incrustation on the surface of pillars that it is attached to the surface of the limestone tightly or loosely has a significant impact on the façade. The covered area by black deposit accounts around 20%-30% on the two pillars and it has a diversiform morphology on the surface of sculpture, but it hasn't impacted the original form. multilayer depositions crust like sandwich biscuit and there is a layer of deposition crust is rough on its surface just like so many stalactites which attach them to limestone's surface. The black deposition crust tend to gather together at someplace such as rock overhangs and carving where will not be washed out by the rain. What we know the crust has been severely affected aesthetic beauty instead of the intensity of squared stone (Figs. 2-3).

Fig. 2 Black deposition shell on the surface

Fig. 3 Black deposition shell on the surface of brackets

We have identified and analyzed the black deposition taken from different positions. Their major elements ingredient and proportions are shown in Table 1, and the main materials can be seen in Table 2.

Sample number	CaO	SO2	SiO2	Fe2O3	P2O5	Al2O3	K2O	TiO2
0691	48.89%	40.70%	4.24%	2.60%	1.80%	1.00%	0.43%	0.38%
0715	49.48%	38.56%	4.39%	2.78%	1.05%	0.82%	0.41%	
0933	49.92%	33.42%	6.74%	5.25%	1.41%	1.76%	0.64%	0.61%
0934	53.44%	38.77%	2.87%	2.09%	1.70%	0.52%	0.30%	0.31%

Table 1 the main elements of composition of the samples

Sample number	the main composition
0691	plaster （$CaSO_4.2H_2O$）、quartz （SiO_2）
0715	plaster （$CaSO_4.2H_2O$）、quartz （SiO_2）
0933	plaster （$CaSO_4.2H_2O$）、quartz （SiO_2）
0934	plaster （$CaSO_4.2H_2O$）、quartz （SiO_2）

Table 2 the main composition of the samples

We have come to a conclusion that their major elements of a couple of black crust samples are Ca elements and S elements, and the sum of other elements just as Si、Fe、P、Al、K、Ti have a 10% share approximately by means of an X-ray fluorescence analysis. The result of XRD tells us the compositions of these black deposition samples are all $CaSO_4.2H_2O$, and it also contains a small quantity of quartz which may be come from the outside dust or limestone residual quartz.

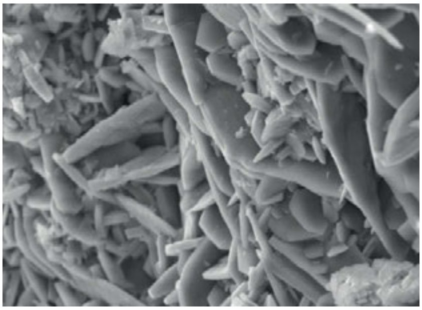

Fig. 4 Plate-like gypsum crystals on the surface of multi-layer deposition of shell

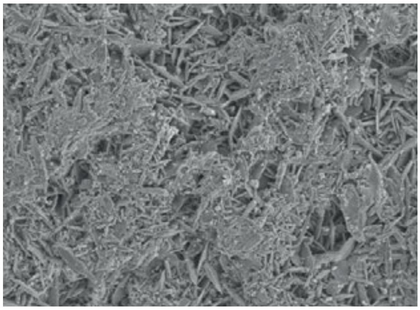

Fig. 5 Plate-like gypsum crystals on the surface of membrane-layer deposition of shell

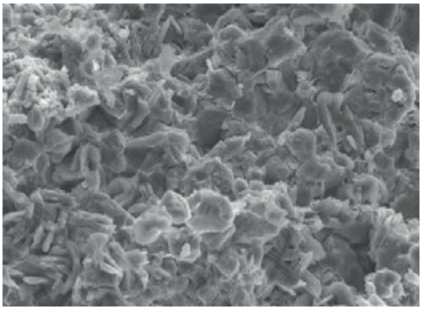

Fig. 6 Gypsum crystals on the surface of stalactite-like deposition of shell

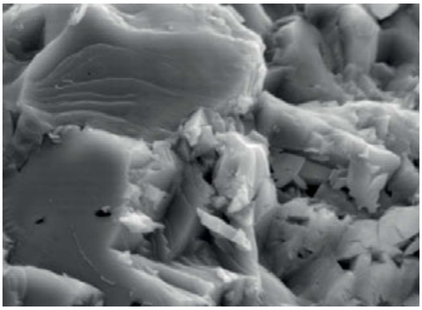

Fig. 7 Fragmentation and dissolution of calcite

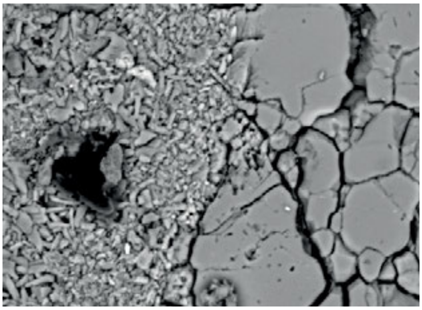

Fig. 8 Morphology of surface-layer deposition of shell

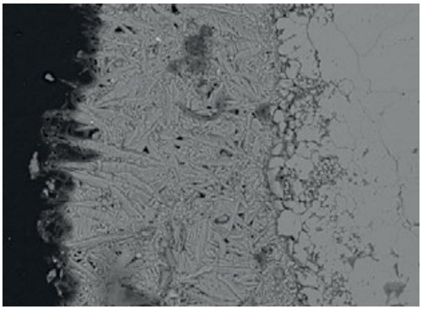

Fig. 9 Morphology of surface-layer deposition of shell

AN ANALYSIS OF MICRO MORPHOLOGY AND STRUCTURAL COMPONENT OF THE BLACK DEPOSITION

The main component of black deposition is plaster, but there is a great difference on their macroscopic morphology. We analyzed the samples of deposition by metallographic microscope and electronic scanner microscope in order to further study their formation.

Figures 4,5 and 6 shows surface morphology of gypsum and the conclusion is that gypsum crystallization of multilayer and membranous deposition of crust is still in a good condition, and an amount of plate-type crystal is around 10 microns in size, Macroscopically, it shows that the deposition of shell is smooth. However, stalactite deposition of shell is coarse on a macro-scale and gypsum crystallization is not complete in the micro. Figure 7 shows us that the calcite crystals were dissolved and transformed into gypsum, and the newly formed gypsum was irregular and did not form a complete crystal. Backscattered electron imaging between an interface of limestone and sedimentary shell can be seen in figures 8 and 9. According to figure 9 that there are not certain of big crystals on the surface of limestone, but a small gypsum crystallization which size is 20—30 micron.

As can be seen respectively from figures 10 and 11 sampling position of black sedimentary shell in the middle of the north pillar and sample microcosmic morphology. Table 3 shows each layer elements' component of the sample, the contents of S element reduce bit by bit from outside to inside, it follows from this that transform calcite into gypsum in the area (Fig. 15) where the deposition of shell is about 200-300 micron thick.

Based on the above analysis, we can confirm, the major ingredient of black deposition shell is gypsum ($CaSO4.2H2O$), and sulfuric acid is rooted in acid rain and $SO2$ coming from atmospheric environment and its contaminant respectively. The major composition of limestone is calcium carbonate which can react with other substances to form gypsum as a result of its pollution. The burning residues produced by oil, coal, etc. and dust emissions and other contaminants stemming from atmosphere gathered together on the surface of limestone which can form the black deposition shell by means of mix them with gypsum along with the process of reaction.

Fig. 10 Sampling site of crust samples

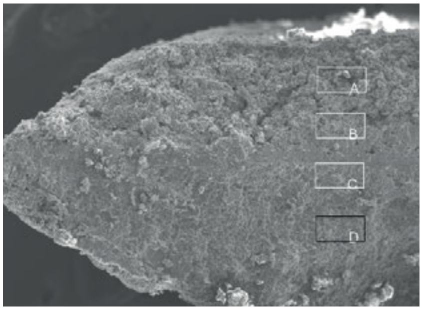

Fig. 11 Microstructure of limestone and deposits

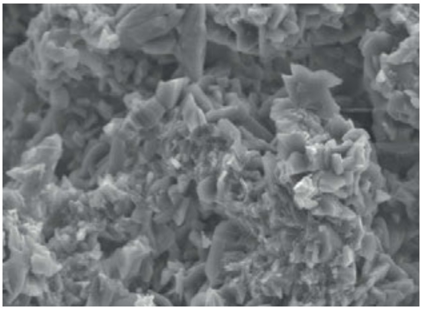

Fig. 12 A regional (outer of deposits)

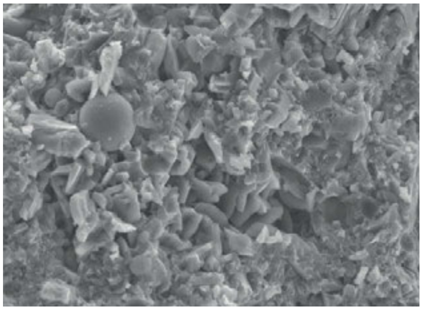

Fig. 13 B regional

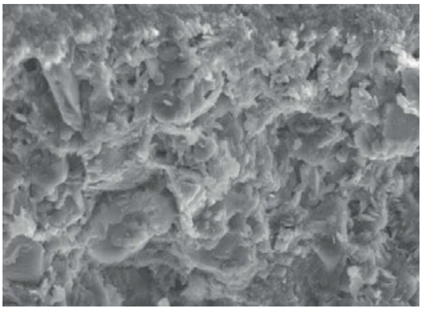

Fig. 14 C regional

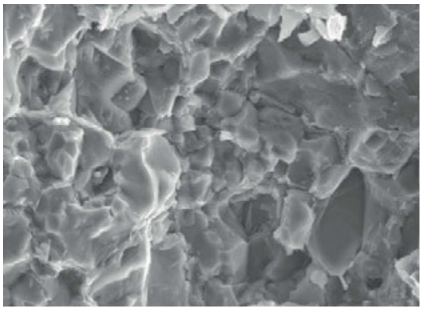

Fig. 15 D regional (inner of deposits)

CONCLUSIONS AND SUGGESTIONS

The major ingredient of black deposition shell is gypsum ($CaSO_4.2H_2O$) on the rock surface of FanTian temple pillars, including the sulfuric acid is rooted in acid rain coming from atmospheric environment and the contaminant SO_2 existing in the atmosphere, the dust emissions and other pollutions stemming from atmosphere gathered together gradually on the surface of limestone which has greatly facilitated a formation of the black sedimentary shell by means of mix them with gypsum.

As the protection of cultural relics is a long term process, we should take various measures and apparatus to monitor the FanTian temple pillars step by step. So we further suggest that there will be a research on FanTian temple pillars's meteorological environment (wind direction, sunshine, rainfall, temperature, humidity, contamination,etc.) and its deformation as early as possible.

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SUSTAINABLE DIAGNOSTIC METHODS FOR IMMOVABLE CULTURAL HERITAGE

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INTRODUCTION

At the present time, cultural heritage is subjected to the effects of environmental degradation and climate change, of socio-economic pressures and the accelerated pace of urbanization, of global tourism and, not least, to the mere passage of time itself. Therefore, the conservation of cultural heritage is a necessity which is not only cultural but it also reflects social and economic aspects of an area. The object of conservation is to manage change in a way that sustains and enhances the significance of cultural heritage. Therefore, based on the concept of "sustainable development" which suggests that economic growth can and must be compatible with better management of the earth's resources for future generations, also the conservation of cultural heritage must always adopt a sustainable approach to the problem and consider not only a cultural criteria, but also the environmental, urbanistic, economic and social factors (Chapuis 2009). In particular, in this paper it is possible to point out how a sustainable diagnostic method to develop a conservation plan can be used on large scale for the immovable cultural heritage.

The condition survey of structures and materials is the first step in the process of developing plans for preventive conservation, maintenance and immediate repairs and for further measures or studies needed to keep the built cultural heritage in a stable and well maintained condition (EN 16096:2012). In fact, maintenance is considered the best way to slow down the inevitable decay of monuments and historical buildings. The basic idea is to sustain minimum preventive measures and simple repairs rather than expensive and invasive restorations, as the minimum measures can be justified both for cultural and economic reasons. In order to plan the necessary maintenance and limit restoration measures, it is necessary to carry out periodic inspections and controls to monitor cultural heritage state of conservation and allowing also the assessment of the first relevant symptoms of decay. Therefore, in order to develop a conservation plan, which can be either for maintenance or restoration, it is necessary to know very well the materials that constitute the objects (EN 15898:2012) so to carry out a diagnosis and identify problems in cultural heritage conservation.

Hence the following points need to be addressed:

- Historical investigation and understanding of the meaning of the object from the point of view of both the cultural identity and the potential tourism development.
- Diagnostics of the structures and surfaces (materials involved and their state of conservation).
- Study of the causes of decay, gathering all environmental factors connected to these.
- Monitoring the deterioration speed through large-scale drawings and the examination of test selected areas identified as the most damaged.
- Choice of intervention: maintenance and/or invasive intervention.

To carry out these surveys are commonly used very advanced scientific techniques as reported in many publications, however, these techniques are expensive and their use cannot be easily applicable on a large scale. Satisfactory results can be obtained also using simpler and cheaper techniques which provide a sustainable diagnostic method but these require experienced personnel in the field of cultural heritage. In this paper are shown some sustainable techniques in order to study the extensive surfaces of built cultural heritage, in particular consisting of inorganic porous materials.

DIAGNOSTIC TECHNIQUES FOR THE MATERIAL CHARACTERIZATION

A macroscopic identification of inorganic porous materials can be performed by a visual observation and by the mapping of their distribution on surfaces. This identification can be carried out through a combination of petrographic, architectural, historic and cultural knowledge of the built cultural heritage. In this survey, it is also important to consider the previous conservative treatments and the historical uses that built heritage had. For example, in the case of the ancient Servian Wall of Rome (Barbera et al. 2008), historical knowledge together with the scientific expertise and conservation of porous inorganic materials has resulted in reducing the number of investigations in these stone materials (Fig. 1).

Fig. 1 Visible remains of the Servian Wall (IV Century B.C.) in Rome

In many cases, the results require further studies through scientific investigations that can be destructive or non-destructive. There are few non-destructive but sustainable techniques that can make a contribution to the identification of materials and their distribution. Most of the non-destructive scientific investigations require portable instruments often very expensive and the results are not always sufficient to characterize the material as regards the mineralogical composition, the microstructure and the porosimetric distribution. Therefore, in most cases it is necessary to proceed with an operation of sampling. The sampling plan is a very delicate operation because samples have to be taken in a limited number, but representative of the different materials and decay (EN 16085:2012).

The most useful and sustainable investigation for the study of such samples is the observation by optical microscope of thin and polished sections of materials. The mineralogical characterization of the material, its microstructure and important information on its porosity and pore distribution, can be obtained from these observations. It is also possible to investigate the stratigraphy of these samples with a petrographic microscope in order to identify materials that constitute the different layers. These qualitative results can provide more quantitative results if processed through image analysis. The optical microscope can also be used for the examination of inorganic pigments present on surfaces through the study of few grains of material.

DIAGNOSTIC TECHNIQUES FOR THE DECAY CHARACTERIZATION

The first step to assess the damage is the macroscopic identification of the alteration and degradation phenomena by visual observation and the mapping of their distribution on the surface of immovable cultural heritage. This stage is crucial on one hand for monitoring the state of conservation, on the other for evaluating the necessary interventions. Water and salts are two of the major degradation agents of stone materials, so investigative techniques are needed to detect them. For example, the analysis of the amount of water can be carried out by sophisticated and non-destructively technologies like portable NMR but also by cheaper and faster techniques such as infrared thermography or techniques based on the dielectric spectroscopy (Di Tullio et al. 2010). Each of these techniques gives different results. In particular, the infrared camera is used to investigate the distribution of water, but may be restricted in the use in underground or indoor environments unless using more sophisticated models.

This method, however, strongly depends on weather conditions since it requires the presence of sunlight or an increase in air temperature, it cannot be used, then, when it is overcast or raining. In Servian Wall case study the infrared camera was used to investigate the change of surface distribution of water and to estimate the sensitivity of the stone to future deterioration (Fig. 2). The moisture analysis can be also performed by a simple gravimetric testing of solid cores obtained by drilling, however, in this case the analysis is destructive.

Fig. 2 Infrared thermography applied on the Servian Wall in Rome

The analysis of the soluble salts can be carried out through ion chromatography, using simple portable instruments based on the dielectric spectrometry (EFD) or by a kit for tests on soluble salts. This latter method gives only semi-quantitative results but sufficient for the preliminary needs. The ion chromatograph is the most appropriate tool to achieve a qualitative and quantitative salts characterization, however, one must consider the availability of this tool, its cost of maintenance and use. Instead, a fast response can be obtained by semi-quantitative analysis, using a test kit, in most cases the level of this response is more than sufficient to meet our needs.

The knowledge of the environmental characteristics (temperatures, humidity, variation of solar irradiation due to the seasonal changes, wind, pollutants) is very important to understand the causes of degradation and in order to plan preventive maintenance. All these data can be found at the regional/local institutions for Health and Environment or through the use of cheaper instruments such as special sensors placed on site.

In order to characterize the state of the decay of the surfaces are also very useful the observations of stone samples under the stereo microscope and petrographic microscope. In particular, one can detect the presence and distribution of the micro cracks and others materials with respect to the constituent material, as black crusts, salts, etc. can be observed. In Fig. 3, you can identify the nature of the stone material and the degradation phenomena. Furthermore, sufficient information can be obtained with an optical microscope equipped with light sources for fluorescence on the nature of biodeteriogens possibly present and their distribution within the material.

Fig. 3 Thin cross section of stone specimen: marble affected by sugaring, superficial carbonaceous particles and micro cracks

DIAGNOSTIC TECHNIQUES FOR THE CHOICE AND EVALUATION OF THE INTERVENTION

Different test methods can be used to choose and evaluate the surface treatment of porous inorganic materials. Most of these tests are covered by the standards (CEN TC/346) because is essential to acquire a common unified scientific approach to the problems and, for the choice of the method of intervention is generally required a preliminary experimentation in the laboratory on specimens (EN 16581: 2015).

The final evaluation of the treatments and their durability can be performed on site through some tests. Contact sponge and Karsten tube methods are the most important non-destructive techniques that allow *in situ* measurements of the water absorption of porous stones (UNI 11432:2011, EN 16302:2013). They are useful for monitoring the change of surfaces behavior as a result of conservative treatment (cleaning, application of water repellents or consolidation treatments). The contact sponge method compared with the water absorption by capillarity (UNI 10859:2000) has the advantage that it is non-destructive, easy to use, portable, and can be used in monitoring programs with very low costs.

In Servian Wall case study the contact sponge was used to investigate the amount of the water absorption of materials before and after the application of consolidating products and during the time (Fig. 4). Even the colorimetric measurements of stone surfaces before and after any treatment allow the evaluation of the intervention (EN 15886:2010). In addition, the method is fast and non-destructive.

Fig. 4 Contact sponge test: on site analysis for investigating the amount of water in different areas and the change of water surface distribution after the application of consolidating products on Servian Wall in Rome

The drilling resistance of materials measured by DRMS (Fratini et al. 2006) and the surface resistance of the material obtained by peeling test (Drdácký et al. 2012) are two other non-invasive or micro-invasive methods usable on site for detecting mechanical properties of the surfaces of stone materials and to verify the effectiveness of the consolidation treatments during the time and to select the quarry materials suitable for substitutions. For example, in Servian Wall case study measurements of drilling resistance (Bandini et al. 2013) are used to verify the effectiveness of the consolidation treatments during the time (Fig. 5).

Fig. 5 Drilling resistance measured by DRMS: on site analysis on areas with different consolidation treatments on the Servian Wall in Rome

CONCLUSIONS

In the case of very large built heritage, the use of economical and simple techniques allows for a greater number of diagnostic tests that can be very helpful to choose a restoration plan and to secure the conservation of a greater number of cultural heritage. This action together with the regular condition surveys, preventive conservation and maintenance can be considered a sustainable approach for the conservation of cultural heritage (EN 16096:2012).

A multidisciplinary approach involving technical and scientific staff (conservation scientists, chemists, geologists, biologists, engineers, physicists, etc.) and historians, archaeologists, architects and curators, however, is essential in order to achieve these objectives. Qualified personnel with a minimum of laboratory equipment and economic portable instrumentation can provide a large part of the necessary responses to a satisfactory diagnostic, even in extreme logistic conditions.

Obviously, the use of new and innovative techniques remains crucial to solve particular problems or if the sampling is not possible due to the specific status of the cultural heritage, furthermore these techniques could become more sustainable in the future so that they may be applicable on a large scale.

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THE CONSERVATION AND 3D VIRTUAL RESTORATION ON THE THOUSANDS HANDS BODHISATTVA OF DAZU ROCK CARVINGS WORLD HERITAGE

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INTRODUCTION

Relics are taken as the invaluable resource, it should be conducted carefully for the relic restoration. There are some basic international rules to which specialists should obey, such as minimum intervention, reversibility and so on. Therefore, it is meaningful to do virtual restoration before the actual one. However, most of relics have an irregular shape and composite color, thus it is difficult to realize the vivid effect. The 3D laser scanning is a new advanced technique both in the region of survey and information in recent years. Because of the advantages in safety, accuracy and efficiency and it has been widely used and played an important role in the conservation of relics. It also takes a new chance for the virtual restoration on relics.

After eight years of unremitting efforts, the conservation project on Dazu Thousand-hand Bodhisattva Statue, which is known as Project One of the National Stone Cultural Relic Conservation, was successfully completed. After the last restoration, Dazu Thousand-hand Bodhisattva Statue reappeared with its past glory and accessed to the public with a resplendent and magnificent decoration (Fig. 1).

Fig. 1 Ortho-photo map of the Dazu Thousand-hand Bodhisattva Statue

The Thousand-hand Bodhisattva in Dazu Rock Carvings was first excavated in Southern Song Dynasty. It is 7.7 meters tall and 10.9 meters wide with a history of over 800 years (Wu, Hou, Wu 2011). It is the largest cliff inscription realized through a variety of techniques, such as carving, painting, gilding and so on. The shape looks like a peacock spreading its tail. This has become an important representative work in Dazu Rock Carvings. It is mainly made of hands, eyes, musical instruments and etc. According to the survey in 2002, the arms of Dazu Thousand-hand Bodhisattva Statue were 830 in total, of which 599 hands were kept relatively well.

However, with the change of the situation at that time, though it was well kept and remained its grand vigor overall, the statue stood in a bad state of conservation due to natural and human factors. Such as rock spalling, finger fracture, color fading, gold crimping, delamination and so on, especially gold weathering off, which not only seriously damaged the image - both from the aesthetic point of view that the artistic value aesthetic - but endangered the preservation of the Statue (Fig. 2) (Hou, Li, Jiang et al. 2016). Moreover, that was one of the reasons why the project of rescuing Thousand-hand Bodhisattva had attracted so much attention, being listed as Project One of the National Stone Cultural Relic Conservation by the State Administration of Cultural Heritage in China.

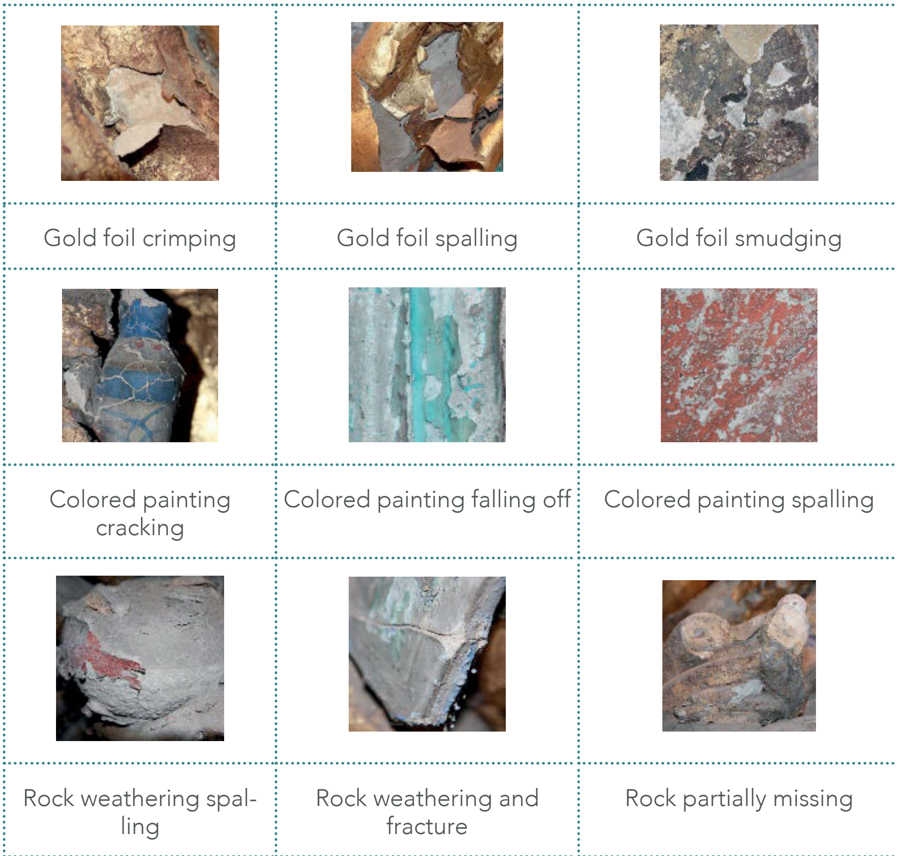


Fig. 2 Typical damages of Dazu Thousand-hand Bodhisattva Statue display

REQUIREMENTS OF CONSERVATION AND RESTORATION

The project of rescuing Dazu Thousand-hand Bodhisattva was of great difficulties to be carried out. This project showed mainly the following several characteristics:

1. High research value Value cognition and analysis, which are the motive and the first step of heritage conservation, are of great concern to the promotion of fellow-up work. People will not care about things lacking, but things of great value can inspire people's desire for protection. As representative work of World Heritage Sites and Buddhist grottoes, the artistic, historical, social, religious and traditional technology research value of Dazu Thousand-hand Bodhisattva Statue should be paid attention to.

2. Large scale With a total area of 88 square meters, Dazu Thousand-hand Bodhisattva Statue can be the largest existing Thousand-hand Bodhisattva Statue in the world.
3. Multi-process involved in the Statue caving As the largest cliff inscription that integrated with carving, painting and gilding, techniques applied in the design of Dazu Thousand-hand Bodhisattva Statue were diverse. Study on these traditional technologies can not only be beneficial to the Statue restoration, but offer constructive reference for other heritage conservation.
4. Badly damaged According to the result of preliminary investigation in 2008, the Thousand-hand Bodhisattva Statue had suffered 34 types of damages (Zhan, Xu 2015).
5. Research and restoration needed to be carried out at the same time Each case of heritage restoration is a unique case. Therefore, in dealing with a specific case, it will be necessary to make a comprehensive analysis of value constitution, preserving environment and current conservation status. In view of these specific circumstances, flexible use of universal conservation theory could also be needful. What was worse, pluralism of carving technics, complexity of damages and a lack of similar restoration experience could increase the difficulty of engineering operations, which made it an exploratory research work. In turn, this required that this project should not be in haste, and it is indispensable to carry out technical study simultaneously at the same time of in-situ restoration to joint "action" tightly with "thinking" (Zhang, Xu, Zhang 2014).

DATA ACQUISITION AND ANALYSIS

In consideration of principles above mentioned, the attention of this project should be focused as much as possible on saving historical information of the Statue to realize authenticity conservation of cultural relics. During this project, science and technology of sorts have been employed. Such as, uncovering the golden foil and pasting it back, fine and high precision 3D information recording with 3D laser scanner, complementing incomplete stone with salient spatial feature model of cultural relics based on high-level scene knowledge and so on. It is the most comprehensive and scientific restoration in history that it has reserved the finest information of the Statue and been the best reference for other heritage protection of the same type.

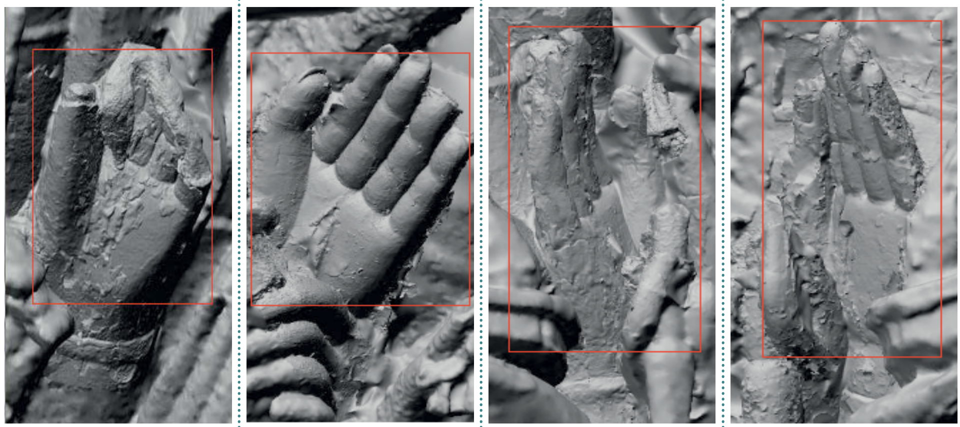
3D information retention, which is also called 3D digital retention, is a method of rapid access to object surface space coordinates. As 3D modeling technology develops, 3D information retention has become one of effective approaches to digital preservation of cultural relics. In the past few years, researchers have conducted extensive and in-depth research, and achieved many significant results. Especially with the appearance of 3D scanner, data acquisition of spatial 3D model has been developed by leaps and bounds. This project also realized the surveying and mapping and digital preservation of the Thousand-hand Bodhisattva with 3D laser scanning technique (Fig. 3). Between 2009 and 2010, the team utilized more than 5 kinds of 3D scanners with different functions to make surveying and mapping. The scanner would emit lasers, followed by computer's calculating its 3D shape. After obtaining the 3D data, the team completed 297 damage maps and 1,855 damage surveys by hand, providing favorable support for restoration work launching and future maintenance program design. This is a significant development of modern heritage conservation.

Fig. 3 In-site 3D information recording with 3D laser scanner

VIRTUAL RESTORATION

Before the adoption of the modern detection and monitoring equipment, the conservation and restoration status were collected only by naked eye or by sending the samples to laboratory, which would be difficult to carry out for technical constraints when it came to large non-movable cultural relics or intangible conservation environment. However, after the adoption of modern advance detection methods and equipment in the field of heritage conservation, restoration and maintenance operation are becoming more and more accurate and scientific. Such as, according to the demands of the Statue's conservation and restoration, the technical procedure of the virtual restoration has been designed, which includes five figures and one table (e.g. collation map, model diagram, construction drawing, section drawing, line drawing and expert feedback form), making non-quantified factors more and more specific and effectively analyzed.

Furthermore, Dazu Thousand-hand Bodhisattva Statue presents an obvious symmetry. According to the orthophoto images, the design laws of the Statue on the overall shape and structure have been discovered. Firstly, there were three lines that divided the whole Statue into four regions. Presumably, the three lines was used to label carving scale and assist the overall work distribution. Furthermore, with the Buddha in the middle as central axis and hands distributed on both sides, Taoist seal and holding instruments were mostly distributed symmetrically with central axis, though at a few places the left and right sides differed. Even if the carving techniques of each hand were different, it was easy to get the basic information through symmetric similarity, such as, performance theme, shape and so on. These layering and symmetric similarity characteristics could not only be beneficial to carving arrangement, but offer ideas and theory basis for modern conservation and restoration work. Therefore, for the damaged and missing parts of an artifact, it is essential to find the evidence for virtual restoration by analyzing the basic geometry of artifacts in the same period or type, so that the effect of virtual restoration can much more fit aesthetic needs of the artifact and be more close to its true historical appearance. Furthermore, many incomplete hands and instruments were just simply restored through the rules by the virtual restoration research team from Beijing University of Civil Engineering and Architecture (Fig. 4) (Hou, Yang, Hu et al. 2015).



ID 8-10-S12 hand	ID 7-9-S10 hand	ID 9-5-S5 hand	ID 9-7-S13 hand
Sample hand	Similar hands		

Fig. 4 Result pictures of research of similar hands (taking ID 8-10-S12 hand of Dazu Thousand-hand Bodhisattva Statue for example)

Additionally, combined use of various techniques and materials, which has broken many records in the heritage restoration history, makes it a pioneer of artifact restoration project. In total, the project used over 1 million pieces of golden foils and completed the restoration of 830 hands and 227 musical instruments. The area covered 222.15 square meters (Tang 2015), and it is the largest restoration projection on the Statue in history.

Accurate data records of the Statue before and after restoration were made with the modern technologies of high definition photography and 3D laser scanning. And it preserved intuitive and detailed information for the Statue. As an important operation of modern restoration, 3D information recording and documentation of cultural relics will be of great significance to the future restoration and research work. Additionally, project team also invited experts to carry out the research and testing of virtual restoration. That is, based on high-resolution images and accurate 3D model data, displaying restoration effects virtually in the computer using the latest development technology, such as computer graphics technology, virtual reality and so on. Virtual restoration provided an important reference for control of engineering restoration effect, and reduced the test time and unnecessary waste as well (Fig. 5).

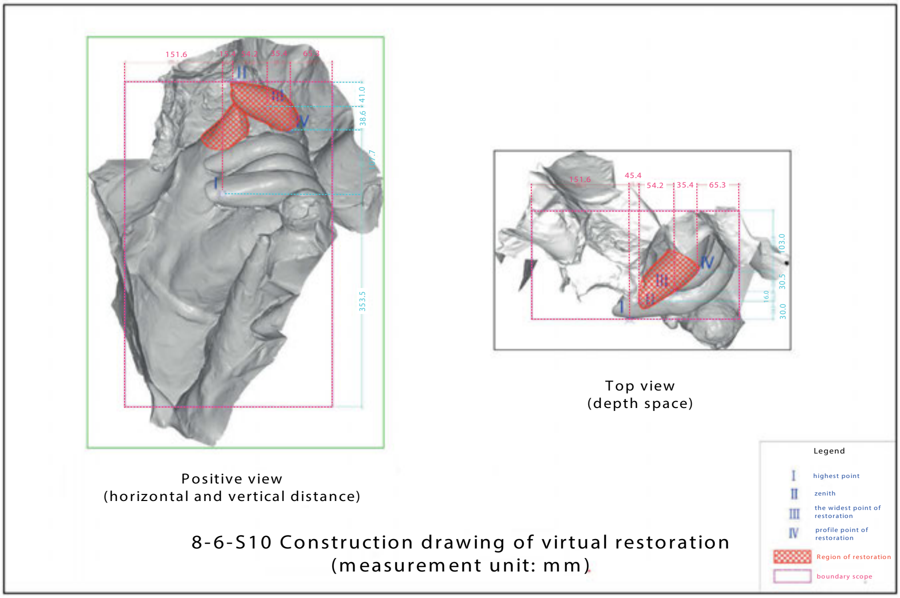


Fig. 5 8-6-S10 Construction drawing of virtual restoration for Dazu Thousand-Hand Bodhisattva Statue in China.

CONCLUSIONS

In the conservation project on Dazu Thousand-hand Bodhisattva Statue, the repair personnel conducted a selection of repair material with a scientific and cautious attitude. Scientific use of modern technical equipment and means provided more safe and effective technical support for conservation and restoration of the Statue. Integrating traditional and modern techniques in the same objective, which was a bold and innovative approach, has achieved good results so far.

The project was officially accomplished on June 13th, 2016. With the support from the State Administration of Cultural Heritage, project owner Dazu Rock Carvings Research Institute, together with the organizer Chinese Academy of Cultural Heritage, invited Dunhuang Academy China, China University of Geosciences Qsinghua University, Peking University, Beijing University of Civil Engineering and Architecture and Hehai University to put their heads together, and teamed with professional and efficient experts, drawing on collective wisdom and absorbing all useful ideas. The team prospected the damages and started its more than four years' protective restoration on April 18, 2011. Thanks to their hard work and outstanding performance, the Statue came into public with a brand new appearance again after 8 years of overhaul. However, just as Tong Mingkang, former deputy director of the State Administration of Cultural Heritage, stated on the completion ceremony that the end of the project was not the end of the protection work; instead, it was a new start. Department of Cultural Relics will keep monitoring and evaluating on the relic, continue observing the cause of the damage, the condition of the damage and take responsive protective measure to avoid further damages and try to remain the solemnity and beauty of the Thousand-hand Bodhisattva Statue for another 800 years.

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CONTROLLING OF BIODETERIOGENS BY USING MICROWAVE HEATING TREATMENTS

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INTRODUCTION

The chemical methods available for the disinfection of biological colonizations, that may induce progressive biodeterioration and associated damages, are widely used sometimes with detrimental effects on the environment. Chemical treatments include liquid biocides and fumigation with gases. The choice of an appropriate biocide is limited by the European Union's Biocidal Products Directive (BPD). This research activity is oriented to study microwave heating method as alternative to biocides, in order to avoid the drawbacks correlated with the toxicity which can pose risks to humans, animals and the environment. The localized and insured microwave heating treatments can be an effective alternative for controlling the biodeteriogens' development. In this paper will be described the results obtained by controlling biotic agents infesting wood artifacts (as insect) and growing on stone surfaces (as lichen, algae, cyanobacteria).

The control of biodeterioration on cultural heritage artifacts includes combatting the decay due to micro-organisms and organisms and delaying the re-colonization (Caneva 2009; Clair 2004). The application of biocide products, alone or in combination with protective or consolidating products, is common practice to prevent further colonization on the surfaces of works of art. Several studies have been carried out on the use of biocides and their combination with others products for controlling an infestation on wood and wooden based materials (Clausia 2011; Ackery 2004) and stone artefacts (La Russa 2010; La Russa 2014). Mixtures of consolidants or water-repellent products with biocides are effective in preventing biological growth on both substrates with low bioreceptivity such as plaster and substrates with high bioreceptivity such as stone but in both cases they can be dangerous for the environment (Pinna 2014).

MICROWAVE HEATING

Recently, the microwave heating (MWH) method has been proposed, becoming one of the physical methods to deactivate the biological growth on stone (Cuzman 2013; Riminesi 2016), together with UV (Van Der Molen 1980), gamma rays (Michaelsen 2013), laser cleaning (Siano 2012; Mascalchi 2015), freeze-drying, strong solar irradiation, and jets of hot water (Tretiach 2012; Pantazidou 1997). These physical methods are designed to replace or to work in combination with traditional methods. The use of microwave heating to control biotic agents was already applied in several fields, in particular in the agri-food industry for disinfestation of grain and other seeds from insects (Nelson 1996; Wang 2001; Burfoot 1998), and for sterilization of soil (Vadivambal 2007; Mavrogianopoulos 2000). The electromagnetic radiation, as well as microwave radiations, are able to heat only certain materials containing polar molecules with an electrical dipole moment (called "dipolar materials") through a mechanism that is quite different from the conventional transfer mechanism, which is why the microwave facilitates selective heating. Microwave heating is due to the molecular rotation in dipolar materials, where polar molecules continuously align themselves with the oscillating electromagnetic field. Rotating molecules push, pull, and collide with other molecules, distributing the energy to adjacent molecules in the material. Once distributed, this energy appears as heat.

The authors, in this paper, have studied the application of a localized microwave heating to treat the biotic agents which infest the wood artifacts and/or the surface of stone artifacts. The biodeterioration process is correlated with chemical and geological composition of the material itself, with the exposure to environmental factors (temperature, humidity, rain, wind, and solar irradiation), and with the frequency and quality of maintaining procedures applied. These factors affect the growth of biological organisms that can determine not only aesthetical alterations (e.g. colored patches, patinas, crusts) of the surface of stone material, but may also erode the material by both physical and/or chemical processes, leading to alteration of the material integrity. When the material is part of a structural element the consequences of the degradation can affect even the stability of the architecture, a fact particularly evident on the wood beams heavily infested by insects or caries.

The design requirements to disinfest wooden materials from woodworm and to limit biological growth on stone surfaces are quite different and, in first instance, they affect the geometry of the applicator with relation to the specific target. The two applications require different applicators. Firstly, disinfestation from woodworm, requires an applicator that deeply heats the material (up to 20 cm). Secondly, when treating biodeteriogens on the surfaces of stone artefacts (algae, fungi, lichens, cyanobacteria) the microwave energy must be concentrated in the initial millimeters. Our approach was assessed by laboratory tests and on site activities (Riminesi 2016).

MATERIAL AND METHODS

The control of biodeterioration on cultural heritage artefacts includes all the activities used to eliminate degradation/alteration forms induced by the biological activity of colonizers (microorganisms and/or macro-organisms), and, whenever possible, the necessary activities to be implemented to delay/avoid the recolonization.

The microwave heating approach has some important advantages over conventional techniques (chemical biocides and mechanical removal) and other physical methods (thermal radiation, UV, gamma rays, laser cleaning), such as: it respects the operator safety, it is environmentally friendly, and has a low-interaction with the substrate thanks to its selective action – with reference to the conventional techniques – treatment extension, color-independence, and penetration depth – with respect to other physical methods.

The evaluation of treatments efficiency against infesting agents of wood (xilophageous insects at different state, eggs, larvae and pupal) and on biological patinas growing on the surface of monumental stone will be described with relation to the characteristics of the microwave system as operative conditions: frequency, power, type the applicators respect to the material under treatment and the target temperature. The best ratio between time and temperature (dose) can be adjusted in accordance with the specific requirements of the biological agent/material to treat, in order to obtain the best performances of the microwave treatment. The efficiency of microwave treatments on stone against biological agent was also evaluated by classical and molecular techniques based on DGGE.

Localized MWH for deep treatments on wood and wooden materials

In a previous work (Bini 1997) has been demonstrated that it is possible to disinfest wooden materials from woodworm by MW heating. In a typical treatment, the infested object is exposed to microwave radiation to increase the woodworm temperature over 53-54°C for 1 minute, while maintaining the temperature of the wood at safe levels, usually no higher than 50°C. In order for the disinfestation to be effective, it needs to obtain a quite uniform distribution of electromagnetic energy density inside a defined "volume" of wood. If within the volume insects are present, they will be exposed to the lethal dose. The treated volume should be as deep as possible, for example up to about 10 cm in order to treat a timber structure of 20 cm in diameter. An efficient control of the heating conditions is ensured by knowing the electromagnetic characteristics of the material, such as permittivity and conductivity (Riminesi 2016).

The dependence of woodworm mortality on temperature (lethal dose) has been investigated by heating woodworms (in particular, *Oligomerus ptilinoides* Wollaston and *Hylotrupes bajulus* L.) in a thermostatic bath for a sufficient time to maintain them at a prescribed temperature for at least one minute. The mortality curve of *Oligomerus ptilinoides* is quite steep (Riminesi 2016), and shows that all the woodworm died above 53.5°C. The similarity between this curve and the curves relative to *Hylotrupes bajulus* L. suggests a temperature response that is practically identical for both families of insects.

The equipment for the microwave heating treatment consisted of a 2.45 GHz microwave generator, a radiative applicator and various ancillary tools to control the power emission with respect to the target temperature (Fig. 1). The applicator was made up of a section of a rectangular waveguide suitable for operating at 2.45GHz in order to satisfy the requirements of deep treatment. A section of waveguide is the simplest applicator for deep heating. Other applicators, e.g. horn antennas, do not conceptually differ from an open waveguide.

Localized MWH for biodeteriogens treatment on stone surfaces

A different approach is needed for treating infestations on surfaces, such as biological patina on stone or plaster. In these cases the heating should be limited to the initial layers where the biodeteriogens are deeply-rooted (in general up to several millimeters) (Riminesi 2016). In addition, the treating temperatures for lichens and fungi must be substantially higher (up to 65-70°C).

The treatment of biodeteriogens on the surface of stone artefacts, as well as lichens, algae, cyanobacteria and fungi, does not require deep heating. The treated volume should be limited to less than 1 cm in depth. These considerations suggest rather different design criteria from those employed for developing microwave applicators suitable for volume heating. The best choice is an applicator where the electromagnetic field is bound to the emitter, i.e. a reactive applicator. A reactive applicator operates in the evanescent field, rather than in radiating mode, and the penetration depth can be easily controlled by varying the geometrical size.

Fig. 1 Microwave heating treatment of woodworm disinfestation

The resonator can be simply schematized with a rectangular waveguide section, short-circuited at one side, and terminating on the shaped aperture (slot) on the other side. The geometry of the slot and size of the resonant cavity with respect to the electromagnetic field distribution inside the material can be calculated by numerical simulation software (Riminesi 2016).

In order to plan the microwave treatment of a biological organism it is necessary to assess the percentage of mortality for different doses (temperature/duration). This was achieved by heating the organisms of interest (lichens and fungi) in a thermal bath at different temperatures and time durations, followed by an analysis of the health status of the biodeteriogens. The first kind of analysis consisted in examining self and induced fluorescence of the thalli lichen. The results are available in Olmi, Bini, Cuzman et al. (2013). Another analysis was conducted using a PAM-2100 Portable Chlorophyll Fluorometer to examine the effectiveness of the photosynthetic system of the organism. Finally, also the molecular identification of fungi to the species level was used to assess the results of the on site treatment (Fig. 2).

Fig. 2 Microwave heating treatment of biodeteriogens growing on stone

CONCLUSIONS

A portable microwave system was tested to disinfest wood from insects and to deactivate biological patina on stone using an applicator. The development of an efficient disinfestation system using microwave heating requires a careful design of the applicator. The choice of applicator depends on the specific biodeteriogen agent and host material, thus information on the morphological and physiological characteristics, in particular the required time/temperature dose for their devitalization, and the characteristics of the substrata are essential.

The microwave test treatments were effective against all metamorphic stages of woodworm, while keeping the wood temperature below 50 °C ensured that there was no damage to the wood or to the surface of the painting. The device proved to be safe according to the most accepted safety recommendations and standards concerning radiated electromagnetic fields in the environment. For the disinfection of biological agents and progressive microbiological damage, the microwave heating is also comply with the restrictions introduced by the European Union's Biocidal Products Directive (BPD). We are now focused on the cumbersome study to discover eventual limitations related to the quick heating of the support. The quick heating in wood could induce several localized stress due to the temporary dehydration of the medium. Will be necessary monitoring the effects of the stress by laboratory tests performed on several specimen of wood. On stone the rapid heating could induce similar stress than in wood, if the moisture content is not negligible. In particular on marble, where the thermal dilatation coefficient is not isotropic, the rapid heating of the substrata may accelerate the granular disintegration phenomenon. Also in this case several tests are in progress in order to verify the appearance of the previous phenomenon after several cycles of microwave heating from environmental temperature up to target temperature (about 65-70 °C).

Others experimentation could be done combining microwave heating with chemical treatments in order to reduce the quantity of biocide necessary to treat biodeterigens and to reduce the health risk to humans, animals and the environment.

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THE CONSERVATOR'S RESPONSIBILITY VS THE VISITOR'S RIGHTS. A DISCUSSION ABOUT FACTORS DECIDING THE CONSERVATION AND RESTORATION EFFECT OF STONE CULTURAL RELIC

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INTRODUCTION

Following the social development and the advances in technology, especially the high availability of information today, the walls of professional fields are being broken by public inquiry and attention. As a public service, cultural heritage conservation has been a public concern.

Before we restorers do any operations on a relic, we never forget its significance in history, art, science, social development and culture, whether in terms of its wide connections with the other fields or its great influence on them. However, between professional recognition and questions and amateur praises and criticisms, which one is more important for the effect of the professional restoration? This is what the people engaged in conservation and restoration of cultural relics should think deeply about.

The effect of the seven-year restoration of the Thousand-Hand Avalokitesvara Bodhisattva of the Dazu Rock Carvings (hereinafter referred to as the Thousand-Hand Avalokitesvara Bodhisattva) has triggered hot disputes inside and outside the field. Discussion about factors influencing conservation and restoration effect should be helpful for us to review our technical behaviors at the same time to enhance the understanding of the public towards cultural relic conservation and restoration.

Fig. 1 The Dazu Thousand-hand Bodhisattva Statue before the restoration

Fig. 2 The Bodhisattva Statue after the restoration

EVALUATION OF CONSERVATION AND RESTORATION EFFECT

In practice, there are mainly two ways to evaluate the effect of cultural relic conservation and restoration: technical evaluation and people's evaluation. Technical evaluation refers to evaluation done through quantification based on scientific data, while people's evaluation refers to qualitative evaluation done through perception relying on subjective experience. These two kinds of evaluations are interrelated one to each other.

Currently, there is only one criterion concerning evaluation of stone cultural relic conservation and restoration effect in China, namely the *Methods for Evaluating Effect of Conserving Sandstone Cultural Relics with Anti-Weathering Materials*. The technical evaluation of cultural relic protection and restoration projects mainly includes a review of technical documents about the projects, which usually provides results of in-situ and laboratory tests, analysis, monitoring data, text, files, drawings, videos, models and records.

Expert evaluation is a main way for evaluating cultural relic conservation and restoration projects. Experts make professional evaluation based on the technical evaluation, on-site surveys, observations and rich experience.

Fig. 3 The Bodhisattva Statue before the restoration, detail

Currently, the technical evaluation system is still in need of further improvement, and there is also wide space for the improvement of the ways of expert evaluation. The restorers should attach great importance to the public comments on the effect of cultural relic restoration and keep in mind that we need to further enhance the communication with those outside our circle and, at the same time, to reflect on our restoration behaviors.

FACTORS DECIDING RESTORATION EFFECT

Usually, a stone cultural relic conservation and restoration project will consist of a series of processes, including survey and design, planning and review, restoration, and evaluation for acceptance. However, there is always a gap between the design objectives and the restoration results. To sum up, there are mainly the following factors:

1. Depth of survey and design. This covers all factors related to the earlier stage survey and design. The availability of integrated supporting facilities, the precision of surveys and the experiment results at the survey stage, all have influence on the design objectives. Usually, at the earlier survey and design stage, there is a relatively tight budget and schedule so that no scaffolding platforms as perfect as those built at the engineering stage will be built for some high and large-scale stone cultural relics during the disease and destruction surveys. Therefore, the sampling, disease and destruction surveys, in-situ tests and experiments will be affected due to the operation difficulties.

   A short design cycle will lead to insufficient time for experiments in materials and techniques. In addition, in-situ tests at the design stage are usually carried out in relatively small and secluded areas so that the test results do not have sufficient significance as reference for evaluating the overall restoration effect.

   The result of these difficulties is that, the seemingly perfect design scheme will be challenged at some stage during the practice and then will affect the restoration effect.
2. Environment for preservation. The environment for preserving immovable stone cultural relics is uncontrollable. This has huge influence on the effect of stone cultural relic conservation and restoration. The principle for cultural relic protection emphasizes the premise of "minimum intervention". This essentially requires us to eliminate the diseases and destruction and main-

tain the stability of the fabric of a cultural relic through less intervention. However, the unstable environment forces us to give the top priority to the stability and safety of the fabric of a cultural relic during the conservation and restoration.

After the May 12 Wenchuan Earthquake, some fingers of the Thousand-Hand Avalokitesvara Bodhisattva fell off. This has been the start of a serious degradation and an alarm for the structural instability of the fabric of the cultural relic. Measures for coping with water and surface weathering cannot "cure the disease that has gone beyond recovery".

Since it is hard to forecast the environmental loading and changing tendencies, technically, it is the only option to solve all the problems faced by the fabric of the cultural relic. In addition, the special environment, featuring high temperature and humidity, also makes it hard to choose materials and techniques that meet the requirements under the "minimum intervention" principle. Therefore, the effect of the cultural relic restoration certainly will be different.

3. Conditions of the fabric. The conditions of the fabric of a cultural relic account the biggest proportion of the factors that will have influence on the effect of stone cultural relic conservation and restoration. This is about the size, shape, texture, craftsmanship, degradation status and historical restoration of the fabric.

   The Thousand-Hand Avalokitesvara Bodhisattva boasts a large size, complicated shape, colored painting and gilding art. It is not well preserved and has been restored for many times. The difficulties are not just about simple splitting or overlapping of various factors. The rock carving layer serves as the foundation for shaping, colored painting and gilding so that it is called the essential carrier of the "thousand hands". The gilding layer is both a decorative layer and a protective layer. However, it is also the layer suffering from serious damages. The colored painting layer sets off the gilding art and the "thousand hands", but it is also a sacrificial layer for guaranteeing the ventilation of the statue.

   Following the progress of the restoration, each hand and each Buddhist instrument needs to be treated in a way that can resolve the current problems and eliminate the root causes. The intervention extension and the depth tested on this cultural relic had never been seen in other stone cultural relic conservation projects. The effect of the restoration of the hand models and small parts at the earlier test and experiment stage shows that this is closely related to the reasons why it is not applicable for the restoration of the entire cultural relic.

A special characteristic of cultural relic restoration project is the uniqueness. Different parts of a cultural relic may have different requirements for restoration in terms of materials and techniques. An option made in earlier stage may not be suitable for so extensive use. Organic silicon was once used to make surface covering and reinforcement for protecting the Dazu Rock Carvings in the areas with the most serious weathering, and a good result was achieved. However, it was only the best choice and optimal result under that circumstance and in that specific area. It can be used as reference for protecting cultural relic under similar conditions in other areas, but it cannot be completely replicable.

4. Restoration techniques. The restoration techniques must keep in line with the original craftsmanship and techniques used to build and make the cultural relics, and must meet the cultural relic conservation and restoration principles. This is actually hard to achieve, because the restoration techniques used in every process for cultural relic restoration has limitation in some way.

Fig. 4 The Bodhisattva Statue, detail

For example, to restore the Thousand-Hand Avalokitesvara Bodhisattva, the lacquering technique was finally adopted as lacquer can be used as both reinforcement agent for the stone cultural relic and adhesive for gold foils. Historically, such technique has been used for four times for the gilding restoration for the Thousand-Hand AvalokitesvaraBodhisattva, proving the effectiveness of this traditional restoration technique. However, to apply such technique, polishing technique aiming to guarantee the stability and smoothness of the lacquer film plays an important role. Therefore, when the lacquering technique is adopted, it is hard to do what is usually done when using chemical materials for reinforcement, namely to operate in small areas so that part of the gilding work can be replaced while part of it can be reserved. So, the effect of the restoration cannot be guaranteed at all.

5. Concepts and attitude. In addition to the objective factors, concepts and attitude also have great influence on the effect of stone cultural relic conservation and restoration. Correct concepts and attitude must be embraced. Here, it should be made clear that: the scientific law that material basis decides ideology cannot be violated.

Fig. 5 The Bodhisattva Statue before and after the restoration, detail

Cultural relic restoration is a dynamic technical activity, and the effect of cultural relic restoration cannot be produced by simply copying the existing eastern or western restoration concepts. The biggest dispute on the effect of the restoration of the Thousand-Hand Avalokitesvara Bodhisattva is the one about the "new" and "old". A restorer shall shoulder the responsibilities to choose the safest and most effective techniques and measures to guarantee the safety of the cultural relics, eliminate diseases and destructions and fully demonstrate the cultural relics' value through sufficient scientific researches and experiments, but not to simply make the cultural relics look "new" or "old".

For the restoration of the Thousand-Hand Avalokitesvara Bodhisattva, more than 20 expert meetings were held to respond to various "unexpected issues" and make adjustments of technique application. That's why the final effect could be shown. In fact, if the purpose is just to keep it "old", the lacquer polishing technique can be used, causing damages to the gold foils and high costs. Thus, it is not the right option.

REFLECTION

Under Article 3 of the *Principles of China on the Protection of Cultural Relics and Sites*, the value of cultural relics and historical sites has been expanded to cover social and cultural value other than the original historical, artistic and scientific values. The amended term provides an additional basis for elucidating the effect of the restoration of the Thousand-Hand Avalokitesvara Bodhisattva. The religious and cultural value of the Thousand-Hand Avalokitesvara Bodhisattva has been embodied through the restoration, and its social value has been enhanced by highlighting its role in local religious activities.

When restoring a cultural relic, the restorers should respect the value of the cultural relic and the objective conditions of its fabric and apply the techniques under the direction of scientific cultural relic conservation principles. Moreover, it is their duty to disclose information about the restoration to the public in a way easy to be understood, so as to extend the platforms for social significance of cultural relic conservation and restoration. Related communication mechanism should be established to strive for more support for the conservation and restoration projects. The outsiders shall have the rights to express their opinions on the cultural relic conservation and restoration activities or provide suggestions for these activities. They shall also have the rights to know the progress of such projects and the inputs in them, and require the restorers to make explanations on the restoration effect and various results.

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II

ENHANCING AND MANAGING HERITAGE SITES

INTEGRATING CONSERVATION AND VALORISATION. THE ETRUSCAN ARCHAEOLOGICAL SITE OF SOVANA IN ITALY[1]

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INTRODUCTION

The Italian conservation tradition and legislation is based on the cultural chain of scientific-historic knowledge, conservation, valorisation and fruition in order to promote a well balanced approach to heritage protection. However, increased academic specialisation, pressing tourist market demands and the fragmentation of administrative and management responsibilities have in recent decades produced unilateral projects and partial interventions.

Integrating conservation and valorisation processes and reinforcing their dialogue using new information technologies is now days considered the most appropriate way to intervene both in archaeological and urban historic sites in order to promote more sustainable results. It is in this context that was elaborated the project financed by the Tuscan Region, with European funds, entitled "TeCon@BC: Technologies for the conservation and valorisation of cultural heritage" coordinated by the Institute for the Conservation and Enhancement of Cultural Heritage–ICVBC of the National Research Council of Italy-CNR, during 2010-2012 (TeCon@BC 2011).

1 A previous version of this paper has been presented at the Conference organised for the 80th anniversary of the Chinese Academy of Cultural Heritage, Beijing 9 July 2015.

The project identified in the Etruscan archaeological site of Sovana, a disadvantaged area, an appropriate case study to better conserve, enhance and re-qualify (Bianchi Bandinelli 1929).

The project comprised different partners, such as research institutes, University departments, public Institutions and private enterprises, that worked under the coordination of ICVBC focusing on the following subjects: innovative materials for the conservation of stone, pictorial (Baglioni, Giorgi 2006), glass (Bracci, Cantisani, Giusti et al. 2006) and metallic (Bernardi, Chiavari, Martini et al. 2008) cultural heritage; innovative technologies for the evaluation of the conservation treatments and the monitoring of environmental factors; tools for the monitoring of the state of conservation of the case study area and digital tools for the valorisation of the archaeological site on three distinct territorial levels of intervention.

The interrelated and integrated approach promoted, between different levels of conservation and enhancement, will be briefly presented and discussed showing the outcomes of the project, considered as best practices to be followed eventually worldwide.

PROJECT OUTLINE: FOUR DISTINCT BUT INTERRELATED STEPS

1. Development of innovative materials for the conservation of heritage assets made of stone, metal, glass and of pictorial heritage goods.
2. Development of innovative technologies for the evaluation of conservation treatments and for the monitoring of environmental conditions/parameters as well as of the state of conservation.
3. Development of ICT tools for the analysis and monitoring of the state of conservation of the Etruscan archaeological site of Sovana and of the durability of conservation treatments.
4. Development of comprehensive ICT tools for an integrated enhancement of the archaeological landscape of Sovana.

New materials: polymers from renewable sources

The use of synthetic polymers is a common practice in the conservation of historical artefacts. However, commercial products often do not satisfy the scientific requirements for application in cultural heritage. In the last years polymers from renewable sources have attracted increasing attention as potential substitutes to petrochemical-based products in many fields. In particular poly(lactic acid) (PLA) has attracted attention. Our research focused on the synthesis and the characterisation of PLA-based polymers for a potential application to the conservation of stone, among other materials. In this respect, modified PLA such as fluorine-containing PLA and copolymers of lactic acid and mandelic acid were synthesised to improve protective behaviour of PLA. Products were characterised by conventional techniques (i.e. NMR, FTIR,UV-vis, GPC, DSC) and tested as protective coating for stone. Performances in terms of water repellent and chromatic effects were comparatively evaluated on selected stone samples with respect to commercial products from fossil fuels. Furthermore the stability of polymers was investigated by accelerated ageing tests (Frediani, Rosi, Camaiti et al. 2010)

Interesting results in terms of solubility in usual organic solvent, protective efficacy, optical properties and ageing behaviour, beside the possibility of removing the coating film after treating with the aim of selective methods such as enzymes, make PLA-based polymers promising materials for application in cultural heritage (Cuzman, Camaiti, Sacchi et al. 2011).

New materials: nanomaterials containing titanium dioxide

Furthermore, regarding new materials, a very active area, currently, in nanotechnology concerns the development of treatments based on photocatalytic titanium dioxide. This compound gives antibacterial, self-cleaning and de-pollution properties to materials on which it is applied. The titania treatments applied on marble or other stone may offer an innovative help for preventive conservation of cultural assets, minimising the cleaning operations and so decreasing the maintenance costs.

In this project, products containing TiO2 as anatase were studied, which is the photocatalytic active form for accelerating the decompositions and oxidation reactions of organic and inorganic air pollutants; thanks to this mechanism, the deposition of dark substances can be reduced. Moreover its antibacterial properties can be useful in order to limit the biological attack on stone (Mecchi, Luvidi, Borrelli 2010).

Titania also gives high hydrophilicity to surfaces. For this reason other solutions, were nanoparticles are associated with hydrophobic compounds, were studied. These formulations were applied on marble, travertine and Lecce stone speciments, and exposed outdoor in an urban area for eight months. On the treated surfaces the morphological distribution of the products, the photocatalytic efficiency of titania and the contact angle before and after their outdoor exposition were evaluated. Before the ageing test, every formulation gave good photocatalytic efficiency, and the formulations containing a water repellent gave hydrophobic properties to the surfaces. After ageing the concentration of titania on the surface and consequently its photocatalytic properties were decreased. In comparison to the other products, the TiO2 nanosuspension (PARNASOS series) preserves the better ability in the degradation of organic compounds (Luvidi, Laguzzi, Gallese et al. 2010).

Innovative diagnostic technologies

Throughout the project a number of new tools and evaluating systems have been developed.

Among these, the development: of a system for measuring in three orthogonal directions of the thermal and hygrometric expansion of stone materials; and of a Peeling Test Device system (Drdackt, Lesak, Rescic et al. 2011) aiming to measure the removed material through the use of a tape, and the necessary strength to remove it (Fig. 1).

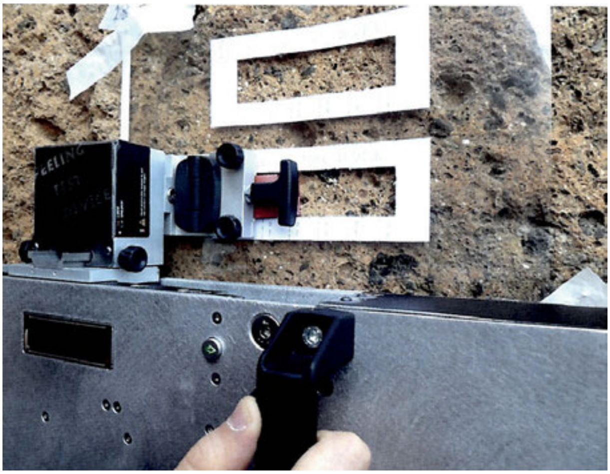

Fig. 1 Peeling Test Device system aiming to measure the removed material using a tape, and the necessary strength to remove it

Furthermore, infrared termography has been used to identify new instrumental methods able to evaluate water repellent treatments; and the relevance of two portable instruments, Raman and mid-FTIR (Colomban, Tournié 2007), has been evaluated in monitoring the synthetic conservation treatments applied on plaster substrates (Fig. 2).

Fig. 2 The monitoring of the synthetic conservation treatments applied on plaster substrates using two portable instruments, Raman and mid-FTIR

Many of the new tools and products have been tested in the case study area, which was chosen among the less enhanced archaeological sites of Tuscany. The Etruscan necropolis of Sovana (Preite 2005). and more specifically the three major tombs, selected, dating back to 1st century BC have a complex structure (Fig. 3). The monumental structure is carved into the rock, while the sepulture area is in cubicula and caves. The tombs' material, red tuff with black wastes, is easily degradated due to environmental factors (temperature variations, water percolation, humidity, diffusion of salts with efflorescence) being a porous material, highly hygroscopic and easily eroded (Camaiti, Dei, Errico 2007).

Fig. 3 Etruscan Necropolis of Sovana (Tuscany-Italy), the Ildebranda Tomb

NEW ICT TOOLS FOR MONITORING

A survey which allows the most accurate documentation, in every detail, of the features of any architectural or archaeological artefact is, without any doubt, the one realised by 3D laser scanner technology. The use of this technology has offered us the opportunity to create a georeferentiated 3D model of the tombs, which can be easily updated and functions as a digital database, for monitoring the state of conservation, the reaction to the consolidation treatments (Tiano, Pardini 2004), as well as the planning of conservation interventions or restoration of the tombs (Fig. 4).

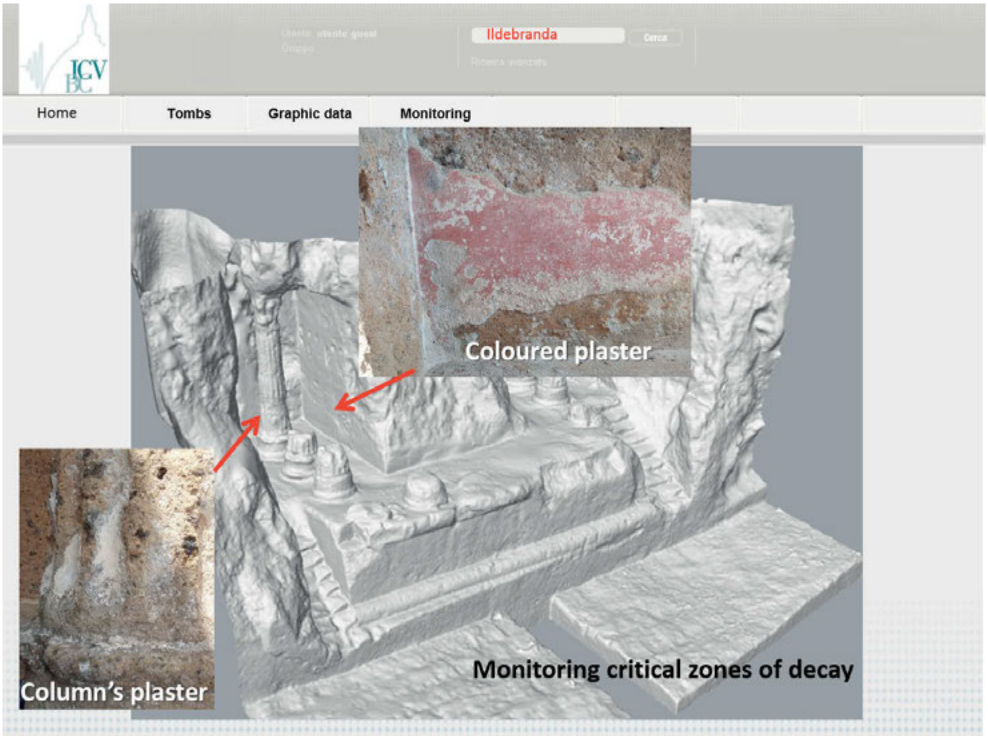

Fig. 4 Georeferenziated 3D model of the Ildebranda tomb. Information system monitoring critical zones of decay

In parallel an Information system has been developed able to manage heterogeneous data (such as climate data, parameters describing the conservation state of the cultural asset, properties of conservation/restoration products, kind of stone) with the aim to evaluate the durability of conservation treatments (Camaiti, Bugani, Bernardi 2007). For this purpose two software were developed: the first (Conexp) manages information derived principally from literature relative to treatments carried out both in situ and in labs; the second (ArcheoSensing) links the climate data monitored on the artefact with the chemical-physical and mechanical properties of the materials which constitute the artefact (Camaiti, Borgioli, Rosi 2011). From the correlation of the two software (Baracchini, 2010) it is possible to get information on the ageing resistance of specific treatments in relation to the surface on which they are applied, to the environmental conditions on which were exposed and to the methodologies with which were applied (Fig. 5).

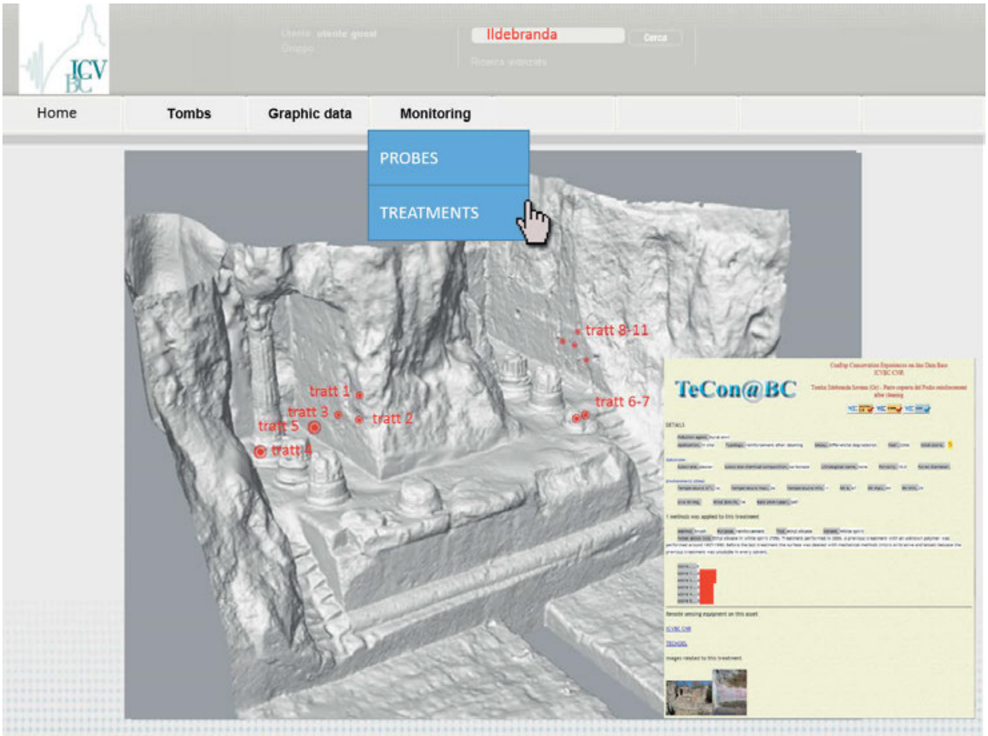

Fig. 5 Georeferenziated 3D model of the Ildebranda tomb. Information system able to manage heterogeneous data with the aim to evaluate the durability of conservation treatments

DIGITAL TOOLS FOR INTEGRATED ENHANCEMENT

The enhancement project of the archaeological area of Sovana focused on three distinct territorial levels of intervention (Porfyriou, Genovese 2011).

1. The creation of a technological application (an App) which enhances one of the more spectacular aspects of the Etruscan necropolis of Sovana, that is the tuffaceous spoor where are situated the three monumental tombs, with an architecturally elaborated façade, of Ildebranda, of Demoni Alati and of Pola (Fig. 6).

Fig. 6 App "Necropoli Etrusca di Sovana"/Etruscan Necropolis of Sovana (© CNR-ICVBC, Tuscany Region)

2. The elaboration of a GIS interactive map, with data offered by the *Sovrintendence* (Regional Offices responsible for the protection of archaeological heritage) for dissemination purposes and for the creation of tourist itineraries (Fig. 7).
3. The development of the software "PlaceMaker" (Sepe 2012) for the promotion of the entire territory of Sovana, by identifying cultural resources and the contemporary identity of places (Fig. 8).

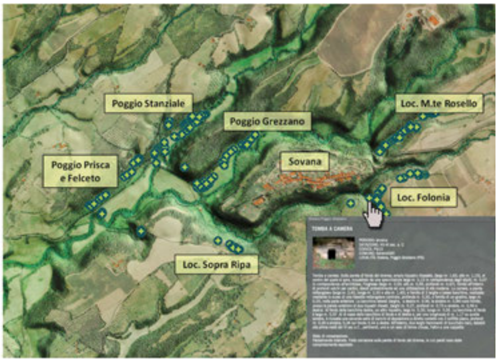

Fig. 7 GIS interactive map of Sovana territory with data bank on disseminated tombs

Fig. 8 Software "PlaceMaker", a multimedia analysis board, for the promotion of the entire area of Sovana

More specifically the creation for iphone/ipad of the App "Etruscan necropolis of Sovana" http://itunes.apple.com/it/app/necropoli-etrusca-di-sovana/id491343419?mt=8 allows to navigate in the "antique landscape", the "contemporary landscape" and to consult the digital archive material. The 3D reconstruction of the "antique landscape" (which can be also consulted on site with GPS) offers the possibility to explore the funeral monuments visiting both the tombs and the funeral underground rooms (Fig. 9). A video constitutes, instead, the "contemporary landscape" alternating actual photographic sequences with 3D reconstructions of the tombs, thus offering a suggestive view of how the landscape could appear in antiquity (Fig. 10). Finally a digital archive (with photos, texts and 3D images) forms the data basis that supports all options of the App. The result obtained indicates a new possible way to undertake in order to overcome the logistic difficulties of field trips in similar archaeological sites (accessibility, security, understanding) and increase synergies among different regions with Etruscan sites, in order to enhance and promote an overall reconstruction of the Etruscan, pre-Roman antique world, which still attends to be unveiled to the large public.

Fig. 9 The 3D reconstruction of the "antique landscape" offers the possibility to explore also the funeral underground rooms overcoming problems of physical accessibility

Fig. 10 3D reconstruction of the "antique landscape" offers a suggestive view of how the landscape and the tombs could appear in antiquity

CONCLUSIONS

The project, as it has been briefly shown, has elaborated products and technologies for the conservation and enhancement of cultural heritage with the aim to promote and improve the fruition of the cultural heritage of Tuscan Region, particularly of the heritage situated in "disadvantaged areas", thus supporting the re-qualification of the entire territory. Such a sustainable aim could have not been reached if not with an equally well balanced and integrated approach (Bracci, Cuzman, Ignesti et al. 2012), based on a multidisciplinary research team (of archaeologists, architects, ICT experts, conservators, chemists, biologists, urban historians, geologists and art historians) and on the close collaboration of research institutes, universities, public and private institutions -- all working for a common sustainable and integrated approach to conservation and valorisation.

In this sense the project developed both innovative products, environmentally friendly, for the conservation of different kind of materials and new tools able to evaluate on different materials the conservation efficacy of the products developed. During the project were also developed models and tools for managing and monitoring conservation interventions, through 3D modelling, and Information systems and were promoted integrated enhancement interventions on heritage assets, through multimedia digital Apps and innovative software, aiming to the valorisation and promotion of synergies in a broader territorial context.

This multitask and multidisciplinary approach integrating different levels of conservation and enhancement produced not only innovative results regarding new materials and technologies as well as ICT applications, but what's more it introduced an advanced methodology that can become a good practice worldwide, thus promoting sustainable protection interventions.

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The Archaeological Parc "Città del Tufo" http://www.leviecave.it/index.php?option=com_content&view=article&id=47&Itemid=55

The project TeCon@BC

http://www.icvbc.cnr.it/progetti speciali/tecon/default.htm

App of the Etruscan Necropolis of Sovana

http://itunes.apple.com/it/app/necropoli-etrusca-di-sovana/id491343419?mt=8

SUI & TANG CITY SITE CONSERVATION IN LUOYANG: A BIG ARCHAEOLOGICAL SITE POLICY IMPLEMENTATION CASE UNDER FAST URBANIZATION

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INTRODUCTION

Conservation and development, preservation and exploitation, social and economic impacts in addition to mere protection: all these are hot issues of heritage policy worldwide. Da Yi Zhi (big archaeological sites, DYZ herein after) conservation in China is especially challenged. On the one hand most DYZs are of wood and earth, more fragile and vulnerable in their nature. On the other hand, there has been severe pressure of industrialization and urbanization within DYZ regions for a huge population at an unprecedented fast speed.

It is in this concern that the 11th Five-Year-Plan (FYP), starting in 2006, was developing an articulated policy of DYZ preservation, first of all in terms of investigation and assessment for each of the 100 DYZ identified by the FYP. Four major tasks were identified: setting up a preliminary management system for DYZ conservation including legislation, education, archaeological and information work, and research; preparing plan outlines for the 100 DYZ and plans for 40-60 of them; implementing exemplary DYZ conservation projects sponsored and guided by the central government; and constructing 10-15 DYZ "conservational interpretation" parks (archaeological parks) of high calibration.

While heritage protection was clearly the trigger of the whole initiative, the idea was also to give a new emphasis on interpretation, and at the same time to improve the living conditions of people living close to these sites, bettering environmental conditions, and looking for positive impacts in terms of economic development. The Ministry of Finance and SACH (Center of Underwater Cultural Heritage) promulgated a funding regulation to manage a special DYZ fund for the whole policy, allocating 2 billion RMB over the 11th FYP (5 billion up to now). Later on, the 12th FYP reinforced the policy, with a total of 150 DYZ now involved.

Since the scale of the DYZ policy is huge, we limit our focus on Luoyang, and more specifically, on the Sui & Tang Luoyang City Site (STL) DYZ project. Both the STL and the city of Luoyang are good candidates, for several reasons:

- First, due to the city's significance in the Chinese history over centuries; one of the capitals, for thirteen dynasties.
- Secondly, from an administrative point of view, Luoyang shows a pioneering tradition in heritage protection.
- Moreover, Luoyang has experienced particularly high rate of economic development in the last decades (from 70.000 to 1.7 million inhabitants from 1949 to 2008, with an average year rate of 5.5%, compared to the country average of 2.5). Urbanization was indeed acknowledged as the major threat for the DYZs.
- Since 2006, Luoyang city started a new wave of heated urbanization, focusing on the attraction of investment (180 billion RMB up to now), economic transformation and the reform of state owned enterprises, development of a New District, rehabilitation of the old city (city-villages transformation, environmental improvement with more green space and parks) and the launch of the international cultural tourism city (LYPG 2007-2012).

In short, both the exceptional persistency of historical heritage conservation and unprecedented levels of economic development (with both threats and opportunities) characterize Luoyang city. For this reason, the city draws a particular attention within the FYPs, now counting 7 of the national DYZ projects, and about 11% of the central Government funding as one of the six special areas set up by the 12th FYP. Within this context, the STL is the most important one, covering almost 68.6% of the overall budget on the Luoyang DYZs (the 7.5% of the total national fund).

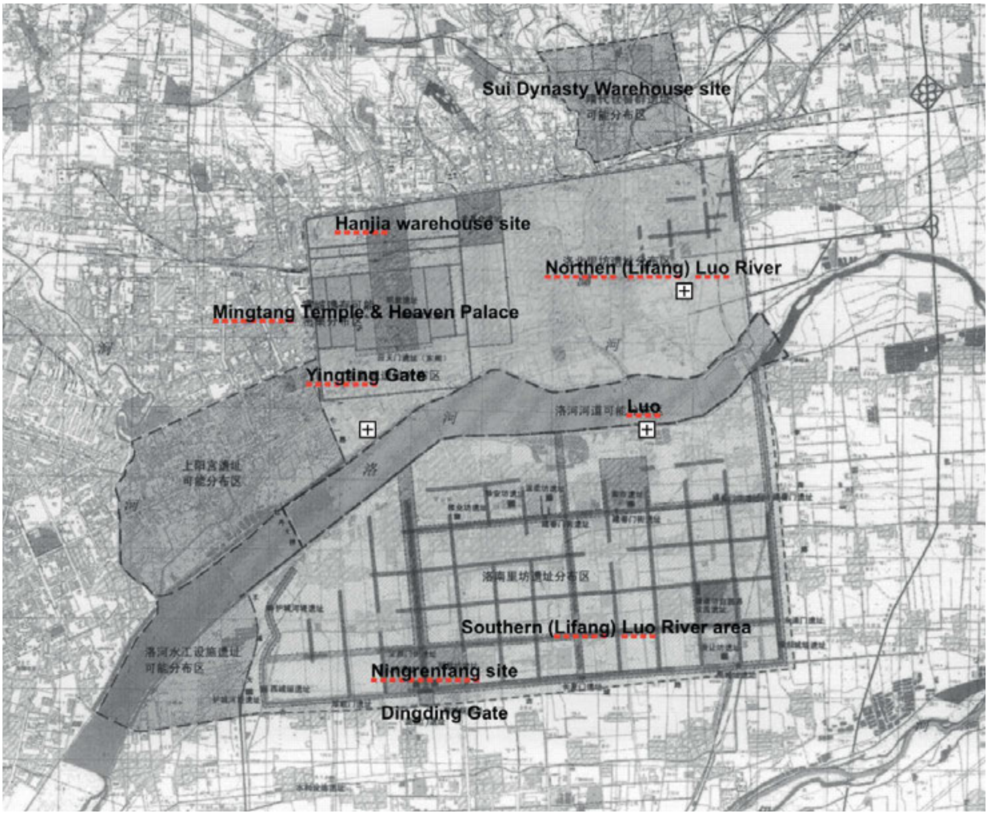

Table1.1 Luoyang Sui & Tang protected area				
Key protected area	General protected area	KPA	GPA	total
1. Northen Luo River area		128,7	1.651,9	1.780,5
Palace city	Other palace city areas	118,6	149,0	267,6
Imperial city wall sites	Imperial city area & outer city wall sites	10,1	585,2	595,3
	Lifang area in northern luo river area		917,7	917,7
2. Warehouse site outside the city		84,7	245,1	329,8

Huiluocang warehouse site clusters	Other sui warhous sites	13,1	245,1	258,1
Hanjiacang site and north outer city walls		71,7		71,7
3. Southern luo River area		490,8	2.090,1	2.580,9
South market site		51,0		51,0
Ludaofang site		44,0		44,0
Dingding gate		309,8		309,8
South city wall sties		86,0		86,0
	Other southern luo river lifang areas **		2.090,1	2.090,1
4. Other protected areas			468,0	468,0
	water conservancy facilites outside the city		0,3	0,3
	luo river area		467,7	467,7
total		704,2	4.455,1	5.159,3
* Including Heaven temple, Ming temple, Yingtian gate, Jiuzhou pool sites etc.				
** inlcuding Ningrenfang				

THE STL DYZ PROJECT: FROM POLICY TO ACTIONS

The STL site: an overview

The historical pattern of the city was divided in several parts: the palace city, the imperial city and the external city. The warehouses, located at the east northern part, were linked to the imperial palace. The Lifang area was located both in the northeast of the city, as well as in the Southern part. There were also important relics in terms of water conservancy network. The vestiges can be classified by type: outer city walls, Palace city walls, outer city gates, Palace city gates, palaces, gardens, buildings, gardens, kilns, warehouses, streets and waterways, water conservancy facilities and other relics. Table 1 provides a picture of these data, calling for two major comments. On the one hand, the degree of extension of the old city (28% of the present city), and the dimension of the protected area is worth underlying (5,159 ha, including 704 ha of key protected area, 15% of the site area). Indeed, this is a "big", a huge site. On the other hand, it should be noticed that this picture is the result of an active protection and research policy carried out over time, both in the previous decades, and more recently after the new projects associated with the 11th FYP.

Protection before the 11th FYP

The staff of the Luoyang Cultural Relics Bureau (LCRB) took several actions in the context of the rapid city development. Reviewing the protection process before the 11th 5FYP is useful to understand why Luoyang city actively participate in the special DYZ policy – a somehow inevitable choice that ended up with DYZ "conservational interpretation" project.

- In 1953, when a tractor factory was doing its feasibility study about location, the director of the Ministry of Culture made a direct intervention at the last minute to move the plant from its original place where the underground ruins of Eastern Zhou city walls was found. This set up a reference example for city planners to set developing areas avoiding archaeological sites.
- More generally, important laws and regulations were issued in the period. Luoyang government introduced an archaeological-exploration-before-construction principle ("On strengthening the protection of cultural relics and monuments", 1981.01.20). Henan provincial regulation "On large ancient sites conservation and management" (July 1, 1995) is the first provision introducing the term "DYZ", with several important concepts later incorporated into the national DYZ policy.
- In terms of archaeological works, already in the 90's, the concept and awareness of DYZ protection received extensive attention; tourism demand was also growing, entailing an active implementation of large-scale archaeological work. Therefore, the archaeological works became increasingly proactive (e.g. for a plan to restore Lu Dao Fang and establish Bai Juyi Memorial Hall, about 7000 square meters of archaeological excavations

were made in 1992 (CASS 1994); a major excavation of Dingding gate site was made in 1997 after some trials in 1980s and early 1990s (CASS 2004).

- In 1992, SACH earmarked 700,000 Yuan of special funds to support a simulation presentation experiment on the Yingtian Gate site, which tried to restore the earthen remains of the eastern gate tower to make it more visible than traditional reburial after excavation.
- In August 1995, the third master plan of modern Luoyang city was published. It presented huge progress, defining the 22 Km2 Lifang area in the south as a protected zone. Only greenery is allowed therein and the New District should be developed beyond it to the further south. This strategy effectively controls the skyscraper from creeping into the Lifang area and make possible a botanic garden open in the future.

In short, important protection works have been done in the period. However, professionals were engaged in a more combating manner against the rapid economic development, the population growth and expanding urban pressure. Those "extremely conservative" measures were becoming increasingly difficult to be effective for site conservation; in fact, the damages suffered by the site already reached a dangerous level.

The STL DYZ project – focus on "archeological parks"

A new emphasis on heritage protection was later defining the national DYZ policy, during three national-level meetings held in Luoyang,[1] with important decisions for Luoyang as well. Through these meetings, DYZ protection ideas gradually became clearer: DYZ "conservational interpretation" took the stage center, mainly in the form of archaeological park development. DYZ protection merged itself in this way with urbanization, improvement of people's living environment, as well as cultural tourism and cultural industries. Already from the first meeting, the idea of the STL Archaeological park (in the Palace area) emerged: protection works would be shifted towards the most problematic area of the city center, to develop a major archaeological site park in order to combine the protection with the general city planning.

From an institutional point of view, it would be interesting to analyze some of the details of the DYZ meetings. Top administration from SACH, the Provincial Cultural Relics Bureau and Local Government jointly showed up, unusual phenomena for such

1 DYZ protection forum, 2006.10.22-23; DYZ protection on the field, 2007.03.21; DYZ protection summit forum, 2009.10.31.

traditionally professional and "marginal" occasions. With the strong commitment shown by the three leadership, the Luoyang Archaeological park got the complete support funds from both the central and local government finance.

Table 3-6 2005-12 years Luoyang city of Sui and Tang Dynasties relics special list (unit: million yuan)

Year	Project name	PRE	PPE	PFC	Funds
2005	S&T Luoyang city site: protection planning	1200			1.200
2006	Dingding gate: preservation and presentation,and archaeological work			25000	25.000
2007	Palace city: protection planning, archaeological survey, exploration and data collection etc.	20000			20.000
2008	Ming Temple: archaeological and presentation; Yingtian gate: preservation and presentation			37000	37.000
2009	S&T Luoyang city site			47000	47.000
2010	Dingding Gate: street (including the camel hoof prints) preservation and presentaton			5000	5.000
	Ming temple: and ming gate preservation and presentaton			12000	12.000
	Jiuzhou pool: site and industrial heritage preservation			20000	20.000
	Southern outer city wall: preservation and presentaton			4000	4.000
	total	0	0	41000	41.000
2011	Palace city site: preservation		20000		20.000

	Ming temple: preservation and presentation			5000	5.000
	Heaven temple: preservation and presentation			20000	20.000
	Outer city wall: preservation		45680		45.680
	Yingtian gate: preservation and preservation			5000	5.000
	Hanjiacang warehouse site (Grand Canal): preservation and presentation			10500	10.500
	Ming temple: preservation and presentation			6000	6.000
	Heaven temple preservation and presentation			20000	20.000
	Yingtian gate preservation and preservation			9000	9.000
	Huiluocang warehouse (Grand Canal): archaeological survey and preservation proposal preparation	8500			8.500
	Huiluocang warehouse (Grand Canal): archaeological survey and preservation proposal preparation	1000			1.000
	total	9500	65680	75500	150.680
2012	Outer city wall southeast and southwest corner: archeological excavation	800			800
	Ningrenfang site: archaeological excavation	1500			1.500
	Yingtian gate: preservation and preservation			10000	10.000
	Heaven temple: preservation and presentation			10000	10.000

	Dingding Gate treet site (southern section): preservation and presentaton			30000	30.000
	total	2300	0	50000	52.300
	Total	33000	65680	275500	374.180
	%	8,8%	17,6%	73,6%	100,0%
PRE: Preliminary expenditure					
PPE: Protection Project Expenditures					
PFC: Protective facility construction expenditure					

Table 3-9 Sui and Tang Luoyang City Ruins amount of special funds project level statistics (unit: million)					
	Expenses				Total
PRE	Preliminary expenditure				33.000
PPE	Protection Project Expenditures				65.680
PFC	Protective facility construction expenditure				275.500
	total				374.180

The development of the archaeological park was involving all major aspects of the S&T city: overall, from 2005 to 2012, a sum of 374 million Yuan was invested (Table 2) in terms of MoF special fund. A few comments are worth on this data:

- First, these are huge sums, in absolute terms, and compared with what was spent before. DYZ can be "big" even in terms of expenditures.
- In terms of "facilities", major expenditures were for the Dingding gate (60 million Y), Park (40), Heaven temple (50) and Ming temple (60) sites, all involving the construction of major presentation facilities, totaling 210 million.
- Moreover, what is astonishing is the nature of expenditures. Though these data are estimated, in the whole only 33 million were devoted to "Preliminary

expenses" (9%), 65 million to preservation projects (18%), while 275 million were for protected facility project (74%).

From the funding arrangement point of view, the relationship between protection and "interpretation and utilization" of special funds present an interesting empirical element. The DYZ special fund's actual expenditure for the "interpretation" is for sure much higher than for the preservation. The special fund, with its subtle, but crucial, shift of a few words, became a critical catalyst for DYZ "conservational interpretation" (MOF 2005). However, this is still an understatement. When considering local government (Table 3), a stronger emphasis on presentation emerge: the Local government was investing in parallel seven times the central funds, with a sum of 2857 million, almost for demolition (1350 at the Park, 27 at Dingding) and removal (1080 at Jiuzhou). In what was becoming a major urban regeneration process, just 100 million were spent for preliminary research and protection out of a sum of 3,231 million Yuan: about 3%.

Table 3.10 - Unit: RMB million

Project Name	Central	Local	2005	2006	2007	2008	2009	2010	2011	2012
S&T Luoyang City site protection Plan	1,2									
1. Northern Luoi River Area										
Palace City site Archaeological Park										
Palace city: protection planning										
Palace city: preservation and presentation proposal preparation										
Demolition		1.350,0								
Land acquisition (allocated)										
Archaeological work for palace city site preservation and presentation	197,0									
Ming temple: site preservation and presentation proposal preparation										

Ming temple: site preservation and presentation										
Heaven temple: site preservation and presentation										
Yingtian Gate: archaeological works										
Yingtian Gate: preservation and presentation	24,0									
Jiuzhou pool and the industrial heritage Protection projects (Luoyang Glass factory)	20,0	1.080,0								
2. Warehouse outside the city										
Hanjiacang warehouse site (Grand Canal): preservation and presentation	10,5									
Huiluocang warehouse site (Grand Canal): archaeological work and presentaion proposal preparation	9,5									
3. Southern Luo River area										
Botanical Garden		400,0								
Dingding Gate										
Demolition, environmental remediation		15,0								
Land acquisition		12,0								
Archaeological work for site preservation and presentation	30,0									
Dingding Gate preservation and presentation										

Dingding Gate street site (Southern Section) preservation and presentation	30,0									
South outer city wall preservation and presentation	49,7									
Outer city wall southease and southwest corner archeological excavation	0,8									
Ningrenfang site archaeological excavations	1,5									
	374,2	2.857,0								
	3.231,2									

	Local input
	Central government funding
	SACH approved the scheme / plan
	Implementation

There are also interesting elements to note in terms of the process itself (Table 3). What strikes is the long period for the approval of the Protection plan (from 2005 to 2010). The time lag was mainly due to the difficulties and controversies emerged between the plan consultants and the local authority, with a bargaining process on the size of protected areas (Table 1 as the result). In terms of consequences, some comments are worth addressing (starting from the less dangerous one):

- Delay in work implementation. For example, in 2011 the central special funds allocated to "outer city wall preservation" project 45 million Yuan, mainly for the protection and consolidation of the north wall. Because this section of the city wall and the surrounding environment are very complex, the project has not yet started.

More seriously, work is lagging behind for what concerns the ruins protection. The exposed fabric of Dingding gate, the two temple foundation sites could not be preserved properly, facing several problems. "The site itself is highly vulnerable and complex, affected by changed conditions of temperature, humidity and water, dust, salt, mold and other factors. Because of the fragility of the soil itself, right now there is already some damaged and cracked parts, mildew and salting out phenomenon, affecting the site integrity, authenticity and site tours".[2]

- Before the approval of the overall protection plan in 2010, several works have been done (the Botanic garden; the whole Dingding project; part of the Park etc.). This is a "normal" practice in China, though the discussion on the Dingding case were nonetheless occurring, despite the plan was not approved: some kind of "informal" control was still at work. However, this raises the issue of degree of control/monitoring along the process.

There are two major examples in this case. The first is Dingding gate. From the beginning of 2006, Luoyang Municipal CRB commissioned the design based on the archaeological relics and related history. Three options of "conservational interpretation" proposals were developed. The first option proposes the construction of a protection shelter of a modern architecture. The second option is to backfill the site and build a replica ratio 1/1 traditional rammed earth gate. The third option, as with the first one, but in a Tang period style. SACH approved in principle the third option but, "the proposal to reconstruct the corridor connecting the gate towers is not approved"(SACH 2008). In the following process, several requirements to revise and improve the proposal were stressed, "in order to maintain the authenticity and integrity of the site" (SACH 2008a). Things turned out differently, though.

A similar situation took place with the Ming temple and Heaven temple sites: huge construction was put in place, resulting in two disturbing buildings (Fig. 1) that distract the possible visitors from the historical meanings of the site.

Fig. 1 S&T city: before and after the DYZ

2 Luoyang City People's Political Consultative Conference Committee, Report on the Luoyang big relics protection and utilization situation, in 2010 November.

DISCUSSION: LOST IN TRANSLATION - FROM PROTECTION TO URBAN REGENERATION

There are important achievements, surely, in what happened at the STL DYZ implementation. The STL has gained substantially in space, identity and political power that has never did before. There are, however, limitations as well. The unusual complexity emerges from the above description, involving land acquisition (lease) issue, demolition of big areas, environmental remediation, infrastructural construction, and "conservational interpretation" facilities development. Protection, strictly speaking, becomes actually a minor issue, a minor expenditure.

What took place in Luoyang, in the name of "conservational interpretation", was an uncontrollable construction boom in the site, with serious issues regarding the "how" things are done:

- they deviate from what was agreed "in principle" with SACH. This shows an incomplete administrative procedure where the "how" is left opaque and out of a precise project scope for a long period;
- they deviate from what international standards (even the guidelines by China) will define in terms of non-intrusive assets, with the construction of new spectacular buildings that are rather unable to help any interpretation.

Started as a protection policy, the transformation of DYZ policy into the rhetoric of Archeological park results in a huge project of urban regeneration, largely out of the control of archaeologists, in a process that can be described as a professional took over by city architects.

Relating to long term aspects, it is important to consider the impact on the complexity of the environment and the heritage, especially the body of the cultural relics, exposure conditions, audience demand and service scale, and a more professional financing and management approach, as well as the daily operation costs focused on the sustainability. However, so far there was too little attention on that.

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PUBLIC ARCHAEOLOGY AS A RESEARCH AND ACTION PROCESS FOR SUSTAINABLE ENHANCEMENT

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THE ENHANCEMENT OF CULTURAL HERITAGE BETWEEN TERRITORIAL INTEGRATION AND SUSTAINABLE DEVELOPMENT

Nowadays sustainability in every sphere of human activity is highly valued, thus it is not surprising that the United Nations (UN) General Assembly declared 2017 as the "International Year of Sustainable Tourism for Development", considering sustainable tourism as the solution to revitalize local economies. This decision follows the recognition by global leaders at the UN Conference on Sustainable Development (Rio+20) that "well-designed and well-managed tourism" can contribute to the three dimensions of sustainable development, to job creation and to trade.

In order to guarantee conditions for a "lasting, inclusive and sustainable economic growth" based on the development of tourism, the UN indicates the necessity to consider not only its economic and environmental implications, but also social and cultural, factors that are closely connected (http://cf.cdn.unwto.org/press-release/2017-01-19/international-year-sustainable-tourism-development-2017-kicks).

This formula would certainly be decisive for the development of countries like Italy - considered by many as a great outdoor museum - where archaeological sites, monuments, museums, libraries and archives, historic towns and cities of culture, provide a multitude of assets on which to base both the cultural and economic future, if properly integrated and enhanced on a broad territorial scale.

In the last decade, there have been attempts to drive the Italian economy towards the promotion of cultural tourism and not just of mass one. However, concepts such as inclusiveness, preservation of place identity, enhancement through networking, rarely have been included in an overall developing strategy. One of the main obstacles has been the fragmentation at all levels of management policies and enhancement of heritage, along with those of local development.

Fig. 1 "Preserving Places. Managing mass tourism, urban conservation and quality of life in historic centres" European Culture Program project (2008-2010) coordinated by ICVBC. The project included some creative labs – as a didactic exhibition staged by students from the historic centre of Rome – raising awareness in the younger citizens on the need for more sustainable tourism (http://www.icvbc.cnr.it/test_eng/1.%20Preserving%20Places_eng.pdf)

Only recently, the Italian Ministry of Cultural Heritage and Activities and Tourism (MIBACT) began to promote approaches of protection and management of cultural heritage based on actions of coordination and integration on a wide territorial basis, stimulating also the exploitation of tourist networks. However, this process has just started and had only an occasional success (http://www.valorizzazione.beniculturali.it/it/valorizzazione-integrata-territoriale.html).

An obstacle to the integration and creation of a systematic strategy have been also the tourist market interests, often leading to a branding and "turistification" of the cultural heritage (Re, Porfyriou 2017), resulting into an "artificial" hierarchy of values with UNESCO world heritage sites and major cultural attractions, on top, and less known sites, at the base.

Furthermore, despite the high historical and artistic importance, many less known sites do not have an adequate attention from local governments. Commonly this abandonment causes both the physical degradation of goods and the community disaffection. This status contributes to discourage and penalize isolated enhancing initiatives. Additionally, in some of those cases the decrease in tourist attractiveness is determined by the proximity of big cultural sites. In fact, under the pressure of the tourism market interests, big cultural sites can boast a large number of funds, both public and private, and a booming reputation among the public.

However, although the "spectacularization" makes them particularly attractive to the public, it determines a dual effect, on one hand, of isolating them from their historical and artistic context – subverting the historical hierarchy of values and the local identity – on the other, of casting a shadow on smaller sites placed in the same territory.

Moreover, the lack of a territorial integration penalizes also big cultural sites: even the overuse of that kind of heritage can have negative effects, physically degrading it and, more generally, its context from both the spatial and social point of view (Porfyriou 2010). On the opposite, the integration of cultural resources in the local development policies would have the effect of enhancing the environment of widespread heritage, also favoring its conservation and sustainable use.

Fig. 2 "Art is Science 2016" was the third national event organized by the Italian Association of Archaeometry (AIAr) and ICVBC at the archaeological site of Cottanello (Rieti). It introduced participants to the importance of both humanities and sciences for the preservation of sites and archaeological findings (http://www.associazioneaiar.com/wp/as/?page_id=438)

PUBLIC ARCHAEOLOGY BETWEEN RESEARCH AND ACTION

If territorial integration brings with it many problems to solve, even the promotion of the cultural heritage is very challenging. It does not end in promotion, but must take into account accessibility to information, the target to which it is addressed and the related interest. This means, basically, that a sustainable development based on the enhancement of cultural heritage would require a major public awareness regarding the importance of preserving both tangible and intangible values of collective heritage.

The growth of public awareness also passes through an adequate communication. However, critical and in depth knowledge on monuments and historic sites, remains too often confined to the university and academic circles. This is particularly true for archeology, where urban excavations usually are being kept away from the curious eyes of the passer-by or interrupted and covered for lack of resources. This distance creates in the public a sense of alienation and the consideration that the archaeological heritage is just an obstacle to modernity. While, on the contrary, would be urged to improve this curiosity and offer a collective support in order to nurture a sense of belonging and care.

Still has to be considered the complexity of the subject and the inadequacy of the research world in communicating it properly to the public. Communication is a skill, one must have studied, and know how to do it.

Even the media have some responsibility in the lack of communication on this subject. This is partially due because media give little or relative importance to that which is un-important for the country and public opinion. Moreover, media are subjected to the market laws and news on cultural heritage does not increase the sales of newspapers. Therefore, they are interested in the cultural heritage only to denounce violations or destructions, to talk about economic transactions, or, rarely, in case of archaeological extraordinary finding.

In such a context, every opportunity to approach the public to the cultural heritage can and must become an action to be exploited in a knowledgeable and well-balanced way. This is what prescribes the "public archeology", not a real discipline, but rather a container of many actions and field applications that share three very specific areas of interest: society, economy and politics.

The "public archeology" has many definitions, but summarizing it can be interpret as a way to develop a relationship with citizens. It is a participatory process of building knowledge and identity based on community involvement and a thorough analysis of public needs. In fact, there are no protocols of action and it is necessary from time to time to experience appropriate solutions.

Fig. 3 "HULBriC 2016" full immersion course, organized by ICVBC and University of Rome "Tor Vergata" offering a highly qualified training on the conservation, planning, valorization, management and social participation issues relative to small historic towns, across different cultures, in an interdisciplinary and comparative way (http://hul-bric.net/training/training-hul-bric/; on the right photo by Gianluca Gasbarri ©)

Based on the experience gained in the field over the years, I would suggest at least three lines of action to be pursued:

- The communication of research results,
- The community participation,
- The training.

1. The communication of research results. Rarely a researcher is also a good communicator, because the academic world has its proper language and rules, often very different from those of generalist information. It is necessary to combine the quality and quantity of academic information with the immediacy and simplicity of the common communication. During recent years ICVBC has heavily invested on the communication of research to the general public, trailed at every level - conferences, debates, open days, exhibitions, fairs of small and medium enterprises - and exploiting the potential of multiple media and tools - interviews on radio, TV, newspapers, websites, social media, informative publications and open source technological applications -.

2. **The community participation.** In order to increase public awareness on the heritage and to bring this in the everyday life of a community, ICVBC has also experimented participatory approaches, attempting a real cultural operation. Indeed, the economic development of small communities can start from the promotion of cultural heritage as long as it is improved the sense of belonging and identity. The researchers can support this process, by soliciting and coordinating synergies present in an area, and by studying social participation solutions able to bring forward the most sustainable results. This challenge has been carried out by ICVBC on several occasions, particularly in the cases of small communities or "borghi", getting interesting results (http://www.icvbc.cnr.it/Progetto%20bilaterale%20ITALIA-CINA_Priverno-Tongli.pdf; http://www.icvbc.cnr.it/test_eng/Territori.pdf).

Fig. 4 "Bilateral project Italy – China for the exchange of experiences in urban conservation and implementation of the UNESCO's Recommendation HUL", between ICVBC and the World Heritage Institute of Training and Research for the Asia and the Pacific Region under the auspices of UNESCO (WHITRAP Shanghai) (2014-2020). The project includes social participative discussions on local development initiatives (on the right photo by Gianluca Gasbarri ©)

3. **The training.** The bridge between the cultural memory and civic society is created through training. In this perspective the ICVBC has promoted different training paths and contributed with multiple actions at various levels (http://hul-bric.net/; https://www.cnr.it/it/diplomazia; https://www.cnr.it/en/node/929). Not only by offering highly qualified training through research for university students, professionals and for Italian and foreign public administrations; but also by promoting a better knowledge of the territory and heritage among younger generations, considered as multipliers of culture,

towards their families and the entire community. ICVBC has experimented various approaches and solutions for teaching.

Fig. 5 "WaterSchool. Promoting the sustainable use of water through the knowledge of the water cultural heritage - 2014" training course for primary schools, organized by ICVBC. The project included some creative labs on the enhancement of water cultural heritage as a didactic exhibition staged by students

CONCLUSIONS

In order to guarantee conditions for a "lasting, inclusive and sustainable economic growth" based on the development of tourism, there is the necessity to evaluate a strategy taking into account not only the economic and environmental implications, but also the socio-cultural ones. This means undertaking a process of research and actions, that at first must bring the community closer to the heritage by developing a sense of belonging and care, then have to make people aware of both the cultural and economic potential of cultural heritage.

Communicating research results, the community participation, the training are some of the key actions required coming from the "public archeology" and aiming at developing a relationship with citizens, and that have been for years the focus of ICVBC's research and actions.

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PUBLIC PERCEPTION AND OPINIONS OF ARCHAEOLOGICAL SITES IN CHINA

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INTRODUCTION

In recent years, a paradigm shift in China's cultural heritage conservation has drawn much scholarly attention. The focus has gradually changed from simple physical protection to a broader and more comprehensive issue of heritage enhancement. In particular, more attention has been put toward interpretation and presentation programs for archaeological sites.

Meanwhile, many archaeological sites, in spite of their newly constructed shelter buildings and huge investment in interpretation facilities, are confronted with serious criticisms about the actual effect of interpretation. They may either be seen as lack of attraction, or be complained to be overinvested, or disneyficated. A main concern is the paradox between overinvestment on presentation facilities and poor effect of the presentation. For example, in Niuheliang archaeological site, central and regional governments jointly allocated over 200 million RMB for three huge presentation buildings, whereas the site itself still appears too boring to the audience.

Given this paradox, one may ask: how should heritage presentation improve its methods to attract more visitors and deliver more effective messages to them. One crucial issue, before developing an interpretative frame, is to understand who the potential audience are, what they really know about the archaeological site, and how they expect to learn from the site. Appropriate methods of interpretation and presentation should be consistent with the target groups' cognitive backgrounds and psychological needs. This would be a reception-oriented approach, rather than the traditional professional-oriented approach.

This is not to say that professional expertise is not important. Quite the country, it entails a broader scope of expertise: not only involving the profession of heritage conservation, but also that from other disciplines in social sciences, namely media studies.

Therefore, this study aims to provide a general picture about the potential visitors of archaeological sites in China. In this analysis, I will discuss two main sets of issues about the relationship between the public and archaeology. First, who are the audience? Second, what they need? The major research questions include: who are the visitors to archaeological sites? How do general public know about archaeological sites? What factors influence their knowledge of archaeology? How do they see the importance of current interpretation methods? How do they want an archaeological site to be presented?

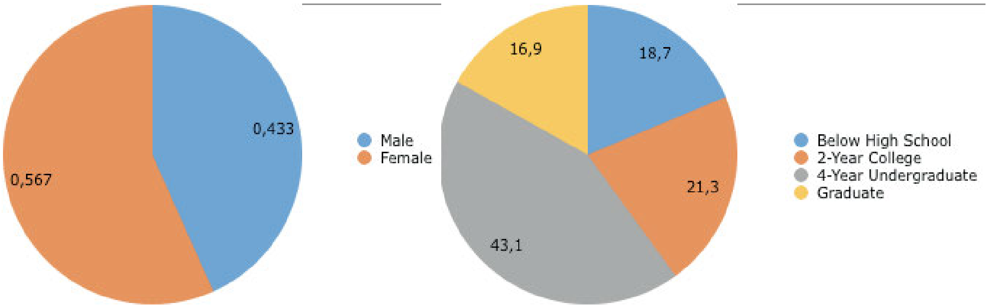
METHOD AND DATA

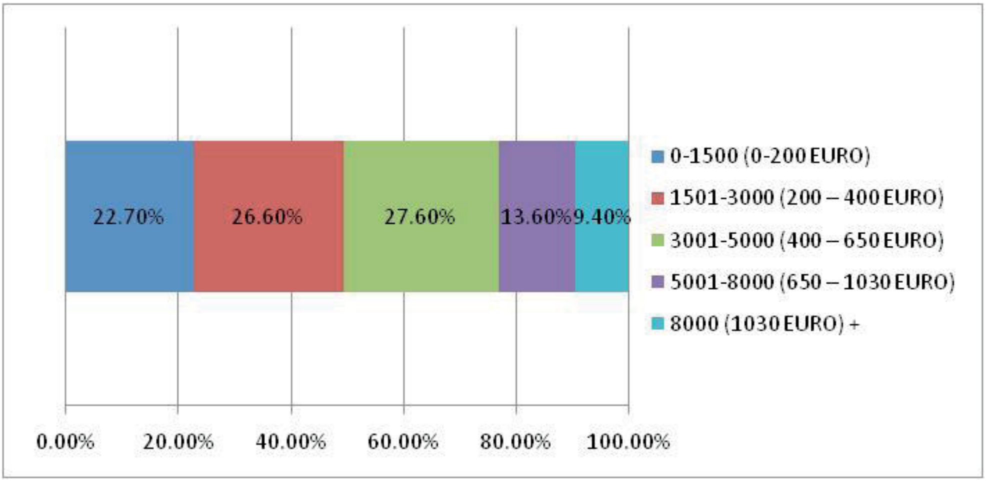
In order to fulfill the abovementioned goal, a survey was conducted to collect data about public perception and opinion on archaeological sites. The survey has collected 1592 respondents in six provinces, including Beijing, Shandong, Henan, Shanxi, Shaanxi and Yunnan. The regions of the survey were carefully selected, representing different levels of socio-economic development, regional features, and the degree of richness in archaeological sites.

The questionnaire includes three main sections. First, basic demographic background of the respondent; second, the respondents' knowledge and perception of archaeological sites; third, their preferences for interpretation and presentation.

Among the respondents, 43.3% are males. The majority are graduates from 4-year colleague (43.1). In terms of income, 26.6% earn 1501-3000 RMB monthly, and 27.6% between 3001-5000. A small portion of respondents earns over 8000 RMB per month. The income pattern generally reflects the average in national statistics (roughly 2500 RMB per month). Additionally, the average age is 31.6, with a relative normal distribution.

In general, the survey and collected could reflect the general public. The respondents could be seen to be good candidates as potential visitors to archaeological sites in that they are well-educated with relatively decent income. Thus, their perception and opinion of archaeological sites may deliver some valuable information for us to reflect on the current presentation and interpretation programs.





KNOWLEDGE OF ARCHAEOLOGY AND INFLUENTIAL FACTORS

First, we examine the level of the public's knowledge about archaeology. We designed a few questions to test it. A set of concepts are provided for the respondents to check whether they have heard about the concepts. The 5 concepts include archaeology, archaeological site, large-scale archaeological site, archaeology museum, archaeological park. Then, we provide detailed options for the definition of archaeology, to let the respondent to check what they think the most accurate one. In addition, we list 10 sites, among which 5 are archaeological sites and the other 5 are not. We ask the respondents to select the sites they think may be archaeological sites.

We create a score system. Any concept, if heard from the respondent, receives 1 point. For the definition of archaeology, one out of the four options is the correct one. If the respondent selects the correct option while ignoring the others, he/she would receive 1 point. If he/she select a wrong answer, he/she would receive -1. Thus, if the respondent selects all four options for the definition, the point for this question is 1-3 = -2.

Regarding the 10 sites for selection, any correct choice deserves 1 point. Therefore, if the respondent gets them all correct, i.e., marking all archaeological sites and ignoring all non-archaeological sites, he/she would receive 10 points. All in all, if one answers the whole set of questions correctly, he/she would get 5+1+10 = 16 points. The lowest possible point is -3.

The following table summarizes the set of questions and the percentage of correct answer:

Question	Option	Point if selected	Average correct answer %
Heard of?	Archaeology Archaeological sites Large-scale archaeological sites Archaeology Museum Archaeological Park	1 1 1 1 1	94.4 93.1 34.7 89 73
Definition of Archaeology	1: evaluation of cultural objects 2: an expedition 3: a research of human history by examining historic remains 4: excavate tombs	-1 -1 1 -1	54.5 85.2 87.2 82.5

Archaeological site of not?	Yuanmingyuan Summer Palace	1	88.9
	Terra Cotta	1	86.2
	Yin Xu	1	81
	Daming Palace	1	65.6
	Zhoukoudian Peking Man Site	1	80.8
	Giant Wild Goose Pagoda	0	41.5
	The Forbidden City	0	37.2
	Longmen Grottos	0	29.7
	Pingyao Ancient Town	0	38.4
	Potala Palace	0	49.6

According to the result, the least known concept is large-scale archaeological site, which is a newly introduced concept over the past decade. In addition, respondents tend to mark non-archaeological sites as archaeological sites. For example, almost 2/3 (66.9) see the Longmen grottos as an archaeological site, which in fact is not.

The final average score is 9.71. Ten respondents answered all the questions correctly, whereas the worst person received only 2 points. Most respondents received 9 to 11 points. If we enlarge the scale to a 100-point one, we could see that most respondents' points would be around 60, just a pass.

What we are more interested, furthermore, is what factors have influenced people's archaeology knowledge. What are the variables that determine the score? We hypothesize that three factors may cause the variation of knowledge degree: economic capital, cultural capital, and social capital. We use income to evaluate economic capital, education degree and routine cultural activity as cultural capital, and occupation as social capital. After running a regression model, we have discovered that social and cultural capitals have significant impacts on a person's knowledge of archaeology, whereas economic capital has little impact.

In particular, the higher the education, and the more likely the person works in cultural heritage related occupation, the higher score he or she will receive in the survey. In addition, ones who like reading and travelling are more likely to have higher degree of archaeology knowledge. In contract, monthly income has no correlation with the score. Another interesting finding is that males are more likely to receive higher score than females. This tells us some information about the potential visitors of archaeological sites: well educated, cultural tourism minded, and more likely to be males.

	Model 1	Model 2	Model 3
	7.13	6.94	6.44
Education	0.69**	0.56**	0.60**
Monthly Income	0.08	0.05	-0.001
Heritage Sector Occupation	1.47**	1.33**	1.30**
Routine Cultural Activity Reading		0.89**	0.92**
Music/TV/Movie		-0.03	0.02
Tourism		0.55**	0.58**
Sports		0.22	0.11
Volunteering		-0.07	-0.06
Shopping		-0.26	-0.11
Games		-0.10	-0.14
Seeing Drama		-0.33	-0.31
Sex (Male=1)			0.42**
Age			0.01

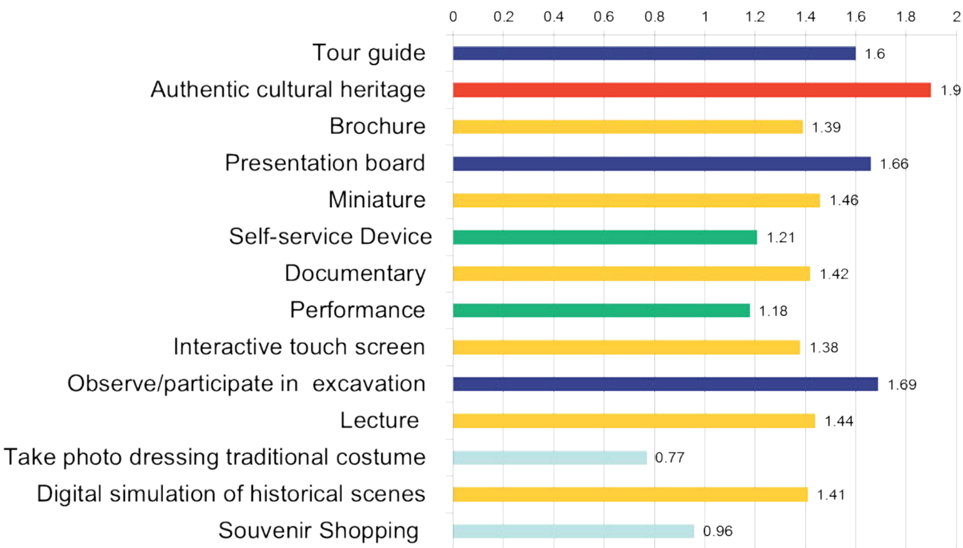
**P<0.01

In sum, the diagram shows how the three kinds of capitals are correlated with each other, as well as their association with the degree of archaeology knowledge.

INTERPRETATION

After analyzing some basic cognitive background of the public about archaeology, we would further examine their preferences toward the ways of interpretation and presentation. First, we list a number of interpretative methods and ask them to give a score of importance for each method. Second, we evaluate how the audience would like to see the archaeological sites' physical appearance. Based on the results, we could see what kinds of interpretation and presentation programs in the future should be promoted accordingly.

We list 14 major interpretative methods for the respondents to score their preferences. The question states: are you interested in the following interpretation methods? Three numbers are given: 2 for very interested, 1 for somewhat interested, and 0 for no interest. Then, for each method, there would be an average score. The following table shows the results:



Not surprisingly, the most interested one is the heritage itself (1.9), followed by "observe/participate in excavation" (1.69), presentation board (1.66) and tour guide (1.6). This result indicates that the focus of visitors is primarily on things that give them closer relationship with the relics. These are the core components a heritage site: relics, description texts, guide, and participation.

In addition, things that have relatively longer distance to the heritage receive medium scores: brochure (1.39), miniature (1.46), documentary (1.42), interactive touch screen (1.38), lecture (1.44) and digital simulation (1.41). It is clear that these methods are supplementary ways to interpret the heritage site. Even without them, a heritage site would also be a completed system of interpretation. These factors, if run effectively, could make great contributions to the interpretation program. However, they are not seen by visitors as a "must-do".

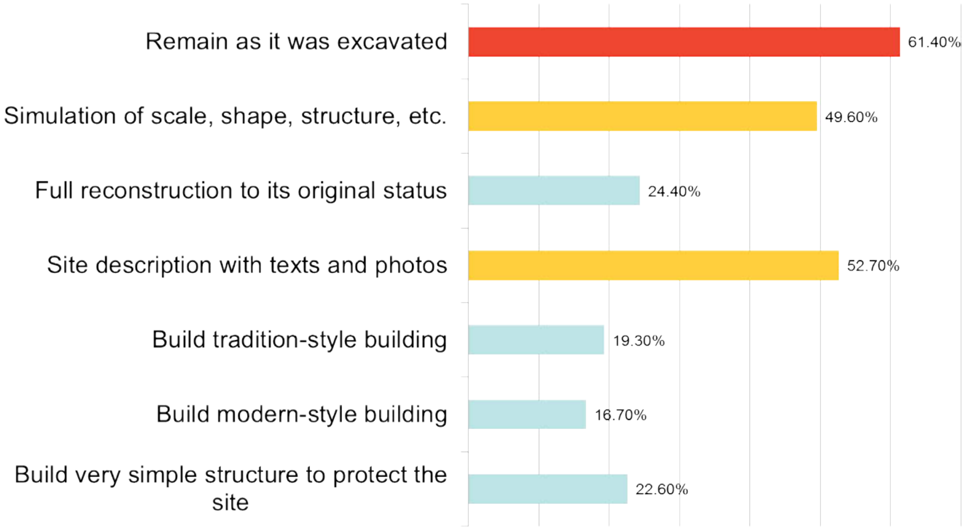
The least favorite factors are souvenir shopping (0.96) and "take photo dressing traditional costume" (0.77), the two most distant things related to the heritage. It is not surprising that shopping is so disliked by the visitors. This is because the quality of the products in China's tourist sites are in poor condition. Some respondents, according to informal interview, said that they would be more interested in souvenir shops in foreign museums, because they are better designed and produced.

The results reveal a very clear psychological and social pattern of the public: their interests decline as the interpretation's distance to the heritage increases. To be specific, the closer the interpretation to the heritage, the higher the interest is. Therefore, any designer of an interpretation program should be aware of the importance of the physical remains, before creating any supplementary programs. Although in recent years a number of new techniques and publicity methods have emerged, the central issue that carries the authentic value of an archaeological site still and always resides in the heritage itself.

PRESENTATION

In China, most archaeological sites are earthen sites, with relatively poor visual quality for presentation. In contrast, in order to make it "fancy," there have been a number of grand-scale buildings serving as the shelter for the sites. This, however, to a large extent distracts the visitor's attention, diminishing the real meaning of the site. There seems to be an assumption that the more grandiose and fancy the building is, the more attractive the site is. However, the assumption has never been tested. It is still unclear what kind of presentation method, namely the appearance of the physical remains, will be the potential visitors' favorite.

Seven options are provided for the respondents to select. More than one option could be selected as one may favor multiple presentation methods. The seven kinds of presentations are as follows: 1, remain as it was excavated; 2, simulation of scale, shape, structure; 3, full reconstruction to its original status; 4, site description with texts and photos; 5, build tradition-style building; 6, build modern-style building; 7, build very simple structure. Below is the result:



The most favorite choice is to keep the site as it was excavated. More than 60% respondents prefer to see this kind of physical appearance of the site. The following two favorite choices are description (52.7%) and simulation (49.6%). Interestingly, none of the other choices that entail "construction" receives supports from more than half of the respondents. 22.6% says a simple structure as shelter is ok. In comparison, reconstruction (24.4%) and buildings, no matter whether in tradition or modern style, are least preferred.

The results reveal a clear but challenging public attitude. Whereas technically a shelter should be built to protect the archaeological site, especially those in earthen materials exposed to the air, the public prefer the site to be like true ruin. The lesser the construction, the more joyful the visitors are.

This psychological tendency could be accounted for by two main factors. First, it shows that the public has been historically minded. They are more inclined to "imagine" history out of the ruins, than to be given a "recreated" vision of history.

They do not care too much about how its real appearance was in history, but they are more concerned with the sensational feeling conveyed by the message of the site. Second, it may also be a result of antagonistic psychology: there have been too much bad constructions. The boom of new and unharmonious buildings has destroyed historic urban landscape, such as Beijing. This makes the general public a sense of hatred towards any form of construction.

DISCUSSION

What can we learn from the result? Combining the public opinions on interpretation and presentation, we could create a table that shows people's idea about archaeological site's enhancement. There are three levels, 1, physical closeness, 2) spiritual feeling, and 3) entertainment. The visitors prefer to have a closer relationship with the site; they are interested in some interaction and participation; and they would be happy to see it kept as excavated. The visitors are relatively fine with new techniques and publicity programs, if there are effective simulations to enhance their imagination of history. In the contrary, they show little interests in entertaining programs, neither do they like any constructions that may distract their sense of history.

	First Level	Second Level	Third
Distance to the site	short	median	Long
Preference of interpretation	Close contact and participation	Technique and publicity	entertaining
Preference of site presentation	Remain as excavated	Simulation	building
Keyword	In touch with history	Feel the sense of history	Entertaining history

Overall, the data provided in this article indicate very important messages for future presentation and interpretation programs. In spite of the seemingly attractive feature of grandiose buildings, high-tech devices, and entertaining programs, the core value of an archaeological site, especially the earthen sites in China, lies in its physical remains and its representation of history. As indicated by our test of the visitor's knowledge of archaeology, the main target group of visitors of archaeological sites should be those with fair cultural and social capitals. For this group of audience, entertaining program seems to be the least favorite one. In fact, it appears that designers of current archaeological site's presentation and interpretation programs have overestimated the effect of entertaining programs, and underestimated the visitors' interests in real history. This has generated some over investment on fancy interpretative programs and grand buildings. It is now the time to have a turn, to be more focused on the narratives that deliver interesting historical messages, to be more focused on the approach to shorten the distance between the site and the audience, and to be more creative in simulation projects that stimulate the audience's imagination of history.

PROTECTION AND MANAGEMENT PLAN FOR THE ANCIENT BUILDING COMPLEX IN THE WUDANG MOUNTAINS

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BACKGROUND

The ancient building complex in the Wudang mountains was listed as World Cultural Heritage in 1994 and State Priority Protected Cultural Heritage Site in 2006. Since the founding of the People's Republic of China, local governments at all levels have been committed to the protection of these buildings and achieved remarkable results in this regard (Fig. 1).

With social and economic development and the improvement of people's living standards, the overall protection and management of the heritage is becoming more and more complex. Firstly, under the circumstance that government spending on the protection of the ancient buildings has been rising year after year and the heritage site has large amounts of money for protecting the main body of the buildings, how to realize effective protection and minimal intervention becomes a new challenge for the heritage site. Secondly, as a place for religious activities that is in use, the ancient building complex in the Wudang mountains has its own characteristics and needs. Since the Tang dynasty, religious activities held there have been an inseparable part of the significance, value and conveyed emotion of the Wudang mountains as a cultural heritage site, whose increased demand has posed new challenges for reasonable and appropriate protection of cultural tradition and correct guidance for religious activities. Thirdly, rapid development of the local tourism industry and economy has posed new requirements to the management level of the heritage site. In this context, the biggest challenge is how to appropriately utilize, interpret and display the cultural heritage while promoting the development of local tourism and economy.

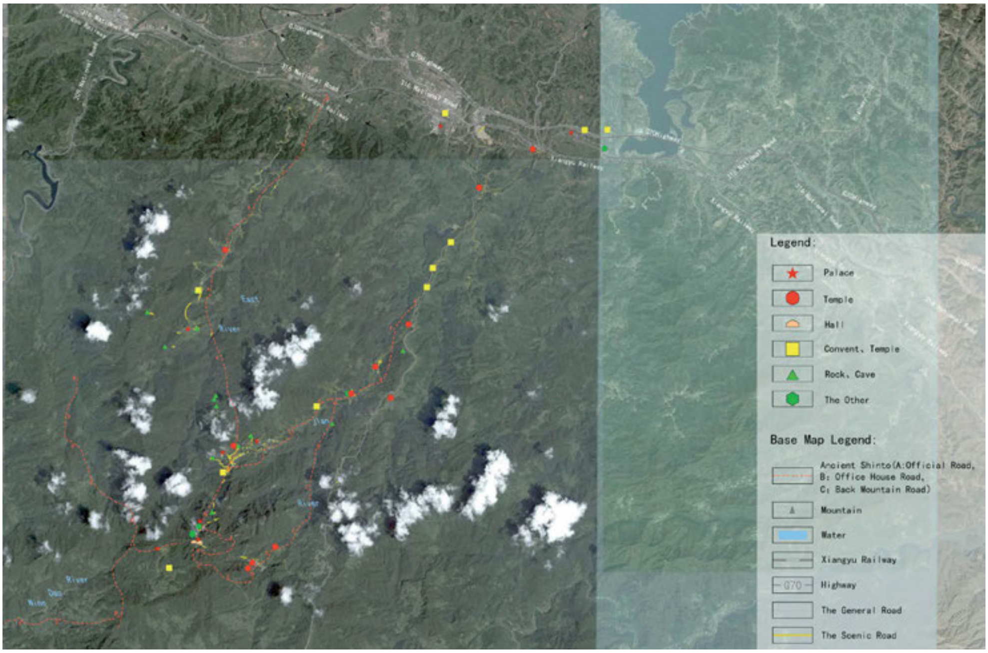

Fig. 1 Satellite image of Wudan mountains area

PLANNING SYSTEM FOR THE PROTECTION OF THE ANCIENT BUILDING COMPLEX IN THE WUDANG MOUNTAINS

Since the Wudang Mountains Tourism and Economy Special Region is located in Shiyan City, Hubei Province, its heritage protection and management work shall be in accordance with the master plan of Shiyan city (2011-2030). But also other plans are closely related with the development of this area, such as the master plan for Wudang Mountains Tourism and Economy Special Region (2007-2020), Wudang Mountains Scenic Area Master Plan (revised) (2012-2025), 12th Five-Year Plan for the Protection of the Ancient Building Complex in the Wudang Mountains, and Hubei Provincial Plan for Protecting the Cultural Relics of Yuxu Palace of the Wudang Mountains (2009-2025).

The preparation of the Protection and Management Plan for the Ancient Building Complex as World Cultural Heritage in the Wudang mountains (2015-2035) is therefore formulated and based on the above-mentioned master plans and detailed plans. This plan aims to preserve the outstanding universal value of the ancient building complex in the Wudang mountains, maintain its authenticity and integrity, rationalize the relationship between cultural heritage protection and tourism development, ensure religious activities to be carried out in an orderly manner, protect cultural traditions, realize sustainable development of heritage, and maximize its social and economic benefits on the precondition of effective protection.

The plan preparation team is established under the leadership of Chinese Academy of Cultural Heritage in conjunction with Hubei Ancient Buildings Protection Center, Bureau of Religion and Cultural Heritage of Wudang Mountains Tourism and Economy Special Region, and other competent departments of the Special Region. In the preparation process, the preparation team fully communicated with relevant administrative departments, the organizations that use the ancient buildings, and other stakeholders to ensure that all contents of the plan are based on a thorough discussion and consensus with these parties. The way the project is planned and organized makes the plan scientific, accurate and feasible.

When the preparation process was completed, the plan was submitted by the provincial department in charge of cultural heritage to the State Administration of Cultural Heritage for approval. Upon approval by the State Administration of Cultural Heritage, the plan was promulgated by the provincial people's government for implementation. All requirements of the plan shall be incorporated into the economic and social development plans, master plans for land use, and urban-rural development plans of the people's governments at and above the county level.

Overview of the property

The Wudang mountains are located in ShiYan city Hubei province in the middle of China. It was approved as cultural heritage by WHC in Dec 1994.The composition of the property included ancient building complexes (Table 1); associated cultural heritage furnishing (such as stone steles in various building complexes, including imperial steles, chronicle steles, steles of divine merits, and other steles with stone carvings); ancient wells, ponds, altars, and other functional facilities; statues, mural paintings, color paintings, altar tables, shrines, and instruments inside the halls, as well as incensories and other artifacts outside; landscape settings (the mountain and river system and the ecosystem formed by the unique geological structure in the region where the ancient building complex in the Wudang mountains is located is an important part of the landscape setting of the complex). Main natural environment of the Wudang mountains includes mountain peaks and rivers within the area. The water system of the Wudang mountains mainly consists of Jianhe, Donghe and Jiudao rivers. In the Wudang mountains, there are 223 ancient trees, among which 31 are first-class ones (more than 500 years old), 61 are second-class ones (300-500 years old), and 131 are third-class ones (100-300 years old). There are two, nine and 12 species of rare plants falling into national class protection 1, 2 and 3 respectively, as well as 12 other species of rare trees in Wudang mountains (Fig. 2).

8 Palaces	10 Monasteries	10 Nunneries	12 Temples	8 Others
Yuxu Palace	Yuanhe Temple	Xiangfu Convent	Yuxu Rock	Gold Hall
Yuzen Palace	Huilong Temple	Chongxu Convent	Laojun Cave	The Ancient Bronze Hall
Zixiao Palace	Fuzhen Temple	Taishan Temple	Prince Cave	Xuanyue Gate
Nanyan Palace	Longquan Temple	Huixin Convent	Cave of the God of Thunder	Jianhe Bridge
Taihe Palace	The eight God Temple	Needle Grinding Well	Lingxu Rock	The first sky gate
Chaotian Palace	Up Temple	God Guan Temple	Huayang Rock	The second sky gate
Qingwei Palace	Middle Temple	The God of Wealth Temple	Lingying Rock	The third sky gate
Wulong Palace	Down Temple	Langmei Temple	Yinxian Rock	Great Tower Manor
	Taishang Temple	Jiangjun Temple	Up Courtyard	
	Renwei Temple	Laojun Temple	Middle Courtyard	
			Down Courtyard	

Table 1 Composition of the Wudang mountain property: 49 ancient building complexes

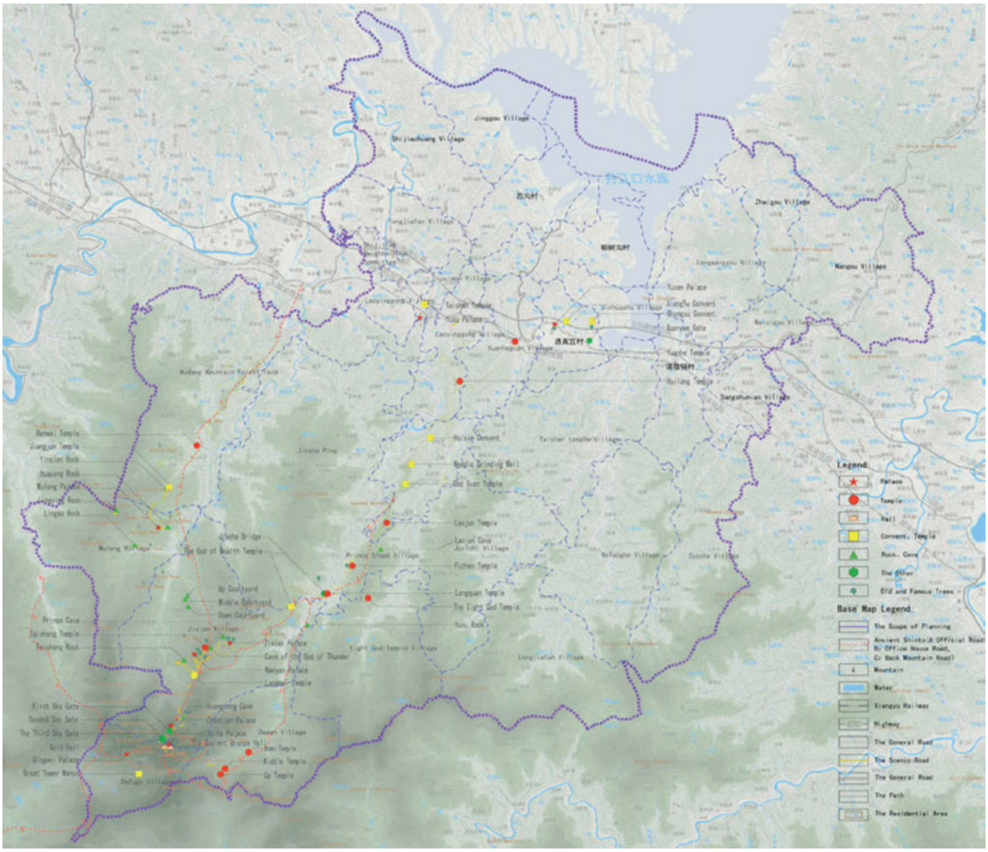

Fig. 2 Map of heritage composition

The value of the Wudang mountains property according to the UNESCO WHS criteria is represented as follows. Criterion (i): the ancient buildings in the Wudang mountains represent the highest standards in Chinese art and architecture over a period of nearly one thousand years (Fig. 3). Criterion (ii): the Wudang buildings exercised an enormous influence on the development of religious and public art and architecture in China. Criterion (vi): the religious complex in the Wudang Mountains was the center of Taoism, one of the major eastern religions and one which played a profound role in the development of belief and philosophy in the region.

Fig. 3 ZiXiao Palace

Planning principles and basic actions

Three are the major planning principles encompassing all actions. The principle of overall protection, according to which based on its outstanding universal value, the authenticity and integrity of all heritage elements of the ancient building complex in the Wudang Mountains should be well preserved, maintained and sustained. The principle of laying equal emphasis on heritage protection and sustainable utilization. Cultural heritage should be preserved as important resources for sustainable social and economic development, and the protection efforts should be sustained too. The principle of balancing the conservation and utilization of the ancient building complex itself and related cultural resources. Construction of a comprehensive protection and display system should be enhanced for the ancient building complex; protection and utilization of cultural heritage resources and regional ecological resources should be coordinated so as to promote all-round development of the region.

The objectives of the plan are, therefore, to truly and completely preserve and sustain the outstanding universal value of the ancient building complex in the Wudang mountains; strengthen the recognition, maintenance and dissemination of heritage value; and bring it into full play in promoting local cultural, social, economic and environmental development. Continuously enhance the capacity of preserving the cultural value of the ancient building complex to achieve overall protection of the heritage.

The unified management regulations, management and coordination mechanisms, and the basic principles of classified protection of heritage elements established by the Plan for the Protection and Management of the Ancient Building Complex in the Wudang Mountains shall be followed continuously. A system shall be established for interpreting the outstanding universal value of the ancient building complex in the Wudang Mountains based on using, interpreting and displaying the conservation plans from the perspective of protecting the positive role of world heritage. On the premise of reasonably utilizing and preserving the heritage value, the social and practical functions of all heritage elements shall be brought into full play so as to realize optimized and sustainable utilization of the entire heritage.

MANAGEMENT RULES

Upon approval of the plan, the protected areas and essential protective measures shall become parts of the *Master Plan of Shiyan City* and the *Master Plan of the Wudang Mountains*. Any modification of the compulsory content of the plan concerning protected areas, management measures and utilization functions is subject to the procedures stipulated in the *Administrative Measures for the Protection of World Culture Heritages* and *Measures for Examination and Approval of Conservation Plans for State Priority Protected Sites*. The property area and the buffer zone in the plan shall be managed in compliance with the *Administrative Measures for the Protection of World Culture Heritages*, the *Cultural Relics Protection Law of the People's Republic of China* and relevant laws and regulations.

Lands related to the safety of the main body of the cultural heritage shall be exclusively requisitioned by the state and used as "land for heritage site" in nature. Construction projects within the property area shall be exclusively related to the conservation, utilization and management of the cultural heritage and landscaping. Any other types of construction projects or blasting, drilling or excavation are prohibited in principle. Where such other types of construction projects as well as blasting, drilling or excavation are necessary in exceptional circumstances, safety of the cultural heritage must be ensured and approval by the State Administration of Cultural Heritage must be obtained through specific procedures (Fig. 4).

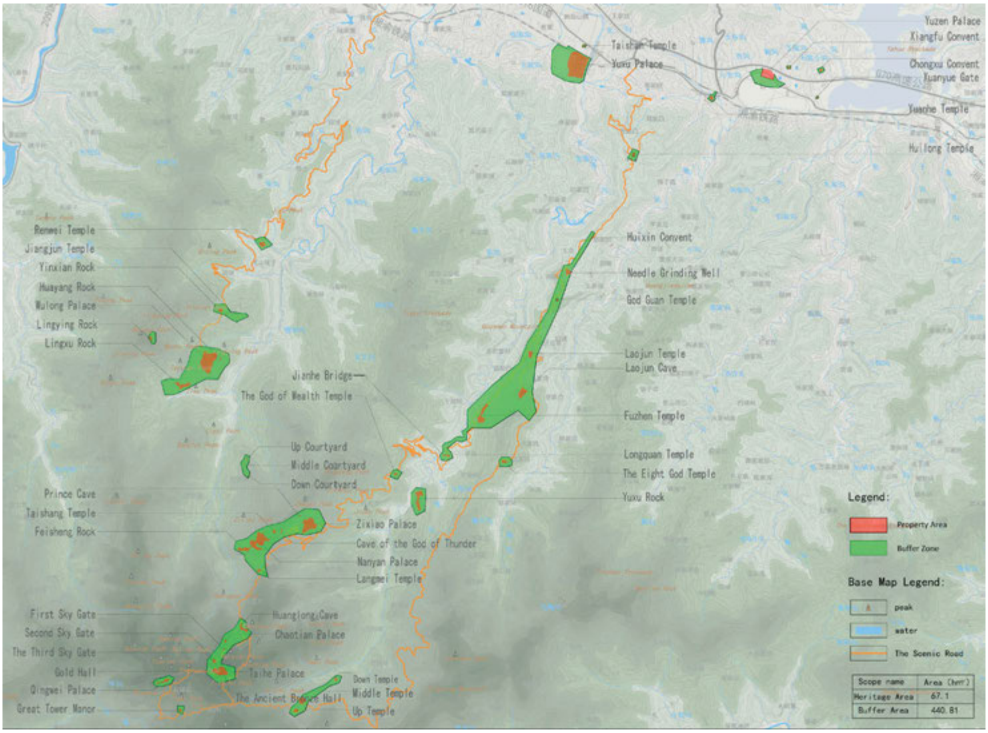

Fig. 4 Scope of property areas and buffer zone

Management Measures for the Buffer Zone

Facilities that cause pollution to the protected historic site and its setting, and activities that may have negative impact on the safety of the site and its setting are prohibited in the buffer zone. Correction measures concerning existing facilities that cause pollution to the site and its setting shall be taken within a specific time limit.

Construction projects within the buffer zone shall be exclusively related to the conservation, utilization and management of the cultural heritage and landscaping. Any other types of construction projects or blasting, drilling or excavation are prohibited in principle. Where such other types of construction projects as well as blasting, drilling or excavation are necessary in exceptional circumstances, safety of the cultural heritage must be ensured and approval by the State Administration of Cultural Heritage must be obtained through specific procedures.

Construction projects within the buffer zone shall be in line with the local traditional style, with a plot ratio of not more than 0.3. The height of buildings within the buffer zones of Xuanyue Gate, Chongxu Convent, Xiangfu Convent, Yuzhen Palace, Yuanhe Temple, and Taishan Temple shall not exceed 3 stories and their eaves height shall not exceed 9 meters. The height of buildings in the buffer zone of Yuxu Palace shall comply with the provisions of Hubei Provincial Plan for Protecting the Cultural Relics of Yuxu Palace of the Wudang Mountains (2009-2025). The height of buildings in the buffer zones of the rest 42 heritage sites shall not exceed 2 stories with an eaves height of no more than 6 meters (Fig. 5).

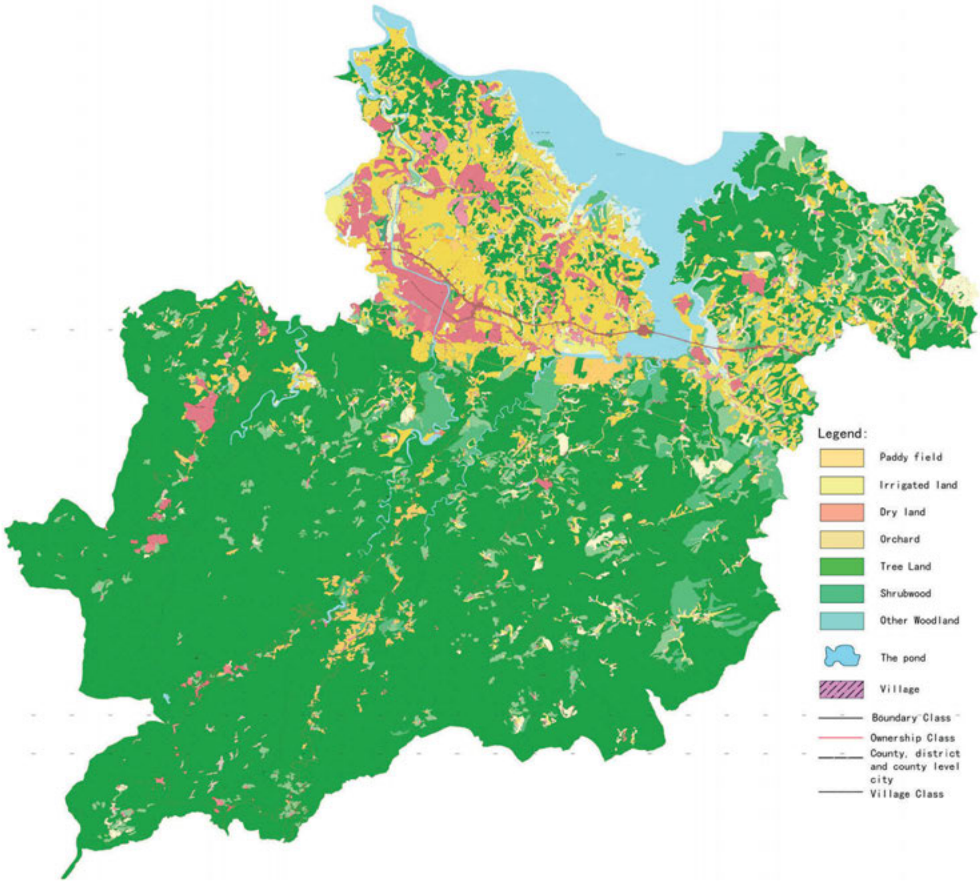

Fig. 5 Land utilization status

The local ecological system shall be managed and improved in accordance with the relevant national laws and regulations, including river dredging, wetland preservation, forest protection, water resources conservation, etc. Organizations and residents in the buffer zones of Yuxu Palace and Yuanhe Temple shall be relocated elsewhere within the period specified in the plan. No new construction, reconstruction or redevelopment activities shall be carried out before relocation. No relocation is necessary for the present residents living in the buffer zones of Zixiao Palace, Huilong Temple, Laojun Hall, Middle Temple, Down Temple, Great Tower Manor and Chongxu Convent. But when the existing dwelling houses are repaired or reconstructed, they must be kept in line with the traditional local style. Specifically, they must be single-story houses with a roof height of no more than 5 meters and the traditional sloping roof made of bluish grey tiles should be adopted.

No new tourist service facilities shall be built within the buffer zones of Nanyan Palace, Eight God Temple, Jianhe Bridge, Prince Slope, Qiongtai Middle Temple, Taihe Palace and Zixiao Palace. The existing facilities shall be renovated in several phases and kept in line with the background and traditional simple color of the heritage site. The present topographic features of the mountains shall be strictly preserved, vegetation of mountain slopes shall be restored, natural landscape shall be well protected, and construction of irrelevant facilities is prohibited.

Except the property area and buffer zone, other zones within the planned area are classified as construction control zones where construction projects may be carried out if necessary, but shall be kept in line with the local landscape without causing any damage to the overall background or the environment. All indexes of land use control shall conform to the requirements of the *Wudang Mountains Scenic Area Master Plan (revised) (2012-2025)*. Otherwise, the indexes shall be adjusted accordingly. The control objective of this area is to protect the harmony between the heritage site and local landscape, keep the environment clean and the river well dredged, and ensure the water quality of the Danjiangkou Reservoir to meet the national Grade-2 water quality standard. The architectural style of buildings in this area shall be well coordinated with the overall background environment of the heritage site, traditional building materials and colors should be used preferably, and the eaves height of buildings shall not exceed 18 meters.

CONCLUSION

The guiding principles can be summarized as follows. Important historical and cultural resources shall be preserved based on careful protection, prompt salvage, rational utilization and stringent management. The role of cultural heritage in social and economic development shall be brought into full play through effective preservation of the authenticity, integrity and outstanding universal value of the ancient building complex in the Wudang mountains. At the same time, overall heritage protection shall promote all-round, coordinated and sustainable economic and social development of the locality.

The key contents of the plan regard defining the carrier and characteristics of the outstanding universal value of the ancient building complex in the Wudang mountains. Establishing the purpose and overall vision of protecting and maintaining the outstanding universal value. Evaluating the status quo of protection and management of the ancient building complex in the Wudang mountains, and putting forward the requirements and measures of protection and management.

Pursuant to the *Cultural Relics Protection Law of the People's Republic of China* and *Administrative Measures for the Protection of World Culture Heritages,* the relevant requirements of this plan shall be included into the economic and social development plans, master plans for land use, and urban-rural development plans of the people's governments at and above the county level. This plan has priority of implementation in the protection of the heritage elements of the ancient building complex in the Wudang mountains. The plan may be revised or amended at any time when necessary according to its implementation results monitored and assessed.

MANAGEMENT OF HISTORIC CITIES AND WORLD HERITAGE SITES: THE ITALIAN CASE

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BACKGROUND

Being heritage complexes, made up of historic landmarks and buildings with architectural and cultural value, the cultural capital of historic city cores conveys a unique cultural atmosphere and sense of place (Licciardi, Amirtahmasebi 2012). Such idiosyncratic character is the result of the accumulated forms of cultural expressions that coalesce into the productive milieu, the styles of buildings and the associated social fabric. Investing in heritage preservation in historic city cores thus means to enhance a resource that is hardly substitutable across space and increasingly worth in the global competition among cities.

The conservation of monuments and sites has a long tradition in Europe dating back to late 19th century, however it was only by mid 20th century that historic centres' protection became an issue and urban conservation legislation was introduced. On these grounds UNESCO and ICOMOS developed in more recent times their Charts and Recommendations.

Urban heritage protection dealing initially with the physical conservation of historic sites it was extended in the 1980s into functional conservation, with the aim to counteract gentrification, and since 1990s it is principally focusing on the protection of the social and cultural characteristics of places endangered by mass tourism and the *disneylandisation* of heritage. This phenomena is getting more and more evident, and risky, for places having high tourist visibility, like those ones recognized as World Heritage Sites by the UNESCO Convention for the protection of world natural and cultural heritage (1972).

Fig. 1 Historic Centre of Morelia, World Heritage Site, Mexico

In this context the monitoring of conservation interventions and policies of the impact of mass tourism in heritage sites have become major tools for a sustainable conservation and development.

This paper intends to approach and develop those topics on the basis of some recent efforts in defining indicators for monitoring and evaluating World Heritage Sites management, and the same "value" of the World Heritage status. This approach, partially already experimented also in the Chinese context, may be further developed on a comparative Chinese-Italian basis and be eventually considered for future possible applications in Chinese WHS.

WORLD HERITAGE STATUS: BENEFITS AND RISKS

The World Heritage Convention is, probably, the most important and diffused instrument to protect heritage at a global scale, and is knowing an increasing attention by analysts and scholars, but still many important issues related to its functioning and its potential are not adequately addressed. The World Heritage "status" shows its capacity to influence relevantly territories in relation -above all- to two main phenomena. The first is the one known as cultural tourism, absolving a function of attractive brand and guaranteeing the unique qualities of single sites. The second one see the UNESCO recognition functioning as catalyst of attention, and may be referred in particular to the sites under pressure or at risk, for instance those ones interested by the *World heritage list in danger,* or the *Reactive monitoring* procedures.

Managing World Heritage sites implies at the present state of the art, many questions and challenges to be faced, including the functioning of the organization structures, the mitigation of pressures and threats on sites, the necessity to drive programs and policies towards generating positive and durable social and economic impacts for the communities living in and around the same sites. Given the complexity of this framework, there are still many open questions in properly managing world heritage properties, especially when we are in presence of urban settlements, cultural landscapes or territorial sites.

A gap is quite evident, for instance, in relation to the setting up of effective tools for measuring and evaluating the management impacts on local economic systems, especially in relation to the additional pressures caused on enlisted sites posed by their augmented visibility.

In 2002, to emphasize the importance of a proper management of heritage, the World Heritage Committee adopted, during its 26th session, the "Budapest Declaration" calling on all partners to support the preservation of World Heritage through key strategic objectives, trying to secure a proper balance between conservation, sustainability and development. At the national level some single nations have taken various initiatives to respond to the specific need for sites inscribed on the World Heritage List to have a management plan focused on the programming of measures to maintain the integrity of the values of sites in order to properly preserve them for future generations.

There is already a consistent literature and research experiences on that issue, according to the worldwide growing interest around the same concept of world heritage and its implications. Among the most recent contributions on this subjects it is worth to recall the text by Leask and Yeoman (2004), Harrison and Hitchcock (2005), van der Aa (2005), Cleere (2006), Leask and Fyall (2006), Frey and Pamini (2009, 2010). In particular were mainly studied until now the aspects related to the nomination process, the stakeholder participation, the tourism impacts of the inscriptions (Tunney 2005; Cochrane and Tapper 2006); the visitor management (McKercher, Cros 2001; Shackley 2006); the identification of the conditions in which the *World Heritage List* brings benefits and, on the contrary, when it may cause risks and threats (Frey, Stainer 2010). There are also many case studies on single sites (for Hadrian's Wall, De La Torre 2003; Stonehenge, Mason and Kuo 2006; Machu Picchu, Regalado-Pezúa and Arias-Valencia 2006; the Yellow Mountain in China, Li Fung and Sofield 2006; Assisi, Borchi 2008; for Hanoi in Vietnam, UNESCO 2008; the puppets district of San Gregorio Armeno in Naples, Santagata, De Caro, Marrelli 2008; Shirakawa-Mura in Japan, Jimuara 2010. And more: for the English sites, DCMS 2007; for the Scottish sites, The Scottish natural heritage/Hambrey consulting study 2007; for some case studies in Italy, Santagata 2011; for comparative international studies: a Pricewaterhouse Coopers LLP 2007; Prud'homme et al. 2008; WH Status 2009.

Available data clearly show how the sites branded by UNESCO are recognized as absolute valuable icons. To be not included in the World Heritage List represents a relevant gap, for instance to promote a place as a cultural tourism destination. Donors are much more motivated to finance projects, for instance in recovering dangers, on sites that can guarantee a worldwide return in terms of visibility. Many countries have set up policies and financial programs to sustain their world heritage sites. Such effects are also measurable in terms of generation of positive externalities, of attention received by the media and policy makers, in terms of comparison with other sites not listed (Peacock, Rizzo 2008).

Despite this picture, as said, managing properly world heritage still represents a big question to be faced, and a large part of the mentioned potential is completely under estimated in management policies and projects. If we take a look to the studies carried on for defining indicators for the evaluation of management efficiency, they are mainly focusing on the project's implementation, without exploring the impacts and effects generated by their execution. Experience on this regard was made at the international level through some trials in the field of natural sites registered to the World Heritage List. Among these, probably the most relevant is the research published in 2008 by the IUCN WH Paper # 23, *Enhancing our Heritage* (EOH project), proposing the adoption of a methodological framework for comparatively evaluating the effectiveness of management of environmental protected areas (Fig. 2).

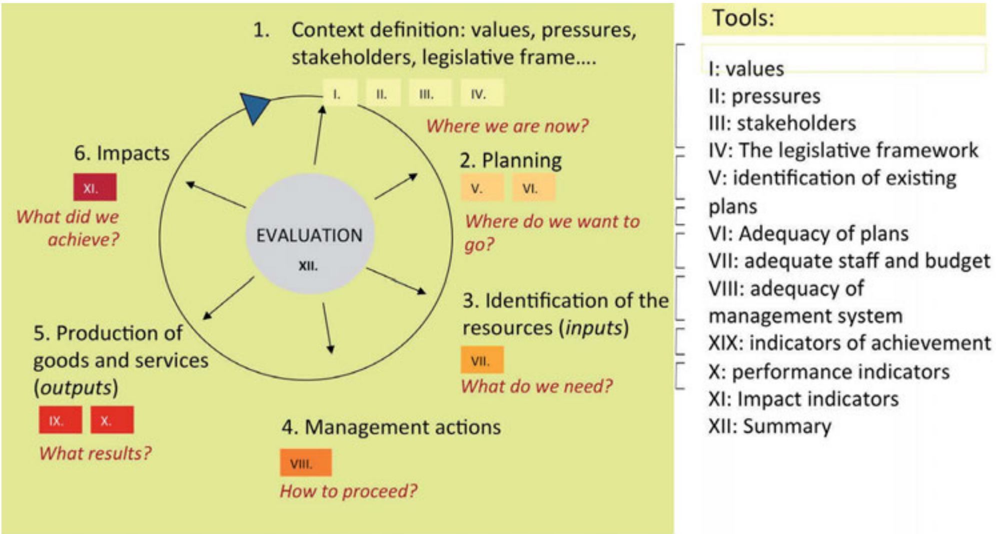

Fig. 2 Enhancing our Heritage evaluation framework (UNESCO, World Heritage Centre 2008)

It still remains largely open the issue related to the monitoring of cultural sites and evaluating the effectiveness and efficiency of management, in terms of performance/ impact results. Two other recent initiatives by UNESCO can be significantly mentioned as important references in this frame. The first one is represented by adoption the Recommendation on Historic Urban Landscape (2011), aiming at reconciling urban development with heritage values preservation, through the definition of proper cooperative schemes allowing to support culture driven development in urban contexts. Few encouraging pilot experiences have been already conducted in this regard in some cities world wide (WHITRAP 2016). And the second one, specifically related to tourism management, is represented by the UNESCO's World Heritage Sustainable Tourism Programme, aimed at developing capacity building tools for World Heritage site managers and other key stakeholders in the destination management, to balance economic development with sites conservation issues.

ITALIAN WORLD HERITAGE PROPERTIES, MAIN PHENOMENA

A recent analysis on management instruments of some selected Italian world heritage places (Re 2011) allowed to draft a picture of the situation and of the main phenomena concerning Italian world heritage cities (Fig. 3).

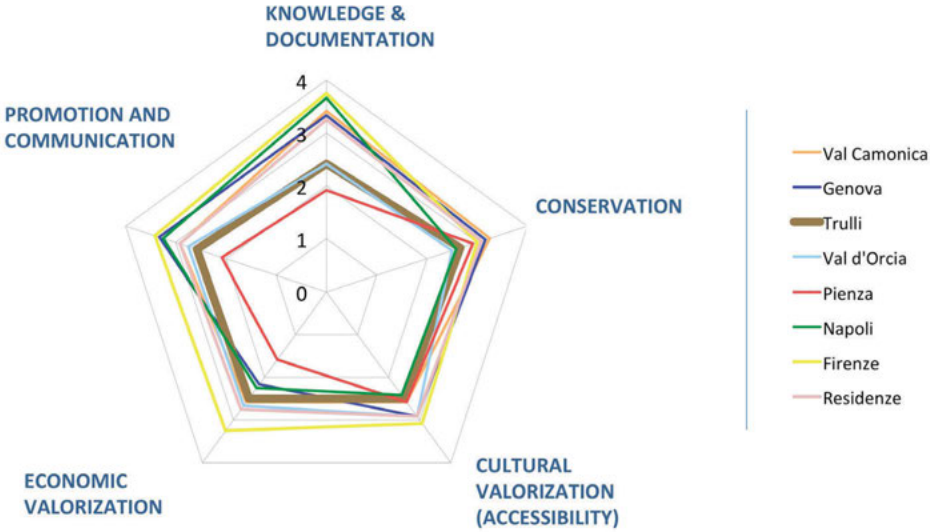

Fig. 3 Evaluation of Italian World Heritage Sites (Re 2011)

Referring to human pressures, they are evidently more present and complex in the historical centres of bigger cities, where the impact of human population is more evident and strong and where it is more difficult to identify and assess the single pressures.

In Genoa and Naples, for example, human pressures are mainly due to the high density of population of the central neighbourhoods, which produces traffic and, in some case, urban blight. The last one in some areas is mainly related to nightlife, while in other areas it is due to poverty and social problems of local population, which sometimes lead to low degrees of civic sense and of awareness of the values of the life context.

Of course, these pressures should be managed and their effects on cultural and historic heritage reduced. However, it is important to be aware that, at a certain measure, they are the evidence of the fact that these historical neighbourhoods still are the centres of local life. This increases the cultural value of buildings and monuments, adding a non material value that should be maintained in order to avoid the transformation of city centres from places of daily life to tourism oriented "non-places".

Car traffic is one of the main pressures of urban sites, such as Florence, Genoa, Naples. It is common, however, also in the non urban areas hosting World Heritage Sites. In these places it is harder to manage this issue, because of the weakness of public transportation systems in rural areas. Sometimes, the proposed solutions to the problem of car traffic, usually new infrastructures, are worse than the problem itself and threaten the integrity of the properties, like in the case of the new tramway line of Florence, running beside the Duomo.

Roads congestion is not the only negative effect of car traffic. It also produces air pollution, which threatens the integrity of some World Heritage Sites, lowering the quality of life around them and, above all, corroding and deteriorating buildings and monuments.

The increase of tourist flows is often seen as one of the main goals of management and valorisation of a World Heritage Site, but at the same time it is also one of the main pressures on monitored sites. The negative effects of tourism appear when it is not strategically managed, not trying to use it as an engine for a comprehensive local development. Among its negative impacts, there are the increase of traffic, a simplification of the local economic system and the excessive use of public facilities by tourists, without corresponding an adequate return.

FURTHER DEVELOPMENTS

Heritage tourism is a growing industry at the world scale. This fact is broadly related to the general expansion and diversification taking place over the past decades in the tourism industry, one of the largest and fastest-growing economic sectors in the world. Despite occasional shocks, the sector proved strength and resilience, with international tourist arrivals constantly increasing from 25 million in 1950 to 1,186 million in 2015 (UNWTO 2016). This last value almost doubled in only 15 years (674 million in 2000) and it is expected to reach 1.8 billion by 2030, according to UNWTO's long-term forecast. The most relevant context in this frame is undoubtedly represented by cities. It is in fact estimated that 70% of all humanity will live in cities by 2050 (UN 2015). This means town and cities will become increasingly important as places to live, work and play. "Sustainable cities" is not by chance one of the 17 UN development goals defined by UN in the agenda 2030 for Sustainable Development.

Fig. 4 Piazza San Marco, Venice

Cities' tourism, in this context, is expected to face the most significant increase in terms of numbers of visitor flows. Some cases around the world (Barcelona, Venice, to mention two of the most studied one) are already showing critical issues in governing such global phenomena and their implications (Fig. 5). All these figures easily allow us to understand how crucial is the management of heritage cities to address the opportunities and the issues that will be posed by this phenomenon.

Some specific aspects look particularly sensitive for further possible research developments in this field:

- Investing in the production of knowledge in order to create innovative models for monitoring the management plans, systems and tools for world heritage sites in relation to tourism issues;
- Establishing an innovative model for monitoring and assessing the impacts of management of the cultural sites, in relation to development and tourism;
- Defining of a checklist of indicators useful to the periodic verification of the impacts of the management of cultural sites, also applicable to situations other than those involving UNESCO recognitions.

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N°1

ITALY & CHINA

Joint Initiatives for Cultural Heritage

CHINA AND ITALY:
SHARING CULTURAL HERITAGE EXPERTISE

This volume inaugurates a series of publications aiming to disseminate the research outputs arising from the CNR-CACH Bilateral Agreement of Scientific and Technological Cooperation - focusing on cultural heritage conservation, valorization and management - signed in November 2014, between the National Research Council of Italy and the Chinese Academy of Cultural Heritage.

This first volume collects some of the papers presented during the international conferences organized by the two Institutions, respectively in Rome on November 2014 and in Dazu on June 2015, when exploring their respective fields of interest and expertise. The following three volumes will be dedicated to the results of the three bilateral research projects financed under the mentioned Agreement and undertaken in the period 2016-2019.

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