

The management of cultural heritage in sites prone to natural hazard

La gestione dei Beni Culturali soggetti a fenomeni naturali

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ABSTRACT - The present paper describes the mechanism for conservation of cultural and natural heritages in many part of the world. Most of them belong now to the UNESCO World Heritage List. In these sites, before the inscription to the list, no management plan was provided and none integration between heritage, landscape and local territory was pursued. In an advanced approach, directly coming from sustainable development theory, there is the necessity of connecting and harmonizing all the different phases of the management of cultural and natural heritages, integrating them into the main features of the real territory and local population. This is the background of “empowerment” that constitutes a new approach considering tangible heritage (natural and cultural), intangible heritages (art, poetry, spirituality), science and technology as elements of the “knowledge” that should empower local population, allowing them the development of their own economy and cultural and social system. In such a way natural and cultural heritages are becoming the engine of the development of a given local community based on the valorisation of their history, tradition and natural feature but properly calibrated in their own specific social and economical infrastructure. In the paper are reported case studies in which an emergency situation triggered some conservation plan and also some of the most advanced experience of “empowerment”. In all cases, strategic element is the realization of a proper management plan dealing with integration of the many feature and components of the territory, in a long term view perspective that is the development and the identity of local community.

KEY WORDS: Cultural Heritage, natural hazard, protection, management, landscape

RIASSUNTO - Il presente lavoro descrive le più avanzate tecniche di gestione e conservazione del patrimonio culturale e naturale in molte parti del mondo. La maggior parte di questi appartengono alla lista del patrimonio mondiale dell'UNESCO. In molti di questi siti, prima della iscrizione alla lista del patrimonio mondiale, nessun tipo di gestione era prevista e nessun tipo di forma di integrazione tra paesaggio, bene culturale e territorio locale era stata attuata. Con riferimento

ad un approccio moderno ed avanzato, proveniente direttamente dal modello di sviluppo sostenibile, è sorta la necessità di collegare ed armonizzare tutte le diverse fasi della gestione dei patrimoni culturali e naturali, favorendone la loro integrazione con le principali caratteristiche del tessuto e con la popolazione locale.

Questo è il background culturale del concetto di “empowerment” che costituisce un nuovo paradigma, considerando il patrimonio tangibile, il patrimonio (naturale e culturale) immateriali (arte, poesia, spiritualità), la scienza e la tecnologia come elementi della “conoscenza”, che dovrebbero responsabilizzare la popolazione locale, consentendo loro lo sviluppo della propria economia, del sistema culturale e sociale. In tal modo i patrimoni naturali e culturali saranno comunque il motore dello sviluppo di una determinata comunità locale basata sulla valorizzazione della loro storia, tradizione e funzionalità naturale, ma opportunamente calibrato nella propria infrastruttura sociale ed economica. Nel documento sono riportati diversi casi di studio in cui una situazione di emergenza ha innescato la realizzazione di un piano di conservazione e anche alcune delle esperienze più avanzate di “empowerment”. In tutti i casi, elemento strategico è la realizzazione di un piano di gestione integrato con le diverse componenti territoriali, in una vista prospettica di lungo termine che è lo sviluppo e l'identità delle comunità locali.

PAROLE CHIAVE: Beni culturali, rischi naturali, protezione, gestione, paesaggio

1. - INTRODUCTION: FROM LANDSCAPES TO CULTURAL HERITAGES

Cultural heritages, represent the trace of human being on the Planet Earth. They are the evidence of thousand years of humanity activity, to adapt our living condition to environment (BOBROWSKY, 2004). Geo-heritage are, on the other side, the earth's legacy to man,

the most spectacular expression on the landscape natural evolution. Cultural heritage can furthermore be divided in three major groups, upon on time: natural landscapes, where the man uses the opportunity provided by environment to survive mainly in terms of rupestral sites; cultural landscapes where the man adapts himself to environment with slight modification of it; urban landscape, with all possible variants, where the man modifies the environment for his evolution. It is nowadays possible to say that the human modification to the environment starts with the development of monotheistic religions that are posing the man above the planet earth. Such a thesis is furthermore reaffirmed and imposed by Darwinism, Trotskyism and capitalism (BROOKS, 2007). The United Nations Educational, Scientific and Cultural Organization (UNESCO) seeks to encourage the identification, protection and preservation of cultural and natural heritage around the world considered to be of outstanding value to humanity. This is embodied in an international treaty called the

Convention concerning the Protection of the World Cultural and Natural Heritage, adopted by UNESCO in 1972. According to the Convention, the following shall be considered as “cultural heritage”: monuments (i.e. architectural works, works of monumental sculpture and painting, elements or structures of an archaeological nature, inscriptions, cave dwellings and combinations of features, which are of outstanding universal value from the point of view of history, art or science); groups of buildings (i.e. groups of separate or connected buildings which, because of their architecture, their homogeneity or their place in the landscape, are of outstanding universal value from the point of view of history, art or science); sites (i.e. works of man or the combined works of nature and man, and areas including archaeological sites which are of outstanding universal value from the historical, aesthetic, ethnological or anthropological point of view). This broad definition can be put into a list of typologies, as in table 1 (from WORLD BANK, 1994), where some se-

Tab. 1 – *Selected types of cultural heritage (modified from WORLD BANK, 1994).*
– Selezione di differenti tipi di beni culturali (modificato da WORLD BANK, 1994).

Main categories	Sub-types	Examples
Sacred sites	Burial sites	Xian, China Tomb Fields, Bahrain
	Sites of religious significance	Mecca, Saudi Arabia Jerusalem, Israel
Archaeological sites	Pre-historic sites	Altamira, Spain Lascaux, France
	Historical sites	Historic roads, bridges, dams, fortifications, and walls.
	Engineering and industrial sites	Marib Dam, Yemen The Great Wall, China
	Submerged or marine sites	Alexandria, Egypt Mahabalipuram, India
	Sites within biologically diverse areas or protected reserves	Tikal, Guatemala Sacred groves, Ghana.
Monumental sculpture	Cave sculpture	Indian Buddhist cave sites Chinese cave sites
	Architectural sculpture	Thebes, Egypt Petra, Jordan.
Monumental painting	Cave or wall painting	Tombs in Luxor, Egypt Tassili, Algeria.
Architecture and town planning	Monumental architecture	Monte Alban, Mexico Copan, Honduras
	Indigenous or vernacular architecture	M'zab Valley, Algeria Chitral, India
	Historic settlements and town centers	Quito, Ecuador San Gimignano, Italy
Historic landscapes	Cultural landscapes	Cres, Croatia Land of the Dogon, Mali
	Historic parks and gardens	Sigiriya, Sri Lanka Shalimar Gardens, Pakistan
	Trade routes monuments and remains	The Silk Route Pan-African trade routes

lected types of cultural heritage are catalogued.

In order to pursue the aims of the Convention, since 1978 UNESCO is providing for the World Heritage List, a list of properties forming part of the cultural heritage and natural heritage which UNESCO considers as having outstanding universal value in terms of a set of ten criteria. After the 31st Session of the World Heritage Committee (2007), the UNESCO's List includes 851 properties forming part of the cultural and natural heritage which the "World Heritage Committee" considers as having outstanding universal value. These include 660 cultural, 166 natural and 25 mixed properties in 141 States Parties. In particular, 378 of them are in Europe, 193 in Asia, 149 in Africa, 110 in America and 21 in Oceania, and this distribution mirrors the world dissemination of the human civilizations. Also the list of most represented countries reflects this aspect: Italy (41), Spain (39), China (35), Germany (32), France (31), United Kingdom (27), India (27), Mexico (27) are at the top of this inventory. A great part of the above sites were and, sometimes, remains are not in equilibrium with environment. They are continuously affected by several factors such as natural and human, with rapid and slow onset. The figure 1 is describing the major disrupting factors affecting cultural heritages (ICCROM, 2006, modified).

Among rapid onset natural phenomena the major role of disrupting cultural heritages is played by earthquakes, floods and landslides. It is difficult to estimate the percentage of losses caused by any kind of phenomena but, while earthquakes and floods hit a very large area and a large number of monuments in the same moment, landslides are acting more locally, at the scale of the phenomenon, and a statistic is rather complicate. As an example, it is possible to say that among the Italian UNESCO sites inscribed in the World Heritage List, 25% of them is affected by mass movements,

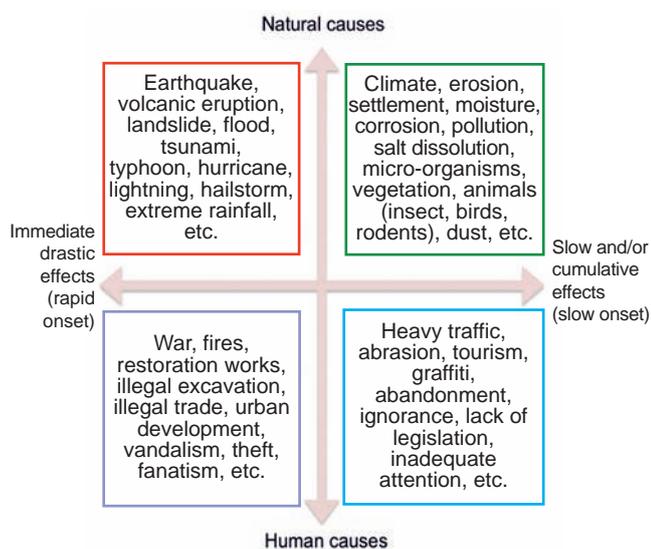


Fig. 1 – Risk factors for Cultural Heritage (ICCROM 2006, modified).
– Fattori di rischio per il patrimonio culturale (ICCROM 2006, modificato).

54% from floods and 82% hit by earthquakes with intensity higher than the damage level. It is also evident that many sites are suffering for multiple hazards. The above reflections, without obviously being exhaustive of the problem list, clearly underline the impact that the Earth Sciences have had in the construction, development and maintenance of the cultural properties; it is evident that the same disciplines have to assume a fundamental role in all the policies that are today necessary for the protection of the heritage. This passage has never been very clear in the past, since the archaeology and the conservation aspects had a strong centrality and autonomy. This point of view is now less evident, with more attention to the integration of different sciences. In reality it is possible to affirm that the protection of the cultural heritage represents an interdisciplinary process (and not multi disciplinary) to the borderline among art, history, science, policies for management and fruition. The following figure 2, from Fitzner B. (2004, modified) it underlines the articulation of the disciplines and the necessary investigations to the resolution of real problems of conservation.

Policies and plans of conservation of archaeological and architectural sites have been mainly oriented to reduce the impact of the human agents of deterioration, like urbanization, construction of public works, the use of the ground for agriculture or the tourist pressure management. In general the adopted measures to conserve the cultural heritage from its destruction by the natural agents have been relegated in background; even if natural processes, specially the geological and geomorphological ones (sedimentation and erosion processes, debris and mud flows, inundations, landslides, fluvial dynamics), remarkably affect the existence of the cultural heritage sites, in this case the usually adopted tasks are emergency works. Nevertheless, the diagnosis of geologic risk and the measures of conservation derived from the same one are necessary if we are intentioned to recover the cultural heritage and to prolong their existence. In this framework, the conservation "*in situ*" is one of the main targets; for this reason the diagnosis of risk and the elaboration of measures of risk mitigation are the most important aims to preserve the cultural heritage (CANUTI *et alii*, 2008).

1.1. - PLANNING MAINTENANCE OR MANAGING EMERGENCIES?

Natural and cultural heritages are the results of historical, social and architectonic evolution, combined with local natural resources and climate condition for a given region in a given period of time. There is no doubt that preserving such cultural and natural heritages is a complex task that require not only simple public financial support but a different point of view that include the relationship among the three items mentioned above. A simple methodology in management, "*sensu strictu*", of

Problem	Scale	Parameter to investigate	Typology of investigation	Involved sciences
Non-visible deterioration	Nanoscale (<mm)	Changes of stone properties (composition, texture, porosity, strenght etc.)	Laboratory analysis	Geosciences, material sciences, chemistry, physics, microbiology, Ecology etc.
Visible deterioration	Microscale (mm<cm)	Decoloration, Mass loss, micromorphology		
	Mesoscale (cm<m)	Deterioration phenomena, alteration		
	Macroscale (whole structures or monuments)	Structural stability, aesthetic appearance	In-situ	Structural engineering, Engineering geology Architecture etc.

Fig. 2 – Scale of the problems and involved disciplines and investigations for the conservation of cultural heritages (FITZNER B., 2004 modified).
 – *Scala dei problemi, discipline coinvolte e tecniche adottate per la conservazione del patrimonio culturale (FITZNER B., 2004 modificato).*

cultural and natural heritages may consider a three steps approach such as (VALENTINO, 1999): knowledge acquisition (research, monitoring, planning, projects, etc.); conservation (maintenance, restoration, capacity building, site control, etc.); fruition (education, knowledge transfer, exhibition, promotion, communication, etc.). These step are interrelated as in figure 3.

Unfortunately, it is quite evident that the real experience is far away from the very simple proposed approach: very often natural and cultural heritages are not properly maintained and attention, and financial resources, are concentrated to them only after a disasters or

because of an emergency. In this approach the management of the site pay attention directly to the conservation phase without the proper preliminary study phase and without having underlined the possibility of future real exploitation and then designed the conservation accordingly. Generally, after the emergency phase, there is a backward attention to the study phase to implement the proper restoration needed but, due to the short time often required and limited resources, this approach is not properly implemented in an efficacy management plan considering the three tasks of above. More sophisticated approaches will be discussed later in this paper. Following are some case studies from important world natural and cultural heritages, highlighting successful stories but also situation where the need of a more rational approach to the management of natural and cultural heritages is required.

1.1.1. - Machu Picchu

Machu Picchu (fig. 4), is the most noteworthy archaeological site of Peru and is included in the UNESCO World Heritage List. Recent studies, carried out by the DPRI of Kyoto University (SASSA *et alii*, 2001 and 2002), pointed out the presence of large mass movements within the archaeological area. Even if the site was well maintained by the Peruvian Government such new information arrived totally unexpected and caused many problem on the development of a proper management plan. In 2001, the Italian Ministry of Education, University and Research (MIUR) approved a

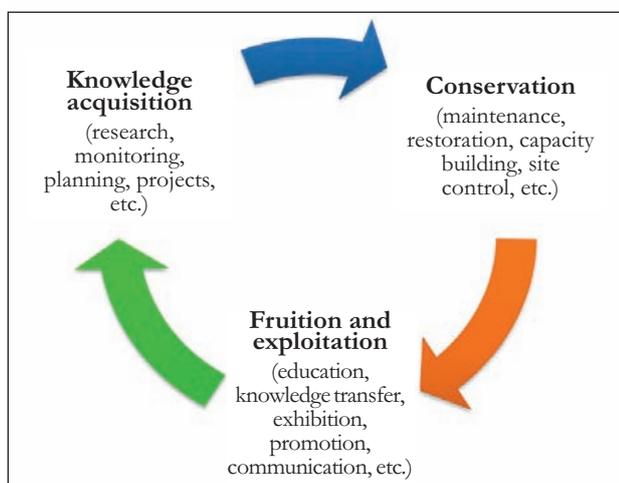


Fig. 3 – Three phases approach in management cultural and natural heritages.
 – *Approccio in tre fasi nella gestione del patrimonio culturale e naturale.*

project for the development of new technologies for remote slope monitoring, based on radar interferometry from satellite and ground platforms (CANUTI *et alii*, 2005, CANUTI *et alii*, 2008).

The project (CANUTI *et alii*, 2005 and 2008) proposes the application of an integrated package of advanced technologies for remote slope monitoring. Synthetic aperture radar interferometry (SAR), implemented from satellite and ground-based installations, has been the core of this integrated package, which also comprehends GPS, optical/satellite image interpretation, field surveys and geological/geomorphological investigations. The proposed techniques are particularly suitable for archaeological sites due to their remote sensing nature, their low environmental impact, and the possibility of investigating surface movements over large areas without direct access to the unstable sites. The geological and geomorphological investigations conducted in the area of Machu Picchu highlight the presence on many slope instabilities, mainly with low depth. Several slope instability phenomena have been identified and classified according to mechanism, material involved and state of activity. They are mainly related to rock falls, debris flows, rock slides and debris slides. Origin of phenomena is kinematically controlled by structural asset and relationship with slope face (rock falls, rock slide and debris slides); the so accumulated materials is the source for debris flow. In the area of the Carretera a precise mapping of debris deposits and past debris flows was carried out, leading to a zoning of processes within the limits of the ancient landslide detected by SASSA *et alii*, (2001). The situation of the slope with the citadel is more complex due to the strong structural control of the master joints on the slope evolution. In this, planar rock slides are mainly affecting the NE flank while rock falls are predominant on SE cliff.

The analysis of monitoring data, integrated with field observations is suggesting (fig. 5):

1 - the stability of the upper part of the citadel were

several GPS sensor do not exhibit any movements; also archaeological structures seem to be relatively undamaged;

2 - the continues rock falls in the S-W side of the cliff and related citadel's border, were also archaeological structure have been damaged by progressive lateral detensioning; this is probably the area with the highest short-term conservation problem.

3 - the presence of a paleo-landslide in the North-East flank, with likely thickness of some tens meters, limited by a tension crack discovered in 2004; in this area neither GPS nor PS from GBR-SAR detected any kind of deformation; in this area also structural geology detect some not regular pattern in the measurement. Finally, the collected data are beginning to give a first picture of the slope evolution of the site. Nevertheless, the analysis of the monitoring data collected from the systems installed by Italian, Japanese and Czech-Slovak groups, together with data provided by Canadians and Peruvians, will allow a better evaluation of the mechanisms of slope processes and of landslides, leading to a complete harmonization amongst the observation of the different research groups involved.

As historical consideration, the data collected suggest the possibility that the site of Machu Picchu could have been selected by Incas also because of the availability of two large block deposits, useful for constructions: one on the so called "cantera" and the second in the paleo-landslide recently discovered.

1.1.2. - *Bamiyan (Afghanistan)*

In the great valley of Bamiyan (MARGOTTINI, 2009), 200 km NW of Kabul, central Afghanistan, two big standing Buddha statues appear to visitors, carved out of the sedimentary rock of the region, at 2500 meters of altitude (fig. 6). The Emperor Kanishka ordered their construction that started in the 2nd century AD for the smaller one,



Fig. 4 – View of Machu Picchu site.
– *Vista del sito di Machu Picchu.*

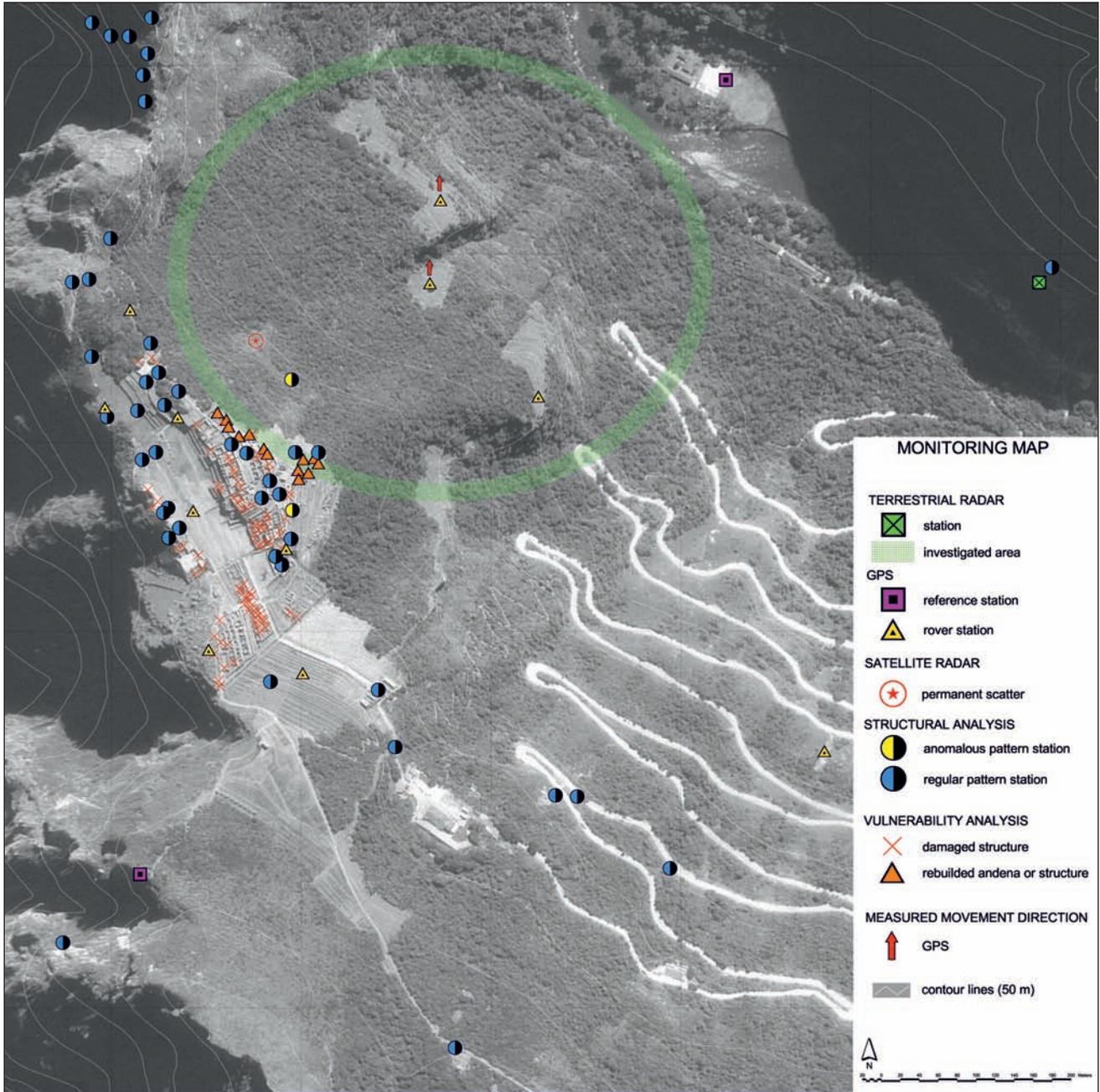


Fig. 5 – Integrated map of surface deformation evidences and present monitoring data.
 – *Mappa integrate delle evidenze delle deformazioni superficiali e del sistema di monitoraggio.*

while the initiation of the great Buddha is likely to be dated III-IV c. AD. Following the tradition, this remarkable work was done by some descendants of Greek artists who went to Afghanistan with Alexander the Great.

The Buddhist art of the Hindu Kush mountain region, where the Bamiyan Valley is located, represents the final flowering of Buddhism in Afghanistan. The kingdom of Bamiyan was a Buddhist state sited at a strategic location along the trade routes that have been connecting since a very long time China and Central Asia with India and the west. Bamiyan served as an important monastic and spiritual centre that hosted crowds of pilgrims and

merchants becoming a hub of intense commercial activity. The village was built between 5th and 9th c. AD in a distinctive phase in the history of Buddhist art, a period of intense cultural and religious exchanges between East and West and a time of great cultural change within the Buddhism religion. During this period of Bamiyan's Buddhist flourishing, two massive Buddha images were carved out in a high stretch of cliff, facing the widest part of the valley. These colossal images are the largest Buddhist sculptures in the World. The greater Buddha stands 53 m in height at the western end of the cliff-face. The smaller one, at the eastern end of the cliff, is about 35

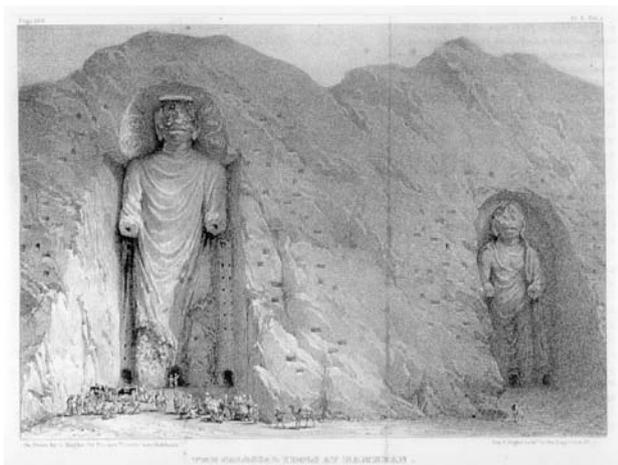


Fig. 6 – The Giant Buddha statues of Bamiyan in a depiction of Burnes, 1834.
– *La statua del Grande Buddha di Bamiyan in una raffigurazione di Burnes, 1834.*

m. The niches containing the statues were respectively 58 and 38 m high. All along the cliff face between these monolithic images, hundreds of caves, of varying size, are carved and used as chapels for private and public worship. Ambulatories, which are further rock-cut chapels and image-niches, surround the larger Buddha and are located at the level of his feet and in correspondence of his head. Most of the rock-cut chapels and ambulatories at Bamiyan are covered by mural paintings, displaying a very rich, differentiated, and important body of early Buddhist paintings. Under the worldwide astonishment, the two statues were demolished on March 2001 by the Taliban, using mortars, dynamite, anti-aircraft weapons and rockets (fig. 7). The Buddhists as well as the world community, UN and UNESCO failed to convince the Taliban to avoid the destruction of this cultural heritage. The fundamentalist Islamic militia, that ruled most of Afghanistan from 1996 to December 2001, followed the edict of their supreme leader who ordered an iconoclastic campaign of destruction for all religious graven images. With reference to the previous approach considering knowledge acquisition, conservation and fruition it is worthwhile that such important monument were even not inscribed in the UNESCO world heritage list at the time of the destruction and included later on as cultural



Fig. 7 – The destruction of Western Giant Bamiyan Buddha.
– *La distruzione del grande Buddha di Bamiyan.*

landscapes. Also in this case there was the need of a disasters to enhance a proper attention to the site and the realisation of a management plan for the whole area.

The result of demolition was impressive: the two large statues were destroyed, the niches where the Buddhas were carved were almost to collapse, many mural paintings were finally covered by asphalt. Slope instability due to the explosion as well as natural processes were quite evident: rock slides, and rock falls have already occurred in the past and during the explosion, and most other areas were prone to collapse. Explosion of March 2001, apart the collapse of statues, produced a deterioration of the stability conditions, mainly in the superficial part of the niches.

In the small Buddha niche, besides the collapse of the statue, three minor rock falls occurred in the top. In the mean time, the blasting produced a degradation of the upper part of the niche in the eastern side. In this area a stair-cave is located inside the cliff and the sect between the stairs and the niche is quite thin (about 30-50 cm). This sector was at that time estimated as the most critical for future stability. The western side, as consequence of an existing buttress, did not suffered substantially. A rock fall occurred and some instabilities were evident in the upper part. In the large Buddha the collapse of statue and the consequent instability of the back side of the niche were the major effects. A small rock fall occurred on the top of the niche. Probably, the thickness of sect between the stairs going up into the cliff and the niche (about 1 m), did not allow a large propagation of the effects of blasting and consequently a severe damage. Under the UNESCO coordination, a global feasibility project for the needed restoration work was initially implemented after an extensive engineering geological investigations in very difficult conditions (e.g. landmines). Field data were collected and a mechanism for potential cliff and niches evolution were provided. The present paper describe all the emergency intervention performed in Bamiyan (Central Afghanistan) for the consolidation of niches and unstable blocks (fig. 8) resulting from the explosion, executed by Taliban in March 2001, aimed at destructing the VI c. A.D. giant statues of Buddha. The effect of explosion was quite dramatic: the two statues totally collapsed but also some small part of the niches fall down and, mainly large part of the Eastern Giant Buddha Niche was close to the collapse. UNESCO was immediately prompt to undertake an emergency intervention for securing the remaining of such wonderful cultural heritages and, thanking to the generous Government of Japan financial support, the works started in November 2003.

The activities were developed according to the following general scheme:

- 1 - engineering geological study of the site, including laboratory testing and field work (the first were conducted in Europe in few samples and the latter conditioned in their execution from the presence of land mine);
- 2 - installation of a high precision monitoring system;

3 - realisation of temporary support infrastructure, to maintain stable the blocks at limit equilibrium, also during the execution of works;

4 - execution of the consolidation work, with professional climbers to avoid any activities below the hanging and unstable blocks, with a system of small and long passive anchors and grouting;

5 - minimisation of impact of anchor heads, with a mixture of special mortar, investigated in detail with the support of ICOMOS expert.

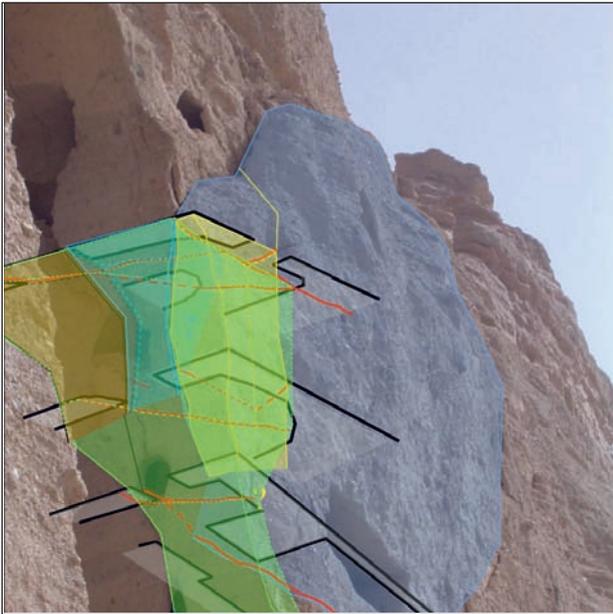


Fig. 8 – Pattern of existing discontinuities at four different stories and reconstructed unstable blocks in the upper East side of Eastern Giant Buddha niche.
– *Pattern delle discontinuità presenti su quattro diversi livelli e ricostruzione dei blocchi instabili nella sommità della parte orientale della nicchia del Grande Buddha.*

The result was quite satisfactory, in an area that is slowly coming out from decades of war, and in which it was necessary to adopt the maximum of professional judgment in identifying weak points and limits in knowledge and, in the mean time, to adopt technologies capable to solve the problems in very short time and in safe conditions. After the investigations started in September 2002 and the practical intervention of October-December 2003, March 2004 and October-December 2006, the cliff and niche of the Eastern Giant Buddha (the most critical part) it is now more stable and the risk of collapse almost avoided. Also, the niche of Western Giant Buddha have been protected from water infiltration. High attention was posed to the methodology for consolidation since the cliff, mainly conglomerate, it presents some siltstone layers exhibiting a very severe slaking process. To avoid any induced vibration firstly superficial nails were drilled by means of 3,6 cm diamond head. Cooling water was reduced at minimum by means of a combined system of compressed air. Deep

anchors were drilled from the further part of the unstable blocks, towards the most critical one. Grouting was made with cement added with super plasticizer to avoid any water release, capable to interfere with the slaking siltstone (figs. 9, 10). Further work will be needed in the future, especially in back wall of both niches but, at least, the major risk to have a collapse involving also the few remains not destroyed by Talibans it is now turned away.

A recent geomorphological field survey has been carried out and reconstructed the main active geomorphological processes along the cliff area mainly related to superficial waters (e.g. erosion, infiltration along joints, accumulation of mud/debris) and slope deformations (e.g. toppling, rock falls, rock slides, jointing). This is for highlight the other portion of cliff and archaeological caves at risk of collapse. The geomorphological survey has been integrated with geotechnical, structural and kinematic analyses concentrated in 18 distinct sections of the cliff where geological processes were more prominent. This to detect and investigate potential failure

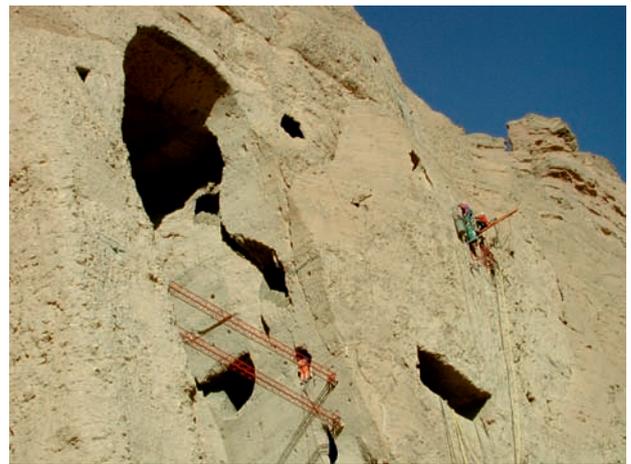


Fig. 9 – Consolidation works on the Bamiyan niche.
– *Lavori di consolidamento nelle nicchie di Bamiyan.*



Fig. 10 – Consolidation works in the Bamiyan cliff.
– *Lavori di consolidamento sulla parete di Bamiyan.*

modes of the jointed rock masses forming the Bamiyan cliff. The slope was divided into two main sections according to a different general orientation of the slope probably due to tectonic effects. The kinematic analysis produced different results for the various slope failure modes analysed according to local structural and geomorphological characteristics of the cliff. A geomorphological map reporting the main processes surveyed in the area has been produced. In addition a preliminary long-term reconstruction of the cliff and valley evolution has been envisaged considering the potential effects of tectonics and climate variability. Finally, a short-term analysis through photographic images is reported comparing some geomorphic evidences from 1910 to present.

1.1.3. - Lalibela

Lalibela is located in the northern-central part of Ethiopia, approx. 600 km north of Addis Ababa in Northern Wollo, one of the most structural food deficit areas of the Amhara Region. The town, which has about 12000 inhabitants, is situated at an altitude of 2500 m. In its centre a unique complex of 11 rock-hewn Christian Orthodox churches is located, cut out of the living rock some 800 years ago whose construction is attributed to King Lalibela (1167–1207). All churches are widely affected by structural damage and weathering (DELMONACO *et alii*, 2010) that are posing a serious problem for the future preservation of these monuments. Geological field surveys, in-situ geotechnical analyses and recognition of various weathering processes have been preliminary carried out in the area providing a classification of the churches according to structural damage. Laboratory tests on volcanic materials have detected a deep alteration of rocks due to chemical and physical weathering as well as the diffuse presence of montmorillonite. This may be recognised as the main cause of the progressive deterioration of the physical and mechanical characteristics of the slope-forming rocks in Lalibela. Following the new scientific findings on the weathering processes affecting the Lalibela Churches it will be possible to detect and implement urgent and medium/long-term protection strategies for the conservation of the monuments (fig. 11).

Looking more in detail the damage on the different Churches it has to be mentioned the situation of Biet Ammanuel where the heavy static load and the reduction of strength due to weathering is producing an important discontinuity pattern that is posing serious problem on the future stability. Likely, the load of the roof on walls is evaluated in about 10 % of the Uniaxial Compressive Strength (UCS) giving further possibilities for a future appropriate static study and a proper consolidation design (fig. 12).

In the same complex of Lalibela, the Church of Biet Aba Libanos is suffering for the possibility of sliding due to a system of cracks dipping 45° onto the façade. The stability of the church have been evaluate



Fig. 11 – The church of Biet Gyorgis in Lalibela.
– La chiesa di Biet Gyorgis a Lalibela.

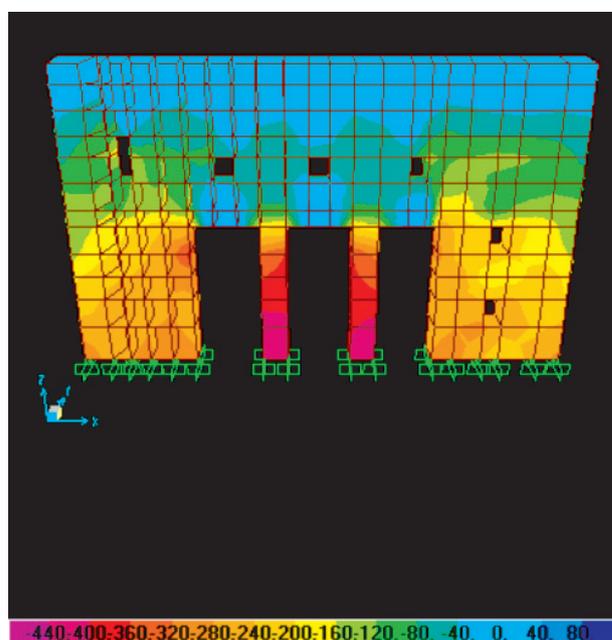


Fig. 12 – Structural analysis of the Biet Amanuel Church showing a load, in the central pillars, of about 4,5 KPa despite of a UCS of 50 KPa.
– Analisi strutturale della chiesa di Biet Amanuel che evidenzia un carico nei pilastri centrali di circa 4,5 KPa rispetto a un UCS di 50 KPa.

with the traditional method of rock mechanic slope stability, giving a picture of a church at the limit equilibrium (DELMONACO *et alii*, 2010). This case study is demonstrating the importance of a real interdisciplinary approach to conservation of rock structure monument due to the possible occurrence of different phenomena in the same site.

1.1.4. - Koguryo (North Korea)

The Koguryo Kingdom was founded around 37 B.C. by the Maek Tribe, who inhabited the narrow river basin in the middle region of the Yalu River. The kingdom de-

veloped uninterruptedly from this foundation, and in 313 A.D. drove out the Chinese Lolang. By 427 A.D. the capital city was moved to Pyongyang. Continuous territorial expansion took place, so that at its maximum Koguryo territory ranged from the Amur River of Manchuria in the north, to the areas of the Han River in the south. The culture of the Koguryo Kingdom is characterized by its international nature and its rapid cultural advancement. The kingdom took a leading role in the creation of unique East Asian cultures by its acceptance of various cultural elements from areas such as China, the Northern nomadic tribes, Lolang, and the Buddhist religion. Important archaeological remains are the Tombs of the Koguryo Kingdom which may be classified into two types; stone-mound tombs, and stone-chamber tombs covered with an earthen mound. In most instances these tombs were built on river-side plateaus, or on mountain foothills overlooking area of river basin. Some stone-chamber tombs contain mural paintings. In the early period these mural paintings were drawn onto the plastered wall, but over time they gradually began to be drawn directly onto the water-polished walls. The themes of the mural paintings also changed, with episodes from the life of the buried couple being most common in the early period, whilst in the later periods depictions of the Four Divine Imaginary Animals were standard. The use of colour was also heightened in this later period, whilst various decorative motifs such as lotus flowers, flames, floral arabesques, the constellations, the sun and the moon came into use.

The tombs were constructed following three main types: at ground level, partially underground, and underground.

The tombs, and the related mural paintings (fig. 13) are now suffering for various problems like (MARGOTTINI, 2005):

- 1 - Humidity
- 2 - Water infiltration (from precipitation and underground water)
- 3 - Structural instability



Fig. 13 – Painting in the Yaksuri mural tomb.
– *Pittura murale nel sepolcro Yaksuri.*

Also not appropriate old restoration and the construction of new access produced some damage to the tombs. These include mainly the reduction of transpiration on the mound as well as structural asset of the monuments, sometimes disturbed by the concrete structures constructed to permit the access to the Cultural Heritage. From the above sentences it is quite evident that any intervention on the tomb has to be absolutely multi-disciplinary, avoiding sectorial actions, often not taking appropriately of care the different and complex relationship among many factors (e.g. humidity, hydrogeology, stratigraphy, structural asset, etc.). As an example a concrete impermeabilization on the mound (sometime useful in principle) may create a barrier to correct transpiration, and then to mural painting conservation, as well as the increasing of a static overload, disturbing the fragile mural structures.

As an example can be mentioned the following tombs:

Yaksuri: the interaction between a local water table, also connected with a nearby reservoir, and an ephemeral aquifer produced by heavy and prolonged rainfall is causing frequent rising dampness;

Annak III: the heavy load of the mound is producing a static instability with generation of fissures that required external support to avoid the collapse. A crack gauge monitoring is now demonstrating the stability of such fissures but the final consolidation has not yet implemented.

Tokungri: the tomb, partially underground, is covered by a mound placed over the ancient soil that is less impermeable of mound's material; during prolonged rainfall the presence of soil with two different permeability may cause the collection of water above the impermeable soil that is later affecting the tomb and the plaster of the mural paintings.

Susanri: the presence of a strata of impermeable granite below the mound is generating an ephemeral water table during prolonged rainfall that is causing water rising into the tomb.

1.1.5. - *Maaloula (Syria)*

Maaloula is a small village located in the Al Qualamoun mountains belonging to the Palmyride belt, north of Damascus, Syria. Here are some of the most ancient evidences of the Christian religion, such as the tomb of Santa Tekla, referred to the 1st C. A.D. Around the tomb and a miraculous spring, a Monastery has been later on constructed. This building is below a hanging cliff with evidences of large rock slide just few hundreds of meter away (MARGOTTINI, 2009). The following figure 13 is giving a picture of the Monastery and of the cliff.

A consolidation of the cliff started in 2009, but without a proper understanding of kinematic and stability condition. A later inspection and investigation was determining:

1 - the area of Maaloula, due to its geomorphological condition, is strongly affected by landslide; major types include rock fall, toppling and rock slide;

2 - the upper part of the cliff is dominated by small size rock fall and slide. Nevertheless, due to the height, even when isolate blocks fall down, they may cause a devastating impact on houses and heritage;

3 - a gigantic rock mass is hanging over the town of Maaolula and partially, over the Santa Tekla Monastery. This mass is kinematically prone to slide but, according to preliminary evaluation, in condition of equilibrium. Nevertheless, the preliminary stability analysis may lead to a potential instability, in seismic condition and very conservative water content and geotechnical parameters. Monitoring data with total station in 2007 confirm these assumption and no evidences of recent displacements have been detected;

According to the above statement it was decided to implement a new project, taking into account the most advanced knowledge in rock mechanics, and to limit present day intervention. These could be constrained to very small block for which an emergency intervention is highly required. In fact, considering the height of the cliff, even a small rock fall can be devastating for the below Monastery (figs. 14, 15).



Fig. 14 – The Monastery of Saint Tekla, on the left, and the hanging cliff.
– Il Monastero di Santa Tekla, sulla sinistra, e la parete aggettante instabile.

1.2. - CAN FRUITION AND EXPLOITATION HELP KNOWLEDGE ACQUISITION AND CONSERVATION?

Past experience considered fruition and exploitation of natural and cultural heritages in some way divided from knowledge acquisition (partially) and from conservation (mainly). This because the relationship with private sector was considered not directly affecting the policies for conservation of heritages. On the other hand, some scientific information were used for a better fruition but financial resources from exploitation quite hardly become available for more scientific investigation and for restoration. Even far is the connection



Fig. 15 – The monastery of Santa Tekla and the cliff and discontinuities.
Data are reporting dip direction and dipping
– Il monastero di Santa Tekla e le discontinuità presenti in parete. I dati riportano direzione e pendenza.

with territory were natural and cultural heritages are located. A new tendency, derived directly from the principles of sustainable development (DI CASTRI *et alii*, 2005) is considering tangible heritage (natural and cultural), intangible heritages (art, poetry, spirituality), science and technology as elements of the “knowledge” that should empower local population, allowing them the development of their own economy and of the cultural and social system. The following figure 16 is giving a possible flow chart about this approach.

The proposed approach is connecting and harmonizing all the different phases of the management of cultural and natural heritages previously described, integrating them into the main features of the real territory and local population. In such a way natural and cultural heritages are becoming the engine of the development of a given local community based on the

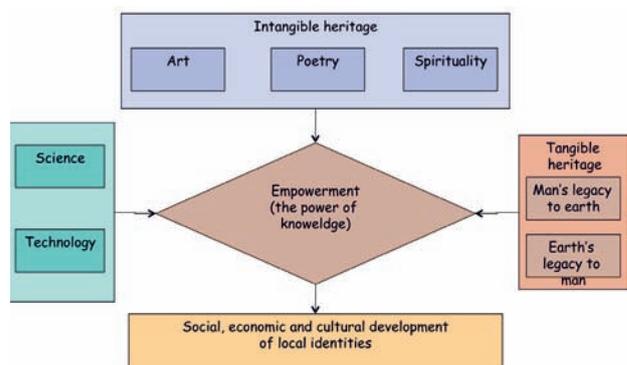


Fig. 16 - Empowerment and development of local community based on cultural and natural heritages.
– Empowerment e sviluppo di comunità locali basato sui patrimoni culturali e naturali.

valorisation of their history, tradition and in other world tangible and intangible heritages. The implementation of the above described process is also connected with the integration of many territorial tools and available expertise and knowledge, within a given geographical context. Such strategy, applied in a given area or “cultural district” may be represented in figure 17.

Some examples, still in implementation, are described below.



Fig. 17 – Strategies for a local economic development based on natural and cultural heritages (VALENTINO, 1999).

– *Strategie per uno sviluppo economico locale basato su patrimoni naturali e culturali* (VALENTINO, 1999).

1.2.1. - Easter Island (Chile)

The project “Moai the journey of light” is a project aimed at the empowerment of the population of Easter Island (Chile), through the integration of many activities, planned by a local foundation supported by international experts (MARGOTTINI & PANDOLFI, 2008). The budget is coming from private international donors.

The already planned initiatives include building capacity in the sector of medicine, the dissemination of local characters and identity through new multimedia techniques, the protection of natural and cultural heritages. This last include either the famous Moai statues, (fig. 18), the landscape and the archaeological village of Orongo affected by landslides on the coastal cliff. Important media event will be a world conference on empowerment of local community, planned for spring 2010 in Paris. During the conference experts will discuss about strategies and methodologies, giving also



Fig. 18 – The Ahu Tongariki with the 15 Moai. In the foreground a lonely Moai.
– *L’Ahu Tongariki con i 15 Moai. In primo piano un Moai solitario.*

voice to representatives of Rapa Nui community as well as other groups from sea and land island. With this last words it is intended to enhance the identity of population that has important uniqueness in their tradition, giving them the background for developing economically their specific cultural “island”, even if in the continent. During the conference a Moai statue will be temporary transferred from the Easter Island to Paris, in front of Louvre Museum, for 5 days, as a messenger of the light of a new policy for a proper cultural and environmental development of local community. In such a project all the different component are strictly tied, proving benefit, for instance, to the increasing of knowledge on the weathering process affecting the statues as well as to the possible remedial measurement. In fact, many investigation have been implemented for the selection of the Moai to transfer in Paris for the exhibition of 2010; these investigation on mechanical parameters of the rock, never implemented before, has included ground penetration radar, electric tomography, rock mechanic testing, geomatic survey, provided a new tool for investigating the weathering of the volcanic tuff composing the Moai (fig. 19).

1.2.2. - Aksum (Ethiopia)

The Government of Italy has returned to the People of Ethiopia a funerary stela (n. 2 in order of height), taken in 1937, during the last world war. The returning of the stela gives the opportunity to enhance the protection of the Aksum Stela Park (fig. 20) in a more effective way.

In order to support the project of re-erection of the stela an Environmental Impact Assessment was performed to evaluate consequences of such activities and possible alternatives (MARGOTTINI, 2006). This introduces to the Planning procedures a process by which the effects of a project and or modification on the environment are evaluated and considered when determining whether a project should proceed. The

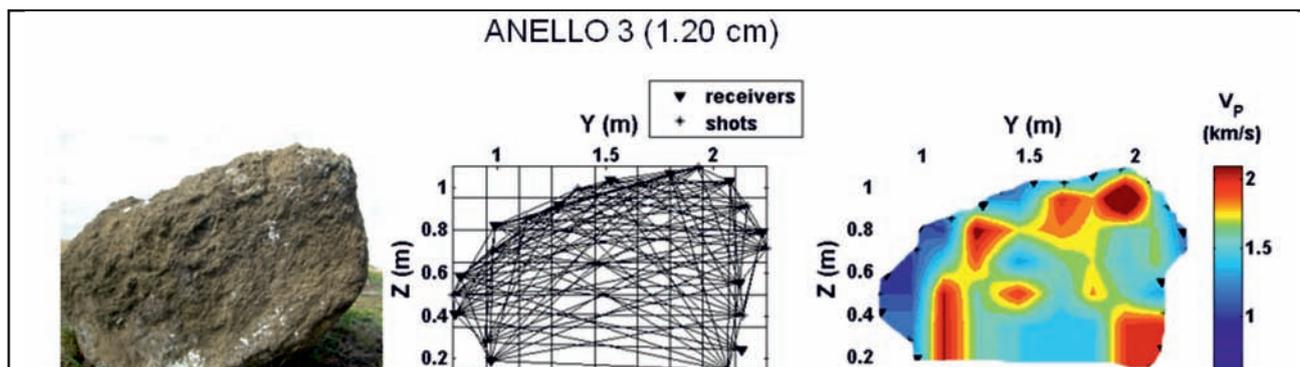


Fig. 19 – Seismic tomography on a Moai of the Easter Island. Different color indicates seismic wave velocity (V_p) showing area of low velocity and then less resistant (Courtesy Prof. L. Orlando, University of Rome – Italy).

– *Tomografia sismica su un Moai dell'Isola di Pasqua. Il colore diverso indica velocità delle onde sismiche (V_p) che mostrano un'area a bassa velocità e quindi meno resistenti (Courtesy Prof. L. Orlando, University of Rome – Italy).*

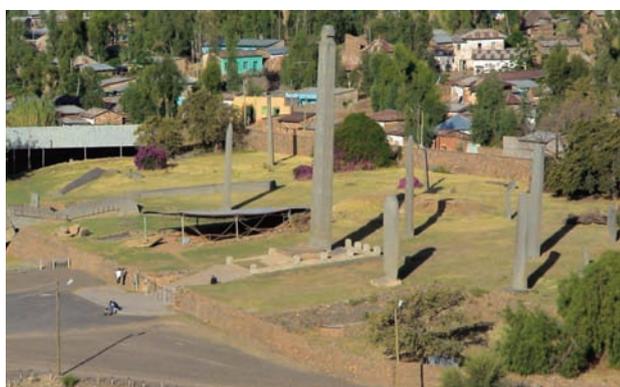


Fig. 20 – The Archaeological Stelae Park in Aksum.
– *Il Parco archeologico delle stele di Aksum.*

environment consists of human beings, animals, plants, soil, water, air, climate, material assets, landscape and cultural heritage and any interaction between these.

Normally the EIS process begins with a review of alternative locations and design options to eliminate or attenuate the environmental impacts at the earliest stage possible. Then follows the screening stage where, normally, Planning Service determines the need for an EIS according to:

- the characteristics of the project (e.g. size, accumulation of developments, natural resource use, waste production, pollution and nuisance, risk of accidents);
- the location of the project (e.g. existing land use, capacity of habitats, designated sites, landscapes of historical, cultural or archaeological significance);
- the characteristics of the potential impacts (e.g. magnitude, complexity, probability, duration, and reversibility).

Where an EIS is required, the assessment normally begins with a Scoping Study to identify the key impacts and issues of concern that warrant detailed assessment. Detailed assessment typically involves impact analysis according to accepted methodologies, consultations and site visits, leading to the evaluation of the significance and magnitude of any direct, indirect, secondary,

cumulative, short, medium and long-term, permanent and temporary, positive and negative effects on the environment from the project. During and following this evaluation, mitigation measures are developed to avoid, reduce or remediate the impacts. The present study describes the investigations, findings and conclusions of the EIS, and any proposed monitoring of the environmental impacts that would be undertaken during and after the re-erection of the Stela n. 2. The construction site for the re-erection of the Stela n. 2 in the Northern Stelae Park of Aksum, Ethiopia would be likely to have significant effects on the environment in terms of:

- Landscape and Visual impact;
- Noise impact;
- Impact on superficial water and drainage
- Geology, Hydrogeology and Seismicity
- Air and Climate
- Cultural Heritage
- Vegetation
- Socio-economic

The key impacts and issues of concern that were identified are addressed in this EIS study. Investigation were performed by means of desk studies, field surveys (geophysics, rock and soil mechanics, geology, noise, etc.) compared with the existing project of re-erection. An hypothesis of landscaping was also provided. All the information were included in the following figure 21, that is describing the feasibility of the site to engineering activities. In detail, a zoning was performed defining areas with full operability even with heavy equipments (green), areas with limited operability only for light equipments (blue) and areas were no operation are allowed due to the presence of potential archaeological remains (red). As complementary information, major archaeological vestiges have been discovered at the World Heritage site of Aksum (Ethiopia). The data collected through “non-invasive archaeological prospection” such as geo-radar and electric-tomographic prospection revealed the presence of many tombs and archaeological remains never discovered before.

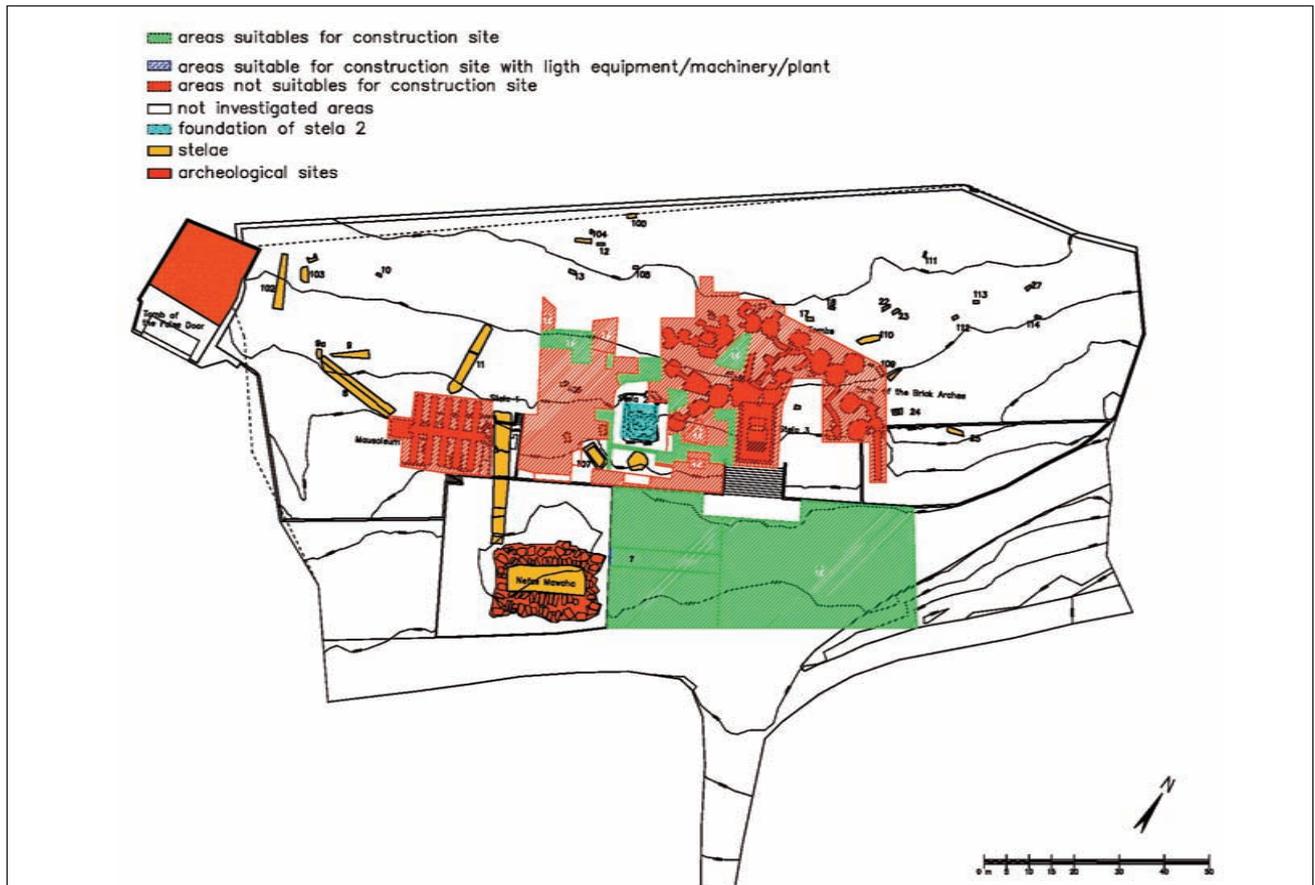


Fig. 21 – The zoning of Aksum Stelae park for the implementation of the re-erection of the stela n.2, returned from the Government of Italy to Ethiopia.
 – La suddivisione in zone del parco delle steli di Axum per la cantierabilità e la ri-erezione della stela n.2, restituita dal Governo Italiano all’Etiopia.

1.2.3. - Civita di Bagnoregio (Italy)

Civita di Bagnoregio (fig. 22) is a small village in Central Italy, located in the top of a volcanic hill and affected by continuous landslides that are progressively reducing the urban area. This is the main feature of a geo-heritage potential park with spectacular phenomena of bad land and clay erosion (DELMONACO *et alii*, 2009).



Fig. 22 – Civita di Bagnoregio with, in the background, the bad lands geo-heritage area.

– Civita di Bagnoregio con il geosito della valle dei calanchi sullo sfondo.

The town was appealed as the “dying town” since, last century, it was believed that there were no chances to preserve this monumental landscape from destruction. The village, one of the most beautiful attractions of the region, was investigated in the last 10 years, to define a general comprehensive master plan for a restoration of town and cliffs, based on an approach capable to solve existing problems and minimizing the impact of interventions (sustainable mitigation) and continuously investigating the site as an open space geomorphological museum. Presently a small part of the cliff has been stabilized by means of new techniques from underground and a more exhaustive intervention is in progress.

The integrated project consists of:

- 1 - Securing the town of Civita di Bagnoregio from rock fall and rock slide;
- 2 - Increasing of tourism capacity of the area;
- 3 - Sustainable mobility to access to Civita (presently a not pleasant bridge is on the spot) and within the bad lands area;
- 4 - Valorisation of the bad land geo-heritage park;
- 5 - Establishing a permanent centre for the study, monitoring, consolidation and maintenance of unstable towns and mitigation of hydrogeological disasters (fig. 23).

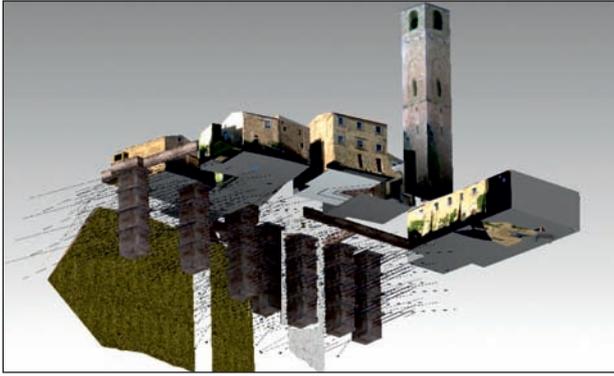


Fig. 23 – The innovative consolidation work for the stabilization of rock slope in Civita di Bagnoregio: Anchors and bolt realized from structural wells.
– *Una innovativa tecnica di consolidamento per la stabilizzazione della rupe di Civita di Bagnoregio: chiodi e ancoraggi realizzati da pozzi strutturali.*

1.2.4. - Poets quarry in Carrara (Italy)

Geo-heritage site are sometimes also the result of interaction between man and environment. This is the case of the Carrara marble caves (fig. 24), (Northern Italy) where the excavation of the very famous marble, produced a unique landscapes, well known in the last 2.000 years. Nevertheless, many quarries are often abandoned after the complete excavation and they pose serious problem for future landscape. Sometime such a quarries become also a place where to put waste and garbage, disqualify the whole environment. There is case in which the application of the principle of inter-connecting in a unique virtual network different “knowledge” such as the empowerment, has provided an exceptional outcome.

This the case study of the Poetry quarry, in Carrara, where a place totally abandoned was recovered by the local Fondazione Mareostrum, to become a place of poetry and art (fig. 25). In a clever perspective, a management plan was implemented, focus the recovering and conservation of the cave on a new function that is



Fig. 24 – The unique landscape of Carrara marble area (wikipedia.org).
– *Il paesaggio unico delle cave di marmo a Carrara (wikipedia.org).*

the relationship between modern art and rock. All the cliffs have been engraved with the verse of famous poets who gave their words for enhancing this unique place. Among them Lawrence Ferlinghetti, Mario Luzi, Paul McCartney, Seamus Heaney, Derek Walcott and others are now permanently in the walls of the quarry. In this new function, the rock is connected with art in a integrated perspective: make tangible and intangible heritages living together and depending each other for surveying.



Fig. 25 – The poet quarry and the rock-words in Carrara (Italy).
– *La cava dei poeti e la roccia delle parole a Carrara (Italy).*

2. - CONCLUSION

The present paper proposes an itinerary among different cultural and natural heritage sites, mainly belonging to World Heritage list of UNESCO, where the sites where scarcely connected with local territory and conservation was mainly the result of an emergency, more than a specific management program. Typical was the case of Bamiyan in Afghanistan, in 2001 even not inscribed in UNESCO world heritage list, that after the destruction become a flagship of a planned conservation integrated with the territory and population. This is because the presence of UNESCO but also other sites are moving in the same direction, such as the Easter Island in Chile. The major message coming from the case studies is that single steps in the management of cultural and natural heritages cannot be considered independent from the others. In a correct management strategy there is the need of integrating main feature of the territory involved from both a social and cultural point of view, existing knowledge in terms of science and technology and the plans for future, for the benefit of ancient remains, tangible and intangible. This is the principle of “empowerment” and this is the principle for giving back to cultural and natural heritages the dignities they had in the past, and not to be a simple fun area, as many often is now-day in too many part of the world.

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