Historical Research Letter
ISSN 2224-3178 (Paper) ISSN 2225-0964 (Online)
Vol.26, 2015

The Conservation Status of the Pyramid of Khufu

DR. ARCH. FIRAS GANDAH
PhD in Architecture Assistant Professor - Balqa Applied Science University, Salt- Jordan .
Address: Lungotevere di Pietra Papa, 61 00146 - Rome / Italy

Abstract
The biggest Pyramid in Giza, the Pyramid of Khufu, one of the most lasting monuments ever achieved, is losing substance through mutilation, pillage and destruction, along with the degrading effects of wind, rain, and sun. Also, the daily flow of 6,000 visitors to the Pyramid of Khufu produce water vapor, carbon dioxide, and heat that forms condensation on the inner walls which become salt deposits that damage those walls.The Tura limestone coatings of the Pyramid of Khufu have been removed over time to build the city of Cairo. This pilferage lasted for centuries and left the Great Pyramid with few traces of its white limestone coating.Changing the environment of the Giza Plateau to green vegetation would shield the Great Pyramids, affected by the deterioration factors related to weather and the arid climate of the Sahara desert. This environmental intervention returns the plateau to its original arrangement of ancient Egypt, when it had canal systems and cisterns for conserving water for domestic and agricultural use. These canals should be found and renovated and made operative. Removal of the fence surrounding the archaeological site to create an (archaeological basin) would reinstate the once pleasant mingling of tourists and locals.
Keywords: Egypt, Giza, Desert, Limestone, Deterioration, Environment.

1. Introduction

The Great Pyramids of Giza, and in particular the Pyramid of Khufu (Cheops), located in Giza (Egypt), from the period 2551-2528a.C. (Fourth Dynasty), it's dimensions: (basic m.230,33 for each side, H. m.146,59, volume mc. 2583.283), greatly amazed the men of the Napoleonic expedition, begun on July 1, 1798, with the landing in Alexandria. In the report, published in the Description de l'Egypte (AA.VV. 2002), the wonder and amazement was mingled with astonishment at the state of degradation, in which they found the Great Pyramid. Their report stated: … Everything you feel is not the admiration, usually aroused by the sight of a masterpiece, but something more profound. The effect is inherent in the greatness and purity of form, in the contrast and disproportion between the stature of man and the immensity of the work produced by his own hand: one's vision cannot capture it, even one's thoughts find it difficult to comprehend. And then, you start to get an idea of this gigantic pile of cut stones, accumulated in an orderly way to the most prodigious heights. Observing it, you realize you are dealing with hundreds of layers of 200 cubic foot blocks weighing 30 thousand pounds, with thousands of others, which are not any smaller, and you try to fathom what force was able to move, carry, and raise such a large number of colossal stones; how many men worked on it, how long did it take them, what devices were used; and the less you can answer these questions, the more you admire the power that had to be exercised to tackle such difficulties.

2. The Conservation Status of the Pyramid of Khufu

But soon, another sentiment overcomes the mind, when one considers the state of degradation of the lower parts: and you realize that man, more than time, has contributed to their destruction. And if time is responsible for what has happened to the top parts, men have thrown down the massive stones, which, tumbling and rolling, caused the rock layers below to crumble. They have also exploited the base of the pyramid as a quarry; and finally at the hands of the barbarians the outer covering has completely disappeared. One deplores this desecration, but if you compare these vain attacks with the majesty of the pyramid, which seems to have not been affected but minimally, you would agree with what the poet Delile said about the monuments of Rome: "Their indestructible stature has conquered time."

Reading this report, it is natural to think that if the soldiers of the Napoleonic expedition had the terrible feeling that the Pyramid of Khufu was in a precarious state of preservation, what must we say today? The degradation did not stop, but continued on a slow but inexhaustible path. Although, the Pyramid of Khufu is one of the most significant and lasting monuments ever achieved by man, the remarkable and changing factors due to deterioration, are inexorably sapping even its amazing size. Figure 1.

Perhaps one is justified in thinking that in the end, this extraordinary monument should no longer be thought of as eternal, since its deterioration day after day, hour after hour, minute after minute, is affecting its very material substance. If observed at the macroscopic level, or if considered at the microscopic level, one can see how many billions of billions of material points the Great Pyramid has lost. But the most shocking consideration is that it will continue to undergo with resignation and stoic endurance, this slow and continuous loss of its original material, and nothing is being done about it. In fact, it requires immediate preservation

interventions to restore stability and a new state of equilibrium superior to what has been attempted in the last decades. We have considered these very aims in the solutions offered in the study we conducted.

The original material of the Pyramid of Khufu that the ancient and wise builders chose to build with is no longer solid and substantial, as when it was built. In fact, after the ancient builders other men have come along, throughout the millennia that have passed and inflicted mutilation, detachments, pillage and destruction. There are also the ravages of wind, rain, sun and other degradations that have tried its greatness, its shape, its material and its essence.

Present day man may see in this architecture the eternity of its essence but always less that of its size, shape and material, which has undergone continued losses that have mutilated some of its great parts.

It is necessary to plan appropriate and respectful conservation interventions, which could alleviate the ongoing loss of material, entailing both macroscopic and microscopic care, attention, patient and careful interventions which do not transform, dematerialize or derange its eternal essence.

Our study was designed as a preparatory guide to conservation interventions, because if we do not have adequate knowledge of how the complex Pyramid of Khufu was built, then we can only preserve it more than try to restore it, as was attempted in the last decades by hands and minds that were unwary and disrespectful of its majesty. In fact, many conservation solutions can be taken from the original constructive modality. That is why we set our goal to establish what is the actual condition of the Great Pyramid. What once seemed unchanged and unchangeable, today, appears eroded by the deterioration and instability of a strongly man influenced environment, which threatens the Pyramid of Khufu to lose its extraordinary primacy it has enjoyed for thousands of years.

It seems logical to propose increased inspections of the Great Pyramids of Giza, one of the largest archaeological heritages of humanity, because in the last decade, as has happened in other archeological places, conditions of the site have changed. These changes are occurring slowly, but surely, and have to do with the general Earth system. The inspections of the Pyramids of Giza, should be made visually and tactically on those stones exposed to the elements, followed by periodic routine surveys with specific analyses and inquiries using equipment and machinery that detect and measure the phenomena of detachment (delimitation), pulverization, fragmentation and flaking in relation to the stone's geological and physical-chemical characteristics put then in relation with the factors and causes of the deterioration.

Even the Great Pyramid shows signs of deep traces of wear and deterioration that are serious and in urgent need. Among these deteriorations we recall the reduction of its precarious outer coating, environmental contamination, entropic degradation, the many visitors it's subject to and the restorations implemented. In particular, Jean Kerisel, who has studied the phenomenon of flow of 6,000 visitors a day who go inside the Pyramid of Khufu, has documented the ensuing strong entropic degradation. There is an enrichment of water vapor, carbon dioxide and heat, which according to the seasons and temperature; increase the condensation visible on the walls of the interior places, and where salt deposits form, that certainly damage the Pyramid walls (Kerisel 1981).

So far, they have been few and far apart alarms launched about the state of conservation of the Great Pyramids, not because there are no problems, but because there were no inspections done the true extent of degradation was not understood, and was exchanged for the older traces produced by the Great Flood. Due to this premise, the conditions remained unchanged and the deterioration factors increased and progressed to the detriment of the monuments, which inevitably lose the material they are made from. Today, more than in the past the degradation phenomena are visible and become more and more irreversible.

Indeed, after millennia, it's unthinkable that everything will remain intact only because the sheer majesty of its size should be a deterrent to the destruction and deterioration of the material that composes the Great Pyramids. Its material has always deteriorated and submitted to entropy, but no one ever noticed due to the structures immense size. Therefore, we hope that these monuments, so ancient and so valuable, are monitored and strictly controlled and properly preserved, avoiding incorrect interventions. They also need a continuous and relentless work of maintenance, due to the visitors they are subject to daily, to protect their very material consistency, now on the edge of collapse, and to maintain levels of security for those who visit the sites.

This advice is given, by those who love these great Monuments of Humanity, have honored them with their professional activity, and possess the scientific knowledge to propose solutions.

In the past, as with the Sphinx, the real causes and deterioration factors were not properly assessed before proceeding with incorrect restoration, that, not only did not stop the deterioration, but increased it, transforming the very image of the Sphinx. So to avoid reaching these extreme, we must act in a preventive and prudent way, avoiding irremediable mistakes.

To counter the natural deterioration in the Giza site requires a study of environmental phenomena that considers the desert factor and the incredible environmental pollution present in the area of Giza and Cairo.

In fact, in the territory of Egypt, there are two deserts, divided by the Nile and the green strip of land that contains it, the Western, called in Arabic al-Sahara al-Gharbiyah, which extends to the east of the Nile from

Sudan to the Mediterranean, while in the west there is the Libyan Desert.

The Western Desert of Egypt is a limestone plateau completely barren without any vegetation. The main characteristic of the Western Desert is the presence of isolated small sand hills, indicative of strong erosive action by the wind. In fact, there is the predominance of seasonal dry winds like the Khamsin that blow with intense violence from March to June, loaded with abrasive dust.

In the Western Egyptian Desert spectacular geological formations are frequent and form romantic landscapes with depressions and basins often below sea level where flourishing oasis often develop (Stoppato and Bini 2001). Within these oases the effects of wind erosion are different than in the expanses of pure desert.

After having briefly considered the deterioration present in the Pyramids of Giza, we will concentrate our attention on the actual deterioration of the original building materials. In fact the phenomenon has now reached such dimensions as to call for the utmost caution to avoid ruptures in the pyramid structures themselves or in parts of them. Indeed, so far we have always considered the pyramid as a building structure that was indestructible, for its size and for the quantity of material that composes it.

In fact, we do not know the amount of material which has already dissolved because of the different factors of atmospheric degradation, nor how many blocks of stone have been stripped or lost due to the anthropogenic degradation. One of the largest losses was the intentional stripping of the outer coat of the Pyramid of Khufu. This coating (made of Tura limestone considered the best lime of all Egypt) was the lime used to build the city of Cairo. This spoilage lasted for centuries and reduced the Great Pyramid to rare traces of its white coating of limestone. As can be seen on the apex of the Pyramid of Khafre. Figure 2.

At this point, some fundamental considerations must be made about the single blocks of the Great Pyramid, which originally were perfectly square. They, in fact, underwent the stress from pressure from the masses above that was spread evenly on each point of contact, on each horizontal face of each individual block. These stresses, caused by the load overhead acted vertically from above downwards and directly on the surface of the underlying block. They were, therefore, balanced by the rigidity of the material used during the construction, and there were never deformities and they followed gravitational pull, excepting the negligible elastic compression of the limestone.

But, after thousands of years, the huge amount of the original material, which constituted the Pyramid of Khufu, is less and less, and therefore the structures inevitably stray away from the ideal form of cubic blocks. Therefore, the original conditions have changed. In fact, today, almost none of the blocks have that ideal cubic form and therefore the surfaces of almost all the blocks have become quite irregular. In fact, they fit tightly together only in a few points, and consequently the pressure in these contact points has risen at a phenomenal rate from hundreds to thousands of atmospheres, and this could lead to breakage, causing the collapse or deformation of the blocks. Already the first symptoms of such phenomena are evident; we know that this could provoke the construction material to move in a specific direction as to avoid the pressure. Predictably the movement will develop from the center towards the outer sections of the Pyramid; creating new side components, which will tend to undermine the structure.

In fact, the Pyramid of Khufu, reduced in its architectural structure by the deterioration of its size and the millennial impoverishment of its blocks, modified into irregular shapes, prompted by the pressure load, which as we said, acting vertically downward, develops sometimes, new side components and favors cracking and flattening of the interior, might implode one day in the not too far future.

So far, the Pyramid has demonstrated to have been constructed in a perfect manner, because the lateral components, which are formed by the contact points of the structure, have remained localized, and if any defect due to the change of the shape and weight of the building material resulted in a slight deformation, this has been absorbed by the other blocks.

But, for how long can dare good fortune continue? Since it was discovered (1925) the Great Pyramid has been subjected to pseudo-restorations, which have changed the size and the shape of the individual blocks. It has never been measured with regularity and has never been monitored carefully and meticulously. There is, however, apparent light "sagging" of the construction, which has been misinterpreted in the past, the real meaning of the Pyramid Khufu's "sagging", as indeed with all the other pyramids of Giza, is material aging, changing its climax (state of balance) and modifying the state of the material points due to degradation, which are canceled out by entropy. And the structure is changing its balance of forces and stresses due mainly to the reduced mass of material. We know that the ancient Egyptians had come up with a solution for these eventualities, creating a stabilizer device, which was the buttress, invented precisely by Impotep in the Pyramid of Zoser at Saqqara.

We noticed during our inspections, that the Great Pyramids of Giza have been deteriorated mostly due to factors related to atmospheric agents, which have impacted the stone material of which they are made. For this reason, we analyzed the "desert" environment on a natural level and in relation to the construction materials used, which have degraded in the same way as the natural aspects. All this has served to understand the causes and to seek solutions to the problems posed.

So, in a desert, like that of the Egyptian Sahara, deteriorations, that cause alterations in the stone materials, are connected to water, temperature, sunlight and wind. In fact, water activates Life by dissolving the minerals contained in the soil, that then undergo leaching to form composts that can be assimilated by animal and vegetable organisms.

Instead, temperature influences chemical activity, which is favored by heat and curbed by the cold and stopped totally by frost. The temperature, in fact, is a distinguishing factor for a desert, because the temperature difference between the terrain and the air causes turbulent motions and irregular winds. Solar radiations heat the ground during the day, while at night the heat accumulated is dispersed.

Finally, wind has a dual function as an agent of evaporation of moisture and of transport of ground material, in which erosion and accumulation transform the ground surface. The activity of these climatic factors in a barren desert, like that of the Egyptian Sahara, has resulted in the serious deterioration of the Great Pyramid's stone, with the factor time accentuating the phenomena. The main factors of deterioration present in the desert around the Giza plateau are: climatic change, physical change and change in the limestone.

Climatic changes are of a superficial and selective nature. The superficial alteration are caused by the arid climate acting on the stone material located in the lower parts of the monuments at Giza, which undergoes temperature variations and water infiltration that penetrates only superficially. The selectivity of the alteration, however, is due to the lithological and structural characteristics of the stone material used in Giza which cannot defend itself from the alteration process. Figure 3.

Alteration processes, therefore, cause firstly micro-fractures then fractures, faults, and other lines of weakness in the stone material already weakened by its exposure to the local variations of temperature and air humidity. The phenomena of this type of alteration, concern flaking, peeling or exfoliation, rupture and granular disintegration.

What is apparent in the end is a huge quantity of debris that in the Pyramids of Giza is, by now, a dramatic regular occurrence. Present also in Giza, are other incredible climatic related alterations, as tafoni (cavernous forms) or alveoli (pockets), or basin shaped alterations. These phenomena occur mainly in building materials whose natural rock is very exposed to arid climatic conditions and in the case of the Great Pyramids alveoli and even basin alterations were noted in large quantities in the Pyramids' building blocks.

The pockets alveoli are morphologically small tafoni (cavernous forms) and their origin is controversial, but there is a general agreement to recognize the importance of salt in their formation (Stoppato and Bini 2001: 32).

The individual pocket cells are separated from each other, and the diaphragm that separates them is resistant to atmospheric changes. Instead the basin alterations are very rare and are present in just a few cases in the Giza Pyramids; they are aligned with each other and similar to the alveoli (pockets).

The physical alteration takes place by a mechanical process caused by the relative abundant moisture, in the form of dew, which in Giza has undermined the structure of the blocks of the Great Pyramids, making them vulnerable to the other changes mentioned above.

Other phenomena undergone by the rows of blocks of limestone of Tura found above the base layer of the Great Pyramids of Giza are the alterations from thermoclastic stress, where the stone material present in the pyramids breaks due to the strong temperature difference between its outer surface and its interior one. In this case, the phenomenon can cause only micro-cracks, which combined with weathering effects produces the results seen at Giza.

In the Giza Plateau a few examples of broken stones due to the presence of water were noticed. In fact the Sahara (desert) around Giza presents the phenomenon of dew in the circadian wet and dry cycle. The days, in which this phenomenon takes place, sometimes exceeds 50 days a year. In particular in Giza precipitation from dew was recorded higher than 20 mm. per year. It is assumed that this phenomenon has affected a great part of the stone materials, natural and artificial, of the Giza plateau.

The major deterioration phenomena, which affected the archaeological remains of the Great Pyramids, are weathering and physical alteration, which over time have upset the architectural structures and their image.

The phenomenon has been studied in part, during our visits, and exhibited here, but should be better analyzed in order to chose the right corrections to be made, so the remaining vestiges of the deterioration factors affecting the Pyramids can be saved. One of the analyses of great importance will be the verification of the porosity of the stone material present in the plain of Giza, which represents one of the main parameters governing the deterioration process. This can help in understanding the deterioration alteration phenomena, so as to obtain useful information for conservation efforts.

The natural stone material which makes up the Great Pyramid presents an intense variety of alteration phenomena completely different in its different textural points (that is, point by point). The basic reason is that the limestone is not structurally homogeneous and its variability within the same stone makes it behave differently in different sections during change and degradation.

However, the artificial stone material (terracotta bricks) widely used in the Pyramid of Zoser degrades

in the same manner as the natural stones, but often taking longer to deteriorate. The degradation is sometimes determined by external aggressive pollutants of natural origin, as seen previously. The bricks of the Pyramid of Zoser are less affected by chemical pollution, since they are less sensitive to acidic dissolution due to their high silicon, non carbonate composition. In fact, the degradation of the Pyramid of Zoser is linked to the presence of salts, which with time favors the "crumbling" of the bricks. This phenomenon is closely connected to the crystallization and dissolution of salts, which occurs in cycles depending on the climatic and environmental variability and variation in the rhythm of the pressure in their internal porosity. It's of extreme interest to notice, that the processes of alteration may be different from brick to brick, due to the difference of compactness and porosity on a small scale which depends on the different mixture used in their construction as well as the firing temperature (which controls the processes of verifications) used. It's also important to consider, that chemical and mineralogical alterations can vary because of the diversification in their structural and textural characteristics, of their porosity and other factors related to this specific parameter.

So studying these phenomena and their consequences could be extremely convenient for the Giza plateau, where we could imagine creating an oasis or vegetation to better protect the archaeological heritage of the Plain, similar to that created at the time of construction of the Great Pyramids with the artificial creation of channels and resulting farmland.

This conservational solution might be the least disastrous and the least expensive that could give an image to the present day location surrounded on one side by the foothills of the sprawling city and on the other by the desert. This environmental revitalization would change the nature of the Egyptian Sahara and the condition of the prestigious archaeological remains, moving away from the most pessimistic predictions of catastrophic environmental changes resulting in increased rate of erosion and of the other natural deteriorations, whose evolution has already been apparent in the last decades. In fact, traces of these harmful effects are already evident in all the pyramids of Giza and Saqqara. And if this intervention isn't decided upon soon their appearance and their structural integrity will suffer greatly. Therefore, we look forward to comprehensive and decisive measures to ensure the conservation of the Pyramids, now so endangered.

A conservation project programmed over time should be designed specifically for the Great Pyramids to intervene and decrease the actual deterioration going on. It is necessary to develop an approach methodology as well as routine procedures of targeted interventions, resulting from careful study and analysis. Also useful would be trial restoration attempts, which would provide over time a continuous act of conservation rather than a large, billionaire restoration, which once completed could see the return of the deterioration phenomena.

The conservative strategy for these grandiose monuments should be consist in a constant and continuous work of maintenance with conservation interventions tied to the original construction technique, which would have to be first be discovered, and then perhaps used to restore the missing parts of the stone and for the maintenance of the materials points.

Also, it has not been taken into account that the monuments of Giza are situated in proximity of the desert on one side and close to one of the busiest and most chaotic cities in the world, Cairo. Where the wind and the sun of the desert, the humidity of the subsoil, rich in underground water and sewage networks, the traffic and the urban pollution, are the explosive mixture, that daily wears down the archaeological site of Giza and produces deterioration to the priceless ancient relics.

All this produces an aggression from one side by considerable quantities of pollution and from the other side climatic factors arising from the desert, which degrades this unique cultural heritage, with a phenomenology of extraordinary proportions. Only the majesty of the Pyramids and their material dimension, made the phenomenon less visible, but no less problematic.

It was found, that the Pyramid of Khafre seems to be at greater risk, because it was built with less expensive labor and is set in the south-west direction, where it's hit mostly by the area's predominant winds, like the libeccio (Garbi), the strong and insistent southwest wind.

Also, the same phenomenon was seen in the Pyramid of Khufu, although it is limited to a small portion of the west side, where the shield given in part by the Pyramid of Khafre and by the small hill, located between the two Pyramids, is missing, therefore leaving the tomb of Khufu unprotected on that side. It is here, that the area's predominant winds rule, so that the blocks placed in the lower rows of the Pyramids on the west facade are still intact, because they are protected, while the unshielded part of the same western facade is eroded by the atmospheric agents. This is another indication of the state of abandonment of these prestigious archaeological remains and how little conservation action has been taken so far. Figure 4.

So far one of the biggest degradation noticed in the Giza Plateau is the absolute indifference with which restoration is carried out and the general indifference towards the abandonment, in which these fantastic monuments lay; in contrast to the great public interest that they stir up worldwide. Often doing a restoration or not doing it can have the same consequences.

Visiting the Giza plateau, this effect is immediately visible in the serious deterioration and state of abandonment, in which all the monuments lay, whether they were incorrectly restored or whether there was no

restoration done, their state of abandonment is very serious.

The conservation status of the Great Pyramids is very serious, but still more serious are the restorations carried out so far. In fact, the restoration work carried out in some smaller tombs of the complex of the Pyramid of Khufu have brought a reversal of the original structure of the archaeological remains with addition of new material, superimposed on the ancient architectural elements. Thus, the end result was only irreversible damage to the original archaeological remains, inexhaustibly affected by pollution from nitrate salts, due to the cement used, in addition to the natural deterioration produced by sunlight, wind erosion, moisture, sudden temperature change, which for millennia have alveolized, scaled, damaged and broken the blocks of limestone of the Great Pyramids of Giza.

The latest restorations or those being done in the small tombs and mastabas surrounding the Great Pyramid are just as serious and when we think they are made by Italian agencies it is even more difficult to accept.

The restoration on the Pyramid of Khufu Complex is totally inadequate for the majesty of the architectural work. They were made using materials and techniques inappropriate to the monument, causing breakage and anthropogenic degradation, as well as nitrate pollution due to the cement used.

Instead the clumsy and inappropriate restoration carried out directly on the Pyramid of Khufu followed the following incorrect procedures:

• The missing blocks (for structural reasons) were integrated with structures in solid brick or stone covered with plaster made from lime and cement of the same exact size of the missing blocks;
• The original wall tiles were integrated (in the Pyramid of Khufu) with a mixture of lime, plaster or cement;
• The completions of damaged blocks were done with cement or bricks and plaster made mostly of cement;
• The oxidized iron clamps in the Great Gallery causes considerable instability of the wall structure made of large blocks, which are breaking because of the metal's oxidation;
• Incorrect placement of blocks in those parts of the Pyramid that have been pilfered throughout time, serving as a quarry for the construction of the buildings in Cairo.

One desires hopes for an intervention that brings order in the area and in the Great Pyramid itself eliminates the severe degradation, which does not allow us to sense the form and material consistency of the archaeological remains.

To this urgent necessity we should create a manual for the conservation and maintenance of the Pyramids of Giza, that foresees the restoration and conservation interventions that should be done with caution and conservation expertise, taking into account how much of the original material has remained. Restoring with materials similar to the original ones and not completely different. A negative example is the restoration work carried out recently in the mastabas and in the small graves around the Pyramid of Khufu.

Differentiation between original materials and newer ones is a euphemism because the patina is the true and only witness of time, living in the original material and always recoverable, even in the presence of dirt. The dirt present in the moment, once evidenced should be removed to highlight the patina to identify it again.

The material to be integrated should be, accordingly, or the original one or one closest to it. In fact, the presence of a different material or a different color hue in the monument becomes an eye sore. In the same way, the shape and the size of the gaps filled in must conform to the size and shape identified at the time of conservation.

Therefore, it must take into account what exactly was discovered and not how it could have been originally, having no testimony of the first act, or evidence of the construction designs of King Khufu's architect.

Therefore, any exaggerated integration not in line with what was originally discovered becomes arbitrary and fanciful and therefore degrades the material, the size and shape of the original, which is obvious on the Giza Plateau with the restoration done so far.

Since we are dealing with the Pyramid of Khufu, the most important monument of antiquity, the one of the surviving wonders of the ancient world, it is hoped that the next restorations offer the guarantee to hold up over time, together with ongoing maintenance, so that the archaeological remains can endure, no longer abandoned to themselves as they are today. Figure 5.

The restoration should aim to revive, support and fix all the deteriorated parts, as well as remove the dirt, which has settled on it throughout time. In addition, the conservative methodology to be followed should be geared to ancient construction materials and techniques, allowing the gaps absent that need to be integrated correctly (methods already tested over time) avoiding to integrate gaps lost, whose form and substance is unknown to us.

2.1 Hypothesis of conservation work

To find a solution to these factors we should take steps to change the environment of the Giza Plateau, making it more green and lush, affording protection to the archaeological remains of the Great Pyramids and other monuments at Giza.

This environmental intervention proposes the plain's original arrangement in ancient Egypt, when the area was settled with a canal system and cisterns, which allowed the conservation of water for domestic and agricultural use.

Therefore, an archaeological study should attempt to find out exactly where the old canalization system was. Once discovered, they would need renovation to become operative again and create the conditions necessary to cultivate the plants and trees that would shield the Great Pyramids, so affected by the deterioration factors related to atmosphere and the arid climate of the Sahara desert.

So, the whole Giza plateau would have a new arrangement of vegetation that would give solace and a new image for the thousands of tourists who daily visit the immense archaeological area, now languishing in disastrous chaos and neglect.

Furthermore, the Supreme Council of Antiquities has recently built a high fence around the Giza Plateau to enclose the area of the Great Pyramids, committing a great error. Giza was always considered the noble example that inspired us to create the archaeological basin, an instrument for the use and participatory management of an archaeological site. Today, this fence has annulled all the praise that was showered on the avant-garde management of the archaeological site, where the presence of the local population, contemporary Egyptian society, became an asset for the enhancement and fruition of one of the largest archaeological heritages of the world.

In Giza, the local population served as a vigilant guardian, gardener, and entertainer, guide, money changer, transporter, chauffer, chaperone, snack provider and translator. Thousands of trades, lawful and unlawful, survived in the shadow of the Great Pyramids. A cheerful population which could give the visitor a moment of distraction among those mighty ruins that remained the main attraction. Perhaps, there was a need for more police surveillance and safety controls.

Today, however, after the ugly fence was put around Giza, there is a separation between the contemporary society from the memory of the ancient Egyptians, who will gift the visitors with those pleasant moments with the sluggish kids, who continually asked for a pen. Where will the thousand vendors go to carry out their survival activities, that will become legal, that guaranteed them secure daily earnings. Perhaps it would have been wiser to organize the local people and makes them participate in the promotion of their cultural heritage rather than opting for repression.

5. Conclusion

Today, to gain access to the site, men and boys cling onto the taxis that bring the tourists under indifferent and indolent eyes of policemen, thus demonstrating the uselessness of the dividing gate, which has confined and relegated the most precious archaeological heritage on Earth, keeping it from the people, who today are its depositary. So, with regret we shall remember the lively young boys intent on selling something or offering rides a camel or an Arabian horse for a short distance, beyond the pyramid Mekaure. We will miss the cheerfulness that framed a day spent on the Giza Plateau; nothing can replace the noisy uproar of the people, who certainly have contributed for decades to the true touristic promotion of the archaeological site. We can, only, hope, that the Egyptian authorities will rescind their decisions and take away the artificially created barrier and create, rather, an efficient police surveillance and let locals and tourists mingle freely. This way the three Great Pyramids are not caged in and the archaeological heritage of Egypt can be experienced together with its true heirs, involving them in cooperative and socio-economic activities that could advance national development and increase Egyptian tourism, recently subjected to terrorism.

References

The Egyptian pyramids were the subject of interest study and scientific literature to be consulted, the subject is vast and cannot be shown that in a little part. We, in this connection, wanted to point out the most important works and the main volumes and those related to our research. In fact, below we are reported the main bibliographical references on the subject that will be inserted in the text, according to special requirements of clarity.

- Arnold, D. 1991. Building in Ancient Egypt. Pharaonic Stone Masonry, New York - Oxford.
- Arnold, D. 2003. The Encyclopedia of ancient Egyptian Architecture, London.
- AA.VV. 2002. Description del l'Egypte, Taschen.
- Atiya, F. 2004. Le Piramidi della Quarta Dinastia, Al Cairo.
- Badaway, A. 1966-1968. A History of Egyptian Architecture, vol. 3, Berkeley - Los Angeles.
- Badaway, A. 1965. Ancient Egyptian Architectural Design. A study of the Harmonic System, Berkeley - Los Angeles.
- Baines, J. and Malek, J. 2002. Atlas of Ancient Egypt, The American University in Cairo Press.
- Borchardt, L. 1928. Die Entstehung der Pyramide an der Baugeschichte der Pyramide bei Mejdum nachgewiesen, Berlin.

- Borchardt, L. 1932. Einiges zur dritten Bauperiode der Grofen Pyramiden bei Giza mit einer Bemerkung zur zweiten Bemerkung zur zweiten Bauperiode der Dritten Pyramiden von H. Ricke, Berlin.
- Boyer, C. B. 1990. Storia della matematica, Mondatori, Milano.
- Badalucco, G. Conoscenze matematiche e geometriche degli Egizi, in http://www.edico1aweb.net/atlan21a.htm (01/08/2005).
- Clarke, S. and Engelbach, R. 1930. Ancient Egyptian construction and architecture, London.
- Clarke, S. and Engelbach, R. 1930. Ancient Egyptian Masonry, Oxford.
- Clarke, S. and Engelbach, R. (updated edition1990) Ancient Egyptian construction and architecture, New York.
- Cimino, F. 1990. Storia delle Piramidi, Milano.
- Cole, J.H. 1925. The Determination of the Exact Size and Orientation of the Great Pyramid of Giza, Cairo.
- Diodoro Siculo, 2001. Biblioteca Storica, Vol. 4, Palermo.
- Diomedi, E. 2001. La Piramide di Cheope, Civitanova Marche.
- Dormion, G. and Goidin, J. P. 1986. Kheops:Nouvelle Enquete, Paris.
- Dormion, G. 2004. La chambre de Cheops - Analyse architecturale, Paris.
- Edwards, I.E.S. 1993. The Pyramids of Egypt, (updated edition) Harmondsworth.
- Edwards, I.E.S. 1962. Le piramidi d'Egitto, Milano.
- Edwards, I.E.S. 1982. Le piramidi d'Egitto, Milano.
- Erodoto 2006. Le Storie, Libro II (124-125), Torino.
- Fagan, B. 1982. Alla scoperta dell'antico Egitto, Roma.
- Fakhry, A. 1959. The Monuments of Snefru at Dahshur I. The Bern Pyramid, Cairo.
- Fakhry, A. 1969. The Pyramids, Chicago.
- Fakhry, A. 1959-1961. The Monuments of Sneferu at Dahshur, vol. I ; The Bent Pyramid, vol. II; The Valley Temple, vol. III; The Temple Reliefs, Cairo.
- Faulkner, R. O. 1969. The Ancient Egyptian Pyramid Textes, Oxford.
- Goedicke, H. 1971. Re-used Blocks from the Pyramid of Amenemhet I at Liszt, New York.
- Goyon, G. (1977) Les secrets des batisseurs des girandes pyramides “Kheops", Paris.
- Goyon, G. 1997. Il segreto delle grandi piramidi, Roma.
- Hassan, S. 1932/1953. Excavations at Giza, vol. 8, Cairo- Oxford.
- Hassan, S. 1949. The Sphinx: It’s History in the Light of Recent Excavations, Cairo.
- Hassan, S. 1960. The Great Pyramid of Khufu and its Mortuary Chapel, Cairo.
- Haase, M. 2003. Das Vermachtnis des Cheops. Die Geschichte Grofen Pyramide, Munchen.
- Hawass, Z. and Lehner, M. 1994. The Sphinx; Who Built It and Why. Archaeology, vol. 47, No 5, 30-47.
- Hawass, Z. (2003) I tesori delle piramidi, Vercelli.
- Helck, W. and Eberhard, O. (1972-1992) Lexikon der Agyptologie, vol. 7, Wiesbaden.
- Janosi, P. 2006. Le Piramidi, Bologna.
- Janosi, P. 1995. Die Pyramidenanlagen der Koniginnen, Wien.
- Jequier, G. 1922. L'architecture et la decoration dans l'ancienne Egypte, vol. 3, Le Caire.
- Jequier, G. 1924. Manuel d'archelogie egiptienne, I:Les elements de architecture, Paris.
- Jequier, G. (1928) La Piramide d'Oudjebten, Le Caire.
- Jequier, G. 1933. Les Piramides des Reins Neit ed Apouit, Le Caire.
- Jackson, K. and Stamp, J. 2002. La Grande Piramide, come e perche e stata costruita, Milano.
- Jacq, C. 1998. I Grandi Monumenti dell'antico Egitto, Milano.
- Infranca, G.C. 1999. Il manuale di restauro archeologico, Roma.
- Infranca, G.C. 2001. Il restauro archeologico, Roma.
- Infranca, G.C. 1998. Archaeological Conservation, Amman.
- Infranca, G.C. (ed.) 2005. Archaeology and Conservation in the Middle East, Roma.
- Kees, H. 1962. Totenglauben and Jenseitsvorstellungen der alten Agypter, Berlin .
- Kerisel, J. 1981. Expansive shale damage Theban Royal Tombs: Egypt, ICSMFE, Stockholm.
- Klemm, R. and Klemm, D. 1993. Steinbruche in Alten Agypten, Berlin.
- Labrousse, A. 1996. L'architecture des pyramides a textes, vol. 2, Le Caire.
- Lucas, A. and Harris, J.R. 1962. Ancient Egyptian Materials and Industries, London.
- Lauer, J. PH. 1988. Le mystere des pyrarnides, Paris.
- Lauer, J. PH. (1948) Etudies complementaires sur les monunents du Roi Zoser a Saqqarah. Reponse au docteur Herbert Ricke, Le Caire.
- Lauer, J. PH. 1956. Les Pyramide a degres monuments typiques de la III dynastie, comunicazione al XXIII Congresso degli Orientalisti, sezione Egittologia, Cambridge.
- Lauer, J. PH. 1976. The Royal Cemetery of Memphis, London.
- Lehner, M. 1997. The Complete Pyramids, London - Cairo.
- Lehner, M. 1985. The Pyramid Tomb of Queen Hetepheres and three Satellite Pyramid of Khufu, Mainz.

- Moritz Ebers, G. 1989. Egitto, Milano.
- Leospo, E. 1982. Saqqara e Giza, Novara.
- Lepre, J. P. 1990. The Egyptian Pyramids, Jefferson (NC) – London.
- Lepius, K.R. 1849-1859. Denkmaeler aus Aegypten and Aethiopen, 12 vol., Berlin.
- Lloyd, A.B. 1970. The Egyptian Labyrinth, JEA, No 56, 81-100.
- Neugebauer, O. and Parker, R.A. 1960-1969. Egyptian astromical texts, London.
- Nicholson, P.T. and Shaw, I. 2007. Ancient Egyptian Material and Technology, Cambridge.
- Maragioglio, V. and Rinaldi, C. 1964-1975. L'architettura delle piramidi menfite, vol. 8, Torino e Rapallo.
- Mendelsshon, K. 1990. L'Enigma delle Piramidi, Verona.
- Moschetti, E. 2005. Lungo il Nilo, Torino.
- Perrino, J.S. 1839-1842. The Pyramids of Gizeh, London.
- Petrie, W.M.F. 1885. The Pyramids and Temples of Gizeh, London.
- Petrie, W.M.F. 1883. The Pyramids and Temples of Gizeh, London (new ed. with updating by Z. Hawass, London 1990).
- Petrie, W.M.F. and Mackay, E. and Wainwright, G.A. 1910. Miedum and Memphis (III), London.
- Porter, B. and Moss, R.L.B. and Malek, J. 1942. Topographical Bibliography of Ancient Egyptian Hieroglyphic Texts, Relieves and Paintings 111, Oxford.
- Reisner, G.A. 1942. A History of the Giza necropolis, London.
- Reisner, G.A. 1931. Mycerinus. The Temples of the Third Pyramid at Giza, Cambridge (Mass).
- Reisner, G.A. 1936. The Development of the Egyptian Tomb down to Access of Cheops, Cambridge.
- Reisner, G.A. and Smith, W.S. 1955. A History of the Giza Necropolis Vol. II, The Tomb of Hetepheres, the Mother of Cheops, Cambridge.
- Rinaldi, C. 1983. Le Piramidi, un'indagine sulle tecniche costruttive, Milano.
- Ricke, H. 1970. Der Harmakistempel des Chefren in Gizah, Wiesbaden.
- Roccati, A. 1982. La littèrature historique sous l'Ancien Empire èggyptien, Lapo, Paris.
- Roccati, A. 1982. Il Museo Egizio di Torino, Torino.
- Roccati, A. 1987. La Magia in Egitto, Milano.
- Sharef, A. 1947. Das Grab als Wohnhaus in der agyptischen Fruhzeit, Munchen.
- Siliotti, A.1997. La Guida alle Piramidi,Vercelli.
- Stoppato, M.C. and Bini, A. 2001. Deserti, Milano.
- Schneider, T. 1994. Lexikon der Pharaonen, Zurich.
- Schott, S. 1970. Agyptische Quellen zum Plan des Syphixtempel, Wiesbaden.
- Stadelmann, R. 1985. Die agyptschen Pyramiden. Vom Ziegelbau zum Weltwunder, Mainz am Rhein.
- Swelim, N. 1983. Some Problems on the History of the Third Dynasty, Alexandria.
- Vandier, J. 1952-1969. Manuel d'archéologie égyptienne, Vol. 1, tomi 5, in 7 vol. e 4 album, Paris.
- Verner, M. 1992. Baugraffiti der Ptahschepses-Mastaba, Praha.
- Verner, M. 1994. Forgotten Pharaohs, Lost Pyramids, Abusir - Praha.
- Verner, M. 2002. Il mistero delle piramidi, Roma.
- Vaghi, F. (ed.) 2001. I misteri delle Piramidi, Colognola ai Colli (VR).
- Vyse, H. 1840-1842. Operations Carried out on the Pyramids of Gizeh, London.
- Zàba, Z. 1953. L'orientation astronomique dans l'ancienne Égypte, et alprécession de l àxe du monde, Prague.
- Zaki Nour, M. and Salah Osman, M. and Iskandar, Z. and Youssuf Mustafa, A. 1960. The Cheops Boats, I parte, Cairo.

List of figures:
- Figure (1) General view of the Pyramids of Giza.
- Figure (2) Remains of the limestone coatings of the Pyramid of Khafre.
- Figure (3) Stone material placed in the lower part of the Pyramid.
- Figure (4) Western side of the Pyramid of Khufu.
- Figure (5) General view of the Pyramid of Khufu with the Giza Plateau.

Figure (1) General view of the Pyramid of Giza.

Figure (2) The remains of the limestone coatings of the Pyramid of *Khafre*.

Figure (3) Stone material placed in the lower parts of the Pyramid.

Figure (4) Western side of the Pyramid of *Khufu*.

Figure (5) General view of the Pyramid of *Khufu* with the Giza Plateau.