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PROTECTION OF AN EARTHEN-ARCHAEOLOGICAL SITE: A COLLABORATIVE EFFORT BETWEEN COMMUNITY AND EXPERTS, CHILE

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Theme 3: Documentation, Conservation and Management of Archaeological Sites
Keywords: Archaeology, consolidation, structures, management

The prehistoric village, Tulor 1, is located about 10 km southwest of San Pedro of Atacama in northern Chile. It is the oldest sedentary archaeological site in northern Chile, whose chronology dates back to 2250 years ago. It was excavated by archaeologists from 1981-1985. At that time, it was clear that the site was undergoing an accelerated process of deterioration, resulting from the advance of a large dune that originally covered it that currently was in the process of withdrawal. Studies were made to find a solution to the natural processes of destruction affecting the site, and it was concluded that the active and irreversible damage is caused by the condition of the environment in which it is located.

Research has shown that the best way to preserve the site was to keep it in a "buried" state. In order for that to be achieved, it was necessary to stabilize the top of the earthen walls, which had been irreversibly degraded, by designing "capping" solutions and binding based on satisfactory studies with more than 20 years of permanence. Moreover, the study of the grain size of the dragged material allowed determining of the minimum particle size necessary to cover the site with a thin layer of sand with similar features, preventing it from being carried away by the winds forecasted by the weather station installed in situ. In addition, and because it is a site whose management and care is in the hands of a small indigenous community, it was necessary to raise awareness of the site's fragility, and to provide technical training for indigenous community to be able to perform the work of supervision and future maintenance.

1. INTRODUCTION

Culture and cultural heritage are living concepts, constantly changing according to societies where they belong. Similarly, the definitions of conservation and restoration have undergone significant changes over recent history; changes that directly affect the materials used in an intervention, the technology applied and, above all, the chosen criteria.

The prehistoric village of Tulor is located in the immediacy of the ayllus of Coyo and Tulor, about 10 km southwest of the town San Pedro of Atacama in northern Chile. The environmental framework is established to the east by the colossal Andean highlands, to the west by the mountain range of the Cordillera de la Sal, which ends northwards to merge with the eastern edge of the great Salar of Atacama. In its surroundings remain active dunes, on which are found scattered shrub species, maintained by subsoil moisture. The chronology of occupation of the site ranges from 800 BCE to 500 CE that is, the settlement would have originated about 2,250 years ago. Some experts have considered it to be one of the best-preserved archaeological sites of the Neolithic period (Barón, 1986).

The site is located on the large area of alluvial deposits of the San Pedro River. The village itself is built on a site of clayey soil. Geological theories hypothesize very different environmental conditions to the present ones of the entire area, theorizing that probably there was a greater availability of water resources, and thus the existence of more vegetation and wildlife than currently. However, fluvial activity, which depends on the climatic cycles of the High Andes, produced over time, sharp changes in the course of the River San Pedro, which moved further away from the Tulor sector.

Dryness drastically deteriorated environmental conditions, making the site uninhabitable and forcing its occupants to emigrate from the territory in which the village was located.

A slow process of desertification began, leaving the ground bare. Strong windstorms dragged the salty sands from the Cordillera de la Sal, forming active dunes that gradually covered the entire site, which also preserved it. It remained in this condition approximately 1,700 years until, in the early decades of the 20th century, the dune covering the site moved southeasterly, revealing the first structures, which was reported by Priest G. Le Paige, in 1957 (Le Paige, 1957-58). For its historical and heritage value, as well as its fragile condition, it was placed by the World Monuments Fund, on its Watch List for endangered cultural sites around the world.

Fig.1 Stallite image from Tulor site (credits: Google Earth)

2. HISTORICAL FEATURES

The main feature consists of 23 circular structures built of earth kneading in situ. Of these structures, linked walls were developed creating passages that connected with enclosures of various mixed forms. In total, 106 structures of different geometry were recorded, evidencing a cellular growth. The enclosures are reached by regular door openings and others are simple openings cut in the earth walls at different times. This indicates that there was a lot of activity and change of use of the buildings during the long period of occupation. Archaeological evidence shows that the enclosures had various uses and functions related to everyday activities occurring therein (Bahamondez and Muñoz, 1997).

3. FIRST ACTIONS OF CONSERVATION

In 1982, an area was chosen, 30m distant from the last vestiges of walls of the site, to construct a polygon for testing, which consisted of exact replicas of the structures number 2 and 3, with their linking walls. A hypothetical roof was also added to recreate the conditions inside the rooms. Here it was possible to accomplish various types of measurements and tests with conventional conservation materials, as well as with various consolidants. The research station on site, included meteorological-measurement equipment that allowed recording the prevailing environmental conditions at the site (Muñoz and Bahamondez, 1990).

Between 1984 and 1989 research was conducted, in order to find a solution to reduce the devastating degradation process to which the site was being impacted. The deterioration observed in Tulor was due to multiple agents, causes and mechanisms. Usually, their action is interconnected, which undermines their identification and subsequent isolation. The main problem was the actively irreversible damage, due to the environmental conditions of the location where the archeological site is located. From the foregoing, it was concluded that it would be necessary to stabilize the tops of the irreversibly degraded walls by designing 'capping' solutions (Morales, 1983), along with the application of consolidating materials that would provide greater resistance against weathering in the most exposed areas.

4. CURRENT PROJECT

The development of the Tulor project was possible through the financial contribution from the Regional Government of Antofagasta through CONAF (National Forestry Corporation) and the University of Antofagasta. The activities carried out between 2009 and 2010 consisted primarily in the design and implementation of solutions to stabilize and to protect the top of walls of the structures, using a technique studied for over 20 years. The analysis of the current condition of the solutions implemented in the years 1989-1990 showed that they have maintained their ability to protect the walls despite the time elapsed, efficiently withstanding the harsh environment of the place.

The first aim was to mitigate the visible and irreversible damage to the structures due to the environment where the site is located. The second target was to train the community of the Ayllo Coyo on issues related to the conservation and management of the environment near which the site is located and cultural remains. This training also incorporated the staff of CONAF, which is currently working in the surveillance of the area of San Pedro of Atacama. Finally, a seminar on the subject of Tulor was convened and attended by relevant people in the cultural field and that related to the theme of the site, Tulor 1.

5. EXISTING CONDITIONS

The first conclusion drawn was that the built remains of the village, on the one hand, are being discovered faster than initially was planned, due to the rapid displacement of the dune that covered them for centuries. This situation induces two opposite effects: on the one hand is the discovery and damage to the remains of structures located to the north, with the consequent degradation and/or disappearance of walls; and secondly, the gradual filling of structures that were excavated during the archaeological research over the years 1981 to 1985, and left exposed to weathering (Llagostera, Barón and Bravo, 1984).

The latter effect, the natural filling of the structures in the last decades, was initially found to be safe and beneficial. However, on the contrary, it constitutes another deteriorating effect that had not been foreseen beforehand. The sand particles that drift with the wind swirling at an average height of the half-buried walls have produced erosion of the structures at the base of the parts that are exposed.

6. AGENTS AND DETERIORATION MECHANISMS

The obvious fact that the site is being slowly rediscovered as the dune advances has proved that, in this situation, structures are more vulnerable to damaging agents, for which there is not nowadays a definitive solution. For this reason, it is necessary to maintain the site in its buried condition. Therefore, it was required to determine the proper characteristics of the filling

Fig.2 Replicas of two village dwellings built as a conservation prectice site (credits: Monica Bahamondez)

and surface covering materials, so that this will not be dragged by the prevailing winds common in the place.

The deterioration observed in Tulor is due to multiple agents, causes and mechanisms. Often these are interrelated, making it rather difficult to identify and isolate them. When classifying the agents of deterioration as intrinsic and extrinsic to the structures themselves, among the former is undoubtedly the raw earthen material used for building the structures, which is highly vulnerable to atmospheric factors. Extrinsic agents include strong and steady winds that drag particles impregnated with soluble salts; a certain amount of summer precipitation, because of the winter in the High Andes; and finally, large temperature differences between day and night, which create severe variations in relative moisture. All of the aforementioned agents act simultaneously, with the exception of the human factor, which is currently controlled (Bahamondez and Muñoz, 1997).

Undoubtedly, the dune that covered the village for over 1,500 years, which is currently in retreat, is the main cause of their destruction. Already in the 1990s, it was determined that the settlement had taken the shape of the dune, which due to its advance dragged sand, leaving the walls at the surface. These, in turn, were soon swept away by the abrasive wind. To this, other damaging agents described below are added.

6.1 Moisture

Although the village is located in one of the driest places on the planet, there are summer rains known as the Bolivian Winter, manifested between the months of December and March. On the other hand, evening relative humidity is close to 100% throughout the year, and the high hygroscopicity of the salts and of the raw earthen material, develop a process to a greater or lesser extent of continuous solubility and re-crystallization of salts on the top of the walls. This process has been confirmed to occur at the surface or immediately below it, depending on the temperature reached by the wall in the hours following wetting. This permanent migration of material, and the regular formation and re-solubility of large crystals within the pores, causes serious micro-structural deterioration, manifested as a progressive lack of inter-particle cohesion or surface dusting.

This phenomenon means that, under a seemingly hard and solid (but extremely brittle) surface, there is a layer of clay, which does not have any structural capacity and, in fact, favors the deterioration process, which cyclically repeated will slough off material from the top of the wall. Cyclical moisture issues are the great enemy for conservation of earthen-built archaeological structures.

6.2 Temperature

During the year, in the Salar of Atacama, high temperatures can be noted during the day, and very low ones during the night, the latter well below the freezing point of water. The effect of this temperature gradient is verified in that part of the wall that is exposed to the weather, provoking at the interface of the "wall buried/wall unearthed" significant differences in thermal expansion, which ultimately translate into a sum of tensions that may culminate in the generation of multiple micro-fissures, cracks and subsequent detachment of entire areas.

Moreover, a wall with a high percentage of liquid water inside is exposed to severe mechanical alterations from the time when the temperature drops below the freezing point. Indeed, the water passing from the liquid to solid (ice) state increases its volume by producing, within the pores, tensions that can irreversibly fracture the structure. This phenomenon occurs mainly at thermal interfaces.

6.3 Wind

The Tulor village is located in a degraded and bare plain in the northern sector of the great Salar of Atacama. It is constantly buffeted by strong winds, which carry a considerable amount of dragged material (brackish soil, sand, and pebbles).

This material, depending on its volume, specific density and hardness, impacts the top of the walls through sandblasting. In addition to this effect, the weakened, by the aforementioned agents, wall is likely to experience progressive deterioration, reaching the extreme circumstances of its almost total destruction. This situation is obvious in semi-unearthed remains of structures around the village of Tulor.

In the first assessment visits, this phenomenon was evident as it was possible to observe the effect of erosion on different structures, which were well documented. Even structures built on the test grounds showed severe damage to their bases as a result of erosion by the winds. From the foregoing, it was concluded that it was necessary to stabilize the top of the walls that had been irreversibly degraded by designing 'capping' solutions (Morales, 1983; Muñoz and Bahamondez, 1990; 1992-1993; 1993)

Fig.3 Removal of salt-contaminated first coating layer. (credits: Monica Bahamondez)

7. PROJECT DEVELOPMENT

7.1 Selection and physicochemical characterization of the earthen material

The first activity consisted of research and testing of the behavior of different soil types in the area (Teutonico, 1998). The possible choices were varied, and finally a type was chosen from an alluvial deposit located at a distance of 60 m to the southwest of the replica houses very similar to that used in the original earthen construction. The raw earthen material selected for the reinstatement of the top of the walls was sent to the laboratory of the National Center for Conservation and Restoration (CNCR) DIBAM for characterization and understanding of its properties. With this result, the archaeological site began being capped, by selecting a homogeneous clay layer, from which material was extracted and collected for use.

7.2 Interventions at the tops of the walls

Two types of techniques were established to condition the walls for intervention. The first related to the remains of the underground walls, in which it was necessary to clear its sides in order to carefully observe the original forms, having as reference the most prominent features at the surface. The second had to do with those tops of the walls that emerge beyond the surface. In this case, the intervention was focused on the frailty of the walls' tops, due to the causes described herein.

7.3 Preparation of the tops of the walls

Considering the current condition of the top of the walls, the extent of damage caused by the exfoliation of layers and efflorescence of salts, of the first step was to remove material irreversibly degraded and unrecoverable. This task was achieved through the careful work of constant evaluation of the materials affected in varying degrees by erosion and salinity. The removal of the damaged layers was limited to the level of the depth of loose saline material that no longer had the ability to adhere to the wall. The tops of the walls were cleaned until the original material was found, which still retained in good condition and consolidation. With a sound substrate, it would be possible to reintegrate new patching material.

7.4 Preparation of the earthen material

The earthen material selected from the location adjacent to the archaeological site, as aforementioned, was extracted by layers and prepared for use by grinding and pulverization. The raw material required for use in the 'capping' solution had to meet special conditions. These relate to the plasticity of the earthen material, which should adapt to the top of the wall, in very different moisture states from that of the material to be incorporated. Should there be much difference between them, there would be and uncontrollable contraction rate and cracking would result in the new layer. In this case, detachment would be inevitable. The solution to this problem is to manage the plastic limit of the earthen material. The right mixture is achieved through careful allocation of the quantities of water and sand, in addition to the amount of wetness at the top of the wall.

The materials used in this procedure complied with the specifications given by the project. The technique, already mentioned as a 'capping' solution on walls built of earth, technically corresponds to a continuous coating of the wall surface to be preserved. One of the main objectives is to serve as 'sacrificial layer' to protect the surviving parts of the original wall. This layer was designed to cope with the various types of damaging agents and to also avoid increasing salt migration to the original parts of the walls. The damage to this capping will not be a great loss, as it is not the original material and, therefore, easily replaceable.

7.5 Integration of a sacrificial layer ('capping' solution)

After removing the unsound material from the tops, the walls were cleaned and the sound parts were stabilized; this was followed by a gradual wetting process in preparation for 'capping'. As mentioned above, this "capping" material in a wet and plastic condition is different from that of the original tops of the walls. The "capping" mixture was prepared by the combination and adjustment of the right proportions of sand, earth and water, taking into consideration the differential behavior in unlike parts of the tops of the walls by the range of types and amount of salts in their structure.

To connect the "capping" mixture to the walls, wooden mallets were produced of ideal size, shape and weight, so as to incorporate the new material using a compressed technique. This allowed the application of the low-moisture capping mixture to better adapt to the tops of walls, which is in a different state of moisture content. Through this process, the moisture content between the wall and the "capping" mixture was standardized, permitting the covering of the tops of the walls, significantly reducing the risk of incompatibility, as well as cracking. The implementation of the capping mixture occurred manually only, by tamping with wood mallets the raw earthen material until optimum condition was reached.

Fig.4 Part of the community team of workers in charge of site management (credits: Monica Bahamondez)

After drying, the eventual appearance of fissures was to be expected. When this occurred, the coating required stabilization through a local reimplementation of the mixture in low-wet condition to those specific areas. Once the earthen "capping" completed its drying process, and when environmental conditions were favorable, consolidation treatments and waterproofing of the coating could be consecutively applied (Schwartzbaum and Seymor, 1983). These processes should not occur in extreme thermal gradients of temperature. If possible, temperatures are required to be moderate and should always be above the freezing point.

The variables to be controlled during the implementation of the different products are unique to the specific site conditions of Tulor, and these were specifically established by the laboratory analyses. The aim of this application was to increase resistance to erosion and to restrict water absorption that carries a certain amount of saline solutions.

7.6 Leveling enclosures

As already extensively described, the wind with sand traveling at high velocities over the surface of the walls is one of the most aggressive agents for the site destruction. The other type of erosion, detected in recent years, is produced on the vertical walls in their lower sector, where abrasive sand swirl occurs, moved by the wind following the circular shape of the enclosures.

To mitigate the effects of this agent, the accumulated sand was leveled naturally within enclosures, filling the low parts and berming higher ones. With this procedure, it was possible to protect the foundations of the walls by evenly leveling the filling within the enclosures. However, this filling can also become windborne and, therefore, abrasive. To maintain a steady and constant filling, a layer of 3/8" gravel was placed. This material, because of its size and weight, cannot be mobilized by high winds; thus, the foundations of the walls that are exposed are protected.

8. CAPACITY BUILDING OF THE COMMUNITY

The work described above was jointly conducted between professionals and members of the local indigenous community. The latter is the most interested party in preserving the site, since it has become an important source of income. Moreover, it is important that they have knowledge on how to maintain the site, repairing small damaged areas and, above all, that they are able to detect conservation problems to promptly notify the appropriate authorities.

Hence, theoretical situations were presented where the indigenous community was introduced to the theme of cultural heritage and associated values. At this point, there was an interesting exchange of information between experts and trainees, as most of the latter had grown up near the site and listened to the stories of their parents and grandparents about it. At the same time, explanatory meetings were also held for local tourist guides, who daily carry dozens of tourists to the site. They were informed on the nature and intent of the work beingcarried out, and the methodology applied.

9. CONCLUSIONS

This paper aims to provide detailed insight on the conservation work implemented to the earthen structures of the Tulor site, accomplished between the months of December 2008 and November 2009. Apart from planning and the previous experience of the experts involved, many surprising factors were found here, as is typical of any planned work of conservation/restoration.

The priority given to the conservation work is justified, as the site was in the process of destruction. In such conditions, appropriate actions intended to mitigate the process are acceptable, although there is still a significant amount of scientific information that has not yet been addressed in this field.

Finally, the participation of the local community is highlighted, which worked carefully on the site, and who also rapidly attained the knowledge conveyed during the training sessions in the field. It is further understood that the work performed is not the definitive solution to the problems the site faces, but certainly, will inhibit the degradation processes. The greater or lesser success of this project will depend on the persistence of the community to perform the maintenance work to which they have committed and to which they have been trained.

Notes

(1) The village is almost entirely covered by the dune, except for the excavated structures. The top of the walls are the parts exposed to weathering, which, as the dune advances, are swept by the wind that carries sand, causing irreversible damage to the site.
(2) The function of covering of the top of earthen walls is to protect the original material and to serve as a sacrificial element to weathering agents.

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CONSERVATION OF RAMMED-EARTH STRUCTURES: THE HISPANO-COLONIAL ARCHAEOLOGICAL SITE OF SANTA FE LA VIEJA, ARGENTINA

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Theme 3: Documentation, Conservation and Management of Archaeological Sites
Keywords: Conservation, protection, museography, interpretation

Abstract

The archaeological site of Santa Fe La Vieja in Argentina preserves the urban and architectural material record of the first settlement of the city (1573-1660). All archaeological structures excavated since 1949 are of rammed earth, and correspond to the lower parts of the walls and foundations of the Council (Cabildo), three churches and dozens of houses.

Since the first excavations, the site was recovered for research and museum use, and various forms of protection and conservation were applied. Due to the loss of the original roofs and the vulnerability of the construction material to the action of environmental agents, the broadest and most controversial issues of design and erection of shelters to protect archaeological structures are questioned.

In the case of Santa Fe La Vieja, from the time the remains of rammed earth walls were excavated, it was necessary to protect them from environmental agents, especially intense and frequent rainfall in some periods of the year. In parallel, the transformation of the site into an Archaeological Park has created demands for visitor access inside the protective shelters, as well as to guarantee its museological treatment. Finally, the inclusion of shelters in the context of a landscape with a strong presence of nature is another issue that should be taken into account when designing protective measures.

The paper discusses conservation actions taken to date. The shelters that have been protecting the archaeological structures are evaluated, and current projects, which aim to achieve better protection, are presented.

1. SANTA FE LA VIEJA: BACKGROUND AND PROBLEMS OF THE SITE

1.1 From city to site and archaeological park

The Santa Fe La Vieja Archaeological Park (SFLV) corresponds to the site of the first settlement of the city with the same name in Argentina, which was founded in 1573 and lasted until around 1660.

In a region populated by hunter-gatherers, the Spanish transplanted their construction techniques to meet the demand for housing and institutional buildings, using earth and wood as building materials. The urban plan refers to the typical grid layout used from the Spanish colonization of South America, which follow the model from Lima (Calvo, 2004, pp. 113-117).

When the city moved 80 km to the south, the founding site was definitively abandoned. During the colonial period, the former enclave was part of a rural area sparsely used. In 1867, the foundation of an agricultural colony of European immigration generated a new and stable occupation; at that date, the area of the old urban plan became agricultural land (farms).

In 1949, Agustín Zapata Gollan started archaeological excavations on land belonging to one of those farms, which uncovered the vestiges of the old town . The excavations lasted for several years and exposed the urban architectural material record the first settlement of Santa Fe (1573-1660) and the structures of its main buildings: foundations and lower parts of walls from dozens of houses, three churches and the Cabildo (Zapata Gollan, 1971, pp. 80-81). A significant number of rammed earth wall structures were not excavated; instead, their location was recorded and they were kept buried to ensure a better conservation.

All archaeological structures are constructed of ordinary rammed earth. Although the French pisé was also used, no evidence of such construction was recovered, possibly because of the methods used during the archaeological excavations.