Baseline for the conservation state of pre-Inka and Inka mining complex of San José del Abra: identification of risks and measures of monitoring and control.

Daniela Bracchitta K.[1]*, Roxana Seguel Q[2]., Diego Salazar S[3].

[1]Conservator, Laboratory of Archaeology, National Center for Conservation and Restoration (CNCR).
[2]Head Conservator, Laboratory of Archaeology, National Center for Conservation and Restoration .
[3] Archaeologist, Anthropology departament, University of Chile.
*e-mail: daniela.bracchitta@cncr.cl

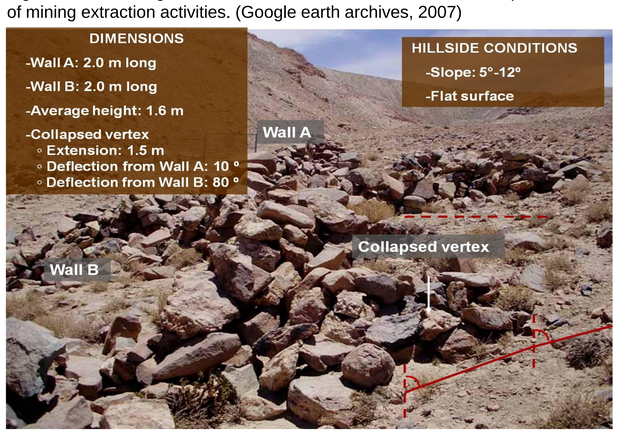
Somewhere over 4000m above sea level

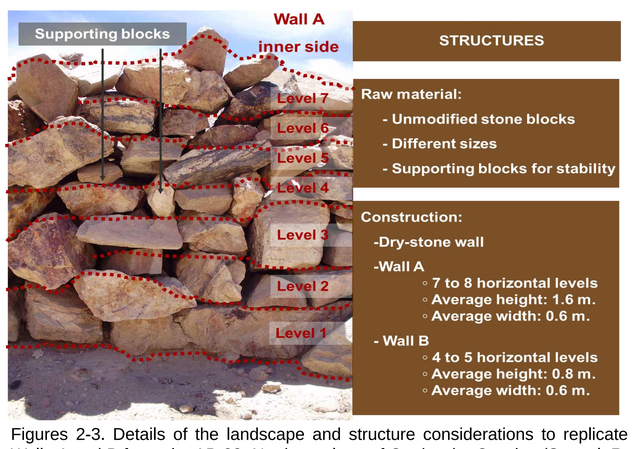
San José del Abra mining complex is situated in the highlands of the SCM El Abra Mining Company property, in Atacama Desert, Northern Chile. It is located to the NW and SE of Quebrada *Casicsa*, at 4000 masl and covers an area of approximately 24 ha. Six main archaeological areas were identified inside the complex, all of which dated to Inka and pre-Inka periods (*ca.* 950–1540 AD). Most of the architecture is made of dry-stone wall structures, the highest number being in the northern slope of the Quebrada, which is characterized by a strong inclination that reaches 35º. Therefore it is very exposed to tectonic activities, environmental and anthropic agents. Other prehistoric mines are known in the Andes, but this complex is unique, not only for its monumentality and outstanding preservation, but also because it documents several phases of ancient mining processes in an area where mining is still the most important economic activity today.

What seemed to be the problem…Back in 2009

The company needed to expand its extraction area. Pit limits of the new expansion would be close to the old mining complex, especially to the sites AB-39 and AB-38, with a projected limit distance of 55 and 70 m respectively (Figure 1). The company's geomechanical department developed a theoretical damage model that showed a potential risk for the structures of the mentioned sites. The peak particle velocity (PPV) calculated for the new limit would be 248 mm/sec, slightly over the threshold for absence of damage, which according to international standards is 204,33 mm/sec [1]. This was considered the main risk factor at that time.

Figure 1. Archaeological area and limits established for the new expansion of mining extraction activities. (Google earth archives, 2007)





Figures 2-3. Details of the landscape and structure considerations to replicate Walls A and B from site AB-38. Northern slope of Quebrada Cacsica (Seguel, R. 2009).

The experimental dry-stone walls and controlled blasting

3 replicas of the most exposed walls were built at 52, 55 and 62 m from the limit of the future pit. They represented the most susceptible walls to collapse by blasting. Raw materials, technical construction, length, height, inclination, orientation and site conditions were matched with the archaeological ones (Figures 2 and 3). In addition, planimetry of the replicas was establish in order to assess any changes. In addition, the Geomechanical department worked on decreasing the PPV below the critical level.
Data monitored during the controlled blasting at 52 and 55 m, were 120 mm/sec, equivalent to a level 0 in damage. That was corroborated by the archaeologist Diego Salazar, who was present during of the detonations (Figures 4 and 5). The mine extension is currently 50-70 m from the archaeological structures (Figure 6), none of which show any alteration related to blasting.

Figures 4-5. Replica of the wall M3 from site AB-39A. It was located 52 m from the experimental blasting. No painted stone fell down during the process (Salazar, D. 2009)

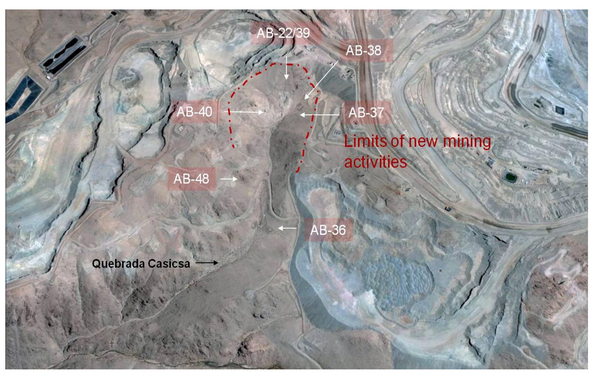


Figure 6. Archaeological area and current expansion of mining extraction activities. (Google earth archives, 2015)

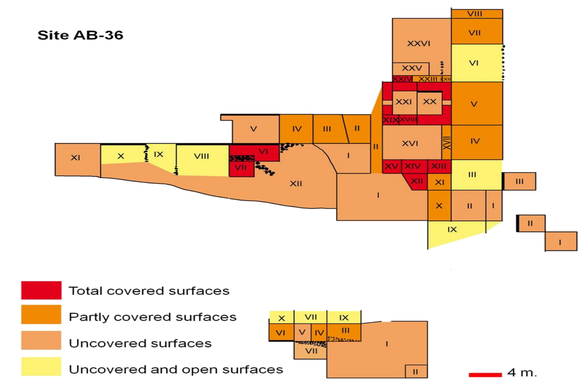


Figure 7. Enclosures diagram of AB-36 site. The different colors indicate the degree to which floor surfaces are covered by collapsed walls (Bracchitta, D., 2009).

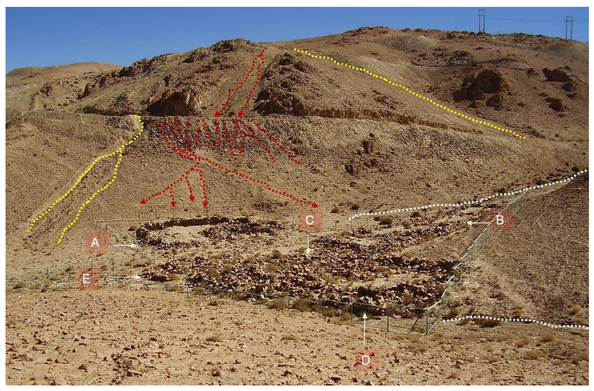


Figure 9. General view of AB-36 site. In white letters are pointed the 5 units of AB-36 site; each one have several enclosures. Dotted white lines show natural runoff and the yellow one those with an anthropogenic origin. In red dotted arrows it is observed minor furrows on the ground (Bracchitta, D., 2009).

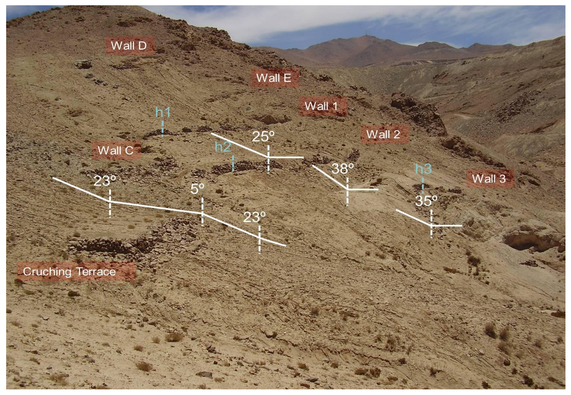


Figure 8. Side view of site AB-39A. Wall structures in association with wall heights and slopes (Bracchitta, D., 2009)

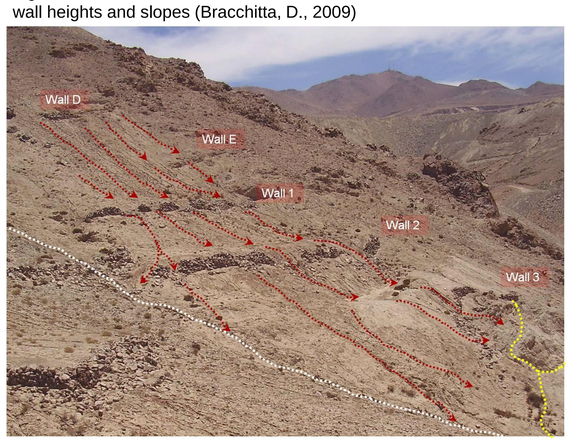


Figure 10. Side view of site AB-39A The red dotted arrows indicate the main furrows caused by surface runoff, and its consequent domino effect on the walls. Dotted white lines show natural runoff and the yellow lines show runoffs with an anthropogenic origin. (Bracchitta, D., 2009)

What really was the problem

Along with the experimentation, baseline work for the conservation of the archaeological complex was elaborated. It included a full study of structures, slopes; indicators, agents and factors of alterations; completed with the evaluation of the integrity of the enclosures (Figures 7 and 8). The study pinpointed that the greatest risk for the collapse of the structures was linked to prehispanic mining activities. Large areas of land clearing and gathering of unconsolidated sediments produced a modification in the topography of the area. In addition with a steep slope (between 23° and 38°), environmental agents such as rain and wind generated an intensive erosion of the land, forming gullies and dragging sediments (Figures 9 and 10). The halt in the prehispanic production and the lack of maintenance due to the withdraw from the area, intensified the erosion processes causing the collapse of the walls and sealing of the shafts (Figures 9 and 10)

Control and monitoring proposal

The control and monitoring proposal for the sites was based on the following:

•Carrying out a photogrammetric study of the complex, in order to systematically detect the transformation processes, projecting in time its speed and dynamics.
•Studying the rainfall regime of the area, so as to establish an ordinal scale that would evaluate the intensity of geoclimatic events
•Stabilizing unconsolidated sediments using geotextiles and eventually managing rainwater runoff
•Rebuilding collapsed walls to safeguard vulnerable structures

Nowadays

This work redefined the hierarchy of the agents of transformation for the mining complex. It was found that the modern mine blasting was not the main threat for the preservation of the archaeological sites; if not, paradoxically, its "archaeological" state. How ever, only part of the control and monitoring measures were implemented. Images of a 3D scanner were taken, and the sites are monitoring biannually for research purpose and verification of the conservation state. Today, gullies are bigger and deeper, and mining activities are surrounding the area; soon or later it will be an island with a difficult access. Nowadays, San José del Abra mining complex is confronted and threatened by two main agents of deterioration: the forces of nature and the forces of progress.

Bibliography

[1] SCM EL ABRA. 2009 (PPT). *Tronadura plataforma fase 10 y evaluación del daño en pircas experimentales*.