2023 IMEKO TC-4 International Conference on
Metrology for Archaeology and Cultural Heritage
Rome, Italy, October 19-21, 2023

When a painting is a history on the rock. An archaeometric approach to rock art production through the case of El Alto-Ancasti's Mountain

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Abstract –

It is a common assumption into rock art studies that a motif express a single painting event, made by an artist in a particular time period. Notwithstanding, a deepen insight on the history of production of rock art panels may shed light to more complex procesess, comprising different stages and many people.

Our research carried out at several archaeological sites in El Alto-Ancasti's Mountain (Catamarca, Argentina), explores the processes of production, uses and transformations of several caves with rock art. Adopting a material approach, we employed non-invasive and micro-invasive techniques to study the inorganic composition of rock paintings and distinguish between different painting mixtures. As a result of this approach, we detected chemical differences throughout particular motifs that allow us to think in several episodes of painting manufacture. In this paper, we describe a case study from the La Candelaria site in order to delve into the merits and limitations of an archaeometric insight to inquiry into the history of painting production.

I. INTRODUCTION

Rock art, which refers to paintings and engravings on rock surfaces, is an archaeological material scattered worldwide. A quick initial view of painted walls at any site could led us to belive that each motif is the result of a single painting event, executed by an artist in a short period of time. This approach allows us to interpret the figures, describe possible scenes and assign chronological references. However, what if some paintings are the result of multiple artists modifying and enhancing each figure over a longer period of time? This possibility exhibits a more complex understanding of rock art motifs as historical products and raises new methodological challenges to investigate these processes.

The El Alto-Ancasti's mountain, placed in the north-western argentine province of Catamarca, hosts one of the most outstanding groups of rock art sites of South America [1]. More than a hundred caves and shelters with rock paintings have been documented along this mountain. Mainly, these rock art caves have been assigned to La Aguada Culture, developed between 600 and 900 A.D. [2–6]. Images of felines, warriors, shamans and fantastic figures characterize the iconographic repertory of this culture, many of which are depicted on the rocky walls [7]. Nevertheless, new investigations describe paintings attributed to previous and later periods of time and connected with other cultures that inhabited El Alto-Ancasti[2,8–10]. In this sense, some of the caves with rock art have been re-interpreted as "open works"[11] or polichronic assemblages[12] to express the diachronic sets resulting from the addition of paintings through time, by La Aguada culture and other -earlier and later- human groups [12–14]. Less studied, however, is the possibility that what we interpret as a single motif is in fact a historical product resulting from various painting episodes.

In this article, we employ a case study to illustrate the relevance of archaeometric studies in comprehending the historical processes associated with the production and transformation of rock art caves at El Alto-Ancasti mountain. Specifically, our research focused in exploring the hypothesis that some figures emerged as the result of many painting events. For this purpose, we have performed a multi-analytical approach that combine non-invasive (X-Ray Fluorescence (XRF)) and micro-invasive chemical analyses (Raman Spectroscopy (RS) and Scanning electron microscopy with energy dispersive X-ray (SEM–EDS)). In the following sections, we review the findings of our research over the past few years and delve into the merits, limitations and challenges of employing archaeometric studies in the field of rock art research.

II. MATERIALS AND METHOD

After several decades of research in El Alto-Ancasti's mountain, twenty-seven rock art sites were documented[15]. Among them, the La Candelaria cave stands out as one of the most distinguished sites. This shelter measures 17 m.

width, 11 m. depth and 1,5-3 m. height. The walls and roof feature 141 rock art motifs, predominantly painted in white tones. Most of the anthropomorphic and zoomorphic figures, especially felines and snakes, are notable examples of La Aguada iconography [4]. Five radiocarbon AMS analyses from organic materials in paintings were executed, dating rock art between 700-1200 A.D.[16]. Macroscopic studies reveal, at least, four instruments and techniques employed in painting application [17]. In addition, differences in white tonalities between several motifs have been found. In last years, other paintings of red hues have been also discovered under weathering deposits of calcium oxalates and gypsum, sometimes underlying white paintings.

Physical and chemical microscopic analyses of rock paintings were carried out to explore the materials used in their production. In this sense, we employed non-invasive studies by XRF and micro-invasive elemental (SEM-EDS) and molecular (RS) analyses on cross-sections. On one side, for XRF studies an Elio (Bruker) micro-spectrometer has been used. The X-ray source was regulated at 40 kV and 20μA to carry out the acquisitions, irradiating the spot for a period of 120 seconds. More than 200 analyses were carried out in La Candelaria, including studies of paintings (150 acquisitions), rock background (45 acquisitions) and natural weathering deposits (18 acquisitions). On the other side, 33 cross-sections of rock paintings were obtained employing a specific protocol for cultural heritage studies [18,19]. Samples (of about 1 mm^2) have been taken using a scalpel and binocular lenses (OptiVISOR), being afterwards stored in 1.5-mL-capacity Eppendorf tubes. Then, each sample has been included in acrylic resin (Subiton®) and polished with sandpaper of different granulometry in order to expose its cross section. Finally, a DM EP model MC 170 HD Leica microscope was used to observe and photograph samples with visible light. Also, each sample was analysed in punctual and mapping modes using a SEM-EDS FEI Quanta 250. Finally, some samples were analysed by Raman Spectroscopy with a Lab RAM HR UV-Vis-NIR Horiba Jobin Yvon. A laser of 632.82 nm was selected and between 2-4 accumulations of 30 to 60 seconds were used. The laser power was filtered in several essays to avoid overheating of the sample.

As an example of the studies carried out, this paper focalizes in one of the most outstanding figures inside La Candelaria. This painting could be interpreted as a fantastic motif of a snake with several bodies and various heads, named as "anfisbena" by other researchers [20] (Fig. 1). Each body ends in a head that combines snake and feline attributes, two of the most important mythological beings in La Aguada culture. As a result of our macroscopic survey, three different white tonalities were detected inside the motif, corresponding to three different bodies of the snake (marked as A, B and S sectors in Fig. 2). Also several overlapping cases have been observed between different bodies of the motif. In sum, all the macroscopic observations led us to formulate the hypothesis of this figure as an assemblage resulting of different painting episodes throughout a longer period of time and many artists. To this end, each body of different tonality was sampled for cross-sections and also analysed using portable XRF.

Figure 1: rock painting of a fantastic figure with snake and feline attributes in La Candelaria cave.

III. RESULTS

Non-invasive XRF analyses have been carried out at 13 points of the painting and 2 points of the surrounding rock background. These studies, in addition to the other acquisitions executed in the cave, allow us to do some considerations. Firstly, XRF analyses enable us to chemically differentiate white paintings from background. Analyses executed on rock exhibit Si, Ca, and Fe as principal elements. Acquisitions on paintings also presents these elements, but with different intensities (more Ca and Fe, less Si). Secondly, XRF studies added data to chemically differentiate white tonalities used to paint each body of the figure. These variations could be explained as changes in Ca and S intensities in different parts of the motif.

Also, three samples were taken from different parts of the motif and three cross-sections obtained. Samples were then analysed using SEM-EDS (mapping and punctual) and RS. The results allow us to chemically differentiate each white tonality. On the one hand, elemental mappings show concentrations of Ca and S in Sample A and B, but exhibit Ca, S and P in Sample C (Figure 2). On the other hand, although SEM-EDS analyses prevent us from making a differentiation between samples A and B, RS studies show signals that enable us to make this distinction (Figure 3). Sample A exposes Raman signals of gypsum in 1007 cm^{-1}, and whewellite signals in 1464 and 1496 cm^{-1}. Sample B only shows gypsum bands. Finally, Sample C displays signals attributed to calcium phosphate (960 cm^{-1}) anatase (134 cm^{-1}) and anhydrite

(1007 cm^{-1}).

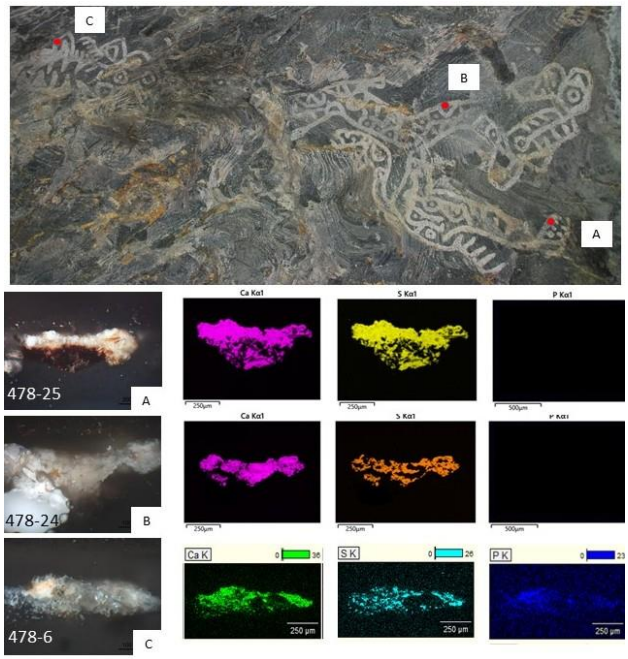

Figure 2: SEM-EDS mapping of samples taken from the snake motif at La Candelaria cave.

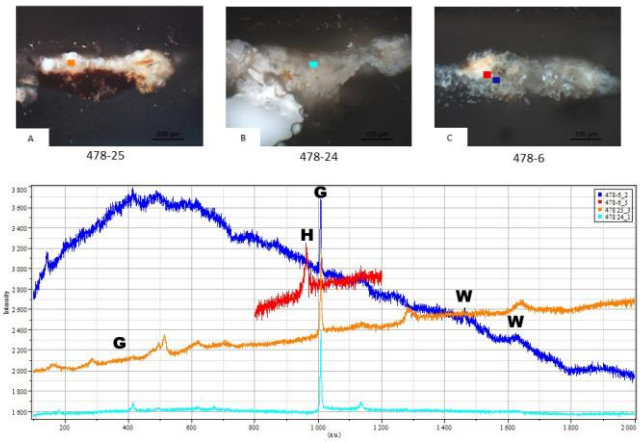

Figure 3: RS results of cross sections taken from La Candelaria cave.

IV. DISCUSSION

The results presented above are part of a larger archaeometric research project in progress focused in La Candelaria rock art. The project has studied more than 50 cross section by RS and SEM-EDS, and 200 non-invasive acquisitions by XRF. This robust foundation gives us a solid basis to interpret the analyses carried out in different parts of the fantastic motif and to discuss the merits, limitations and challenges of physical and chemical approaches to rock paintings.

Firstly, we must highlight the fact that the coincidences between macroscopic and chemical evidences are noteworthy. Each of the three different snake bodies distinguished accordingly to colour hues agrees with the chemical differences discovered. These data allow us to propose at least three painting episodes in the production of the figure that we can observe today. The overlapping cases detected between different bodies give us some chronological clues to think of this painting process as a historical assemblage of several parts transforming and enlarging the previous motif.

Secondly, we need to discuss some problems that arose when we employed non-invasive and micro-invasive techniques in researching rock art from La Candelaria. Among them, the heterogeneity of rock painting and the X-Rays penetration below the target surface stand out as the main problems. Regarding the former, increasing the number of acquisitions and performing statistical data analysis, such as PCA studies, could help us to obtain a more objective understanding of the chemical components of the paintings. Other researchers have used this statistical approach[21] and now we are exploring the possibilities of such insight.

Regarding X-ray penetration, other investigations have also stated the difficulties of discriminating the elemental composition of the paintings from the rocky background and weathering deposits in rock art research [21,22]. In our experience, many of these problems can be minimized or solved by combining non-invasive studies with micro-stratigraphy analyses of cross sections. This approach enables us to identify and chemically characterize each layer from rock to painting or possible weathering deposits and, then, extrapolate these results to correctly interpret punctual non-invasive studies. In this sense, we have to emphasize the utility of a complementary employment of non-invasive studies, as a screening method, with cross section analyses of some samples to answer specific questions regarding the complexity of rock art samples.

V. CONCLUSION

Rock art from the El Alto-Ancasti's Mountain is well known in South-American archaeological research. Although most of sites have been assigned to La Aguada Culture (600-900 A.D.), recent studies have revealed a more complex painting history with earlier and later figures. In this work, we continue inquiring into these processes but changing the analysis scale. To this end, we have selected one painting from the La Candelaria shelter as a study case to explore the hypothesis of a diachronic production of several motifs.

As presented above, archaeometric studies have unveiled new chemical information that allows us to differentiate between various painting mixtures along a single figure. In the case of our study, this mean that the

figure of the snake can be understood as the product of, at least, three paintings episodes, perhaps related to different chronologies and artists. This understanding radically changes our previous ideas about rock art figures as the result of a single painting event executed by the motivation of a single artist. This new insight highlights the extensive and more complex history of rock art sites, which we are only beginning to understand. This new data also expands our proposal of understanding rock art panels as assemblages to a motif scale.

Regarding the methodological approach employed, results obtained highlight the relevance of neutron analysis techniques, such as XRF and RS, in exploring materials used in rock art production and the particular histories of painting manufacture at each cave. The combination of non-invasive and micro-invasive techniques emerged as a promising approach whose results also could be enhanced by the development of new portable instruments [23,24]. Finally, it must be said that cross-disciplinary studies between archaeology, chemist, physics and heritage conservation are essentials to go beyond physical and chemical data and explore new topics such as the history of rock art sites, the social practices associated with painting production and different conservation problems.

VI. ACKNOWLEDGEMENTS

This article summarizes the work of many researchers and friends of our interdisciplinary group based in Buenos Aires, Córdoba and Catamarca. I am grateful to the following people for their valuable contributions: Fernando Marte, Marcos Quesada, Marcos Tascon, Eugenia Ahets Etcheberry and Matias Landino. Also I acknowledge the invitation of the session organizers and the commentaries and suggestions done by two anonymous reviewers. This research was made possible thanks to several fundings: PICT 2021-0503 and PICT 2019-4113 (Agencia Nacional de Promoción de la Investigación, el Desarrollo Tecnológico y la Innovación); PIBAA 2021-114 and PIP 11220200100358CO (Consejo Nacional de Investigaciones Científicas y Técnicas).

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