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About fires and paintings: Three stratigraphic insights on the history of a cave with prehispanic rock art

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ABSTRACT

How to connect rock art with the social practices developed around it along time? Trying to answer this question, in this paper we propose a method to link three different approaches that share the same stratigraphic principle: the excavation of the cave's floor sediments, the confection of a Harris' matrix of the painting process of one of the panels with rock art; and the study and further chemical analysis (SEM-EDS and Raman) of micro samples taken from the figures painted and the rock underlying. The potential of every single approach is multiplied by the interconnection given by the discovery of small layers of carbonization in the cave's walls as a result of several combustion events (hearths) done inside the cave. It must be highlighted, that this crucial information was obtained by using a novel methodology previously developed by the group of authors (Tascon et al., 2016). It allowed us to identify and chemically characterize superficial as well as underlying soot layers. Besides, the combination of this piece of information with other archeological evidences was vital to obtain a holistic view of the historical process developed at the caves of Oyola's archeological site, in the Argentinean northwest. Despite this is a case of study, the potentialities of this methodology can be spread out into other shelters with similar characteristics.

1. Introduction

In the archeological studies of rock art exist some difficulties to understand the historic process that shaped and transformed panels with paintings or engravings in their relation with the other social practices carried out in those spaces at the time. Even though stratigraphy is one of the main archeological methods to establish temporary sequences of activities (Carandini, 1997; Harris, 1991; Roskams, 2003; Russell, 2000), its application into certain fields of the archeological record still represents an issue; such as the case of caves with rock art. The first problem of using stratigraphies in shelters with rock art is that in many places there are not stratified sediments to perform an excavation. In the cases that there are, and diggings are carried out, other problems arise regarding the link between findings and strata in the floor with the paintings on the walls. One way to solve these problems is the localization of small rests of pigments in the floor strata or sometimes little-painted rock fragments detached from the walls (Aschero, 1988; David et al., 1994). In these situations, mostly exceptional, the difficulty lies in recognizing what kind of paintings correspond to those pigments, in order to avoid linking together all the figures from the wall with the stratum where the rests fragments were found.

In other cases, sequences of rock paintings are built by the stylistic study of the motifs or, whenever exist, using the overlapping between figures to create stratigraphic matrixes of the painted panels (Chippindale and Tacon, 1993; Loubser, 1984; Russell, 2000). Nevertheless, in these situations, the observed historic processes of the walls are still disconnected from the rest of the activities inferred from the stratigraphic findings in the floor, what prevent a global vision of the events happened in those caves.

In this paper, we offer an alternative approach to address some of these problems that resumes, combine and complements other valuable

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methodological and technical developments done by different researchers (David et al., 1994; Russell, 2000; Steelman et al., 2002). For this matter we propose the application of three related approaches which, beyond the differences, have in common the use of stratigraphic principles: 1) stratigraphic excavation of soil sediments of a cave following Harris' (1991) guidelines; 2) micro-stratigraphic study of small samples of rock art for optic and petrography microscopy, and underlying stratum combined with chemical analysis by means of micro-Raman spectroscopy and scanning electron microscopy with elemental analysis by energy dispersive X-ray spectroscopy (SEM-EDS); 3) the confection of stratigraphic sequences of the panels with rock paintings from the studied overlays and stylistic characteristics of the paintings.

Each of these approaches has its own possibilities and limitations to achieve a comprehensive knowledge of the social practices done in the shelters with rock art. Each one has been used widely with valuable results in the study of paintings and engravings (Chippindale and Tacon, 1993; David et al., 1994; Loubser, 1984; Rogerio Candelera, 2014; Russell, 2000; Steelman et al., 2017). But, as we propose in this paper, their interconnection improves the advantages and allows us to get a global vision of the historical process (Pauketat, 2001) carried out in those places, possible to be complemented –in future studies- with the direct dating techniques applied to rock art research (Bonneau et al., 2017; McDonald et al., 2014; Russ et al., 1992; Steelman et al., 2017; Troncoso et al., 2015; Whitley, 2013). In this paper, we demonstrate an alternative methodology to integrate these different stratigraphic perspectives through the discovery of different fire's evidence. Basically, it consists in the localization of small carbonization layers in the cave's walls and sediments, resulting from fires performed within caves along history. Therefore, connecting these events, along with chemical and dating information, a high amount of new information regarding the relation of the social practices with the wall paintings can emerge.

In fact, this work take the methodology and conclusions proposed in a prior article from this group (Tascon et al., 2016), where we characterized chemically the paintings and soot layers at Oyola, and combine this valuable information with other archeological evidences such as the floor excavation, the stylistic and overlapping studies of figures and the micro-stratigraphic analyses of paintings. While in the first article we focus on the technical development of a method to distinguish, either superficial or underlying, black paints from soot deposits, in this opportunity we use this protocol to obtain complementary information to connect the history of production of the rock art panels with other activities performed in the cave at each time.

As a case of study, the methodology hereby showed was applied to one of the most important caves with rock art in the archeological site of Oyola (Cave 7), located on the hills of *El Alto-Ancasti* of the Province of Catamarca, in the northwest of Argentina. We believe, however, that results and methodological articulation we have applied may be an example for any other different shelter with rock art with similar characteristics.

2. The archeological site of Oyola

The archeological site of Oyola is located nearby the homonym community, in the east side of the *El Alto-Ancasti*'s mountain at the Catamarca province, in the northwest of Argentina (Fig. 1). First reports of this site were from some descriptions made by Amalia Gramajo and Hugo Martínez Moreno (Gramajo and Martínez Moreno, 1982, 1978), who in the second half of the past century had documented eight shelters with rock art within a batholith or circular pluton of 2,5 km of diameter. Caves and shelters are set at the base of big granite rocks immersed in a deep wood in the hill, near current Oyola town (Fig. 2, a and b).

Since 2009, our team has been conducting archeological research on this site. After several years of prospecting the area, we have documented 30 new shelters with paintings and engravings (Gheco, 2017, 2012; Gheco et al., 2013; Quesada and Gheco, 2011) which, together with the other eight described by Gramajo and Moreno, make a total of 38 caves and shelters with rock art. Despite of this fact, there may be still some more caves and shelters with rock art immerse into the deep forest.

In the Oyola's caves there are a great diversity of zoomorphic, anthropomorphous and geometrics motifs, in white, red and black color (Fig. 2, c and d). For a long time all these paintings, as well as the rock art in all the mountain, were attributed to *La Aguada* culture, according with similarities between some of the painted and engraved motifs with the characteristics designs of the pottery from that culture (De la Fuente, 1979a, 1979b; De la Fuente et al., 1983; De la Fuente and Arrigoni, 1975; De la Fuente and Díaz Romero, 1979, 1974; Gordillo et al., 2000; Gramajo, 2001; Gramajo and Martínez Moreno, 1982; Nazar et al., 2012). These social groups inhabited the *valliserrana* region of northwest Argentina in the second half of the first millennium of the Christian era (approx. 500–1100 CE). They shared diverse political, economic and ideological aspects, standing out a relatively similar iconographic repertoire embodied in ceramic objects, stone sculpture and rock art (González, 1998, 1977).

Nevertheless, from different studies we have detected some indicators that allow us to think that these caves with rock art in Oyola, far from being a homogeneous group representing a unique moment, are the result of multiples painted events in a period of time that, we suspect, may comprehend centuries before and after *La Aguada* culture. The great diversity in the styles of the paintings, the overlapping of motifs, the heterogeneous chemical composition of pigment mixtures, among others, support the definition of these shelters with rock art as the outcome of a process of adding motifs along time, transforming and giving a whole new meaning to the panels in each different period of time (Gheco et al., 2013; Quesada and Gheco, 2015).

In this paper, we will be focus on cave Oyola 7. This shelter is at the base of a large granite rock, situated in the highest place of one of the numerous hills that characterize the landscape of the zone. Its interior is 14 m long, 4 m width and 1,6 m tall, what makes it one of the biggest caves of the place. After a few years of comprehensive surveys, we have documented 75 rock art motifs in the walls and roof of the shelter, made in white, black and red colors (Gheco, 2012). The presence of a ground with stratigraphic deposited sediment that could be excavated, plus the numerous chemical and stylistic studies made on the shelter's paintings, gave us the impulse to choose this cave to develop the following study.

3. Materials and methods

The different techniques of analysis that we outline in this paper share, as the main basis, the use of stratigraphic principles. This method, initially developed in the field of geology, supposes that order in the layers (sediments, paintings or pigments strata) reflects the sequence of the events of deposition/application that created them. In this way, the older layers or strata are, generally, stratigraphically set beneath the younger ones, which allows not only to give a relative order to the strata but also to give a sequence of the activities done at this place, inferred from the findings documented in every single one.

Despite the common emphasis on the stratigraphy, each of the procedures used in this paper has very particular technical and methodological characteristics, which will be briefly described in the next subsections.

3.1. Stratigraphic digging of Oyola 7 ground

For digging Oyola cave 7 ground, we followed the archeological stratigraphic principles mentioned by Edward Harris (Harris, 1991) and the proposal of the Museum of London Archeological Services (M.O.L.A.S.) for the register and description of stratigraphic unities (Harris et al., 1993; Spence, 1994). In this digging method (Bibby, 1993; Carandini, 1997; Roskams, 2003), the fundamental unities of

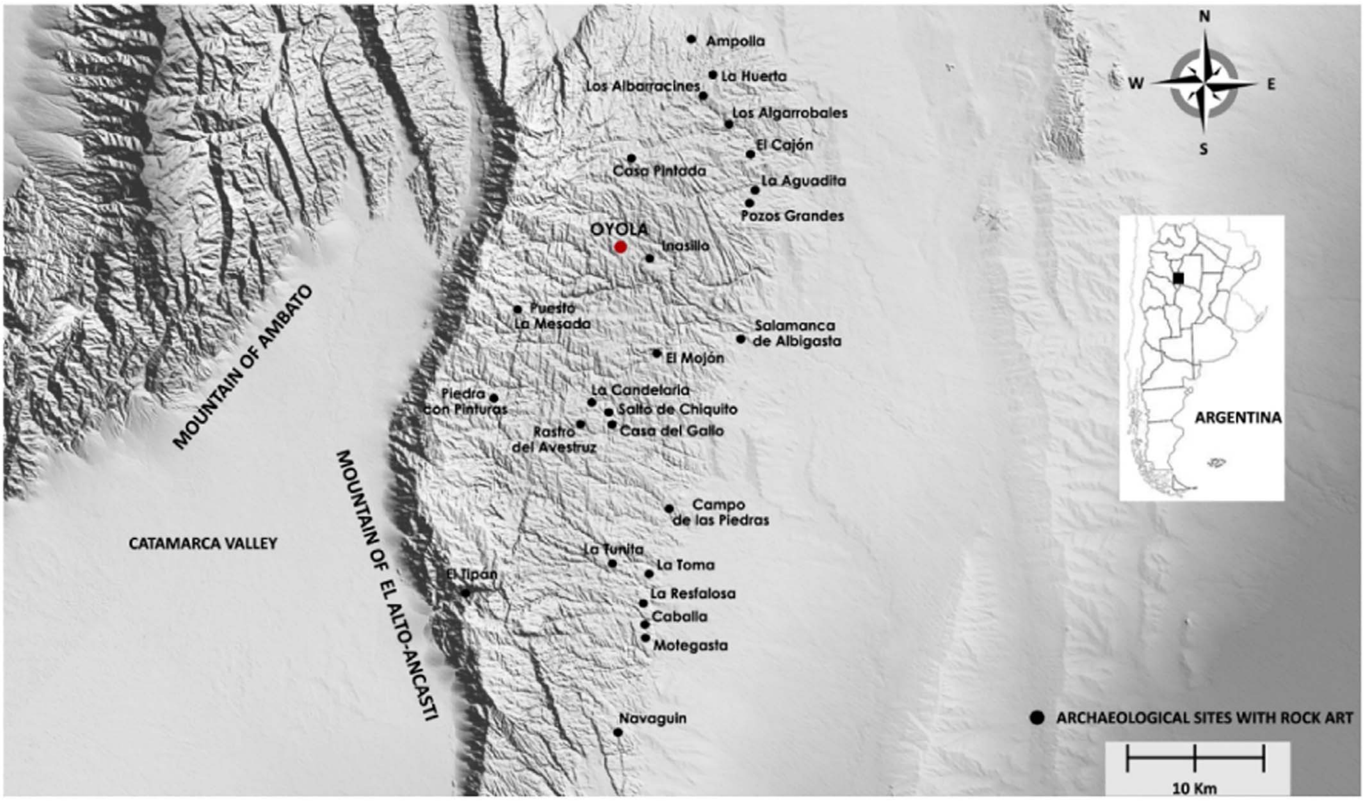

Fig. 1. Archeological sites with prehispanic rock art documented at the Mountain of El Alto-Ancasti.

analysis are the sedimentary matrixes where inclusions and/or interfacial elements produced by material extraction are found. During the excavation stratigraphic unities are recovered, and are considerate as unique events of deposition representing an action or a group of them (Carandini, 1997). According to this point of view, every single stratigraphic unit acquires meaning because of its own characteristics and also for the stratigraphic relationships with the rest of the units, at the same time the meaning of material inclusions is mostly given in relation to the matrix that contains it.

Within Oyola 7 a 35 m^2 area was excavated, which represents almost the total sediment potentially available for digging. So far, the recovered stratigraphic sequence yielded 114 stratigraphic units –SU-,

Fig. 2. Oyola's archeological site: a- outside view of Oyola 7. b- Inside Oyola 7. c and d- Examples of prehispanic rock art at Oyola 7. (For interpretation of the references to color in this figure, the reader is referred to the web version of this article.)

which were sequenced in a partial matrix of Harris that, from future diggings, will be modified according to new findings.[1]

3.2. Micro stratigraphies of rock paintings and supports

An important part of the process of the micro-stratigraphic analysis is the sampling method, in which the process may have several considerations, mostly related to the compromise between the representativity of the samples and the paintings conservation. In this particular case, samples of rock art were taken according to conservation criteria and, at the same time, seeking the most representative results; meanwhile, in the areas where there were not motifs, a systematic representative sampling was carried out, according to the analytical standards of sampling (Miller and Miller, 2010).

Forty-three samples were taken from paintings and rock support of Oyola 7, according to previously completed protocols, using a scalpel and binocular lenses (OptiVISOR, Donegan Optical Company, U.S.A.) for deeper precision. The samples, smaller than 1 mm^2, were stored in 1.5 mL capacity Eppendorfs. Later, they were processed according to the procedure described by Marte et al. (Marte et al., 2014). Every sample was included in acrylic resin (Subiton®), thus, its transversal section is shown perpendicular to the field of view, to be polished afterwards with sandpaper of different granulometry. Observation and photography of the samples were achieved using a DM EP Leica microscope (visible and ultraviolet light sources were used in normal and polarized modes), images were recorded using a Leica DFC280 digital camera and processed with Leica Application Suit 4.0 software in order to document general and particular aspects of the stratigraphies. Then, samples were analyzed by micro-Raman spectroscopy using a Lab RAM HR UV–Vis-NIR (Horiba Jobin Yvon) spectrograph equipped with two monochromator gratings and a charge coupled device detector. A grating of 1800 g/mm and a hole of 100 mm resulted in spectral resolution of 1.5 cm^{-1}. The spectrograph was coupled to a microscope with 10 ×, 50 ×, and 100 × magnifications. Laser line at 514 nm (Ar^+ laser) was used as the excitation source and filtered to ensure power density was low enough to avoid sample overheating. Typically, for a 50 × magnification spot diameter was about 2–3 μm. Elemental composition analyses were carried using a SEM-EDS FEI QUANTA 200 (FEI, Oregon, USA). A BDS detector was employed for elemental imaging, an accelerating voltage of 20 kV and a current of 1.1 nA at a working distance of 10 mm were used. Samples were metalized with gold.

3.3. Stratigraphy of rock paintings of a panel from Oyola 7

Since some decades ago, the stratigraphic principles defined by E. Harris were applied to rock art studies, aiming to build relative sequences of the painting of panels in different archeological sites (Chippindale and Tacon, 1993; Loubser, 1984; Rogerio Candelera, 2014; Russell, 2012, 2000). Most of these papers were based on the study of overlays between paintings as the main tool to sequence the motifs. However, scarcity of overlays in the Oyola caves compels us to add new lines of evidence to build the matrixes.

In this paper several analytical techniques were used in a complementary way, with the aim to build the stratigraphic matrix of the painting events that had originated a single panel at Oyola 7. Those were: the overlays study, the outcomes of the chemical analysis from pigments mixtures, the stylistic studies of the paintings and the detection and confirmation of carbonization layers observed *in situ* in the cave and, then, founded in the micro-stratigraphies analyzed.

[1] The excavation of Oyola 7 has not yet been completed.

4. Results and discussions

4.1. A stratigraphy of Oyola 7 grounds

As an outcome of the excavations on Oyola 7 were detected eleven combustion events, twenty six vertical interfacial elements (holes) with its respective filling, thirty seven horizontal strata, eleven of them are made of ashes deposits. Each stratigraphic unit has been interconnected in the matrix expose in Fig. 3. In the interior of these strata were located and documented in 3D several fragments of lithic material in quartz-cores, flakes, some sharp instruments and even small projectile points, animal bones some of them calcined- and not decorated pottery sherds. These materials are in process of analysis, but the preliminary studies allow us to interpret the history of Oyola 7 as the result of several moments of intensive occupation of the cave interrupted by episodes of lower activity in the shelter. These differences of more intense and less stratigraphic activity define, at least, five stratigraphic cycles (Carandini, 1997), where the materials detected point to recurrent and temporally short practices done in each cycle, as the last steps of the manufacture of lithic instruments, the use of small pottery vessels exposed to fire, the burn of fractured camelid's bones and, specially important for this article, the lit of little hearths near the rocky walls of the cave (Figs. 4 and 5).

In the lower part of the walls of the cave, we observe intense black stains that, before beginning the excavation, a patina product of granite rock deterioration have been considered. Afterward, we have excavated the area and could observe the relationship between the hearths and the blackened area of the nearest walls, that is why we began to suspect that it could be soot because of the combustion of hearths. As an example, we could describe one of the cases that made possible the connection between the painted motifs in walls of Oyola 7 with the hearths documented on the ground. In the northwest side of the cave, near to one of the entries, rests of an ancient hearth were excavated (SU 60 = SU 46) just below the rock paintings of Panel A (Figs. 6 and 7). As Susan Mentzer (Mentzer, 2012) point out, we could define a hearth by the discovery of burned sediments with ashes and carbon in a tripartite sequence that usually presents, from bottom to top in stratigraphic terms: 1- Substratum with thermal alteration. 2- Ashes. 3- Carbon. This is the case of SU 60 = SU 46, so we interpret it as a hearth. These stratigraphic unities were excavated under the SU 3 and 24 and have been deposited above SU 63 (Fig. 6). We found the basin of the hearth, SU 149, composed by burned sediments, with 10 cm depth and 50 cm of maximum diameter. Filling the basis we discovered many fragments of carbon and ashes. Around it were founded three holes (SU 49, 50 and 65) that, because of their shape, might be the marks left by the stones that, probably, were the limit of the hearth. The basin has been excavated near the rocky wall of the cave, just below the Panel A of rock art. In this sector of the cave, the roof is low, 1, 6 m. height.

According to the findings of the aforementioned strata, is possible to think that at certain point of the cave's history, a fire was lighted and this place was used as a hearth for an indeterminate time yet. The combustion covered the nearby wall and part of the roof with soot, staining, in this way, all the surface of a black color (Fig. 8). Later, that hearth was deactivated and the stones that delimited the hearth were removed.

4.2. A micro stratigraphy of the paintings

One of the problems to face in this paper was to establish a criterium to differentiate black paint layers from carbonization vestiges of former hearths. Based on previous works of our group, it was probed a method to distinguish the nature of the black layers (Tascon et al., 2016). For that, cross-sections from rock art samples were morphological compared with correspondent samples from areas of the wall without paintings but with evident signs of soot. Fig. 9a exhibits different stratigraphies of the soot layers deposited in the walls of Oyola 7. These

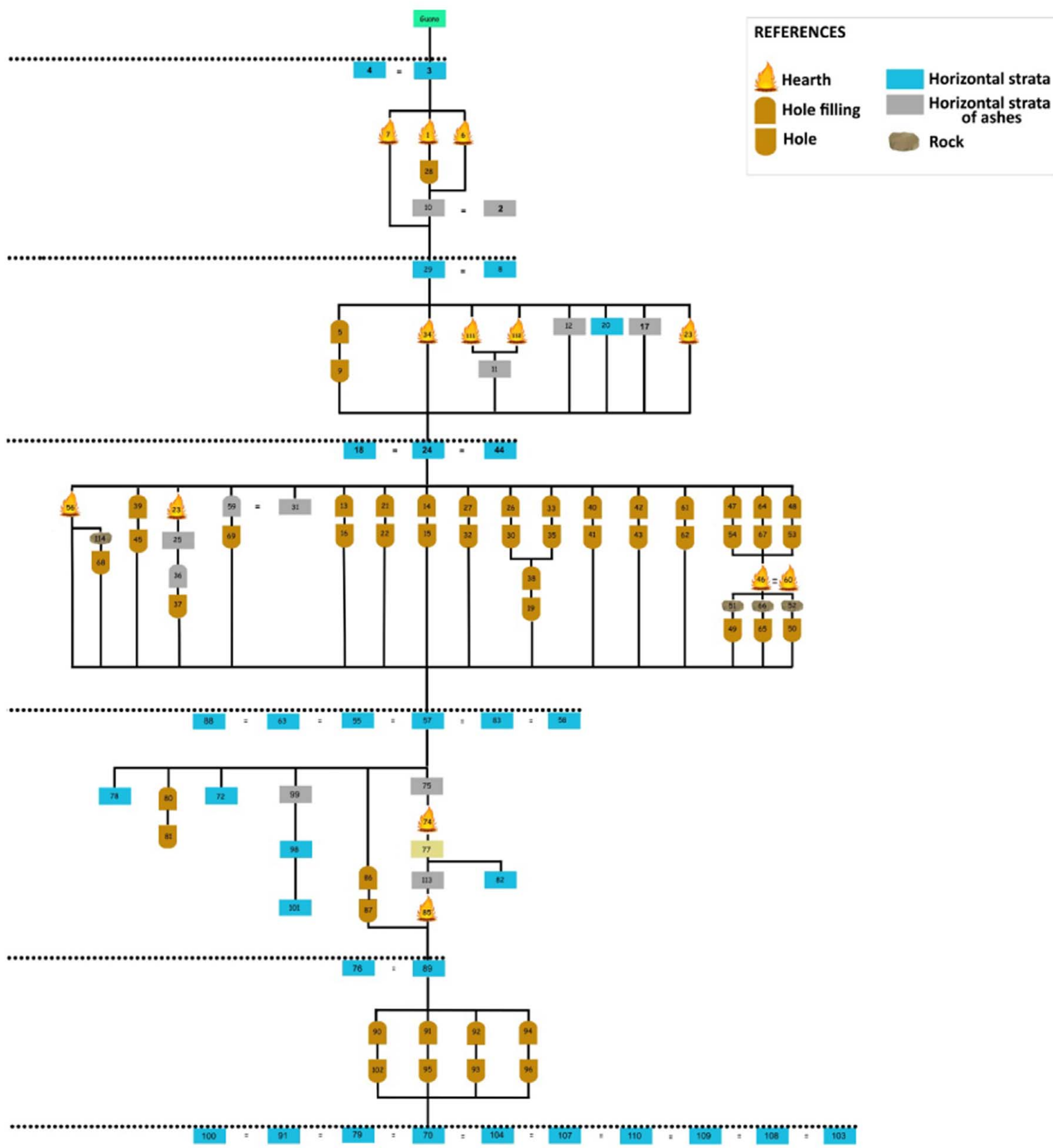

Fig. 3. Stratigraphic matrix of Oyola 7.

images allow us to see several black layers that have continuity and a homogenous undulating form. It is possible to see that the black layers are very thin and have similar layers underlying and overlapping. The Fig. 9b shows photos of the micro-stratigrapy of black paintings that could be compared and distinguished from the soot layers. The difference could be observed by the thicker black strata and the larger size and irregular shape of the particles. The average thickness of soot layers is about 8 μm while black strata thickness is around 27 μm. Several samples of both, soot layers and black strata, were measured and an average of ten measurements were taken from each layer and stratum using Leica Application Suit software. These morphologic differences between layers of soot and black paints only could be achieved by the microscopic view of the sample's stratigraphies, possible to be combined with spectroscopic analysis to obtain the chemical composition of each layer. For this, the different layers that compose each sample were systematically analyzed with Raman microscopy.

In Figs. 10 and 11 are shown the outcomes of the analysis made by micro-Raman spectroscopy of one sample taken of the blackened zone of Panel A (also see Fig. 8, sample 1, 329-7-1) and one sample of a black painting at Oyola 7 (329-7-11). Using this technique it was possible to observe, in the soot sample, that those layers in which it supposed to be carbonization depositions, the spectra collected in that area show as main component amorphous carbon (Fig. 10). This can be noticed because of its two characteristics bands, one corresponding to the crystalline graphite, which is located near to the 1580 cm^{-1} and, on the other hand, the band which corresponds to the disordered structure of carbon or glassy carbon, which is located in a 1350 cm^{-1} bleed approximately (Beyssac et al., 2003; Potgieter-Vermaak et al., 2011). Besides, in the area between the two layers of carbon of the soot sample, it is possible to notice the presence of whewellite, which characteristics Raman shifts are 1464, 1491, 1631 and 896 cm^{-1} respectively. This crystalline form of the calcium oxalate is, normally, a result of the biodegradation by lichens (Edwards et al., 1997; Lofrumento et al., 2012; Ruiz et al., 2012; Russ et al., 1999; Watchman, 1993, 1991). It may indicate that layers enclosed by carbon strata could be formed along the time elapsed between different hearths, due to the

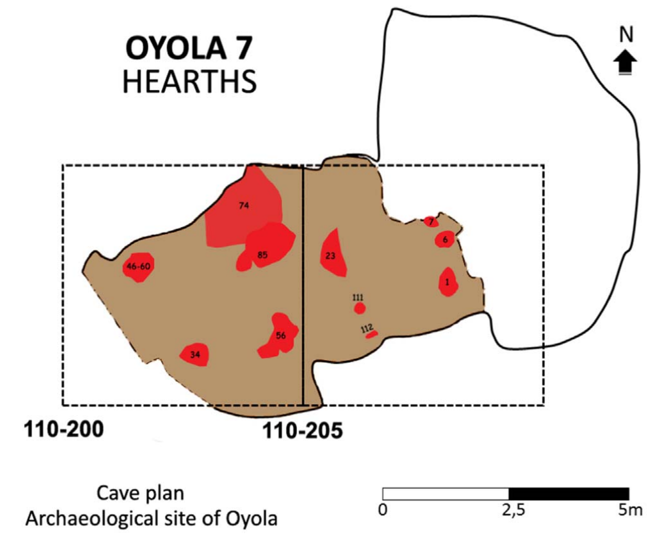

Fig. 4. Oyola 7 plant with hearth location. Note that this plant exhibits simultaneously all the hearths discovered in the excavation at different levels.

gypsum at 619 and 1007 cm^{-1} (Edwards et al., 2000), perhaps as a charge to improves the adhesion and preservation properties of the mixture (Fig. 11). The absence of gypsum at the possible soot layer (Fig. 10) supports the idea of the distinction between the black painting mixtures from the carbonization layers of the hearth combustion.

To reinforce results from Raman spectroscopy, samples were analyzed by SEM. In Fig. 12a) is shown a micrograph taken with optical microscopy of the soot sample 329-7-1, as a reference, while in Fig. 12b) is shown an image of the same sample, taken by SEM using backscatter electron detection (BSD). In a gray scale, the brighter parts are detected as zones with elevated atomic numbers, or heavy, elements while darker zones indicate areas with very low atomic number, or light, elements. In this particular case, the areas matching what in the optical image was presumed as carbonization deposit are black, characterized later on with Raman spectroscopy. That indicates clearly the presence of organic layers. Additionally, this is better shown in the mappings made by SEM-EDS for different elements (Fig. 12c). The particular case of Carbon is matching in space with the zones attributed to carbon by Raman spectroscopy and by the photograph taken with BSD detection. The rest of the elements such as Al, S, Ca, O and Si were practically non-specifically localized in all samples. Regarding S and Ca

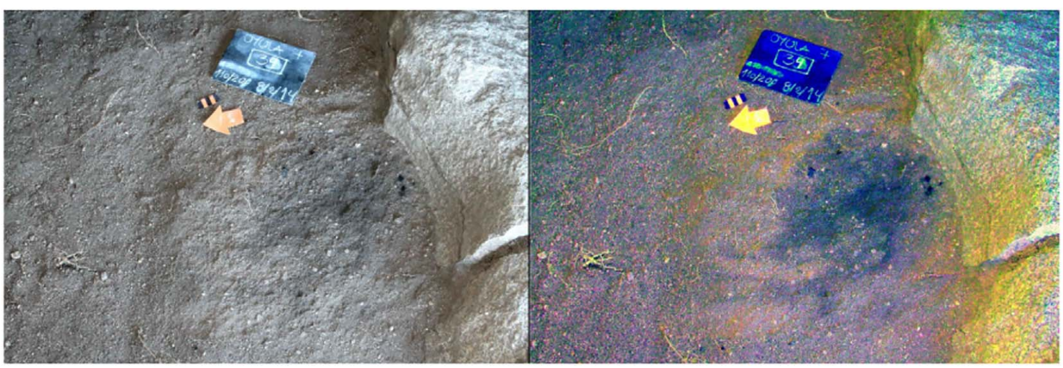

Fig. 5. One of the hearths discovered at Oyola 7 (SU 34). The right image has been processed with D-Stretch software (Harman, 2008) to highlight the blacked zone corresponding to the carbon relicts.

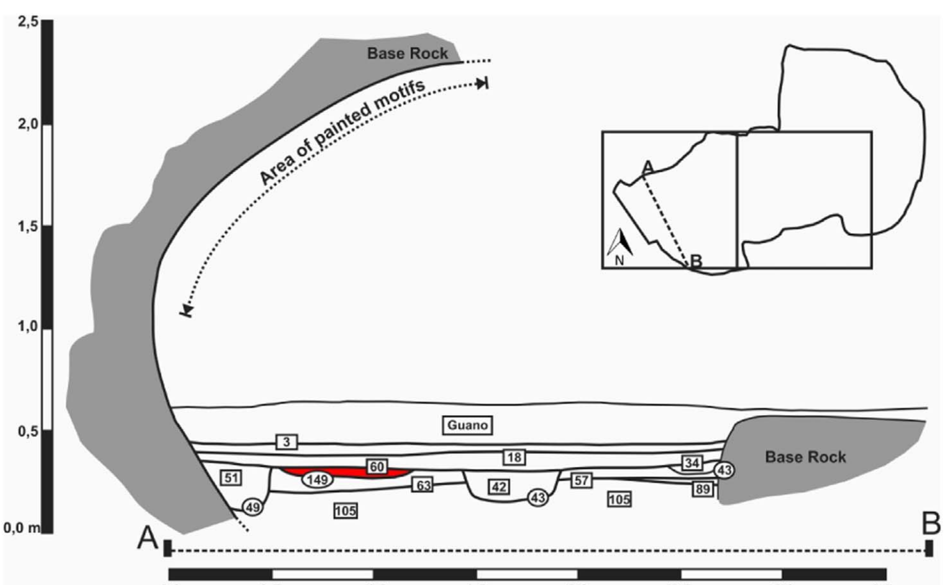

Fig. 6. Section of the stratigraphy of Oyola 7 at the zone where the hearth has been discovered.

action of these organisms and not because of superposition of different paintings.

In addition to the carbon bands corresponding to the pigment, the analysis done at the black painting sample show the bands of the pictures, are probably due to the presence of gypsum, this was confirmed later by micro-Raman spectroscopy.

In sum, the morphological differences detected between the soot layers and the black paintings, plus the results of the chemical analyses

Fig. 7. Excavation of the hearth SU 60 = 46. The images were processed to highlight the ashes. Note the holes of the rocks around the fire and the proximity with the wall.

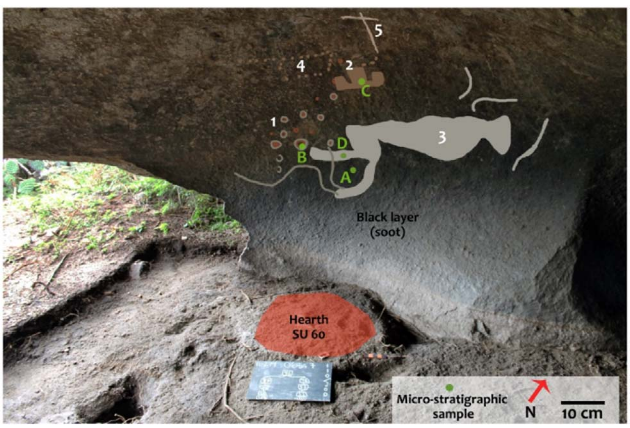

Fig. 8. Panel A of Oyola 7. Note the proximity between the hearth SU 60 excavated in the ground and the black layer in the wall. The green points exhibit the location of the micro-samples taken. The rock paintings were digitally traced. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

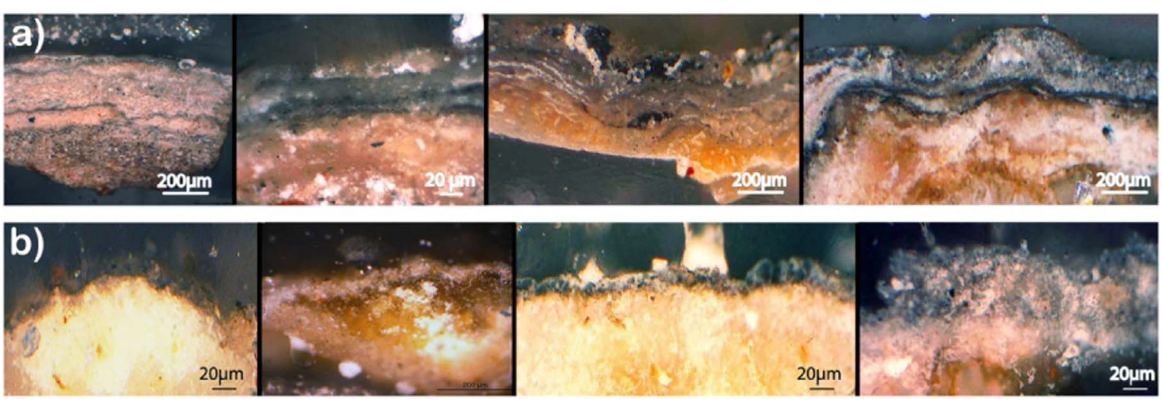

Fig. 9. Micro-stratigraphic photos of: a) possible soot layers and b) black paintings.

by Raman and SEM-EDS and the proximity of the hearth SU 60 discovered in the excavation just below the blacked wall, allow us to support the interpretation of this black deposit as the carbonization vestige resulted from the fire event. Although other hypothesis of the origin of the black layers at the rock walls must be explored in future works in order to discard other possible causes (Steelman et al., 2002).

The same methodology was applied to study the rest of the samples taken from the rock art motifs and the rock where they were painted (Fig. 8). In Fig. 13 are shown some of the processed samples, where several carbonization layers were identified by micro stratigraphies.

Panel A, shown in Fig. 8, corresponds to the area of the wall of Oyola 7 nearest to the place where the described hearth was excavated. This panel presents different kind of motifs with several overlapping. As could be seen in Fig. 8, at this panel we took three samples of the paintings (sample 2, 3 and 4) and one from the blacked area of the wall without paint (sample 1). Taking into account the study of the samples, we were able to find other superpositions in a micro-stratigraphic level. In the first place, besides pictorial layers, we can observe the presence of some translucent layers and others grayish. Second, and more important yet, we can observe that in all the micro stratigraphies of this panel (Fig. 13) the soot layer is stratigraphically disposed under rock art layers, which locates it in an older time regarding the paintings. In this way, it is possible to establish a relative chronology sequence among rock motifs of this panel and the hearth event that generated the deposition of carbon layer (hearth).

4.3. A stratigraphy from the painted panels

This mentioned panel has five rock art motifs; some of them are in a real deterioration state (Fig. 14). However it is possible to distinguish some characteristics that allow interpreting the Motif #1 as a jaguar figure from the concentric circles in white and red that refers to the stains of such feline. Other figure, painted in light color, present a geometric form that has been designed as V.R.U.B. –Vertical Rectangles United by the Base- (Motif #2) and it is seems to be associated with an aligned dots (Motif #4) of the same color. The Motif #5, unlike the other figures of the panel, has been done by engraving and it is possible to be linked with the Christian crosses painted in many places with pre-Hispanic rock art, during the processes of idolatries extirpation developed by the Spanish invaders. Finally, the deterioration of the Motif #3, in white color, inhibit any kind of interpretation.

As we described in the previous section, some of the paintings have been sampled and analyzed chemically. Particularly, this sector concentrates mostly of the overlapping events of this cave, some of them barely recognizable. In order to get closer to the history of this panel painting process, we have to emphasize some important issues. First of all, is possible to observe that the jaguar figure (Motif #1) is located above –in a stratigraphic sense- Motif #3. At the same time, the

Fig. 10. Raman analysis of a soot layer 329-7-1 of Oyola 7.

geometric motif that we have assigned as V.R.U.B. (Motif #2) seems to overlap the jaguar. This situation, very difficult to observe even with advanced photographic techniques, has a solid base on the stylistic studies developed in Oyola, which link these geometric figures to the latest moments in the history of the painting process (after 1000 A.C.). On the other hand, the figure of the jaguar is associated with the characteristic iconography of the region during the second half of the first millennium A.C., which is linked with the above mentioned La Aguada culture (González, 1998). In other sites nearby Oyola, some of the V.R.U.B. figures are related to horses and horsemen, characteristic of the Colonial period, what reinforces, even more, its recent chronology (Nazar et al., 2013). On the other side, the group of aligned dots (Motif #4) presents a very similar chromatic tone to a V.R.U.B. (Motif #2), for what we suppose they might be the outcome of the same painting event and, because of that, contemporaneous. At last, the Christian cross (Motif #5) made by engraving the patina surface of the rock could be considerate as the last event of the sequence, after the arrival of the Spanish. Fig. 15 exhibits the stratigraphic sequence that result of all mentioned relationships of stylistic and overlapping studies.

5. Conclusions: A layer (of charcoal) to connect three stratigraphies

All the described approximations above mentioned represents a stratigraphic perspective about the history of a cave with rock art. Every single one allows expressing in a graphic matrix the temporary relations among different anthropic and natural events. Nevertheless, the analytical possibilities increase if we can connect them, in an attempt to associate certain episodes of the stratigraphic history of the ground's cave with what happened at the same moment on those walls. But, as Thembi Russell (Russell, 2000) expressed, there are major difficulties to associate the rock paintings with the shelter history and, mostly, all of the motifs are consider in a whole, in a homogeneous way.

As we previously suggest, one of the more striking characteristics resulting from Oyola 7 stratigraphic excavation is the localization of small combustion events in places near the walls. These fires, developed in different moments of the cave's history, had produced soot rests that got attached to the rocky friezes and can be detected as layers of charcoal in the micro stratigraphies of the small samples taken from the painted walls. In certain occasions, as in Panel A, those layers are under or above, in a stratigraphic sense, paintings and, because of that, is possible to know the relative temporal sequence that links the soot

Fig. 11. Raman analysis of the black painting 329-7-11 of Oyola 7.

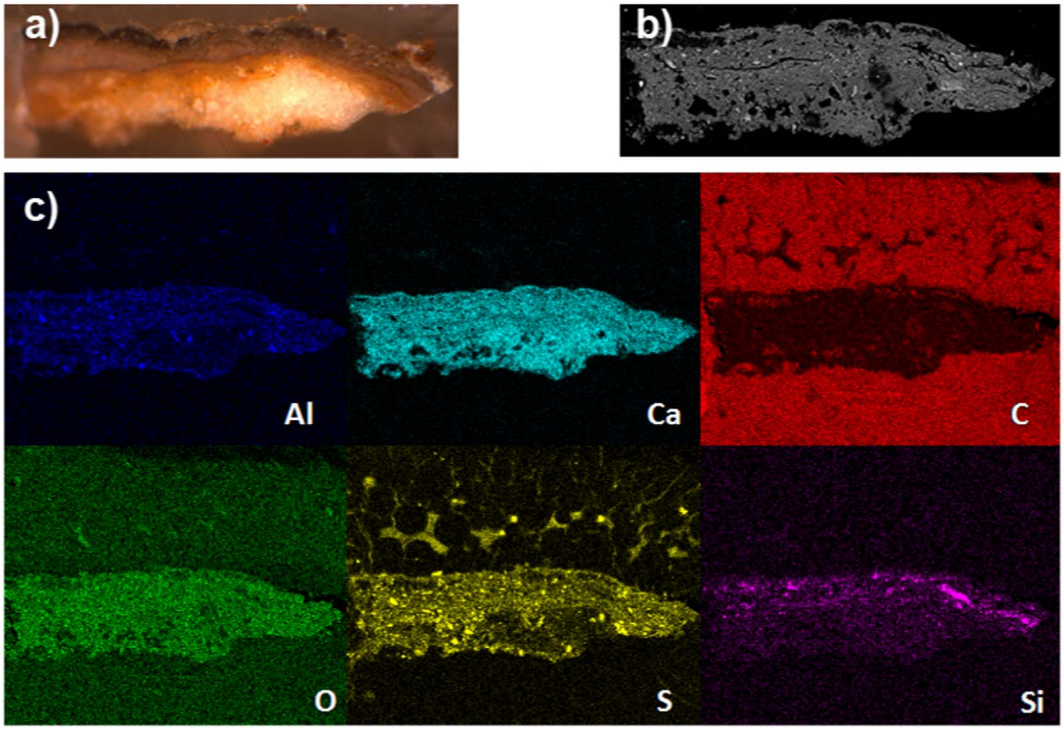

Fig. 12. a) Micrograph of cross section of sample 1 from Panel A with a magnification of 200 x.; b) Picture taken with a SEM-BSD; c) analysis of the cross section with SEM-EDS.

layers with the sampled rock motifs. Later, this sequence may be connected with the Harris matrix of rock art of painted panels and so incorporate other figures that were linked with the superposition study, stylistic-morphologic study and chemical analysis. In this way, the suggested stratigraphic sequences for the ground where we detected the hearth (SU 60), the painted panels and the micro samples of the walls and paintings may be linked using the layers of carbonization as a conducive thread.

Fig. 16 exhibits, as an example, the interconnection stablished between the different matrixes developed along this paper for the Panel A of Oyola 7: the floor stratigraphy, the wall stratigraphy and the micro-stratigraphies of the samples analyzed. In the first one, at the left of the Fig. 16, we could see the matrix that link in a temporal order the strata excavated just under the Panel A, specifically the hearth SU 60 performed in this place. In the middle section of the Fig. 16, we describe the matrix sequence of production of the Panel's A paintings from the stylistic and overlapping data. Finally, at the right section of Fig. 16, we exhibit that, from the micro-stratigraphic view of the samples, the first painting done at this panel (Motif #3) is situated above, in a stratigraphic sense, the soot layer. In this way, the carbonization deposit resulting from the hearth SU 60 allow as to interconnect the three approaches described.

These relations allow us to obtain a bigger picture of the history of that painted cave that goes further the approaches focused only on rock art, and integrate it into a framework of relations with other social

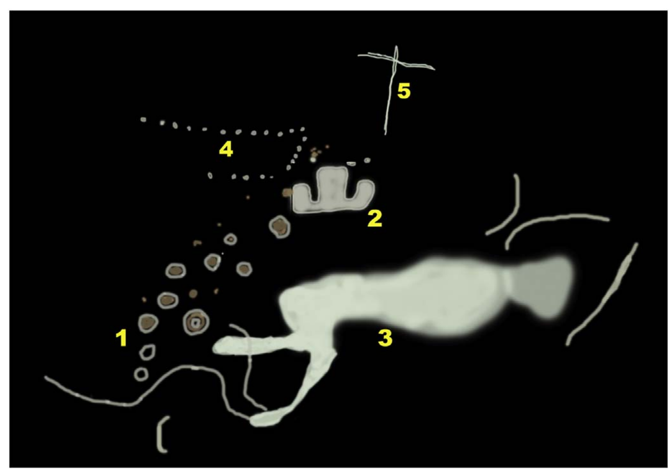

Fig. 14. Panel A of Oyola 7. The paintings have been digitally traced. (For interpretation of the references to color in this figure, the reader is referred to the web version of this article.)

practices. Even if the image is, without a doubt, still a simplification of the activities developed within those spaces, is possible to recover some of the clues on how those practices could have been along the history, from the study of the materials found in the digging and its relation

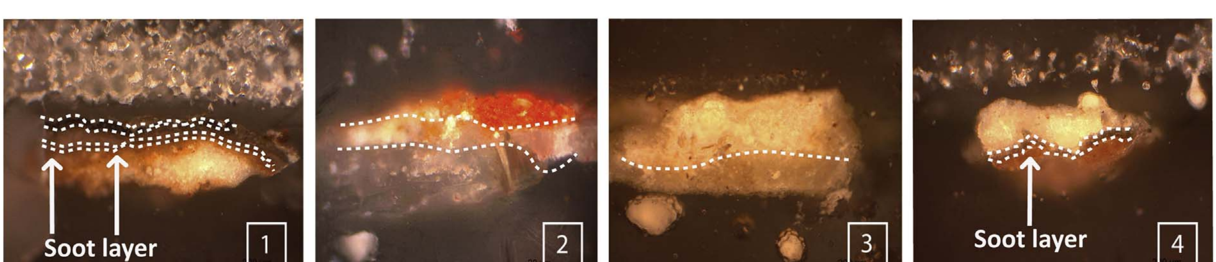

Fig. 13. Micro-photographs of the rock art's samples of Panel A of Oyola 7. Note the soot layers indicated with doted lines.

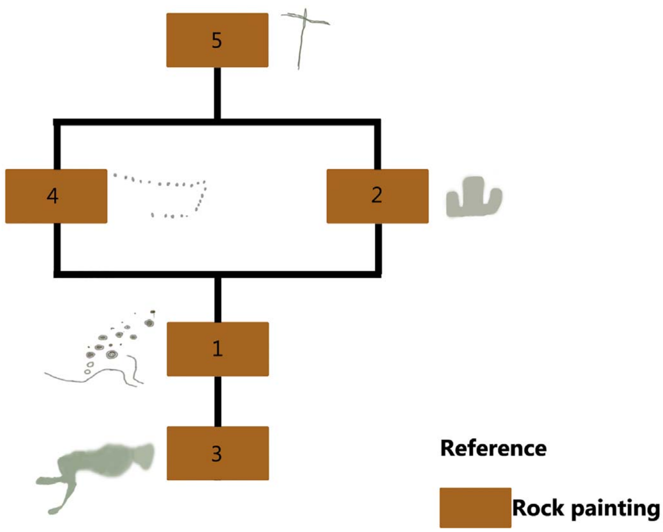

Fig. 15. Harris matrix of the panel A of Oyola 7.

with every single wall painting event.

To this matter, the localization of carbonization layers in the wall stratigraphy is a very useful resource. The soot and its relation with the combustion events found in the excavation and set in the matrix of the floor, allow us to know that the rock art motifs of the panel studied were made after the fire event (SU 60). Even though we do not have absolute data of this hearth, a radiocarbon dated from an older layer –SU 63- locates all this group of activities in a moment after 1260- + 90 AP (740 A.C.). In this way, the possibility of having a relatively reliable connection between the stratigraphies of the wall and the ground by the soot layers, allow us giving a preliminary chronology to the group of rock paintings of this panel. This chronology may be confirmed in future works by direct dating of the paints using the techniques currently in use to date rock art (Bednarik, 2002; Bonneau et al., 2017, 2011; McDonald et al., 2014; Russ et al., 1992; Steelman et al., 2017; Troncoso et al., 2015; Whitley, 2013).

Nevertheless, this method of connection has its limits. The sedimentary deposits excavation resolution doesn't allow documenting the whole hearths that took place in the cave. Different taphonomic processes influence in this sense, because of with this technique we only get access to a minimum number of combustion events. The study of other micro stratigraphies of the wall of this cave, where are observed four and even five overlapped soot layers, allows us suspecting that the number of hearths were bigger than the number detected with the digging.

Despite these limits, we believe that the described method may become a very useful tool to connect the historical processes registered in the walls, ground stratigraphies and micro samples. In this way, the

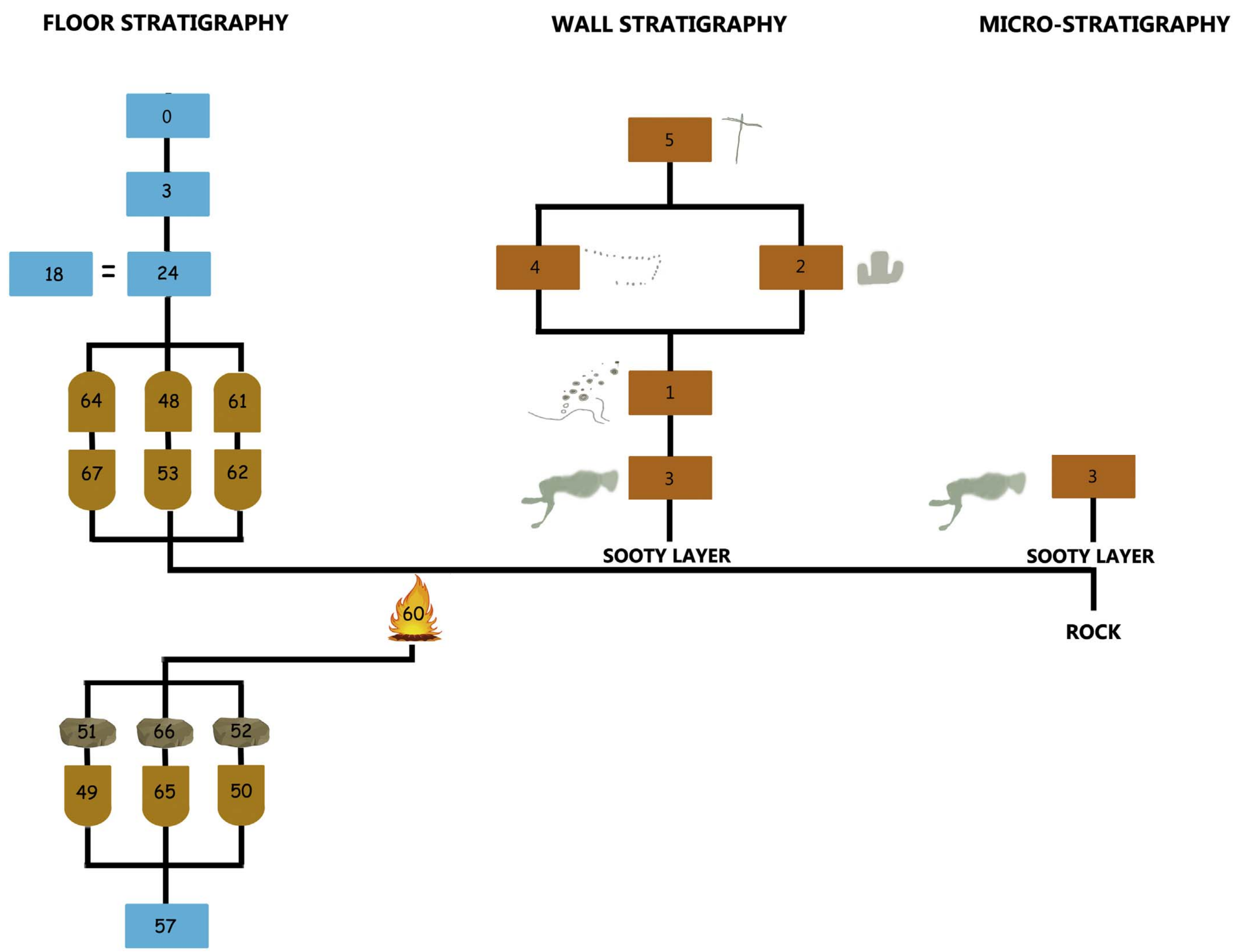

Fig. 16. Connection between matrixes of the floor stratigraphy of Oyola 7, the rock art stratigraphy of Panel A and the micro-stratigraphies taken from the paintings and blacked zones. The soot layer corresponding to hearth SU 60 and deposited before the rock paintings allow us to link the matrixes.

soot layers gain an important role, which multiplies the possibilities of knowledge that other techniques of analysis, traditionally explored in rock art sites in a disconnected way, give.

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