KEYWORDS: *Rock painting – Pigment – Spectrometric analysis – Stylistic analysis – Peru*

ROCK PAINTING WITHIN SOUTHERN PERU IN THE CONTEXT OF PHYSICOCHEMICAL ANALYSIS OF PIGMENTS

Józef Szykulski, Beata Miazga and Jakub Wanot

Abstract. The article pertains to rock paintings recorded during studies conducted in 2017 and 2019 by an international archaeological expedition at numerous sheltered sites in the Río Atico basin and Vilavilani region in the Río Caplina catchment area within southern Peru. During the research, archaeological sites with rock art were registered, the state of preservation of the paintings was documented, and it was determined what factors were causing their destruction/degradation. The form and thematic scope of the paintings were also determined while defining four styles/stylistic conventions (styles 1–4) of the rock painting in the area in question. New arrangements regarding the superposition of representations/paintings made it possible to define the time sequence of their creation (relative chronology). Multifaceted physicochemical analyses of colouring substances were also carried out, which allowed determining their chemical composition. The mineral origin of all colouring substances has been confirmed, i.e. they should be described as inorganic pigments. At the same time, conclusions regarding the source of origin of the raw material used for their acquisition were presented. During the research, changes in the colours of individual paintings were observed, which provides the basis for conclusions regarding the chemical processes that caused them.

Introduction

Southern Peru, *Extremo Sur/Costa Extremo Sur*, is a vast geo-cultural area covering the departments of Arequipa, Moquegua and Tacna, as well as the northern part of Chile, extending to the Camarones valley located south of Arica (Szykulski 2010a, 2010b). Its topography is characterised by a relatively narrow and arid Pacific coast, enclosed by a belt of hills and plateaus forming the Andean foothills known as the *Cordillera de la Costa*, located to the west of the Andes massif (Szykulski et al. 2016: 11–13).

The area is home to numerous rock paintings. Most of them are found on the walls of caves and rockshelters, located in the valleys of rivers and streams cutting through the western slopes of the Andes and the *Cordillera de la Costa*. The most frequently mentioned are paintings from Pintasayoc and Sumbay caves in the Arequipa Department as well as the Toquepala 1 caves in the Moquegua Department (Muelle 1969, 1970; Ravines 1972; Linares Málaga 1973, 2004; Lumbreras 1977; Neira Avendaño 1990; Hostnig 2008, 2009; Szykulski 2010b; Szykulski et al. 2014; Bewziuk 2018). On the other hand, only perfunctory (random and incomplete) information is available about paintings from other sites, based on photographs of varied (mostly poor) quality or imprecise sketches obtained by the researchers from the residents of the region or tourists (Linares Málaga 1973, 2004; Strecker 2012).

Chronologically, most of the cave paintings from southern Peru are attributed to the hunter-gatherers of the Archaic Period (c. 9000–3700 BP). With reference to southern Peru and northernmost Chile, it is assumed that hunter-gatherer communities, and the economic and settlement model they represented, survived until about 1500 BP. At the same time, two stages of cave painting development for the Archaic Period should be distinguished, which can be described as naturalistic and schematic. It is assumed that naturalistic representations appeared earlier than schematic depictions (Hostnig 2008: 231, 234; Szykulski 2010a: 91; Sepúlveda et al. 2017). However, painted images related to the pre-Columbian communities of the ceramic period (the so-called agro-ceramic communities) or the beginning of the colonial period are relatively rare (Diaz Rodriguez and Rosińska 2008; Sepúlveda et al. 2017).

Regarding the paintings created by the hunter-gatherer communities of the Archaic Period, it should be stated that they mainly concern the subject of hunting. The central and leading motifs are naturalistic images of animals, shown in motion or a static position, with visible anatomical features that allow the identification of specific species. Due to

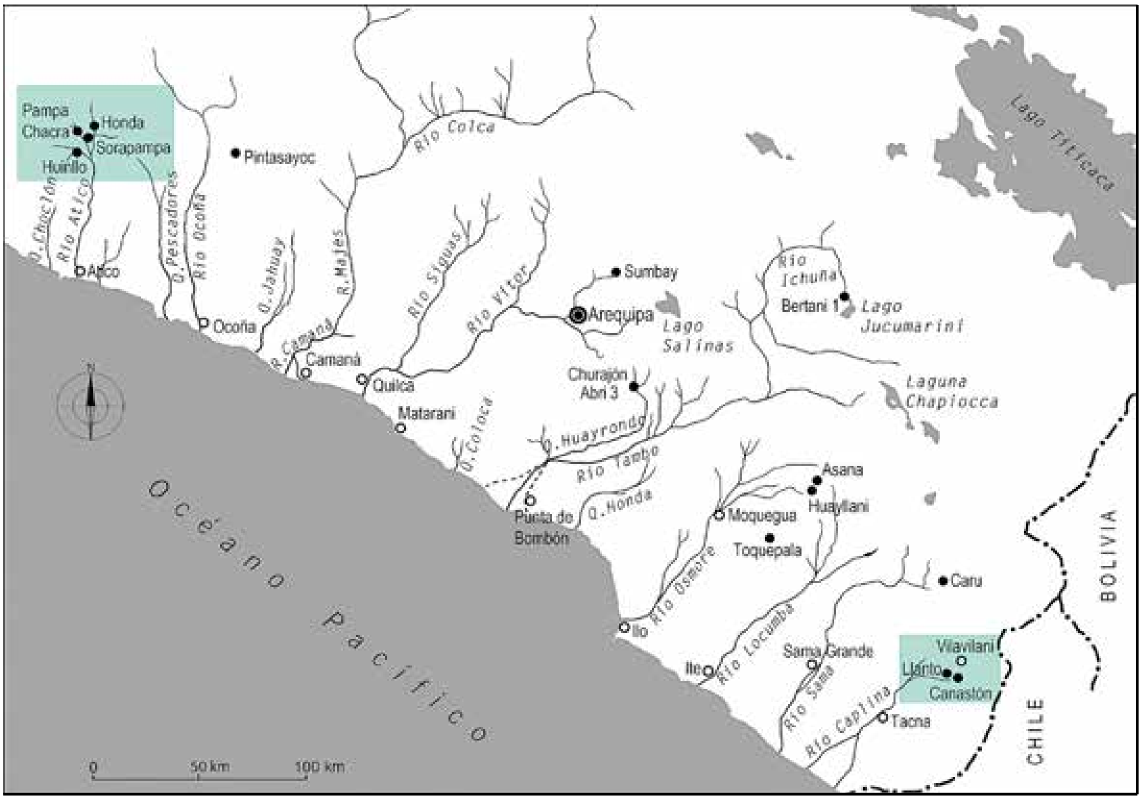


Figure 1. *Southern Peru; location of the research areas mentioned in the text within the Caplina and Atico River basins (elaborated by N. Lenkow).*

their distinctive anatomical characteristics, most of them are defined by researchers as camelids (Neira Avendaño 1990: 17; Guffroy 1999; Cardona Rosas 2002; Linares Málaga 2004; Jakubicka and Wołoszyn 2005: 95; Szykulski et al. 2014, 2016; Bewziuk 2018). Much less common are presumed depictions of other animals, such as the deer, fox, peccary, lesser rhea or large cat species.

This group of camelid representations includes, among others, similar in terms of technique and style, 'naturalistic' paintings from the Pintasayoc and Sumbay caves in the Arequipa Department and the Toquepala 1 cave in the Tacna Department as well as most of the paintings from the catchment areas of Caplina and Atico Rivers (Muelle 1969, 1970; Ravines 1972: 135–139; Neira Avendaño 1990: 17; Guffroy 1999: 26–43; Jakubicka and Wołoszyn 2006: 95; Szykulski 2010b: 165, 166).

It should be emphasised that most of the works on rock art from southern Peru lack a deeper analysis of their form, themes and colours as well as their differentiation in terms of time and space. There are also no findings regarding the colouring substances used. In this context, the multifaceted work carried out by Rainer Hostnig in many locations of southern Peru is a significant exception (Hostnig 2008, 2009; Szykulski 2010a: 91; Strecker 2012: 357).

Therefore, the results of studies conducted by the Polish-Peruvian expedition at cave sites in the Andean valleys of the Tacna Department (Caplina River basin) and in the valleys of the Atico River basin within the central part of Arequipa Department can be considered as a source of essential information (Fig. 1).

Description of the sites

Rock paintings from the Caplina River basin

In this area, a concentration of cave painting sites occurs near the village of Vilavilani, situated within the Palca District in the Tacna Province. Some of them were recorded at the beginning of this century, during the implementation of the Qhapaq Ñan research project. They are located in the valleys of the Vilavilani, Canastón, Llanto, Macle, Corral and Honda streams, belonging to the catchment area of the Caplina River, where over 20 sites have been discovered (Ayca Gallegos 2004). Paintings from 13 sites in the Canastón and Llanto valleys were documented and analysed (Fig. 2).

The analysis of the geological structure of the region shows that the profiles of both valleys are formed by the layers of dacitic and rhyolitic tufa belonging to the Pliocene Huaylillas Formation. They rest on the Miocene Moquegua Formation, comprised of layers of conglomerates, sandstones, tuffaceous sandstones and clay levels. Below is an earlier Huilacollo Formation (Flores et al. 2004; Alván et al. 2020). Cave sites with paintings are found within Huaylillas stratification layers, sometimes reaching the boundary of the Moquegua Formation layers. The analysis of rock samples forming rockshelters and caves with paintings indicates that they are built of igneous volcanic rocks, commonly referred to as porphyry. These are rhyolite tuffites or acidic igneous rocks (rhyolite-tra-

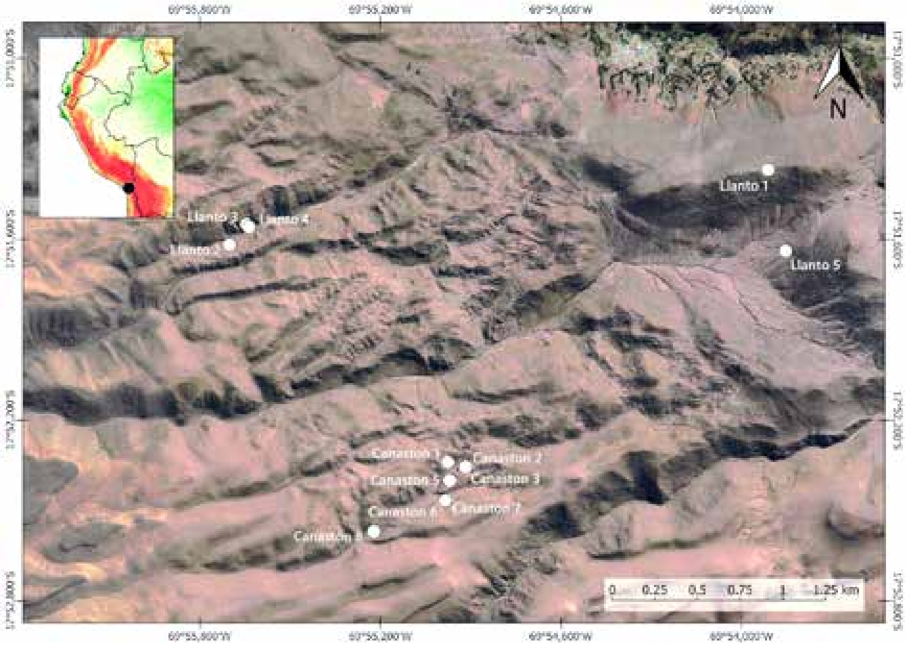


Figure 2. Southern Peru, upper part of the Caplina River basin; location of the sites mentioned in the text. Based on Google Earth Pro and Carta Geográfica Nacional, 36-x Palca (elaborated by M. Furmanek).

chyte) with traces of metallic mineralisation. Thus, their main ingredient is silica (SiO_2), so the cave sites here are not of karst origin.

The studies were carried out in the Canastón stream valley, in the Canastón 1 – Canastón 8 rockshelters, and in the Llanto valley in the Llanto 1 – Llanto 5 rockshelters. The paint layers from Canastón 1, Canastón 3, Llanto 3 and Llanto 4 were analysed (Fig. 2). At all those sites, the shallow shelter wall is eroded, with peeling off painted rock fragments and the pigment layer itself.

Canastón 1 (3505 m.a.s.l.): a rock-shelter in radiolite tuffite. Vertical cracks in the rock divide the shelter into three panels. In the central part panel are paintings depicting 'galloping' animals (Fig. 3). Peeling of paintings is observed. The images are naturalistic, with a distinctive head shape and muscle detail included, which allows their easy identification as camelids. Some animals have 'javelins' embedded in their bodies, depicted as lines extending from the 'corpses' (Fig. 3). The animal on the right side of the middle panel is partially covered with a red-orange stain. Below the central panel, separated by a row of dark red dots, are disproportionately smaller images of people, made with several thin dark-red lines. Even lower, also separated by a row of dots, a representation of a dark-yellow, even-hoofed animal made in a different stylistic convention can be observed. Dark-red lines extend from its back, indicating that the image destroyed an earlier one made in red. On the right panel, there are two large dark-red camelids, made in the same stylistic convention as the central motif (Fig. 3a). From the central part of the rump of the animal on the left, the dark-red colouring substance was collected for analysis (CA1/1/16). Above the animals, there is a dark-red circle filled with dots. Remains of a red colouring substance are visible next to it;

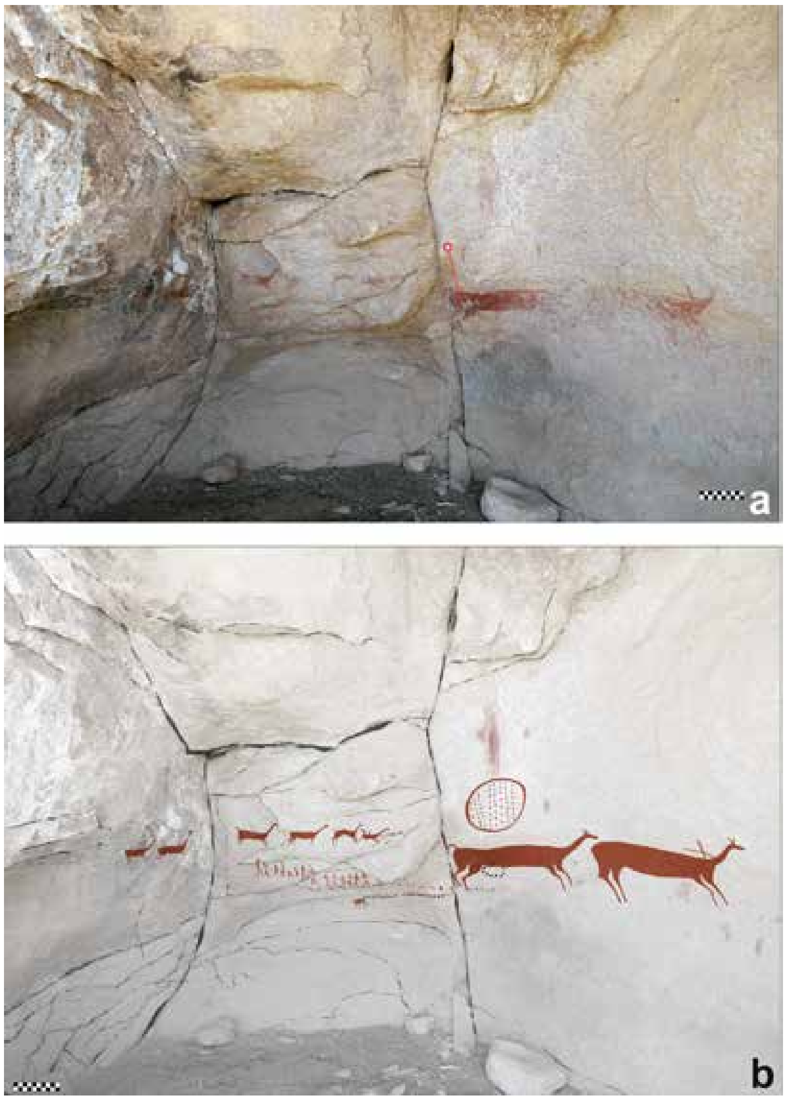


Figure 3. Caplina River basin, Canastón Stream valley: (a) Canastón 1 site with paintings and a marked place of sample collecting, (b) 2D depiction of the painting panels from the Canastón 1 site (elaborated by N. Lenkow).

Figure 4. *Caplina River basin, Canastón Stream valley: (a) Canastón 3 site with paintings and a marked place of sample collecting, (b) 2D depiction of the painting panels from the Canastón 3 site (elaborated by N. Lenkow).*

a similar image was also found in the Canastón 5 rockshelter.

Canastón 3 (3504 m.a.s.l.): a rockshelter in radiolite tuffite located between the Canastón 2 and Canastón 4 archaeological sites (cf. Fig. 2). Paintings are located on the left side of the shelter entrance (Fig. 4). They contain depictions of camelids with visible muscles, in various shades of red, green, white and yellow. The peeling of the paintings is clearly visible. The paintings are all made in the same stylistic convention. A superimposition of colours can be observed, i.e. yellow images overlap dark-red ones, and light-red images overlap green ones. In this convention, a dark-red camelid covers a white image that is, in turn, overlapped by a yellow painting (Figs 4a and 4b). Within the left part of the panel, several dark-red and yellow lines (human silhouettes?) that are not in any form of apparent interaction with the animals can also be observed. Green (CA3/1/16) and red (CA3/2/16) colouring substances were collected for analysis from the rump of the animal images (Fig. 4a).

Llanto 3 (3439 m.a.s.l.): a rockshelter in acidic igneous rocks (rhyolite-trachyte) with traces of metallic mineralisation. Two 'naturalistic' representations of camelids are visible in a small recess above the entrance to the rockshelter. A yellow image partially overlaps a fragment of the red

Figure 5 (below). *Caplina River basin, Llanto Stream valley: (a) Llanto 3 site with enlarged details of the paintings and a marked place of sample collecting; (b) 2D depiction of the painting panels from inside the Llanto 3 rockshelter (elaborated by N. Lenkow).*

depiction. Inside paintings are concentrated in the central part of the rockshelter (Fig. 5). Also, the peeling of the paint residues can be observed here. The interior of the rockshelter contains images of camelids in motion, with visible muscles (Figs 5a, 5ab). The animal depictions in yellow and various shades of red colour show a varied, mainly poor, state of preservation (Fig. 5). Red (LL3/1/16) and yellow (LL3/2/16) colouring substances were collected for analysis from the rump of a zoomorph (Fig. 5).

Llanto 4 (3445 m.a.s.l.): a rockshelter in igneous rocks (rhyolite-trachyte) with traces of metallic mineralization. Paintings are concentrated within the panel to the left of the entrance to the cave. The paintings show two black images of camelids with visible muscles. Above them, an image vaguely resembling a Pleistocene *Hippidion* horse can be observed (Figs 6a, 6b). This animal could survive in isolated Andean enclaves until the beginning of the Holocene (Alberdi et al. 2001). The paintings' colours, style and arrangement indicate that the horse and camelids form one composition. Front-facing human figures can be seen at the horse's torso, made of several thin black lines and partially overlapping with the animal, which indicates that they were added later. A red-orange to brown camelid can also be observed in front of the shelter entrance (central panel), partially covered by a black painting. Front-facing human figures made of several thin brown lines can be observed at its side (Fig. 6b). There are also silhouettes in red, complemented by a lighter shade of red, made in a different stylistic convention than the black images from the left panel. The black colouring substance (LL4/1/16) from the camelid image's rump was analysed (Fig. 6).

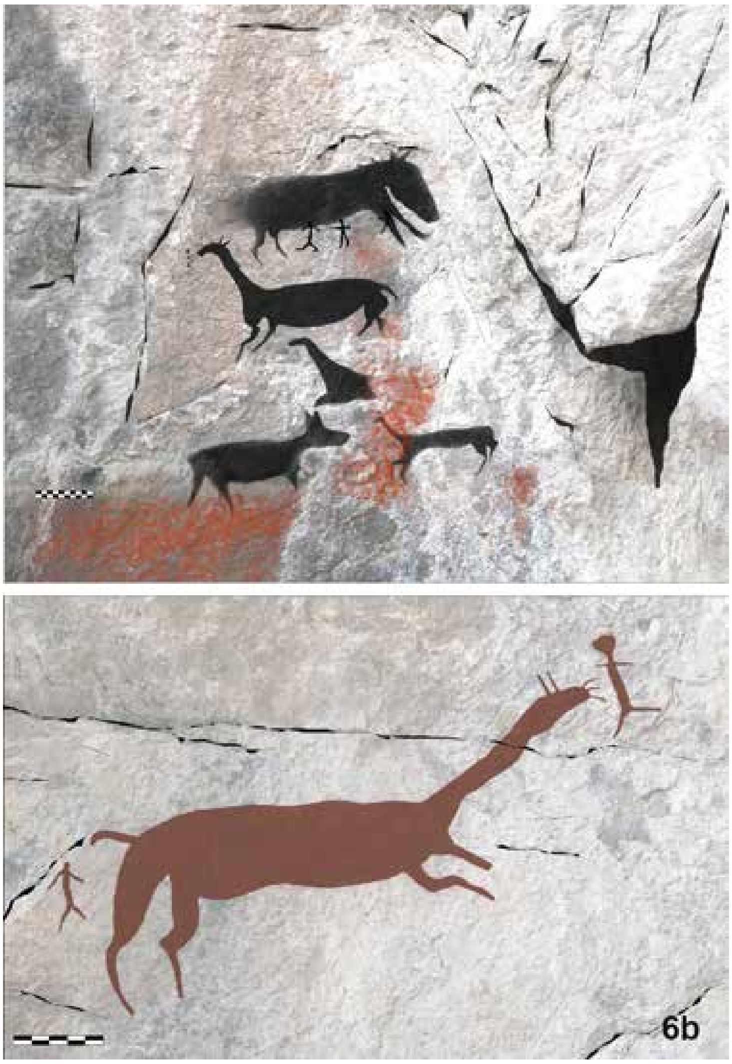


Figure 6. *Caplina River basin, Llanto Stream valley: (a) Llanto 4 site with enlarged details of the paintings and a marked place of sample collecting; (b) 2D depiction of the central and left painting panels from the Llanto 4 rockshelter. Superposition of painting representations is observed (elaborated by N. Lenkow).*

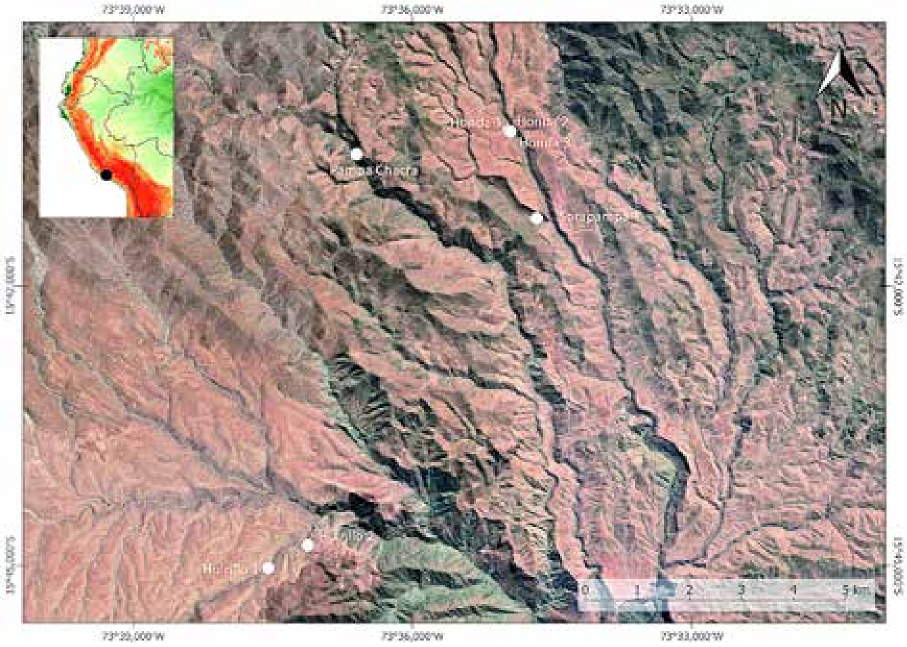


Figure 7. *Southern Peru, upper part of the Atico River basin; location of the sites mentioned in the text. Based on Google Earth Pro and Carta Geográfica Nacional, 32-o Chaparra (elaborated by M. Furmanek).*

Rock paintings from the Atico River basin

The area is located in the Chaparrá District, Caravelí Province, Arequipa Department. The studies were conducted in the valleys of the Honda, Sorapampa, Crucero and Huinllo streams. The geological structure of the region is typical of southern Peru and northern Chile. Similarly, as in the Vilavilani region (Caplina River basin), the valley profiles are formed by layers of dacitic and rhyolitic tufa belonging to the Pliocene Huaylillas Formation, which rest on the Miocene Moquegua Formation (Flores et al. 2004). The studies were carried out at Honda 1 – Honda 3 sites in the Honda valley, Sorapampa 1 in the Sorapampa valley, Huinllo 1 and Huinllo 2 in the Huinllo valley and Pampa Chacra in the Crucero valley (Fig. 7).

The painting layers from the Honda and Sorapampa valleys were analysed (Fig. 7). As well as in the case of the sites from the Vilavilani region, the analysis of rock samples forming rockshelters and caves indicates that we are dealing here with volcanic igneous rocks, both rhyolite tuffites and rhyolite-trachyte. Thus, those cave sites are not of karst origin. Just as at the cave sites from Vilavilani, infiltrations, delamination, wall erosion, falling off rock fragments, and peeling of the paint layer have been observed at the archaeological sites of this region.

Honda 1 (2815 m.a.s.l.): a shallow cave in igneous volcanic rock (radiolite tuffite), located on the right bank of the Honda valley. The paintings can be observed all over the cave wall, but their concentration is in the front part. The cave's walls are covered with paintings made in various stylistic conventions (Fig. 8). Most are red and white, some yellow, showing red and yellow representations of camelids in motion with clearly visible muscles. Schematic images of animals overlap the red paintings in white as well as white realistic representations of camelids and 'human' figures in the contour technique, all made in different stylistic conventions (Fig. 8a). The paintings have partially faded due to sunlight, which reaches the interior of the cave between 11 a.m. and 2.30 p.m., directly affecting the part of the rock's surface located opposite the mouth. Peeling of the paint layer is also observed. A sample from the dark-red paint layer (HO1/1/17) from the rump of a large camelid image (left part of the panel) was taken

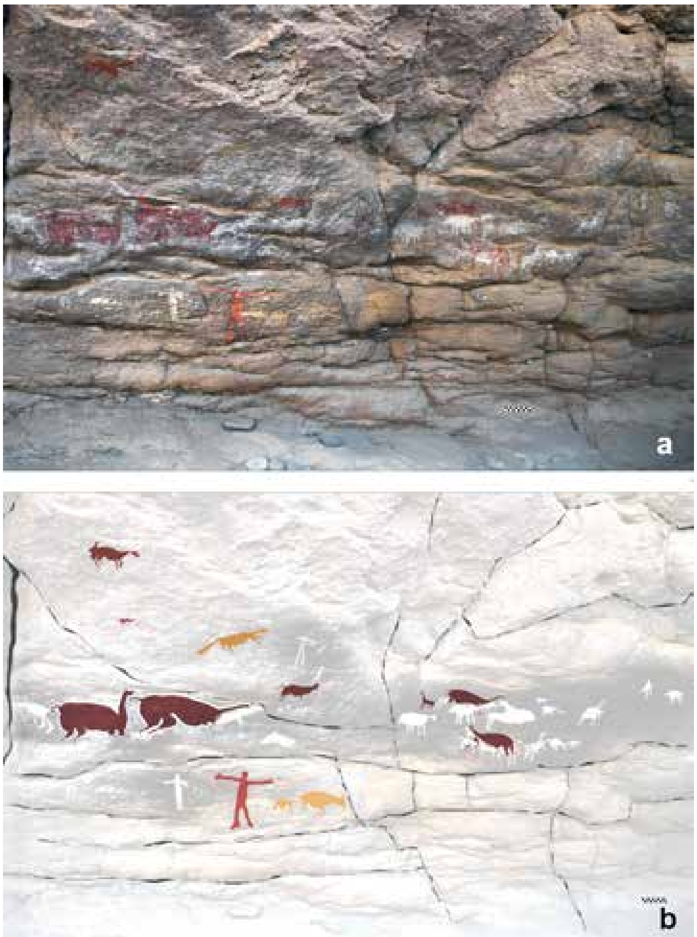


Figure 8. *Atico River basin, Honda Stream valley: (a) Honda 1 site with paintings and a marked place of sample collecting; (b) 2D depiction of the painting panels from the Honda 1 cave (elaborated by N. Lenkow).*

for analysis.

Sorapampa 1 (2698 m.a.s.l.): a cave in igneous volcanic rock (radiolite tuffite), also known as Escondido. It is located on the right bank of the Sorapampa Stream valley. The central painting shows a 'naturalistic' representation of a camelid in red, with visible anatomical features (Fig. 9). Below are schematic red 'human' figures with their hands raised. To the left of the main image (left panel), a partial depiction of a camelid showing an elongated neck and the front part of the body can be observed (Fig. 9a). To the right of the central image (right panel), there are vertical wavy lines and 'human' figures made of red, yellow or black lines. The latter are clustered at the top and bottom of the wall in what seem to be dancing poses (Fig. 9b). The yellow figures sometimes overlap the red ones, although they are all painted in the same convention. Other images within the right panel depict seated figures in red, overlaid with white outlines of anthropomorphs positioned upside down (Fig. 9c). Other undefined images in black and yellow can also be observed. Samples of red paint were collected for analysis from the central camelid representation (SP1/17) and the torso of the individual (SP2/17) depicted below the main camelid representation (Fig. 9).

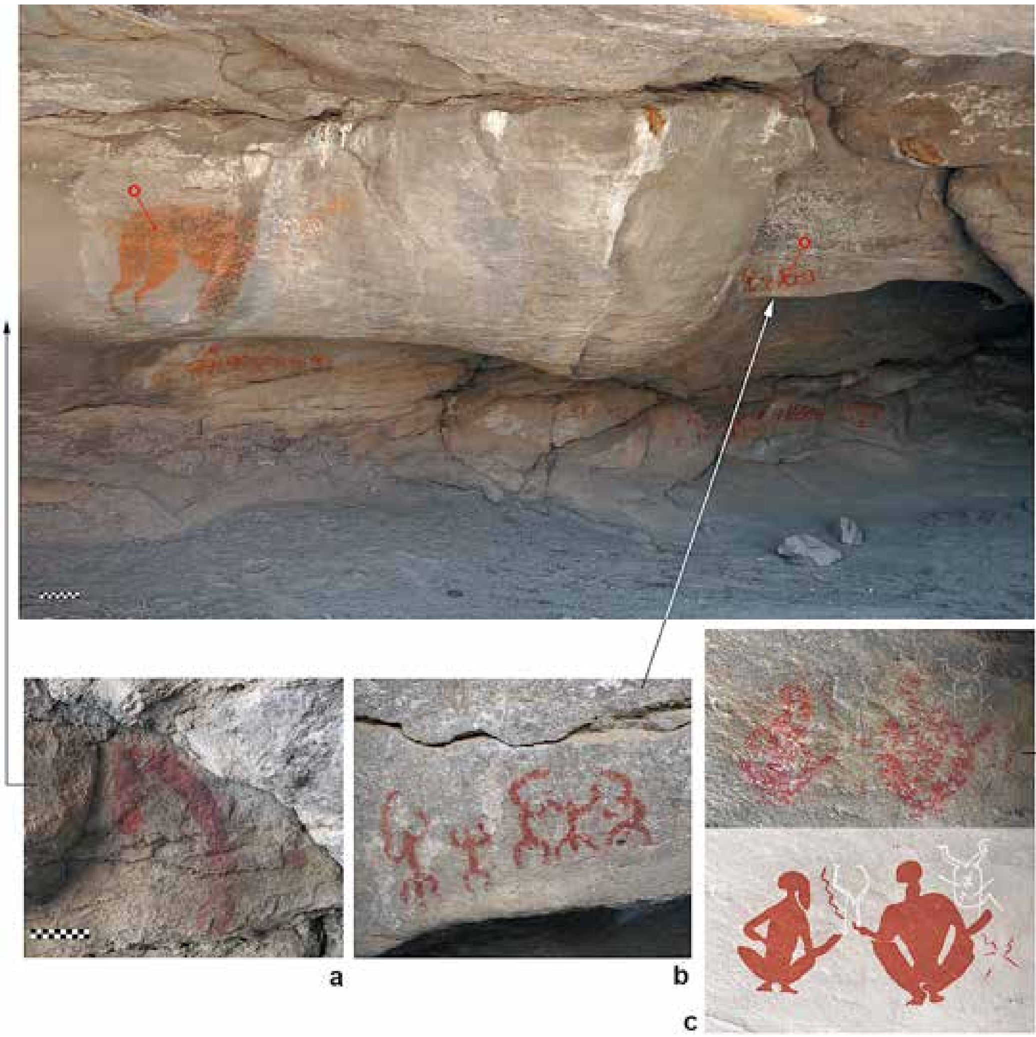


Figure 9. *Atico River basin, Sorapampa Stream valley; interior of the Sorapampa 1 cave with enlarged details of the paintings and a marked place of sample collecting, (a) left panel, (b, c) right panel (elaborated by N. Lenkow).*

Field research procedure and paint layer analysis

Archaeological field survey

Fieldwork in the upper part of the Atico basin and the Vilavilani region of the Caplina-Tacna catchment area was carried out along mountain valleys where several caves and rockshelters with paintings were observed (cf. Figs 1, 2, 7). Their documentation included geographical coordinates, size, absolute height and location in relation to the river valley. The registration report also contains data regarding the artefacts found within the site, including the mouth of the cave/rockshelter, as well as the materials found on the slope adjacent to the archaeological site. Rock samples were collected from the walls of the sites to determine their exact type. Photographic documentation of the paintings occurring within the individual sites was also conducted, and samples of the colouring substances used in the paintings were taken.

The samples were collected according to a protocol designed to maximise results while considering the guidelines and regulations of the Peruvian Ministry of Culture. Those tasks were performed during the dry season, which in this part of the Andes lasts from late April to December. The sampling process took place between 9 and 11 a.m., when the interior of the caves/niches did not receive direct sunlight, negatively affecting the sample.

The samples were collected using a surgical scalpel on the largest area of the painting. Due to the nature and size of the paintings, it was mainly the rump of an animal or another plane surface, for instance, an individual's torso. The collected material was placed in glass vials with a stopper, which were then deposited in a container protecting them from the negative impact of the sunlight. The samples were described according to a strictly defined scheme, noting the dates and times of their collection, the archaeological site symbol and the specimen number, as well as the name of the researcher performing this activity. Photographic documentation and a description of the part of the painting from which the material sample was taken have been placed in a separate list.

Laboratory research

Analyses of the colouring samples from southern Peru pictogram sites were performed with a desktop Spectro Midex x-ray fluorescence spectrometer equipped with a molybdenum lamp and an SDD semiconductor detector; 45 kV excitation energy, 0.4 mA current. The scanning electron microscopy method coupled with an energy dispersion spectrometer (SEM-EDS) was also used, enabling the analysis of the chemical composition and providing information about the sample structure (microscopic imaging). A Hitachi S-3400N scanning electron microscope with a tungsten cathode was used. Images were recorded using BSE back-scattered electrons, and EDS measurements were taken with a Noran System7 analyser equipped with a Thermo Scientific Ultra Dry detector. This measurement allows for semi-quantifying the content of elements in the tested sample. It was conducted in the so-called low vacuum, at a pressure of 30 Pa and an accelerating voltage of 30 kV. The samples were also analysed in visible light with a Hirox RH 2000 digital microscope. Next, the samples were supplemented with molecular tests, which allowed determining their phase composition. For this purpose, x-ray diffraction (XRD) tests were performed using a MiniFlex diffractometer by Rigaku with a HyPix-400 MF detector. The tested range of 2 theta angles was 3-120°. The x-ray tube operated under the conditions of 40 kV/15 mA. During the conducted analyses, the composition of black, red, yellow and green colouring substances was determined from the rock paintings in the Caplina catchment area (Vilavilani region) and the Atico River basin.

Laboratory examinations of colouring substances were carried out in the Laboratory of the Institute of Archaeology of the University of Wrocław, Poland. The analyses aimed at identifying the bedrock on which the paintings were created were conducted at the Polish Geological Institute, National Research Institute, Carpathian Branch in Cracow, where cutting of rock samples, microscopic examinations and testing the impact of chemical reagents on particular samples were conducted.

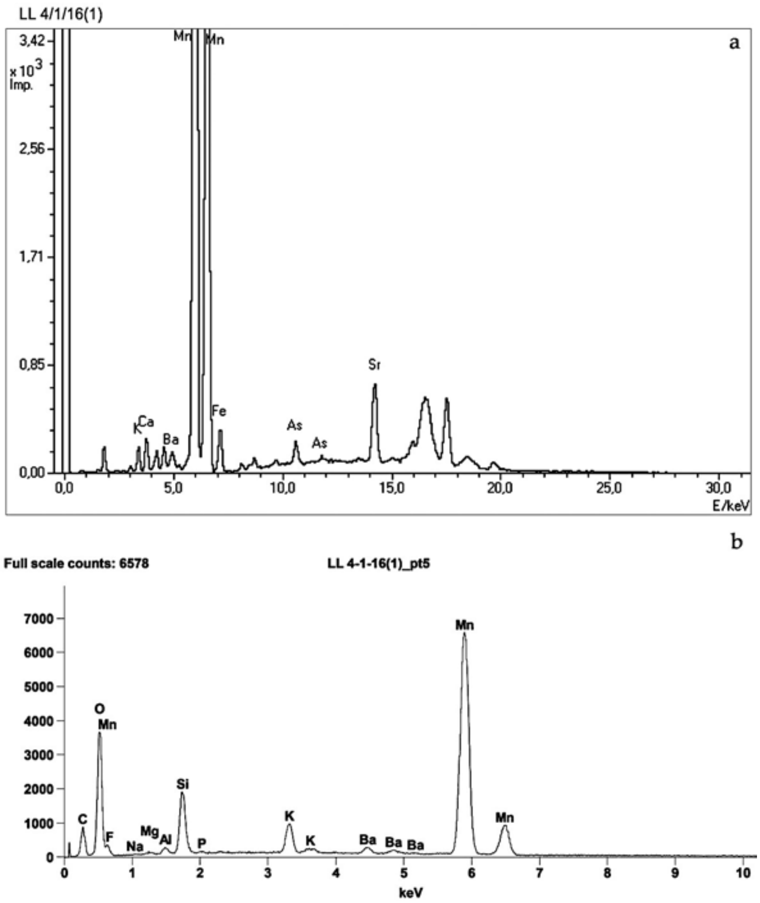


Figure 10. Black sample (LL4/1/16) from Llanto 4 rockshelter: (a) XRF energy spectrum; (b) EDS spectrum.

Identification of colouring substances

The analyses allowed determining the composition of colouring substances of black, red, yellow and green hues. They come from the paintings recorded at the Canastón 1, Canastón 3, Llanto 3 and Llanto 4 cave sites in the Río Caplina catchment area (Vilavilani region) as well as from the Honda 1 and Sorapampa 1 cave sites in the Río Atico basin (cf. Figs 2 and 7).

Río Caplina basin (Vilavilani region)

Black

The black sample (LL4/1/16) comes from Llanto 4 (cf. Fig. 6). Due to its dusty structure, it was necessary to stabilise it on graphite tape. An XRF analysis indicated manganese as the major metallic element (Fig. 10a). Iron, calcium, potassium, barium, strontium and small amounts of arsenic were also found. SEM-EDS tests also indicated manganese as the primary component (Fig. 10b).

Various shades of red

The top side of the sample from Canastón 3 rockshelter (CA3/2/16) with an intense applied red colour was marked as 1, and the black underside as 2 (Fig. 11a). Strong signals of manganese and iron were recorded on the topside (1) as well as less intense signals of rubidium, strontium, calcium and potassium. Weaker manganese signals were also recorded on the underside (2), which is unsurprising because Mn is present in lithic raw materials. Iron levels were also lower, while the potassium and rubidium levels were higher (Fig. 11b).

EDS spectrometer tests showed similar values. Working at 42× magnification, the spectrum of the whole surface was obtained. Its study/interpretation showed that the strong peaks of silicon and weaker peaks of iron, manganese, titanium, aluminium and magnesium were present (Fig. 12). The colouring substance and substrate components were also defined by spot EDS analysis (Table 1).

Small rectangular structures visible in the image show strong signals of strontium, sulphur, oxygen and manganese (Fig. 12). Larger and darker ones, apart from silicon, oxygen and manganese, also show the presence of iron. A relatively high proportion of strontium and sulphur was found, which seems to be due to the presence of strontium sulphate in the substrate. An analysis of the red manganese and iron compounds was carried out to define the red colouring substance layer. An XRD test was performed, and the Fe_2O_3

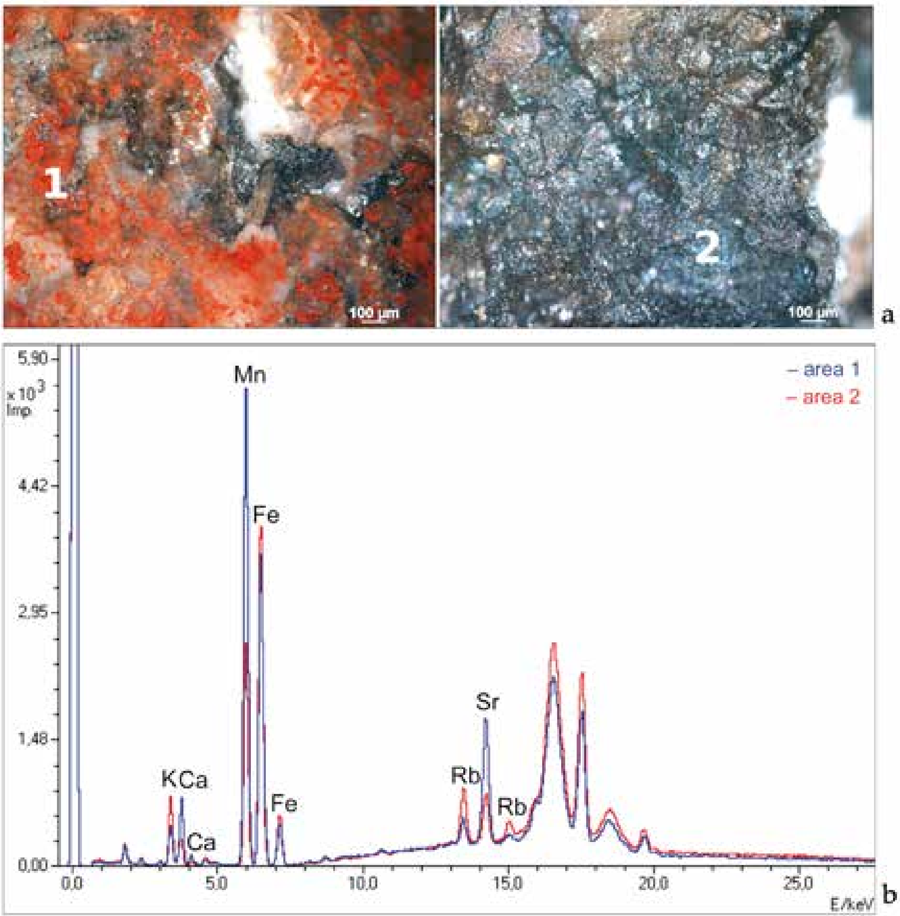


Figure 11. *CA3/2/16 sample: (a) microscopic image of the top (1) and bottom (2) side of the red colouring substance; (b) ED-XRF spectrum.*

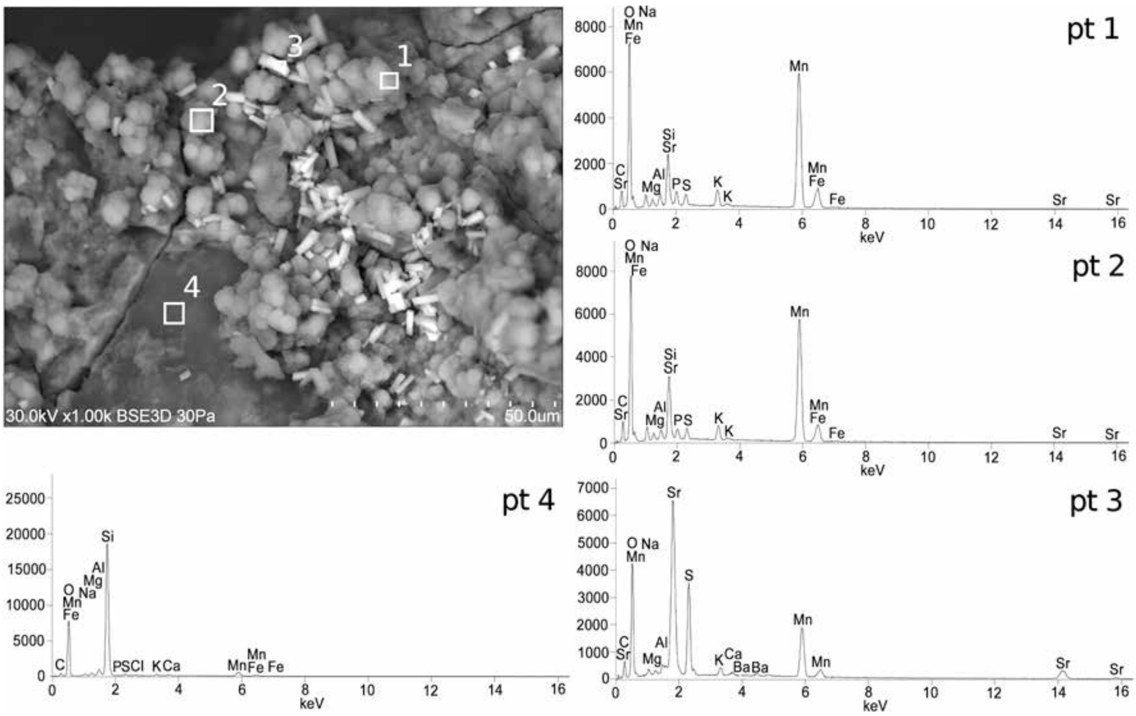


Figure 12. *CA3/2/16 sample: SEM microscopic image and EDS spectra from selected places.*

Area	Chemical elements (% of the weight)													
	C	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Mn	Fe	Sr	Ba
1	7.8	46.8	3.8	1.3	1.5	5.6	1.4	1.0	-	1.6	-	28.0	1.0	0.2	-
2	8.8	48.5	4.1	1.1	1.1	6.7	1.1	1.0	-	1.3	-	25.1	1.0	0.3	-
3	9.0	50.5	1.2	0.7	0.3	-	-	9.4	-	0.8	0.3	9.8	-	17.2	0.7
4	5.0	57.2	1.1	0.9	1.4	30.6	0.2	0.4	0.2	0.3	0.2	2.2	0.2	-	-

Table 1. *Elemental composition of the CA3/2/16 sample made for different areas in Fig. 12.*

signals were superimposed on the obtained diffractogram. Spectral analysis of the peaks excluded haematite as the major component of the colouring substance. At the same time, interpretation of the XRD spectrum confirmed the presence of intense signals of metallic iron and manganese carbonate ($MnCO_3$, known as rhodochrosite) with an intense red colour (Fig. 13).

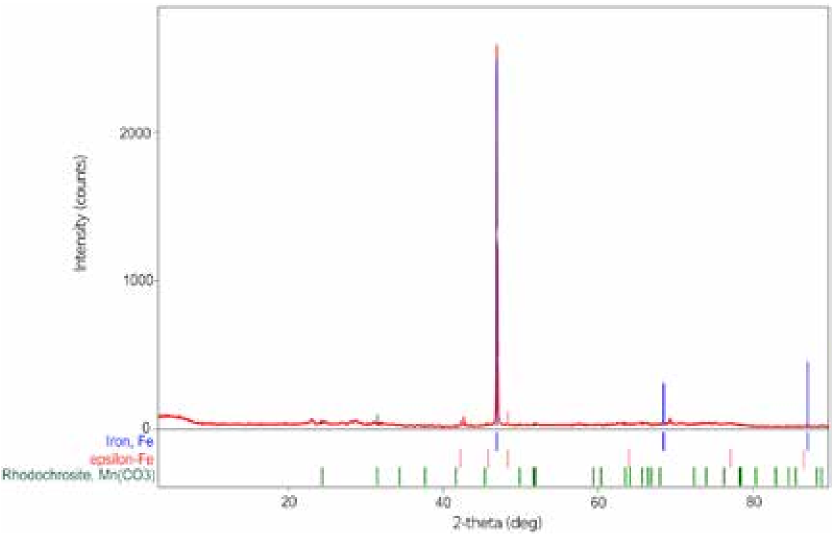


Figure 13. *CA3/2/16 sample: XRD image, rhodochrosite and metallic iron pattern, showing the diffractogram of the sample with identification of phase components. Results of the semi-quantitative EDS analysis indicate that the manganese, carbon and oxygen contents correspond to the stoichiometry of the $MnCO_3$ creation (cf. Table 1).*

Another red sample comes from the Canastón 1 rockshelter (CA1/1/16). The colouring substance layer residue (area 1) and the rock substrate (area 2) were examined (Fig. 14). The microscopic image (Fig. 14a) shows much darker and brownish-red than in sample CA3/2/16. Spectroscopic analyses aimed at determining whether differences in imaging are due to different chemical compositions. An x-ray fluorescence spectrum examination of sample CA1/1/16 showed intense signals of metallic elements attributable to iron and calcium (Fig. 14b). The main ingredient was found to be iron pigment (most likely haematite), intense in the red part (area 1), accompanied by a calcium mineral (possibly gypsum), which is either a component of the colouring substance or of the prepared substrate; the analysis of the rocks on which the paintings were made excludes the presence of calcium mineral in their composition.

Due to the signal distribution, the colouring substance was defined as haematite red. Other signals, 100–300 times lower in intensity, were considered insignificant. On the other hand, microscopic and analytical SEM-EDS tests also indicate the presence of silicon, sulphur, calcium and iron compounds as well as oxygen.

The red sample from the Llanto 3 rockshelter (LL3/1/16) consists of fine-grained red crumbs several hundred microns in size (Fig. 15a). No traces of substrate rock were found. An XRF spectrum analysis showed strong iron signals. Other metallic

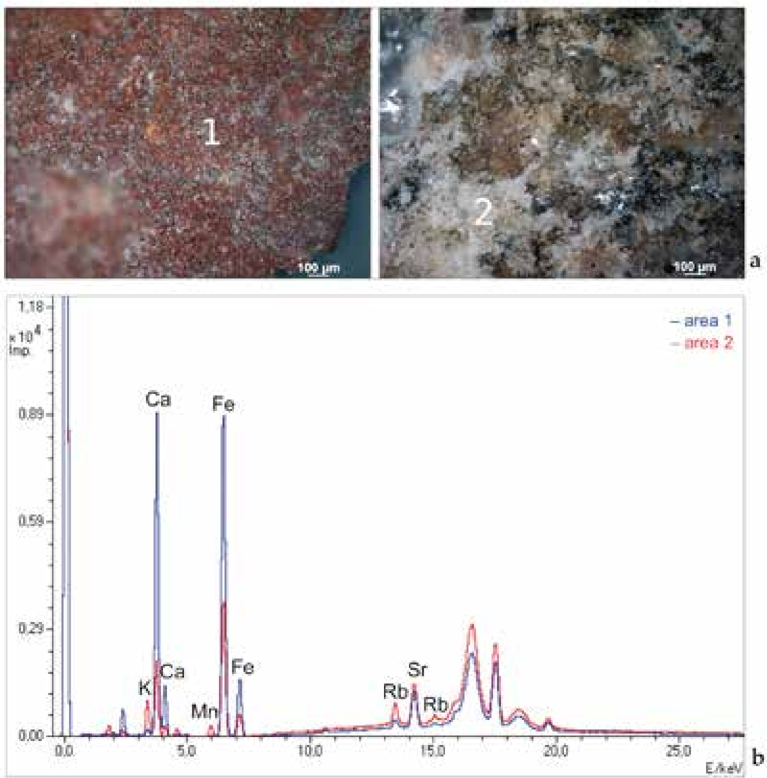


Figure 14. *CA1/1/16 dark-red sample: (a) microscopic image of the painted layer (1) and surface (2); (b) XRF spectrum image, analysed in both areas.*

elements (calcium and potassium) were only present in small amounts (Fig. 15b). An XRD analysis was also performed, and the obtained diffractogram indicated a haematite signal to be the most intense. Signals of another iron compound (α-Fe_3C) were also discovered. A large number of iron signals and a lack of analytical lines of other elements indicate the haematite origin of the sample (Fig. 15c).

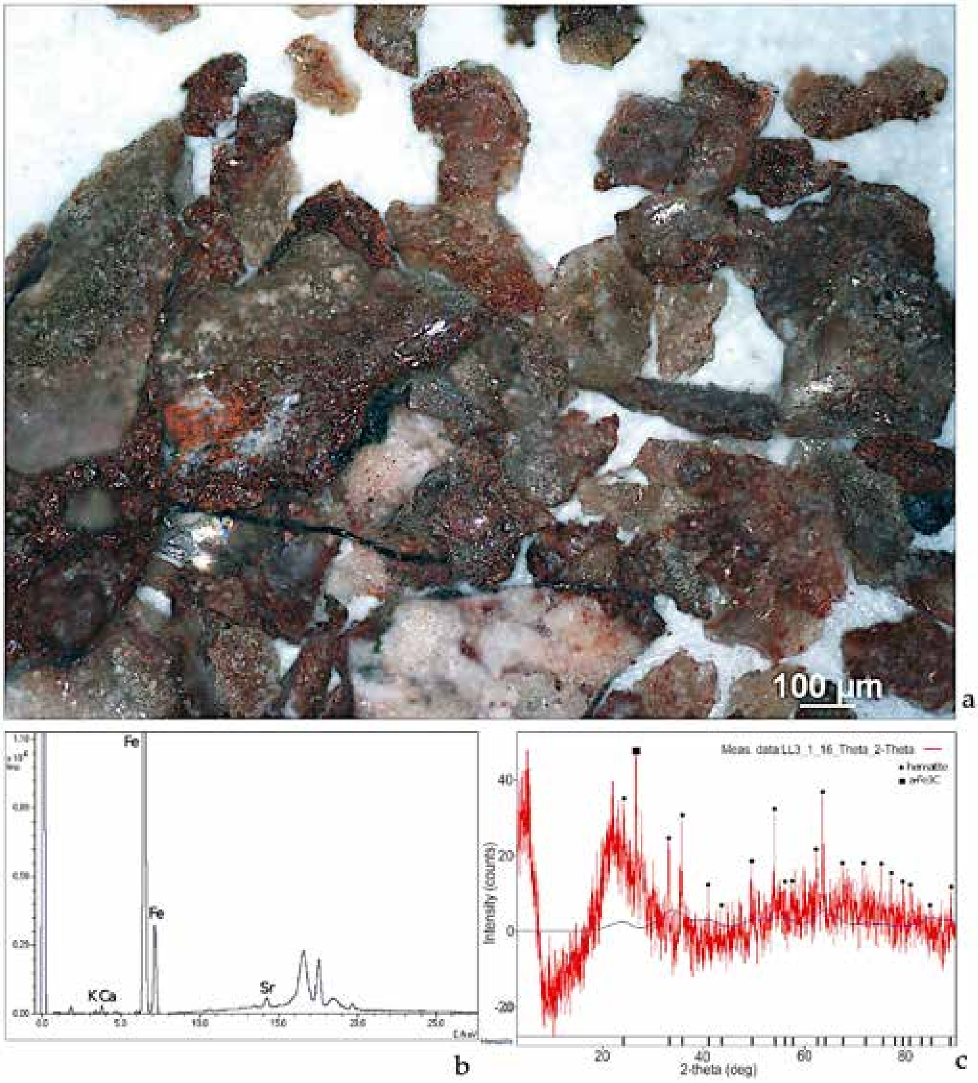


Figure 15. *LL3/1/16 dark-red sample: (a) macroscopic image, XRF spectrum; (b) diffractogram; (c) signals of the haematite and α-Fe_3C pattern marked.*

Yellow

Sample (LL3/2/16) from the Llanto 3 rockshelter is a yellow powdery substance (Fig. 16a). XRF tests show strong iron signals and less intense manganese, calcium, potassium, rubidium and strontium signals (Fig. 16b). On the other hand, an SEM-EDS analysis showed strong signals of silicon, oxygen, iron, aluminium and carbon as well as residues of other elements (Fig. 17), which confirms the mineral origin of the tested substance. Strong iron signals, coexisting with compounds of silicon and other light elements, allow defining the sample as yellow ochre. The brownish tinge visible in some parts of the substance (Fig. 16a) may indicate the presence of manganese oxides (III and IV), recognisable on x-ray spectra (Hradil et al. 2003).

Green

A green colouring substance from the camelid depiction in the Canastón 3 rockshelter (CA3/1/16)

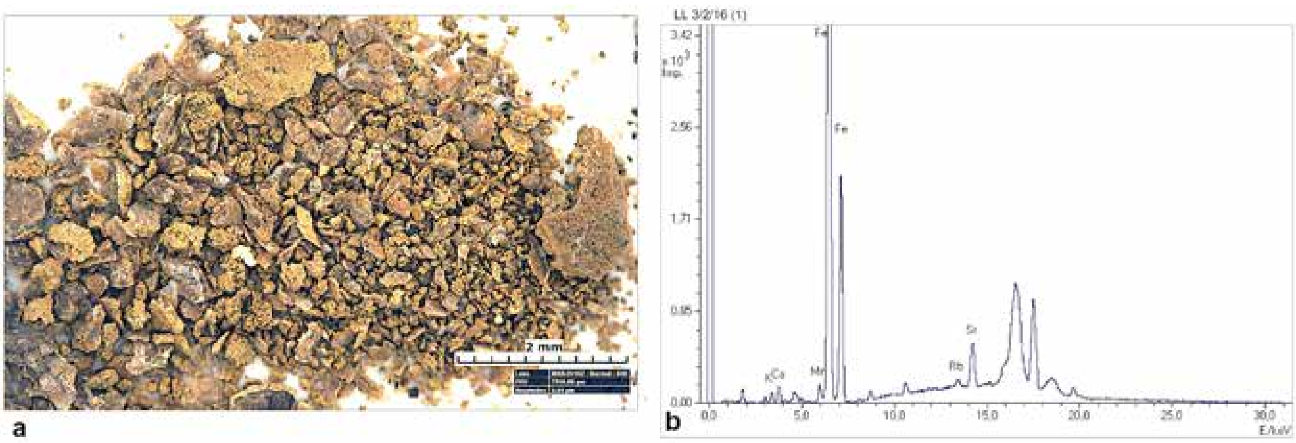
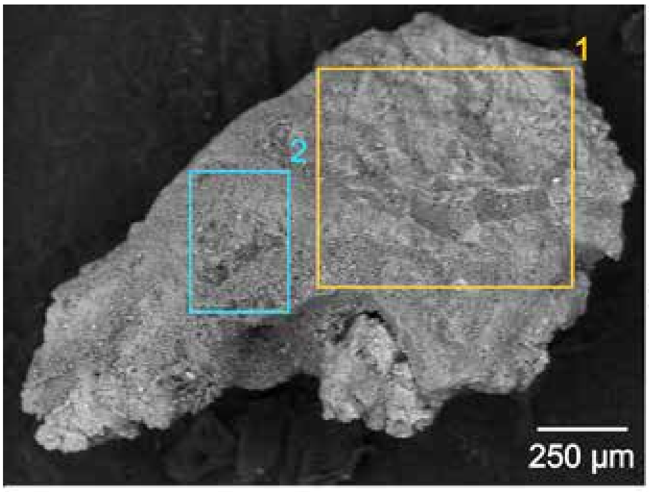


Figure 16. *LL3/2/16 yellow sample: (a) microscopic image. In the right part of the photo, a fragment subjected to-SEM-EDS analysis; (b) XRF spectrum.*



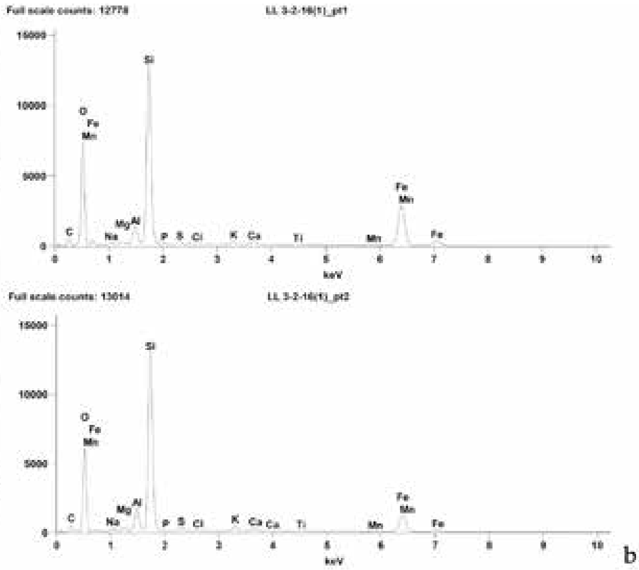


Figure 17. LL3/2/16 yellow sample: (a) microscopic image with research areas marked; (b) SEM-EDS energy spectrum from both areas.

was submitted for analysis. The sample thickness did not allow for separating the paint layer from the rock substrate. A microscopic examination, as well as XRF and XRD analyses, were performed.

Three areas of the sample with different shades of green were tested by XRF (Fig. 18): area 1 on the topside, area 2 with a dark shade, and area 3 with a light-green shade (Figs 18a, 18b) on the underside. Signals of copper were recorded in all the samples, the strongest in area 1. In area 2, tests also detected signals of iron, manganese, calcium, potassium, strontium, sulphur and chlorine, as well as traces of lead (Fig. 18c). In area 3, in addition to strong copper signals, there were iron and manganese signals, albeit less intense than in area 2. An SEM-EDS point analysis confirmed strong signals of calcium, copper, strontium, sulphur and chlorine (Fig. 19a).

Examination of the sample at high magnification enabled the identification of places with particularly high peaks of copper and chlorine (Fig. 20a, pt 1) as well as crystals containing silicon and oxygen (Fig. 20a, pt 4). Semi-quantitative data show that 32% copper is accompanied by 10% chlorine and carbon, and 36% oxygen. Silicon (3.8%), magnesium (3%), calcium, aluminium (1.5%) and iron (0.2%) are present in smaller amounts (Fig. 20b). On the other hand, the results of EDS analysis (Fig. 20c) and x-ray diffraction (XRD) indicate that the most intense signals come from mineral substances, mainly containing silicon and oxygen (SiO_2). At the same time, malachite was excluded as the main component of the sample, but other copper compounds, including chloride, were indicated, such as paratacamite, atacamite or nantokite (Fig. 19b).

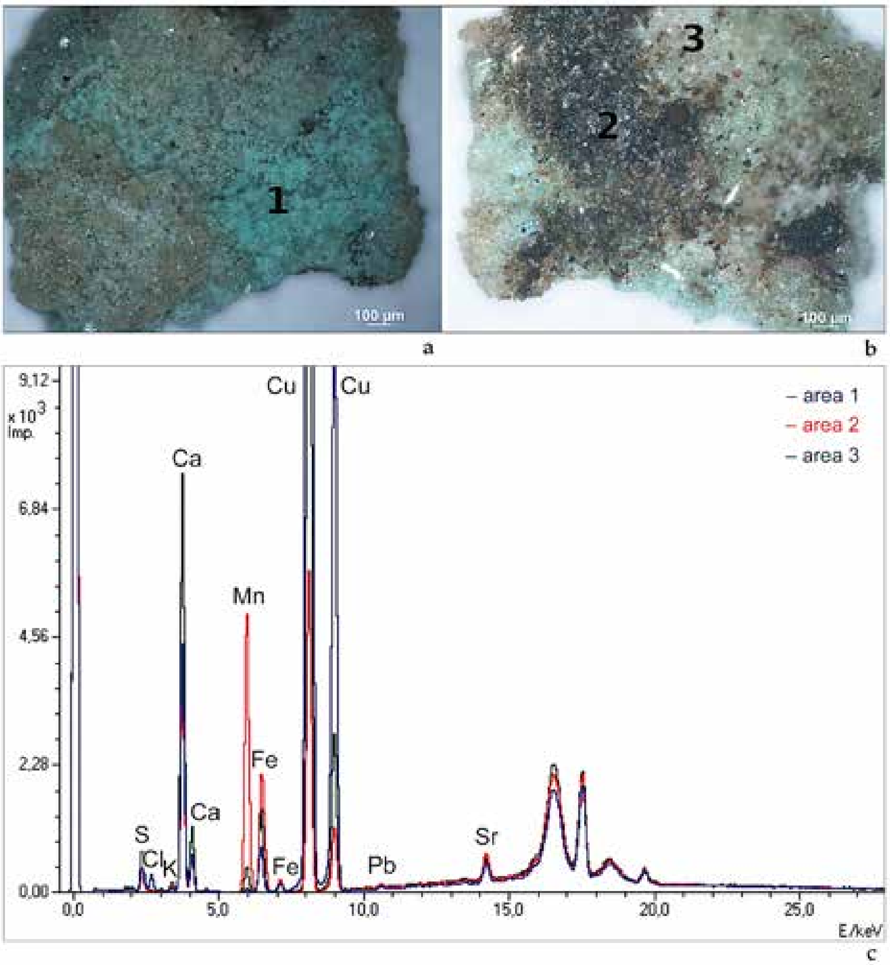


Figure 18. CA3/1/16 sample: (a) microscopic image of a green colouring substance with test areas 1; (b) test areas 2 and 3 marked; (c) ED-XRF spectrum.

Atico River catchment area

Microscopic analysis of the colouring substance from the Honda 1 rockshelter (Ho1/1/17) confirmed the presence of dark red-brown colour on the sample underside along with red-orange areas. Iron signals were recorded in the XRF spectrum for both top- and undersides (Fig. 21a). To determine the substrate, a clean cross-section of the rock was also examined, marked as area 3 in the XRF spectrum. The results indicate that apart from iron, there are also other metallic elements (calcium, potassium, rubidium and strontium). However, the intensity of their signals is much lower (Fig. 21b). Thus, the pigment should be considered haematite. On the other hand, an XRD analysis (Fig. 21c) shows that apart from α-Fe_2O_3 (haematite), there are also Fe and manganese oxide (MnO_2) signals, which explains the darker shade of red (Hradil et al. 2003). The results of analyses from Honda 1 are very similar to those obtained during the study of the sample (LL3/1/16) from the Llanto 3 site near Vilavilani in the Caplina River drainage basin (cf. Fig. 15).

Two bright-red samples were obtained in the Sorapampa 1 cave. The first is a powdered substance (SP1/1/17; Fig. 22a), showing iron, calcium, manganese, potassium and strontium signals. Iron was the most predominant in the mix, indicating that the colouring substance was made of iron pigment (Fig. 22b). Traces of a colouring substance are hardly visible in the other sample (SP1/2/17; Fig. 23a). The analysis consisted in comparing the spectral images of both sides of the sample. The topside contained stronger iron signals (blue line), while the

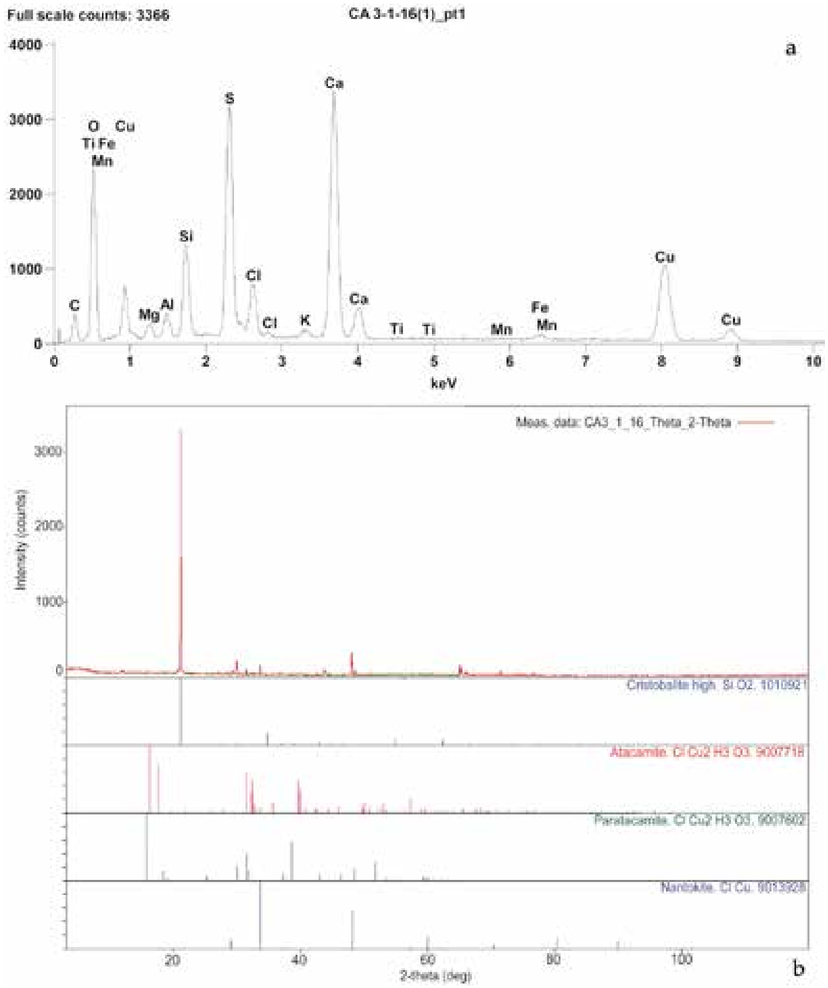


Figure 19. *CA3/1/16 sample: (a) EDS energy spectrum; (b) diffractogram with the silica (cristobalite), atacamite, paratacamite, and nantokite signals marked.*

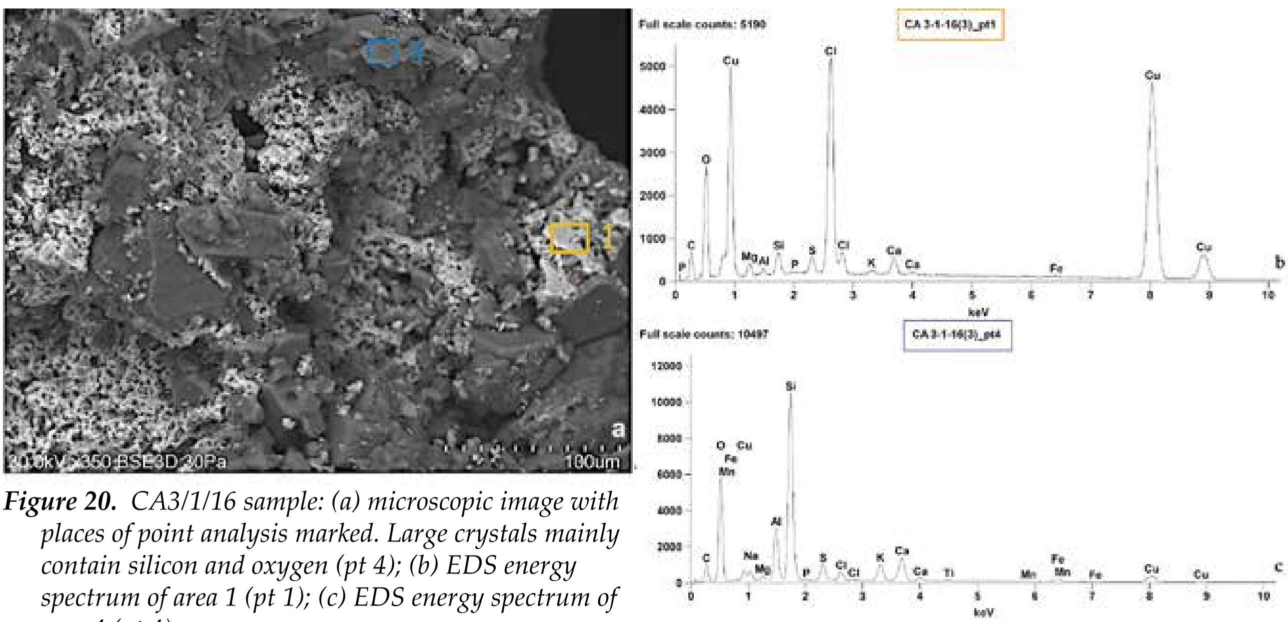


Figure 20. *CA3/1/16 sample: (a) microscopic image with places of point analysis marked. Large crystals mainly contain silicon and oxygen (pt 4); (b) EDS energy spectrum of area 1 (pt 1); (c) EDS energy spectrum of area 4 (pt 4).*

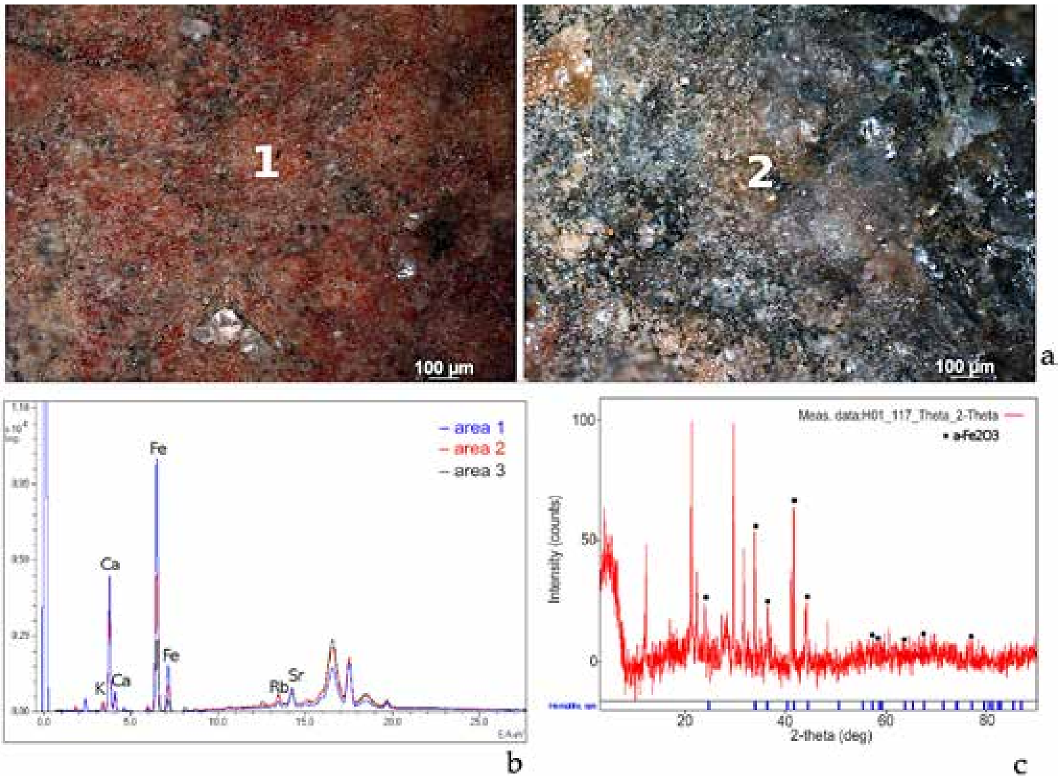


Figure 21. *Ho1/1/17 sample: (a) microscopic image of the top (1) and bottom (2) side of the red colouring substance; (b) XRF spectrum image in three research areas; (c) diffractogram with synthetic haematite and α-Fe_2O_3 signals marked.*

underside showed calcium signals from the substrate (red line; Fig. 23b). An SEM-EDS test indicated that the sample also contained aluminosilicate substances (Si, Al, O) as well as magnesium, calcium, sodium, chlorine and iron, which are components of the reddish paint (Fig. 24).

Discussion and conclusions

The rock paintings from the Vilavilani region in the Río Caplina basin and the Atico catchment area show only sporadic traces of humanly caused deterioration, as seen on the walls of the Llanto 1 cave, where, in addition to 'naturalistic' depictions of camelids, modern inscriptions are also visible (Fig. 25). Most of the damage is due to sunlight, which causes colour decay and fading. Other destructive factors include humidity and changing temperature, both annually and daily, as well as the influence of wind and air currents carrying sand and fungal spores, which developed especially during high humidity, i.e. in the rainy season and shortly after it. Such phenomena resulted in delamination, falling of painted rock fragments and peeling of the paint layer. The lack of patina and a small number of growths and infiltrates on the damaged surfaces indicate that most of them come from recent decades, suggesting the influence of the global climate change on the Andes mountain region. This phenomenon is best seen when we compare the extent of the Andean glaciers in the 1980s and 1990s with their present ones (Szykulski 2010a: 26; Bárcena Ibarra et al. 2020).

Colouring substances

Laboratory analysis of the chemical composition of colouring substances showed that they should all be considered as of mineral origin (Table 2).

The black pigment from the Llanto 4 rockshelter was found to be manganese-based. This is not surprising as studies of pre-Historic New and Old-World sites confirm the use of manganese compounds, specifically

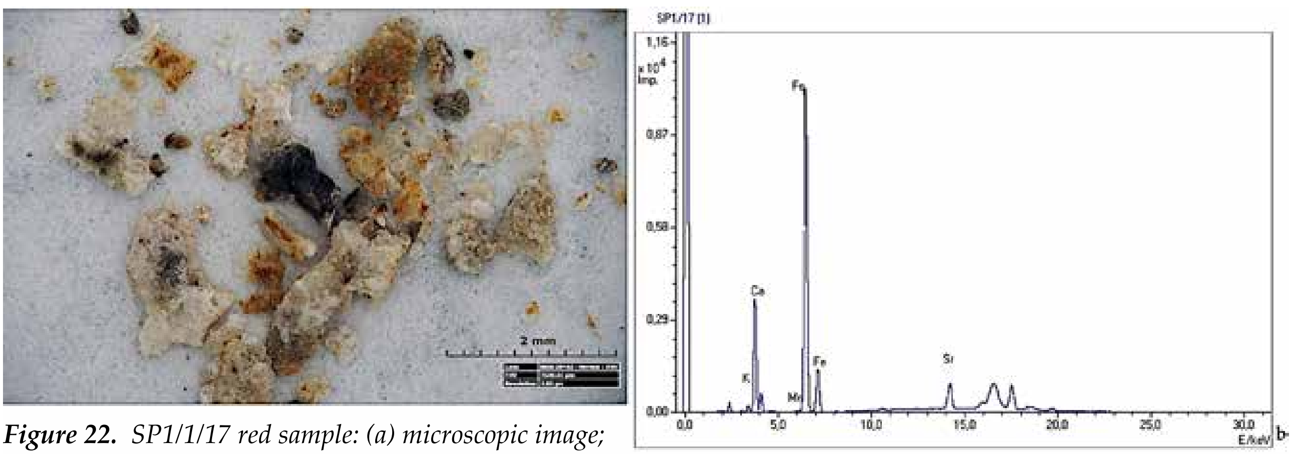


Figure 22. *SP1/1/17 red sample: (a) microscopic image; (b) XRF spectrum.*

manganese oxide (MnO_2) pyrolusite, to obtain the black colour (Clark 2002; Rampazzi et al. 2007; Brooks et al. 2008; Eftekhari et al. 2018; Siddall 2018).

Significant differences in the composition of various shades of red pigments were observed. The intense red colour of Canastón 3 (Fig. 4) was obtained from the non-haematite compound of iron and rhodochrosite (manganese carbonate), a relatively rare mineral with the intense red colour found in southern Peru copper deposits (Anthony et al. 2001–2005). Conversely, the bright red colour in the Sorapampa 1 cave paintings was obtained using an iron-based pigment.

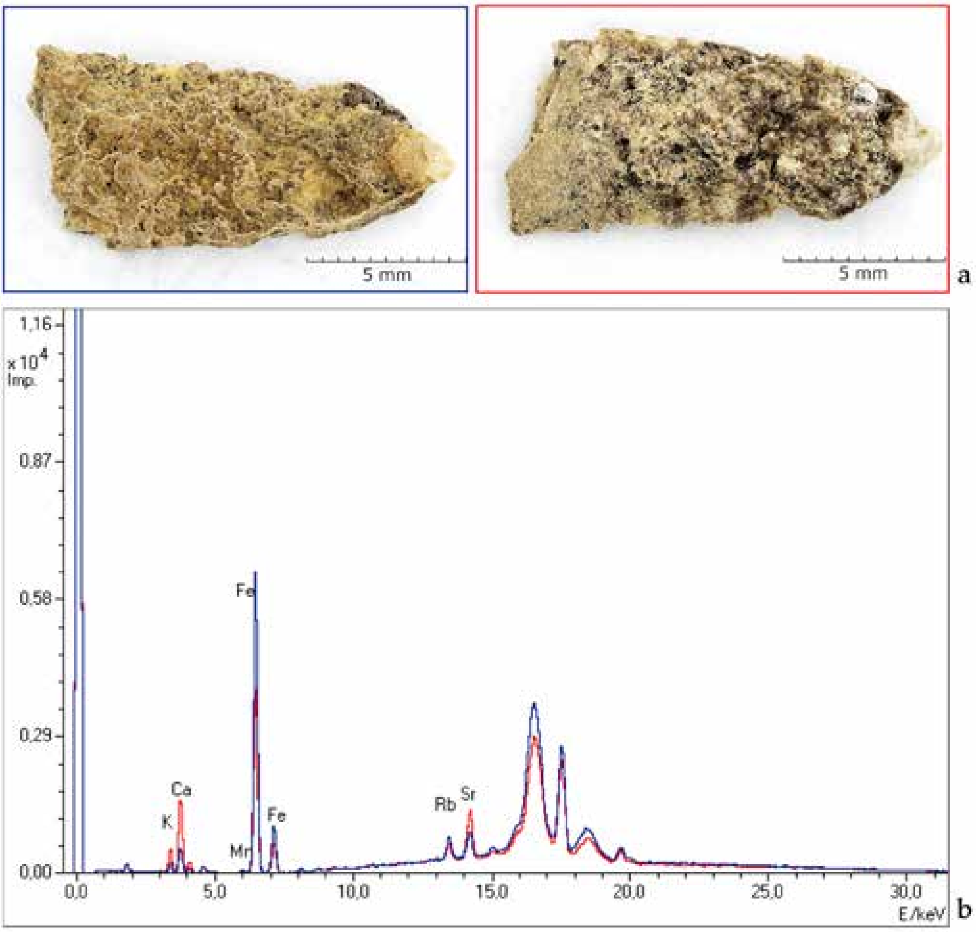


Figure 23. *SP1/2/17 sample: (a) microscopic image of the top (blue) and bottom (red) side; (b) XRF spectrum.*

Dark-red pigments from Canastón 1, Llanto 3 and Honda 1 (cf. Figs 3, 5, 8) were defined as iron oxide, i.e. haematite red, which is a part of the so-called earthy colour palette (Hradil et al. 2003; Brooks et al. 2008; Siddall 2018). Like any other such pigment, iron oxide is often mixed with clays and silica (Clark 2002: Table 5), which was also confirmed by the analyses performed in this study.

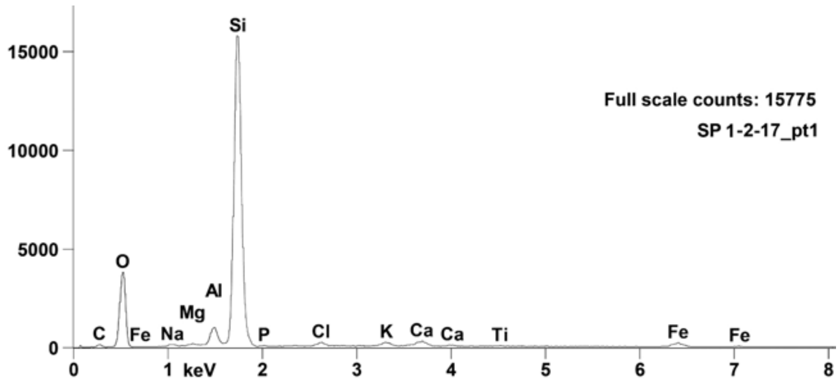


Figure 24. *SP1/2/17 red sample; EDS spectrum image, strong signals of aluminosilicate substances and iron (approx. 6–7 keV) visible.*

Analysis of the yellow paint layer from the Llanto 3 rockshelter (cf. Figs 5, 5a) showed iron compounds of yellow ochre, often used in rock paintings (Edreira et al. 2001; Clark 2002; Brooks et al. 2008; Dos Santos et al. 2018).

The green colour is particularly interesting in the context of the conducted studies. Assuming that the original animal images probably were brown, which reflected the natural hue of the fur, their present colour could be a result of copper compounds' deterioration. It is also possible that the original pigment could be a dark-red copper mineral, e.g. cuprite, which over time turned into greenish compounds, such as malachite or copper chlorides. Therefore,

Figure 25. *Llanto valley; Llanto 1 rockshelter, painting and modern inscription.*

Catchment area	Archaeological site	Sample code	Colour	Sampling place	Identified elements*	Possible colouring substance (pigment)
Caplina	Llanto 4	LL4/1/16	black	rump of the animal Fig. 6	manganese, iron, calcium, barium, potassium, strontium, arsenic	manganese oxide
Caplina	Canastón 3	CA3/2/16	intense red	rump of the animal Fig. 4a	manganese, iron, rubidium, strontium, calcium, potassium	rhodochrosite
Caplina	Canastón 1	CA1/1/16	dark red	rump of the animal Fig. 3	iron, calcium, sulphur	haematite
Caplina	Llanto 3	LL3/1/16	dark red with a hint of brown	rump of the animal Fig. 5	iron, calcium, potassium	haematite
Caplina	Llanto 3	LL3/2/16	yellow	rump of the animal Fig. 5	iron, manganese, calcium, potassium, rubidium, strontium	yellow ochre
Caplina	Canastón 3	CA3/1/16	green	rump of the animal Fig. 4a	copper, chlorine, magnesium	paratacamite, atacamite, nantokite, degenerate copper compounds (cuprite?)
Atico	Honda 1	Ho1/1/17	dark-red with a hint of brown	rump of the animal Fig. 8	iron, manganese, calcium, potassium, rubidium, strontium	haematite, manganese oxide
Atico	Sorapampa 1	SP1/1/17	vivid red	rump of the animal Fig. 9	iron, calcium, manganese, potassium, strontium	iron compounds
Atico	Sorapampa 1	SP1/2/17	vivid red	torso of the individual Fig. 9	iron, calcium, sodium, chlorine	iron compounds

Table 2. *Summary of the results of laboratory analyses of colouring substances from cave sites in the Caplina and Atico Rivers basins (CA – Canastón; LL – Llanto; HO – Honda; SP – Sorapampa).*

the presence of light-green chlorides may be associated with the use of a special type of pigment or result from the aging process of the copper pigment, e.g. cuprite. Cuprite (Cu_2O) is a red-brown substance that could be present in the original paint used to draw the camelids. Under special environmental conditions, e.g. increased salinity, this paint may transform into copper chloride compounds (Naumova and Pisareva 1994; Scott 2002: 83–87, 265). Such environmental conditions are characteristic of the Andean areas of southern Peru, western Bolivia and northern Chile, where there is high salinity, as evidenced by extensive areas with layers of salt, the so-called *salares*. Within the mountain valleys themselves, salt deposition results from evaporation and condensation, which is particularly intense a few weeks after the end of the rainy season, lasting from April to the beginning of June.

Such changes, resulting in such a drastic change of colour, were found in the paintings in the Canastón 3 rockshelter, where the depictions of camelids in green colour can be noted (cf. Fig. 4), as well as in the Honda 3 rockshelter, where the camelids are brown-red. However, their ears and heads turned green with time (Fig. 26a). A similar process was also observed in the Pampa Chacra shelter (Fig. 27b). The use of pigments based on copper compounds is confirmed by other studies (Naumova and Pisareva 1994; Scott 2000, 2002; Brooks et al. 2008; Siddall 2018).

In the context of the information obtained on the chemical composition of the colouring substances, it should be noted that manganese, iron compounds (rhodochrosite), haematite, ochre and copper compounds (cuprite) are present in most of the mountain valleys of southern Peru and northern Chile, including the Río Caplina and Río Atico basins. Manganese and copper are mined in these areas, for example, at Cerro Carnaval and Cerro Pelado in the Tacna department, where cuprite also occurs. At the same time, copper, as well as the accompanying minerals and compounds — in clusters of various sizes — also occur on the surface. They were, therefore, relatively easily accessible to the Archaic Period hunter-gatherer communities as well as to the later pre-Columbian inhabitants of this region (Bellido and Narváez 1960; Petersen 1970; Acosta et al. 2011a; Acosta et al. 2011b; Torres Gonzalez et al. 2017). It should be noted that not only in pre-Columbian Peru but also in many other pre-Historic cultures of the Old and New Worlds, inorganic colouring substances (e.g. ochre) were used to highlight social status and, at the same time, were associated with rituals. Minerals and the colouring substances derived from them were often traded over relatively long distances, which makes it difficult to trace the source, especially when the material has been previously processed (Siddall 2018).

Functions of cave sites with paintings

While examining the cave sites with paintings in the Caplina and Atico catchments areas, only in the Sorapampa 1 (Escondido) cave a microlithic core and two debitages formed due to core reduction were recorded. However, studies of the other sites did not confirm the presence of artefacts or cultural contexts, indicating that hunter-gatherers camped there. The lack of traces related to the production and use of lithic tools, so commonly observed in other rockshelters inhabited by hunter-gatherer communities, suggests a different than residential purpose of the sites with paintings.

Similar conclusions have also been suggested by the results of excavations from the painted cave of Toquepala 1 in the Cimarrona stream valley within the Tacna Department (Fig. 1), where only traces of a hearth and a single blade with a handle were recorded. This contrasts with the presence of numerous relics in the neighbouring Toquepala 2 rockshelter (Muelle 1970), both on the surface and in the settlement layers, indicating that this place was inhabited by hunter-gatherer communities who made the paintings and used the cave of Toquepala 1 probably for ritual purposes. The notion that the authors of the paintings were members of the community living in the Toquepala 2 area is supported by the fact that in the lower layer of this rockshelter (layer 4), remains of

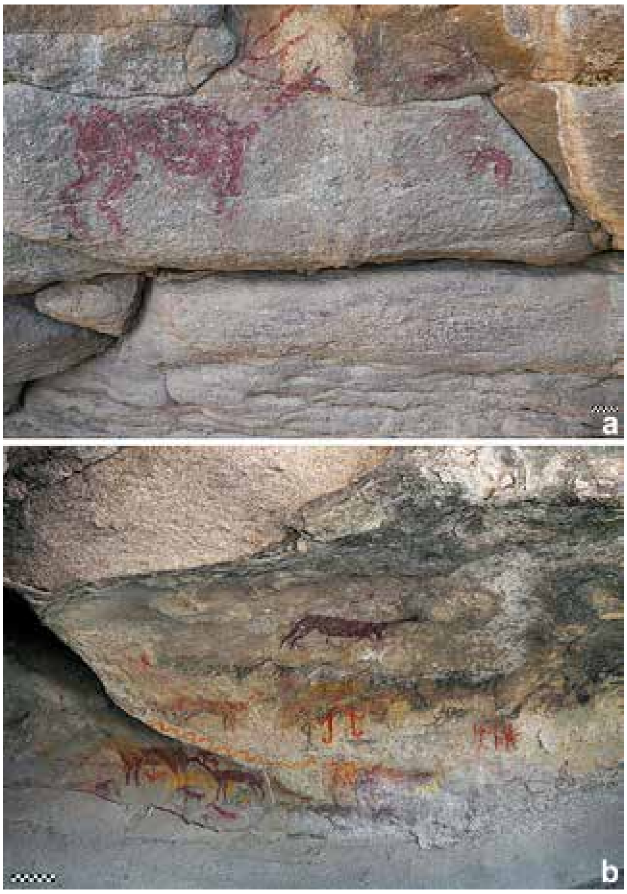


Figure 26. *Rock paintings: (a) Honda valley, Honda 3 rockshelter, depictions with traces of copper compounds oxidation; (b) Canastón 7 rockshelter in the Canastón Stream valley. Superposition of painting representations is observed.*

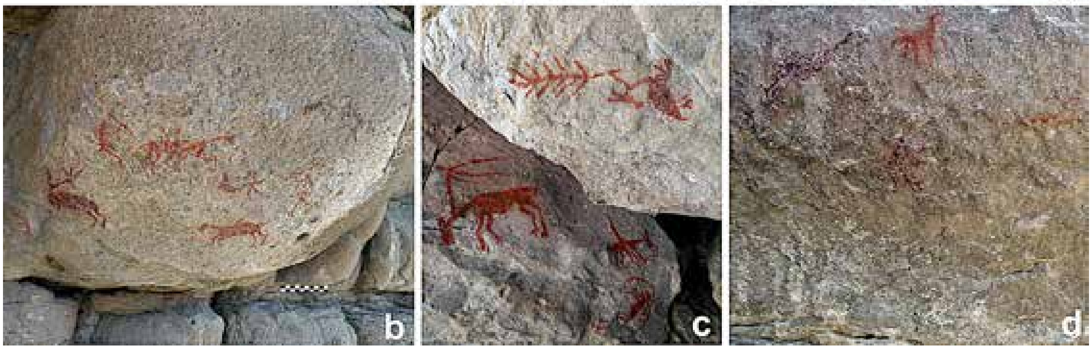


Figure 27. *Crucero valley, Pampa Chacra rockshelter: presumed narrative images suggested to illustrate hunting, killing and trapping animals in trap-ditches (a–d); (b) painting with traces of copper compounds oxidation.*

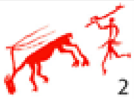
Sites / Styles	CA 1	CA 2	CA 3	CA 4	CA 5	CA 6	CA 7	CA 8	LL 1	LL 2	LL 3	LL 4	LL 5	HO 1	HO 2	HO 3	SP 1	HU 1	HU 2	PCh
 1	X		X	X	X?	X	X	X	X		X	X	X	X		X	X	X		
 2			X						X							X		X		X
 3	X	X		X	X		X			X		X		X	X		X		X	
4 								X						X	X		X	X	X	

Table 3. *Comparison of the examined archaeological sites from valleys in Caplina and Atico Rivers catchment areas (CA – Canastón; LL – Llanto; HO – Honda; SP – Sorapampa; HU – Huinllo; PCh – Pampa Chacra) with rock paintings and the 1–4 painting styles occurring in them (X = present). The order of painting styles — 1 (oldest) to 4 (youngest) — determines the chronological sequence resulting from the superposition and character (themes) of representations.*

pigments and flat stones covered with it (interpreted as the paint palettes) were discovered (Ravines 1972: 153; Szykulski 2010b: 126).

Also, within the painted cave of Pintasayoc near Ispacas, no contexts indicated the presence of gatherer-hunting communities (Neira Avendaño 1990; Jakubicka and Wołoszyn 2005). Similarly, no artefacts related to hunter-gatherer communities have been recorded in the painted Bertani 1 cave, located in the upper part of the Tambo River basin, which contrasts with the abundance of lithic material found within other shallow rock niches in this region (Szykulski et al. 2016: Fig. 23). An exception in this context is the painted Sumbay 3 cave (Cayma District), where disturbed cultural layers with lithic material were found (Neira Avendaño 1990).

On the other hand, it should also be mentioned that the remains of hunter-gatherer camps accompanied by only single paintings have been confirmed for the Toquepala 2, Caru, Churajón-Abri III and Huayllani (cf. Fig. 1; Ravines 1967, 1972; Figiel 2010; Szykulski 2010b: 118, 125–135). These were heated by sunlight during the day, which undoubtedly predestined these places to be habitable.

In light of the abovementioned findings, it can be assumed that the richly painted archaeological sites (caves and rockshelters) in southern Peru — or at least most of them — served a function other than residential. Therefore, it should be assumed that people appeared occasionally and stayed there for a relatively short time. The purpose of their sojourns may have been diversified rituals related to hunting magic, initiation ceremonies or other rites of passage. The subject matter of the paintings also suggests this.

Painting styles

The stylistic analysis of paintings from the Vilavilani region (Caplina River basin) and the Atico catchment area allows defining four painting styles/conventions (Table 3). There are also single representations or just their fragments, which cannot be related to other painting genres in terms of style. The main point of reference is the camelid and human images present in the composition of all four styles. The superimposition of paintings was decisive in determining the time sequence of styles and the order in which colours were used (Bednarik 2002: 1216).

The first style/convention ('*naturalistic style*') presents camelids as the main thematic axis (Table 3). The animals are shown in a 'naturalistic' manner, galloping or standing still, displaying visible muscle details and a characteristic head shape. They are often 'stabbed with javelins' (Figs 3, 3a, 26a), and many have visible lines around their necks, which seem to represent bolas. This group also includes the black image from the Llanto 4 rockshelter proposed to represent a Pleistocene *Hippidion* or *Equus* horse (Figs 6, 6a). On the one hand, this gives rise to speculation about this painting's age, possibly dating back to the turn of the Pleistocene and Holocene. On the other hand, it can also suggest a longer-than-expected survival of this species within the remote parts of the Andes (Alberdi and Prado 1992; Alberdi et al. 2001).

In the painting representations of the first style, the human figures are depicted using only a few thin lines. People are shown frontally, mostly statically, unarmed and not in any form of interaction with the animal. Only sporadically can we see an attempt to represent movement by showing the feet in profile (Fig. 6a, Table 3). They are also disproportionately smaller than the camelids (Figs 3, 6, 6a) and seem to be only an addition to the animal-focused imagery.

Black as well as dark and light-red colours were used for the paintings, less often also white and yellow. There is likewise a brown or brown-red colour with green inclusions, indicating deterioration of the copper-based pigment, as we can see in the paintings from Honda 3 and Pampa Chacra archaeological sites (Figs

26a, 27b), which sometimes resulted in the entire painting turning green, as may be seen in the paintings found in Canastón 3 (Figs 4, 4a).

Colour superimposition was recorded in Canastón 3, Llanto 3, Llanto 4 and Honda 1, which confirms that black, green (originally brown), dark red and white were used earlier than yellow and light-red (cf. Figs 4, 5, 5a, 8). This is also indicated by the painting arrangement in the Canastón 7 rockshelter (Fig. 26b) as well as within the Huinllo 1 (Fig. 28a) and Huinllo 2 archaeological sites, where, however, no laboratory analyses of the pigment have been performed.

The second style/convention ('*narrative style*') includes hunting scenes, with light-red and white as dominant colours, occasionally complemented by dark-red, yellow and brown (Table 3). The narrative compositions depict a camelid as a central motif, shown naturalistically and in motion (Figs 27, 28a). The second style differs from the first in the presentation of the animal head, mouth and hooves as well as its body arrangement resulting from the presented scene. Contrary to the first style, animals seem to interact with human figures or are confronted with the situation the latter caused (Fig. 27). People with 'weapons' (hunters?) and other individuals without armament (watchers/shamans?) are still shown schematically, although frequently with elements of clothing. However, they are disproportionately smaller than the animals but are expressive in nature and usually shown in motion and profile. Sometimes sexual characteristics (genitals) are marked. The paintings show 'animal hunting' and 'slaughtering' as well as 'bleeding animals stabbed with a javelin' (Figs 27a, b, d). There are also a 'pregnant female' and 'animals caught in the ditch-trap' or 'chased into snares (Figs 27a, c). The following hunters' equipment and its use seem to be shown: javelin, atlatl/spear-thrower, bolas and possibly a lasso.

Figure 28. *Huinllo valley, Huinllo 1 rockshelter: (a) depictions in various stylistic conventions; (b) paintings of style 4.*

The third style/convention ('*outline style*') shows schematic representations of people and animals made in various shades of white, black, yellow and red (Table 3). It is often difficult to define the species of the animals (cf. Fig. 8). Anthropomorphs are painted with thick lines. Contrary to the first and second styles, where arms and legs bend at the acute angle, here they are arched. Also, in the third style, sometimes genitals are painted as well (Figs 6, 9). Some of the images seem to show a dance scene with an arrangement of dance figures, e.g. in the Sorapampa 1 cave (Fig. 9). Images of the third style frequently overlay the representations of the first and second styles, as we can see, e.g. in the Honda 1 cave (Fig. 8).

Paintings of the fourth style/convention (Table 2) are made in the *contour technique*, mainly in white, less often red. The outline is usually not filled with pigment, and often line marking is used instead, i.e. the outline is filled with parallel lines (cf. Figs 8, 28b). Most of the paintings are narrative and naturalistic. The form and technique of their performance resemble petroglyphs, which in the case of southern Peru are considered to be younger than the early paintings. The people in the images sometimes show sex characteristics and elements of 'armament' and 'clothing'. The paintings also show structures seemingly intended to hold or capture game (Fig. 28b). It could be assumed that the 'scenes' of 'chasing animals into snares' depict activities related to the early stage of camelid domestication in the high-elevation puna sites of southern Peru

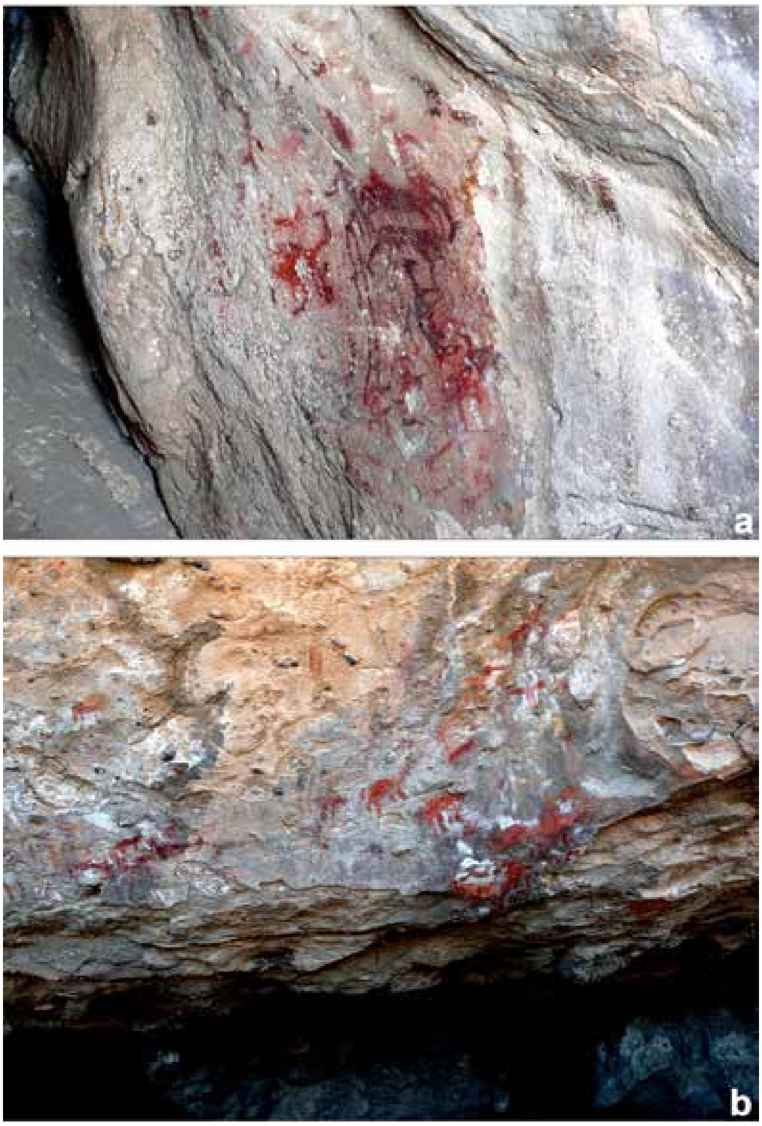


Figure 29. *Cimarrona valley, Tacna Department; (a) rock paintings in the Toquepala 1 cave, (b) rock paintings (third style) in the Toquepala 2 rockshelter.*

(*Extremo Sur*), a process which seems to date back to the mid-5th millennium BP (Kent 1987; Wheeler 1998; Mengoni Goñalons 2008: 65–66; Stahl 2008: 128–129; Dudognon and Sepúlveda 2013). Fourth-style images frequently overlay representations of the first and second styles, as we can see, e.g. in the Honda 1 and Huinllo 1 caves (cf. Figs 8, 28a). During the research, however, no overlapping between the representations of the third and fourth styles was observed. Therefore, it is impossible to determine their mutual chronological relationship.

The analysis of painting styles and their superimposition provides grounds for conclusions regarding their chronology. In light of the recorded findings, the first and second styles seem to be the earliest, showing strong similarities. This is evidenced by the apparent convergence of forms and similar narrative arrangements, such as galloping camelids with a 'javelin' stuck in their bodies or 'incapacitated' animals with a 'bola' around their necks (cf. Figs 3, 26, 28a).

It should be emphasised that the second painting style has a much greater variety of themes than the first one. As mentioned before, there are discrepancies in presenting anatomical details of animals, including the head and hooves. However, the main difference lies in presenting man-animal interactions in the second style, where people appear as the active (causative) side of the presented 'scenes'. Apart from the proposed use of javelins and bolas, they seem to use improved hunting methods, including ditches, traps and snares.

There are no grounds for unequivocal conclusions regarding the time sequence of the two styles; no superimposition was found. It should be noted that the second style includes the oldest (partially painted over) images from the Toquepala 1 cave in the Tacna Department (Fig. 29a), with the suggested chronology dating back to the turn of the Pleistocene and Holocene. Namely, radiocarbon dating results (Y-1372) of the sample taken from the hearth in Toquepala 1, located in the oldest stratigraphic layer of the cave, gave a result of 9490 ± 140 BP (Ravines 1967; Muelle 1970). However, there is no evidence of a direct link to the paintings. Other dating (Y-1325), due to the lack of evidence of the anthropogenic nature of the sample (avian guano), cannot be taken into account (Muelle 1970: 187). Nevertheless, it should be remembered that in the Toquepala 2 rockshelter, adjacent to Toquepala 1 site (Fig. 29b), flat stones with remains of colouring substance were recorded in the stratum belonging to the oldest phase of settlement, interpreted as the paint palettes used to prepare depictions within Toquepala 1 (Ravines 1972: 153). These finds were accompanied by the types of stone points attributed to the Early Holocene period (Ravines 1972; MacNeish et al. 1980: 68; Aldenderfer 1998: 131; Szykulski 2010b: 126, 127, 141–143).

At the same time, it should be stated that in the case of paintings from the Caplina River (Vilavilani region) and the Río Atico catchment areas, and those from the Toquepala 1 cave (Fig. 29a; Kauffman Doig 1983: 119, 120), the paintings in the first and second style are overlapped by the third and fourth style, which confirms that the third and fourth styles are chronologically younger in the context of the development of the rock painting from southern Peru. This opinion is also confirmed by the analysis of the paintings from the Honda 1 cave, where the representations of the third and fourth styles are also younger than the depictions in the first style (cf. Fig. 8). The time sequence of clearly different representations in the third and fourth style remains to be established. It should also be noted

Figure 30. *Yanahuara district, Department Arequipa; rock paintings in the Sumbay 3 cave.*

that the fourth style, which includes paintings in the Honda 1, Sorapampa 1, Huinllo 1 and Huinllo 2 cave sites (Figs 8, 9, 28; Table 3), can also be found among the images in the Sumbay 3 cave (Neira Avendaño 1990; Hostnig 2009: 33–38). Most of them constitute animal outlines filled with line patterns (Fig. 30). Such a depiction can also be found on the walls of the Bertani 1 rockshelter mentioned above, situated in the high-mountain zone of the Tambo River basin (Szykulski et al. 2016: 31–32).

Styles and socioeconomic changes

Considering the paintings from the Vilavilani region in the Caplina catchment area and the Atico River basin, it should be stated that despite the stylistic differences and undoubtedly different chronology, they are all the work of the hunter-gatherer communities of the Archaic Period inhabiting mountain valleys of the Andes. The subject matter of the images unambiguously indicates this, different from the paintings and petroglyphs attributed to pastoral and agricultural communities (Diaz Rodriguez and Rosińska 2008; Dudognon and Sepúlveda 2013). However, formal analysis of the painting styles allows observing significant differences that seem to reflect changes over time in people's perceptions of reality and the definition of their role in the world around them.

The first style presents human beings as static, and the second as the initiators and performers of activities. At the same time, hunting and capturing animals depicted in the scenes from the second and fourth styles seem to document the beginning of a long process of transition of archaic hunters-gatherers to the next stage of development, i.e. the domestication of camelids and the formation of pastoral-agrarian communities (Pearsall 2008: 113). In the case of the second style, it seems the animals are trapped only to be slaughtered later (cf. Figs 27a, c). Therefore, we can talk about pre-domestication at most, a process known as herd protection, consisting in protecting animal herds from predators competing with humans (Harris 1996; Ducos 1999).

The images in the fourth style show structures such as primitive fences and enclosures (Fig. 28b). This seems to indicate that these paintings are related to the stage directly preceding animal domestication, i.e. physical separation of some wild animals from the rest of the population (Yacobaccio and Vilá 2002; Gallardo and Yacobaccio 2005). However, these actions are by no means tantamount to domestication, which is defined by clear differences in anatomical structure and appearance between wild and domesticated animals (Wheeler 1998). The latter phenomenon may be exemplified by comparing the llama and alpaca with vicuña and guanaco.

We can currently distinguish between the osteological material of domesticated and wild camelids (Nuevo-Freire and Ozzán 1996; Wheeler 1998). However, it should be emphasised that such distinction concerning painted images would be extremely difficult. Despite certain attempts, we still do not have precise procedures to draw unambiguous conclusions in this regard (Gallardo and Yacobaccio 2005). Practically speaking, the distinction between wild and domestic camelids in rock paintings of the Archaic Period is currently based primarily on associations and conclusions resulting from the paintings' formal features. Thus, images classified as hunting scenes might depict wild camelids and conversely, human-animal interaction that resembles herding defines a domesticated animal.

Using such a distinction, there is no basis to claim that any of the analysed rock paintings from Caplina (Vilavilani region) and Atico catchment areas represent domesticated animals.

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