KEYWORDS: ***Cyclopean shelter – schematic art – Morphological residual model – 3D scanning***

ROCK ART IN PORTUGAL'S BORDER AREA

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Abstract. Based on new graphics surveys, several engraved rocks on the right bank of the river Erges associated with two cyclopean shelters situated in its flood bed (Tapada da Foz, Segura, and Foz do Ribeiro das Taliscas, Rosmaninhal) are presented. These occurrences, attributable to recent pre-History, document common recording techniques (pecking and abrasion) and in the case of Ribeiro das Taliscas shelter fine incisions. The shelters, with very irregular surfaces, have multiple petroglyphs, especially inside, where traditional recording techniques are very difficult to apply. The support surfaces are difficult to represent without distortion, and the engraved motifs often offer difficulties of interpretation. To overcome these, we decided to use three-dimensional scanning technology to record the engraved rock surfaces and complement this information with the Morphological Residual Model (MRM), a tool created by one of the authors (HP) that enhances perception of small and faint irregularities. This combination of techniques has great advantages over traditional methods of recording, like efficiency, objectivity, three-dimensionality, versatility and, in particular, greater portability, lower cost and greater speed of execution.

1. Introduction

This paper follows our presentation at the International Rock Art Conference organised by IFRAO in Cáceres (Spain) in 2015, in the meeting devoted to the scientific study of rock art. Under this thematic framework, other petroglyphs in open-air outcrops and in several stelae located on the plateau to the west of the river Erges will be object of future publications.

Special attention is given to two cyclopean constructions, forming small shelters (Tapada da Foz and Foz do Ribeiro das Taliscas) in the valley of the river's flood zone. In the inside of the shelters pecked petroglyphs (Tapada da Foz) and incisions (Foz do Ribeiro of Taliscas) are preserved. The constructions date, at least of the first shelter, from pre-History (Fig. 1).

The recording approach consisted of the combined

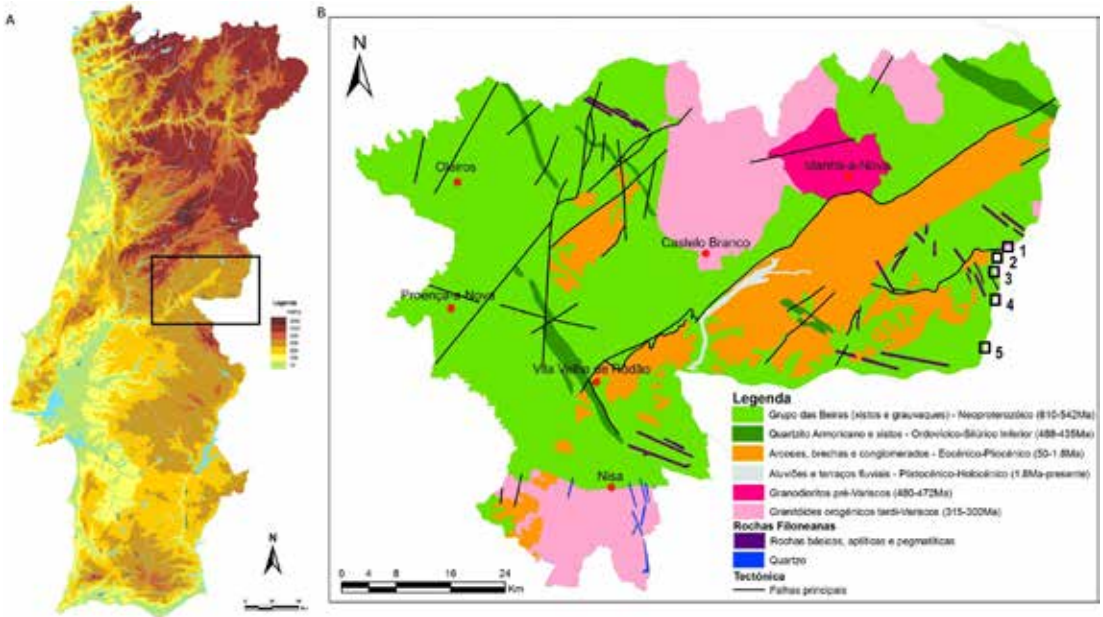

Figure 1. *Location in topographic map. Location of sites mentioned in the text in the geological map of Geopark Naturtejo (source:* www.naturtejo.com*). 1 - Segura (shelter); 2 - Abrigo Catarina (shelter); 3 - Tapada da Foz (shelter); 4 - Tremal 2 and Foz do Ribeiro da Enchacana 1 (outcrops); 5 - Foz do Ribeiro das Taliscas (shelter).*

application of photogrammetric techniques, for the three-dimensional representation of the construction of the two shelters, with morphological residual model (MRM) (Pires et al. 2014), to so depict the artwork from these two shelters. The advantages of this technique over traditional recording methods, in particular three-dimensionality, higher contrast depictions, objectivity, versatility and portability, have overcome the main difficulties in the identification and tracing of rock art experienced in previous studies (Henriques et al. 2011 and 2012).

Figure 2. *View of Erges river at Mistro.*

2. Location and environment

The river Erges, whose source is in the Serra de Gata (Iberian Cordillera Central), defines the border between Portugal and Spain for a distance of over 50 km and crosses mostly metasedimentary rocks of the Neoproterozoic (610–542 Ma). However, in Monfortinho, it breaks through a crest of Armorican Quartzite (488–435 Ma) and, next to Salvaterra do Extremo and Segura (Fig. 2), focuses on granitoids of Tardi-Variscan orogeny (315–300 Ma), forming magnificent river canyons (Rodrigues et al. 2008). In the adjacent platform overlooking the river Erges on the west side appear folds of detrital deposits from the Eocene-Pliocene (50–2 Ma) forming flattened surfaces.

This river, of torrential characteristics in winter and small flow during the summer, has a free regime except at the confluence with the River Tagus where it is submerged by the Cedillo dam. The valley, with very little human presence, has high natural and landscape values and has been partially integrated in the International Tagus Natural Park and in the Geopark Naturtejo from the Meridional Meseta, where several geo-monuments stand out, like the canyons of Monfortinho, of Salvaterra do Extremo and of Segura.

In 2007, the river Erges was evaluated for the National Plan for Dams with High Hydroelectric Potential, but was not selected for investment. In 2005 and 2007 surveys have been performed independently by two different teams of archaeologists on the Spanish bank (Nobre 2008, 2009) and the Portuguese bank of the river (Henriques et al. 2011, 2013), resulting in the

Upstream

	Right bank (Portugal)			**Left bank (Spain)**		
	Graphic typologies: painting (Segura) and petroglyph (others)					
Sites	Others	Circles	Anthropomorphs	Circles	Others	Sites
				1	•	Segura
Mansa	•					
				10	•	Abrigo Catarina
					•	Rock 6
Tapada da Foz	•	2	22			
Enchacana 2	•					
Enchacana 1	•		6			
					•	Rock 5
				1		Rock 4
Tremal 2	•	1	3			
Tremal 1	•					
				6	•	Rock 3
Ribeira Salgueirinho	•					
				12	•	Rock 2
				9	•	Rock 1
Fainina	•					
Foz Ribeiro das Taliscas	•					
Total		3	31	10	29	Total

Downstream

Table 1. *Distribution of the main graphic typologies from Erges river sites, listed from upstream to downstream. Segura is the only site with a painted motif, all others are of petroglyphs.*

Figure 3. *MRM application to petroglyphs from Tremal 2 with anthropomorphous motif, bar and semicircle.*

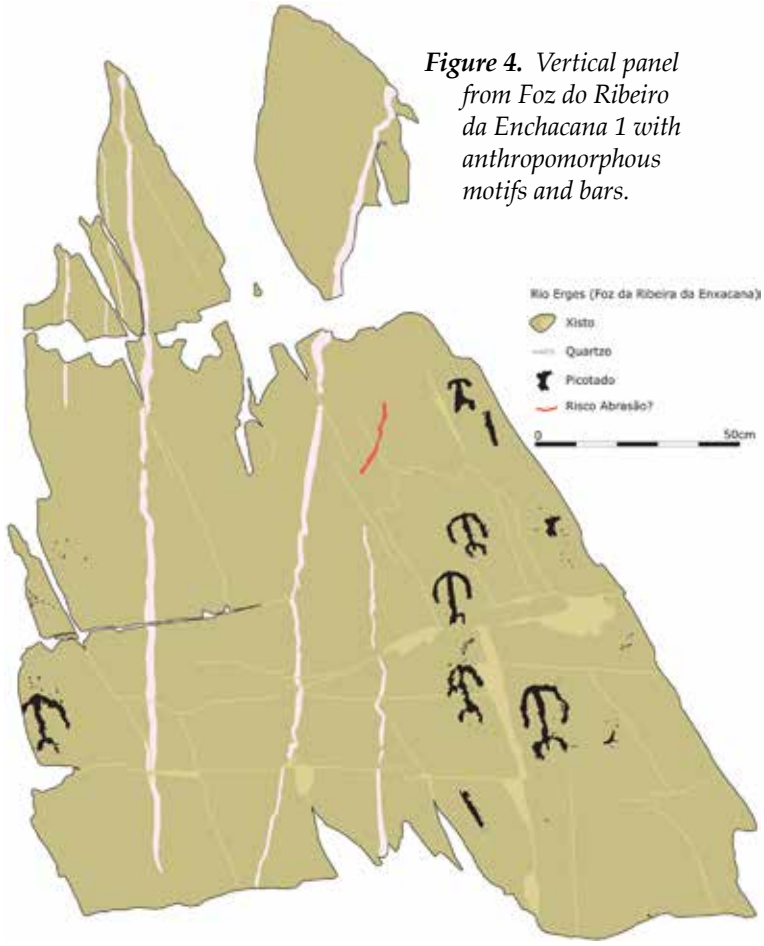

Figure 4. *Vertical panel from Foz do Ribeiro da Enchacana 1 with anthropomorphous motifs and bars.*

identification of 16 sites with pre-Historic rock art on outcrops, in a natural shelter (Abrigo Catarina) and in two built shelters (Tapada da Foz and Foz do Ribeiro of Taliscas).

The graphic symbols present in those sites are dominated (Table 1) by anthropomorphous depictions, especially on the right bank, and circular shapes, mostly on the left bank of the river Erges, which seems to represent a symbolic border. Apart from these there are also pecked 'clouds', cupules, incised linear figures, a possible zoomorphic figure and indeterminate motifs.

More recently, two panels with red paintings were discovered in a natural shelter located in the fluvial canyon of Segura (Martins and Nobre 2013), located upstream. The iconography of these panels is dominated by 'points', mostly arranged in regular sequence, and a circular figure with rays ('sun shape').

The identified petroglyphs and paintings in the lower reaches of the river Erges integrate, organically, into a wider graphic universe, of regional scale, spread over different sites and forms of representation (Bueno et al. 2009, 2011). The symbolism documented on the river Erges, mainly the circular and anthropomorphous shapes, correlates with the so-called complex of rock art of the Tagus (Gomes 2010), with the petroglyphs in megalithic graves in the surrounding region (Bueno et al. 2006), and with the painted motifs in shelters in the mountains of San Pedro (Bueno et al. 2006) and São Mamede (Oliveira and Oliveira 2012). This graphical reality is primarily anchored in a dense network of pre-Historic graves, mostly of dolmen type, in the surrounding area, in the regions of Cáceres (Bueno et al. 2006), Portalegre (Oliveira 1998, 2008) and Castelo Branco (Caninas 2012; Henriques et al. 1993).

In the group from the right bank of the Lower Erges — the study of which we are presenting here — in addition to the two shelters mentioned above we highlight the sites of Tremal 2 and Foz do Ribeiro da Enchacana 1, characterised by the presence of acephalous anthropomorphous figures and bars which we interpret as incipient anthropomorphous figures.

At Tremal 2 (Fig. 3), on an irregular and wavy sub-horizontal bench that extends from the rocky shore into the river, near a foot passage, three anthropomorphs were identified along with a semicircle, a bar and other pecked motifs, embossed on sub-vertical surfaces. In the group in Figure 3, the bar forms a pair with the anthropomorphous motif. However, we could also assume that the arched rock ledge, above the bar, might have featured a groove connecting to the upper limbs.

In the vertical panel of Foz do Ribeiro da Enchacana 1, facing the river — the only site that we recorded with the traditional method— six anthropomorphs where depicted (Fig. 4) along with two bars oriented as the trunks of the other anthropomorphous motifs. Again, this situation suggests that they represent incipient or unfinished human figures.

The anthropomorphs represented on the Erges are generally acephalous, mainly with arcuate arms, and in some cases without legs, equivalent to what is known in the rock art of the Tagus river. This is the case for figures 10 and 20 of Fratel rock F155 (Baptista 1981), for rock 50 São Simão (Baptista et al. 1978), for rock 37 Lomba da Barca (Gomes 2000), in shelters with paintings such as El Buraco (Bueno et al. 2006), in the shelter of Louções

Figure 5. *The shelter of Tapada da Foz, front view (left) and rear view (right).*

(Oliveira and Oliveira 2012), and in megalithic graves such as the dolmen of Guadancil I (Bueno Ramirez and Balbin Behrmann 2000).

The anthropomorphous figures may date from the second half of the 4th millennium and the 3rd millennium BCE, according to the proposals of António Martinho Baptista (phase II megalithic, in Baptista 1981) and Mário Varela Gomes (southern period, in Gomes 1987) for the Tagus rock art phasing. Such a chronology corresponds to significant parts of the megalithic graves in the surrounding area (Bueno Ramirez and Balbin Behrmann 2000; Cardoso et al. 2003).

3. Using 3D scanning to survey cyclopean shelters

Due to their organic, non-geometric nature, these types of shelters are very difficult to survey using conventional techniques. The shape of these constructions demands a high density sampling survey for a reliable representation, which cannot be achieved by means of measuring devices like tapes, electronic distance-meters, total station or GPS.

In recent years, 3D scanning technologies like laser scanning (LS) and photogrammetry have become more affordable and are being progressively considered a standard in archaeological studies. They can deliver the data needed to describe these complex morphologies, saving time and costs when compared with conventional methods. Although they can achieve equivalent results in terms of data processing, photogrammetry presents an important advantage over LS when it comes to reaching remote areas only accessible on foot: portability. Nowadays, all that is required to accomplish a photogrammetric scanning survey is a digital photo-camera and some dimensional references. These can be achieved in different ways, ranging from a simple scale reference to a complete geographic referencing system.

3.1. Methodology

The shelters of Taliscas and Tapada da Foz were surveyed using the same methodological approach, based on photogrammetry and structure-from-motion (SfM) techniques. Sequential sets of photos were taken from very small parallax distances in order to create a visual structure that can be later rebuilt in a photogrammetric model. The contribution of SfM algorithms has brought automation to most of the processing need to extract 3D data (point clouds) from two-dimensional sets of photos.

At the end of the field campaign we have collected about 1000 photographs from each of the shelters, at three levels of detail: the first documenting the close neighbourhood, the second providing a close-up view of the shelter's construction elements, and the third documenting the site interior.

For referencing each of the surveys we have used a set of marks painted on the stone surface that were captured in the photographic coverage and were measured using a GPS device in order to assign it to a global coordinate system. In this way we were able to calculate real world coordinates for the set of marks defining the scale and the roto-translation matrix of the photogrammetric model and, consequently, for all information produced afterwards. Although it is not of easy operation and availability, a D-GPS device can solve the problem of precise geo-referencing in remote areas.

3.2. Tapada da Foz

According to a previous description (Henriques et al. 2013), the shelter of Tapada da Foz (Fig. 5) consists of three huge slabs of metasedimentary rock tumbled as an outcrop with two uneven surfaces. The larger slab configures the front and back of the shelter while the smaller two slabs close the openings in the rear of the shelter. The cavity has a sub-rectangular plan and sub-triangular section. Beyond the entrance, oriented at 90°E, there are two openings to the outside, one at ground level, facing the east, and another high, facing south, forming a 'window'. The position on those blocks indicates that the construction is either previous to or contemporary with the petroglyphs. In this place, a mill may have existed, indicated by the presence, in the river bed, of the arched base of a dam.

In Figure 7 several planimetric and perspective views extracted from the 3D scanning campaign are

Figure 6. *The shelter of Foz do Ribeiro das Taliscas, front view and perspective from the left bank of Erges river.*

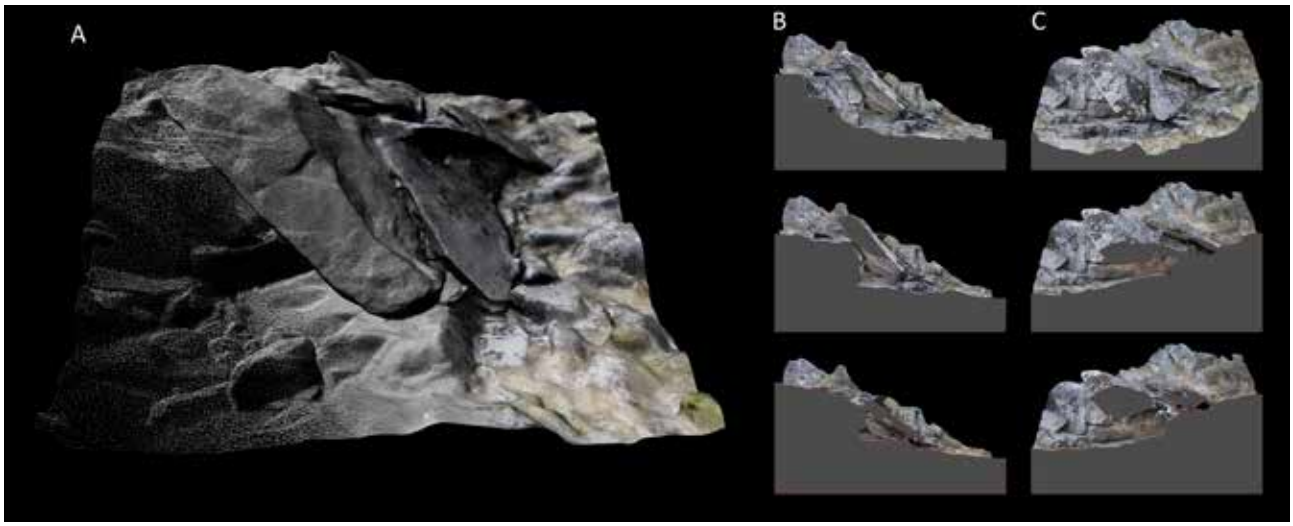

Figure 7. *Views from the 3D model of the shelter of Tapada da Foz: (A) view from the 3D model showing (from left to right) the point cloud, the wireframe model, the mesh and the final colour texture; (B) sequential transversal sections; and (C) sequential longitudinal sections.*

presented, showing the structure of the shelter. The use of the photogrammetric methodological approach allowed us to calculate a dense point cloud from each shelter (around 1 cm GSD), delivering a faithful digital representation of the surfaces that compose these constructions. From here we were able to extract different types of graphical representations, ranging from sections to interactive 3D models.

3.3. Foz do Ribeiro das Taliscas

The shelter of Foz do Ribeiro das Taliscas (Fig. 8) is located a few metres away from the river bed, at the point where the river could be crossed on a dam associated with a mill. The shelter is bordered by three huge blocks of sedimentary rock, whose layout suggests that this is a construction. The structure is based directly on a flattened surface of the bedrock. It has an entrance facing northeast, set back from the river, and another in the front position, facing the river bed, having been enlarged to facilitate access to the interior. In this place there was a rotation mill and miller's house at a higher elevation. However, it is likely that the shelter was also used for resting. In Figure 8, several planimetric views of the 3D model achieved through a photogrammetric survey are presented.

4. Combining 3D scanning and MRM to survey and depict rock art

Using the same approach as for the shelters, we have built a 3D model of each of the engraved panels with a resolution ranging from 0.2 to 1 mm, according to the depth of the petroglyphs. For the shallowest ones a higher resolution was needed to record the small morphological discontinuities that form the petroglyphs. In certain cases (like in panel 1 from Tapada da Foz shelter) this resolution was not enough to establish a clear discontinuity between rock surface and engraved motif. The use of MRM allowed the creation of images with clear depictions of the motifs related to the shape of the stone where they are located and, moreover, to create a record that can be used in the future to achieve more information than that already processed.

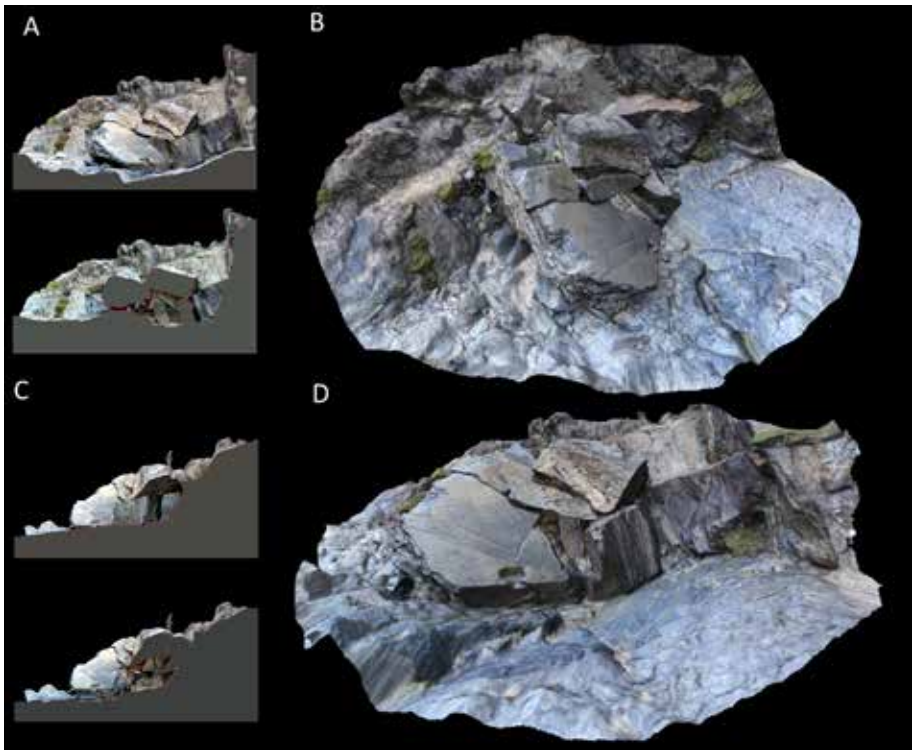

Figure 8. *Views from the 3D model of the shelter of Taliscas: (A) longitudinal sections; (B) perspective view from south; (C) transversal sections; and (D) perspective view from northeast.*

Figure 9. *Digital orthophotography from panel 1, Tapada da Foz.*

4.1. Methodology

3D scanning techniques are a new way of recording shape that is producing incredible results in several archaeological fields, from landscape to rock art. Nevertheless, we are still learning how to profit from the enormous amount of data that is being produced. A new approach that is revealing that there is a lot more data available then the one that we are using is the use of morphological trend removal algorithms to contrast subtle shapes. In the present case we have used the MRM, an algorithm developed by one of the authors (Pires et al. 2014) to produce contrasted images of the petroglyphs.

4.2. Tapada da Foz

The graphic ensemble from Tapada da Foz is distributed mainly inside the shelter but also outside it, in different positions (panels). Besides 'identifiable' figures, dispersed non-figurative pecked petroglyphs can be found. The petroglyphs occur on blocks positioned at the bottom of the cavity (panels 1 and 2), on the outcrop forming the floor (panel 3), on the faces of an opening ('window') facing south (panels 4/5, 6), on the front face of the large covering slab (panel 7), on the inner face of the same slab, on the shelter ceiling (panel 9) and on an outside surface (panel 8). In the panels located well above the ground, mainly on sub-vertical surfaces, the dominant forms are anthropomorphous. On the floor, a slightly sloped and wavy plane (panel 3), there are dispersed and grouped peck marks and cupules, but no anthropomorphs.

This group of petroglyphs was an interesting case for testing the applicability of MRM, with differentiated results according to a greater or lesser morphological discontinuity between the petroglyphs and their support, according to the depth of the percussion marks.

In panel 1, at the bottom of the shelter, figurative petroglyphs with a very shallow pecked surface were difficult to contrast using 3D scanning in combination with MRM. However, the figures, comprising an acephalous anthropomorph with bent up arms and some indeterminate forms, were successfully detected and recorded in photographs because of the natural contrast between the colour of the rock surface and the patina of the pecked motifs (Fig. 9).

Panel 2 (Fig. 10) corresponds to two sides of a rock situated at the floor level in an area of difficult access, at the bottom of the shelter under a slab that, apparently, fell over it. The application of MRM provided a good representation, although with different contrasts between the petroglyphs present on both sides. On the front face, the most accessible to the observer, the contrast provided by the MRM results allows identifying an acephalous anthropomorphous figure, trunk and long arched arms and short legs, surrounded by at least eight cupules, one above that figure, four on its left and three on the right.

The contrast is enhanced by the chromatic variation between the petroglyphs (reddish yellow) and the stone (green). The other side, facing the wall of the

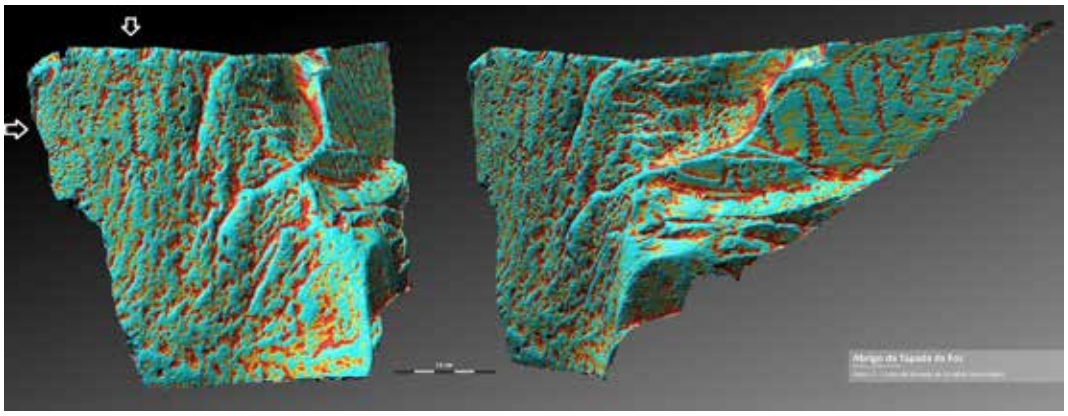

Figure 10. *MRM from panel 2; the arrows indicate the anthropomorph surrounded by cupules.*

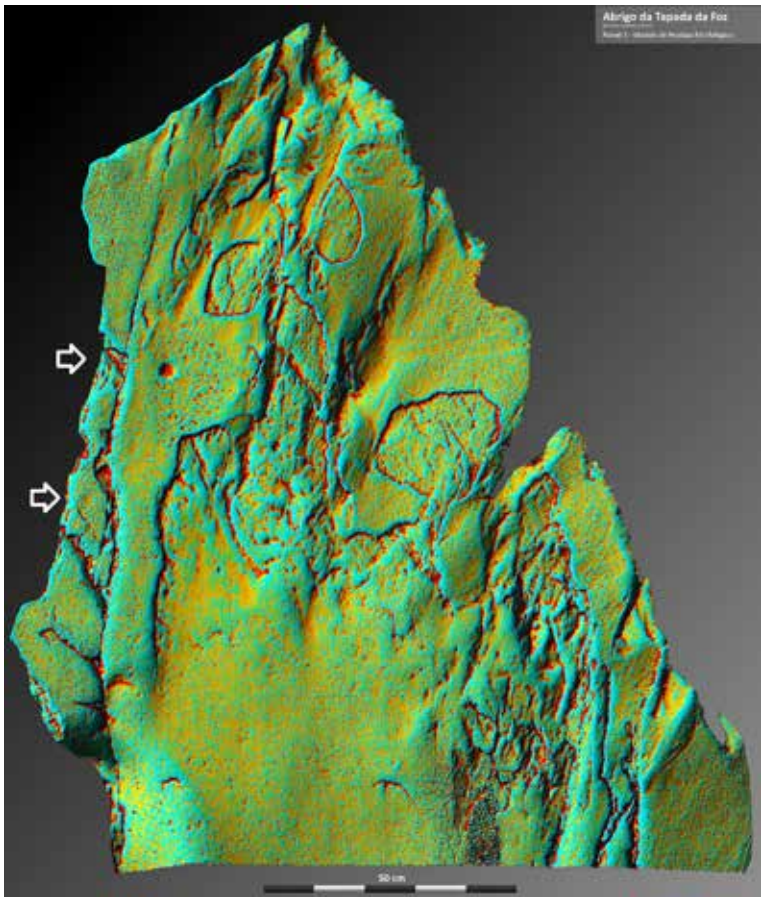

Figure 11. *Panel 3 results from MRM calculation, corresponding to a part of the floor of the shelter. The arrows indicate the position of the two cupules.*

shelter, presents four figures in sequence whose size is adapted to the shape of the panel. The smaller figure on the right may be an anthropomorph accompanied by an indeterminate figure, followed to the left by three acephalous anthropomorphous figures, the first of them showing a thicker trunk and traces of legs. MRM provided a faithful representation of the set that is in an inaccessible location for surveying methods like direct tracing.

Petroglyphs different from the previous typology were found on the outcrop that forms the floor of the shelter. The surface of panel 3 (Fig. 11) is exfoliated at several points, so that there may have been other motifs. A pecked curve-shaped area was identified, defined by discontinuous dints, inside of which was a small cupule of 2 cm diameter. Beside this pecking cloud there is another cupule (1.5 cm diameter). At another point there is an elliptic figure defined by thick and discontinuous indentations. The floor presents also dispersed pecking. The results achieved with MRM provided a faithful representation of the morphology and texture of the rock, although the contrast of shallow pecking is weak.

Most of the petroglyphs inside the shelter are on the sub-vertical faces of panels 4/5 and 6, the faces of two blocks that define a high, window-shaped opening facing south. The panels 4/5 correspond to the face that forms the right side of this window, relative to an observer positioned within the shelter (Fig. 12). They were not processed because of the difficulty of generating contrast through the MRM in very shallow petroglyphs. By naked eye, five anthropomorphs and a horseshoe-shape petroglyph could be observed, made from continuous and discontinuous sequences of dints on a rough convex surface.

Panel 6 (Figs 13 and 14), corresponding to the left side of the window, comprises several figures difficult to identify, given the discontinuity and shallow depth of indentations. These figures occur on a very smooth surface confined to the top of the rock. On the left side of the panel (Figure 13-B), there is an isolated anthropomorph with the trunk line over the arc forming the arms, which apparently is followed by two or three more anthropomorphous figures, the first of which presents an arc at the top, defined by a sequence of dints.

Other indeterminate figures follow and, appearing isolated on the right side of the panel, an anthropomorph depicted by its upper limbs and trunk. Some of these

motifs seem to profit from the arched edge of the smooth surface of the panel to complete their representation (through a suggestion of upper limbs?).

On the front face of the large block that forms the roof of the shelter there is a single figure, inscribed on a vertical plane, an anthropomorph, 5.2 cm high and wide, with head, upper limbs and trunk traced by continuous pecking. On the ceiling, which corresponds to the internal face of this block, near the 'window', was observed an anthropomorph defined by thin, discontinuous peck marks. The engraver adapted the anthropomorphous figure to fit the narrowness of this panel.

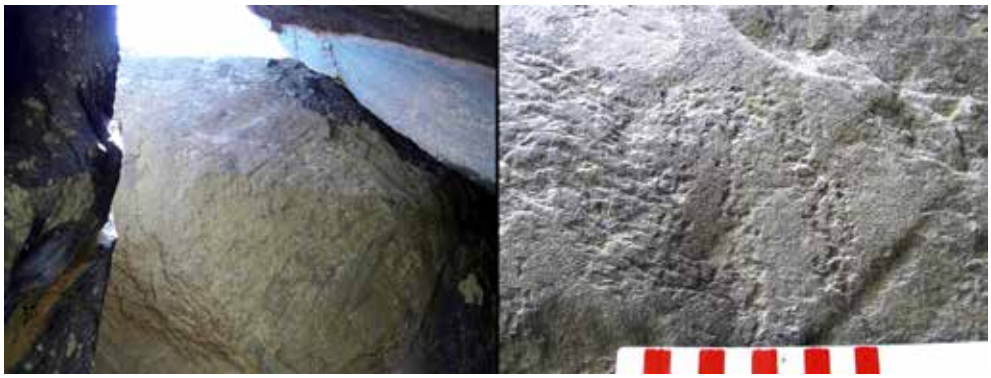

Figure 12. *(A) View of the rock surface on the right side of the window (panels 4/5); (B) detail of an acephalous anthropomorph.*

On another surface at the bottom of the shelter, over panel 2, is a circle with a central point, engraved once again by removing the original patina of the rock to create a chromatic contrast. Along the rear opening of the shelter, facing north, is an elliptical motif with a maximum diameter of 6.7 cm, made from large indentations in discontinuous sequence. Last, on the outside near the entrance of the shelter, another pecked circle was identified.

4.3. Foz do Ribeiro of Taliscas

Two different petroglyph techniques were observed in this shelter, pecking and fine incisions, apparently corresponding to different occupation times. Motifs

Figure 13. *(A) View of the rock surface on the left side of the window (panel 6); (B) detail of the engraved area; and (C) an acephalous anthropomorph.*

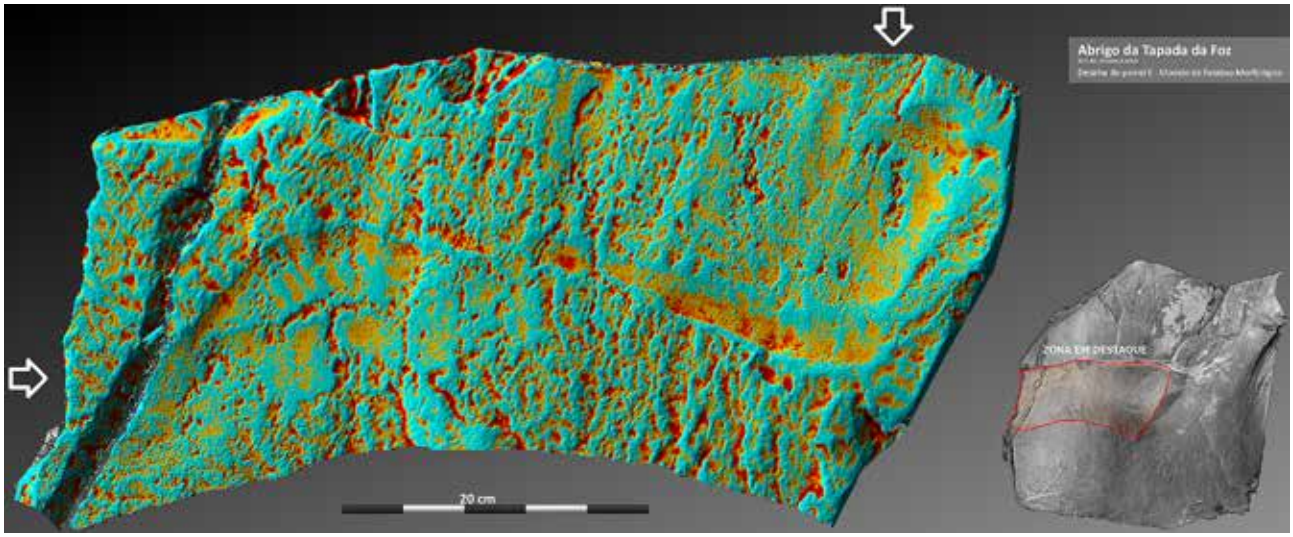

Figure 14. *MRM from panel 6. The arrow at the right side indicates the location of the anthropomorph from Figure 13C .*

made by pecking/pounding are concentrated on a large sub-vertical panel over a loose block, outside the shelter near the main entrance, and are related to the presence of a mill. These recordings consist of numbers, including dates of the eighteenth to twentieth centuries, letters and geometric motifs.

Inside the shelter, thin incisions were identified, non-figurative with multiple overlaps, located mainly on the vertical face of a block with sub-trapezoid contour that forms the wall of the northeast side. Most of these incisions have been suggested to predate the Iron Age (Henriques et al. 2012) although there is, at the top of the panel, a signature of a name, with a lighter patina, maybe of coeval age to the use of the mill nearby.

5. Conclusions and final remarks

This work focused on the study of two shelters, unique in the regional archaeological context, because they are cryptic human constructions, consisting of large local rock blocks, and thus megalithic, but nevertheless well disguised in the rocky landscape of the valley that surrounds them. Moreover, they are located at places of easy river crossing, which were used in recent times to install cereal grinding mills using hydraulic energy.

In at least one case, the shelter of Tapada da Foz, it is possible to propose a pre-Historic age of its construction. In fact, the vertical orientation of the anthropomorphs, present on different surfaces within that shelter, clearly indicates that the recordings were made on a pre-existing structure rather than natural outcrops. The question is whether the construction of this megalithic vault, whose entrance is facing east, is contemporary with the petroglyphs or older than they are. The discussion about the chronology of the shelter of Foz do Ribeiro das Taliscas is more problematic and will depend on the study of the incised petroglyphs that occur inside it. This shelter presents megalithic features that relate to the other shelter, such as the orientation of the entrance to the east and a window to the south.

The frequent depiction of anthropomorphs, very similar to each other and identical to that occurring in a natural shelter located upstream (Abrigo Catarina), and also on outdoor outcrops (Tremal 2 and Foz do Ribeiro de Enchacana 1), might suggest a ritual character for the Tapada da Foz shelter. The anthropomorphs, whether they are in a higher or lower position, are always on vertical or sub-vertical surfaces. At Tapada da Foz, the figures are more strongly pounded (greater depth and contiguity of indentations), are at the bottom of the shelter and, therefore, are less accessible. The dense group of figures on the sides of the 'window', more accessible, and adjacent to the entrance of the shelter have a discreet expression, are shallow and of discontinuous sequence. However, their perception may have been intentionally enhanced by the raking light provided by the 'window'.

Another type of engraving technique documented here consists of removing enough of the surface of the rock to generate a chromatic contrast between the well-exposed bedrock and the surrounding patina. These techniques, scraping and shallow pecking, thin and discontinuous, with reduced morphological contrast, hampered the performance of the MRM technique. This difficulty extends also to the fine incisions documented inside the shelter of Foz do Ribeiro of Taliscas.

The limitations that MRM revealed in these cases are due to the need for very high resolution 3D scans rather than to the method itself. Although the scanning technique we used allowed calculating sub-millimetre resolution point clouds of the rock surface, it was found that it was insufficient to contrast the anthropic markings with their natural support.

These graphic-symbolic manifestations are, certainly, correlated with the funerary megaliths of the surrounding plateaus, whose presence is abundant in adjacent areas, on both sides of the Tagus and Erges rivers.

Finally, we honour the artist David Almeida, recently deceased, citing a text published at *http://escritadapedra.blogspot.pt/* about the iconography of the acephalous anthropomorphs from Erges river, during a visit to these sites in the company of one of the authors (FH):

> I was watching my companions. As I followed Francisco advancing to a higher elevation, I did not see his head because his back described a perfect arc segment that hid it ([…] I estimate that the slope of the valley is about 45 degrees). With all the doubts that this thought may give rise to, I think the figuration of these acephalous anthropomorphs may come from the way that, like I experienced, when climbing the valley towards the village, these men saw each other and, thus, represented themselves.

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