A "negative" view - the post-processing enhancement of rock art digital image using Inversion Tool and Brightness/Contrast Levels – The case of petroglyphs at the lower Negro river basin, Brazilian Amazonia

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Abstract. The application of the Inversion tool and Brightness/Contrast levels displayed in the image menu of the Adobe Photoshop software, version 7.0, to the post-processing enhancement of petroglyph's digital image comprises the topic under discussion here. The rock art sample analyzed encompasses superficially abraded or superficially pounded/abraded petroglyphs on heavily weathered igneous rock surfaces, mainly meta-granites of the Jauaperi Complex, Guyana Crystalline Shield. Particularly, these petroglyphs are located on the riverine environmental context of Lower Negro River basin, Brazilian Amazonia. It was observed that this technique of enhancement improves the access to visual information concerning: (1) the identification of the morphological structures of the figures; and (2) the understanding of its chronological sequencing by enabling the perception of different weathering states (repatination rates) among figures in a panel. This preliminary experience of post-processing enhancement on the Rio Negro sample is presented here in order to make it more explicit and testable, open to criticism, comparisons and replications.

Key Words: Petroglyphs; Brazilian Amazonia; Inversion Tool; Digital Enhancement.

Resumen. El presente artículo concierne a la aplicación de la herramienta de Inversión y de los níveles de Brillo/Contraste disponibles en el sub-menu de Ajustes del menu Imagen en la Barra de Herramientas del software Adobe Photoshop, versión 7.0, para el pos-processamiento de fotografias digitales de petroglifos. La muestra en la cual estos procedimentos fueron testeados compreende a petroglifos ejecutados por abrasión superficial o percusión directa con abrasión superficial en rocas ígneas fuertemente intemperizadas. Estas rocas son principalmente meta-granitos del Complejo Jauaperi en el Escudo Cristalino de las Guyanas, insertadas en el contexto ambiental perifluvial de la cuenca del Bajo Rio Negro, Amazonia Brasileña. Particularmente, esta técnica de mejoramiento de la información visual actúa em: 1. La identificación de las estructuras morfológicas de las figuras, y 2. en la percepción de los distintos níveles de repatinación entre las figuras de un panel, lo que ayuda en el entendimiento de su secuéncia cronológica. El objetivo de esta nota és presentar los resultados preliminares de esta experiencia de posprocessamiento digital en la muestra del Rio Negro de forma explicita y testable, abierta a las críticas, comparaciones y replicas.

Palabras clave: Petroglifos; Amazonia Brasileña; Herramienta de Inversión; mejoramiento digital.

Introduction

This note concerns the post-processing enhancement of petroglyph digital photography using the inversion tool and brightness/contrast levels displayed in the adjustments sub-menu of the image menu presented in the toolbar of the Adobe Photoshop software, version 7.0. Inversion is understood as the transformation of the positive image on a negative form of itself. Basically, colors are inverted and what was brighter in the positive form becomes darker in the negative and vice versa, darker becomes brighter.

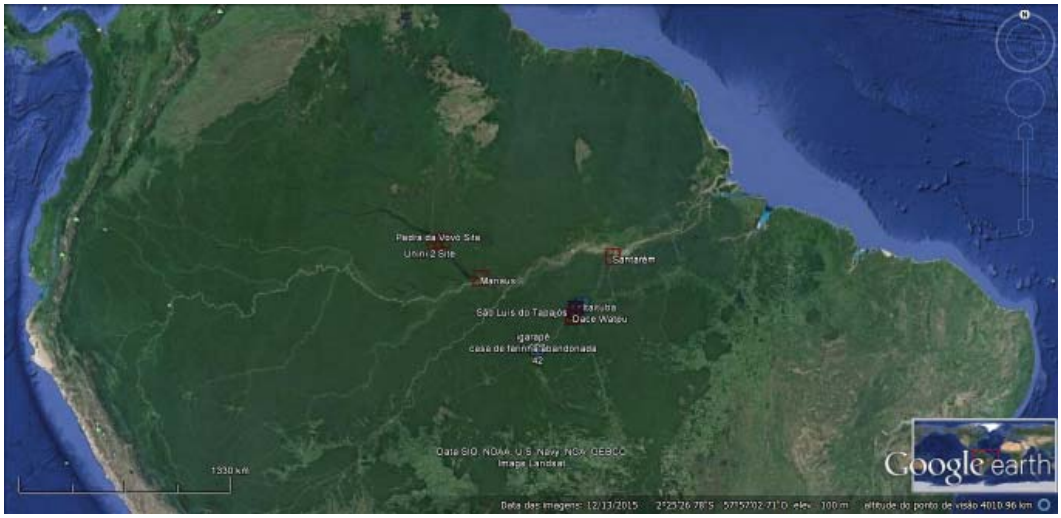
The sample under consideration comprises superficially abraded or superficially pounded/abraded petroglyphs on heavily weathered igneous rock surfaces, mainly meta-granites of the Jauaperi Complex from the Guyana Crystalline Shield of northern South America (Fig. 1).

Particularly, these petroglyphs are inserted in riverine humid tropical environmental context at the Lower Negro River Basin, Brazilian Amazonia(Fig. 2). There is no known age estimation to them and no cultural affiliation can be securely stablished, beyond a likely Amazonian Indigenous Holocene origin. Nevertheless, the sample exhibits recognizable patterns of formal attributes and a known geographical dispersion, which permits to be archaeologically acceptable its definition as a hypothetical discrete behavioral unit, the *Unini* graphic profile, or style (Valle 2012; 2015).

This graphic profile is characterized mainly by large zoomorphic figures (with an average over 40 cm in length) of quadrupeds and ornitomorphs, in several morphological configurations, shown in profile and, in many cases, expressing the indication of movement by the positioning of limbs, tails and heads. Although other kinds of 'animal' representations do occur, the types described above are the most common (Fig. 3).

Anthropomorphs, despite in lower numbers and frequency, are also present in this sample in three generally distinct configurations: (1) isolated, in frontal posture with facial traces and a dressed body; (2) in groups, with very simple and schematic forms graphically connected to each other, varying from two up to thirteen figures resembling collective ritual dancing scenes; (3) and isolated or zoomorph related figures 'playing flutes' or 'blowing on a pipe'. Sometimes, zoomorphs are also displayed holding on a long linear graphic structure, resembling a pipe, exhibiting a characteristic posture.

Geometric figures are rarely associated to this repertoire, but when they occur they are clearly less repatinated than the others and sometimes superimposed on top of the others. This suggests that they probably belong to another time frame and also to another cultural-symbolic context of visual communication, posterior in age and associated to a different graphic profile with a wider spatial dispersion (Valle 2012).



Figures 1 and 2. Satelite images of the sample area. Google Earth.

Figure 3. A typical example of Unini Graphic Profile. Rock n. 2, Unini 2 site. Photo by Raoni Valle (2006).

The sample's geological situation (i.e., the southernmost expression of the Guyana shield meta-granitoids in Amazonia Basin), environmental context (i.e., harsh humid tropical weather coupled with seasonal submersion for long periods in highly acidic dark waters - nine months underwater and three months of insolation, per year), and also its technical characteristics (slight abrasion, or slight pounding followed by slight abrasion, both techniques executed one after the other but in a superficial way), poses some problems to rock art formal analyses.

Particularly, two basic goals of rock art formal analysis are directly challenged by the factors listed above: (1) identification of the morphological features of the figures and (2) understanding of the chronological sequences through which panels were constructed diachronically that can be estimated by the different weathering states (repatination rates) among figures.

The aim of this note is to present an account on the experience of post-processing enhancement of petroglyph digital image in the referred sample, in order to make it more explicit and testable, open to criticism, comparisons and replications.

Describing the procedure

Finding Inversion Tool

In the 'Image Menu', at the superior tool bar of the working screen of Adobe Photoshop, version 7.0, it's possible to find the 'Adjustments' sub-menu and there the 'Invert' tool (Fig. 4).

Applying the Inversion Tool

Inversion is the transformation of the positive image on a negative form of itself. Basically, colors are inverted in their respective array of complementary colors. Complementary colors are pairs of colors that when combined annul each other creating grey-scale patterns, and producing the most striking contrast when juxtaposed. What was brighter in the positive form becomes darker in the negative and vice versa (darker becomes brighter). This process allows for the observation of unique perspectives on some of the image's low visible nuances (Fig. 5).

Occasionally, this operation improves the visual perception of slightly distinct patterns of textural and colorimetric variations among different weathering rates inside each technical mark in a panel's image. Field documentation and post-processing analysis have proven that this procedure is useful when applied to softly abraded or slightly pounded and abraded petroglyphs on heavily weathered igneous rock surfaces. The results obtained address the two basic problems in formal analysis mentioned before: (1) morphological identification and (2) chronological sequencing.

Calibrating the Inversion with Brightness/Contrast levels

Once the image is inverted, it is common that it is not yet adequate for visual analysis. Although, on occasion, it can bring immediate distinguishable results, usually, some kind of 'calibration' is necessary after inversion in order to emphasize and amplify its resolution. The manipulation of brightness and contrast levels has shown good results on that task (Figs. 6 and 7).

Comparing results

The observation of the figures 7 and 8 allows the identification of three (3) graphic moments: (1) the figure (s) on the top left corner, poorly visible even in the inverted/calibrated image, more likely to be the first moment, the most ancient conceptual-mechanic intervention (s); (2) the big quadruped zoomorph on the

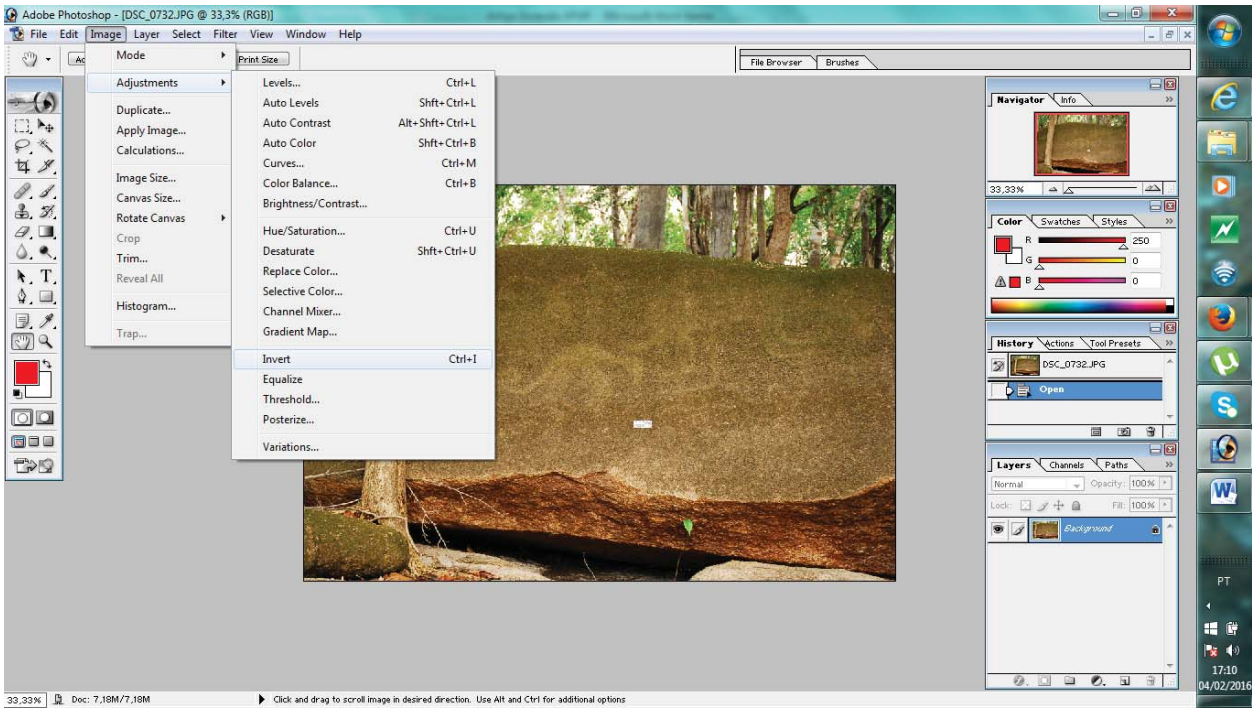


Figure 4. Working screen showing Image menu, and Adjustments sub-menu opened.

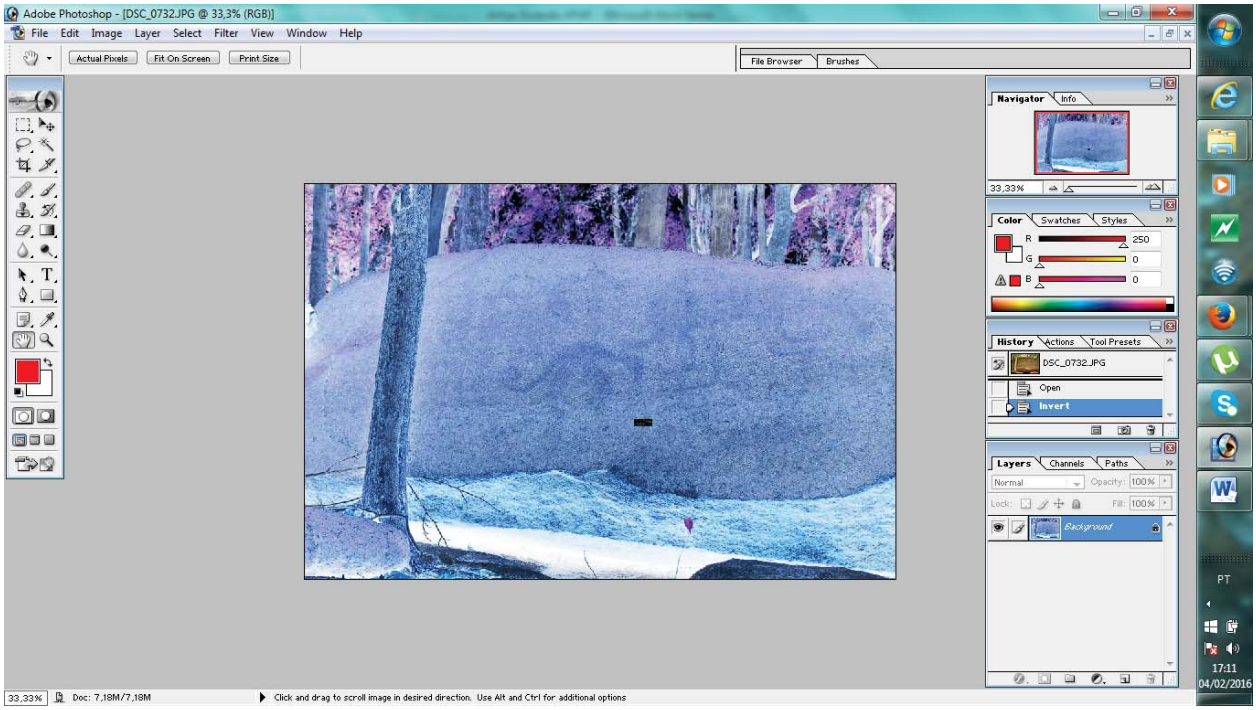


Figure 5. The inverted – negative - form of the same frame. Colors are inverted and what was lighter in positive becomes darker in the negative form and vice versa (darker becomes lighter).

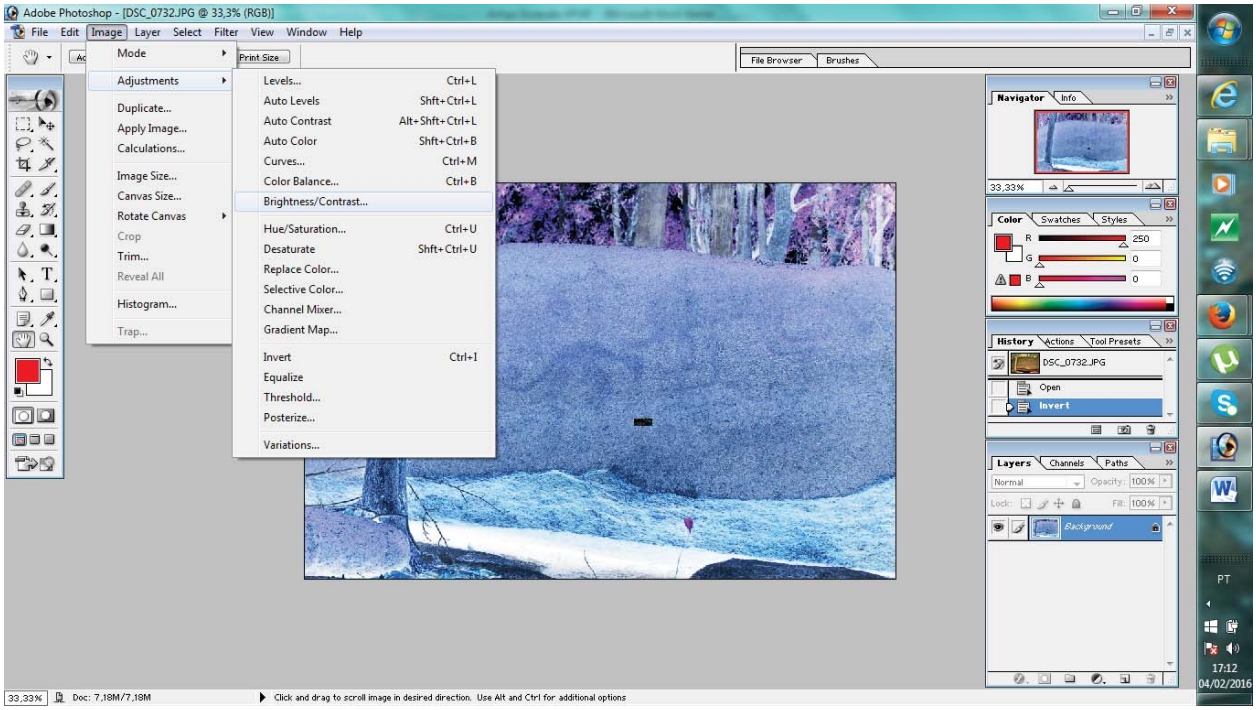


Figure 6. After the inversion comes the calibration step. Frequently, the image does not become actually enhanced just after inversion. In order to do so, it's necessary to perform a calibration step. Adjustments on brightness/contrast levels serve this purpose in a satisfactory manner.

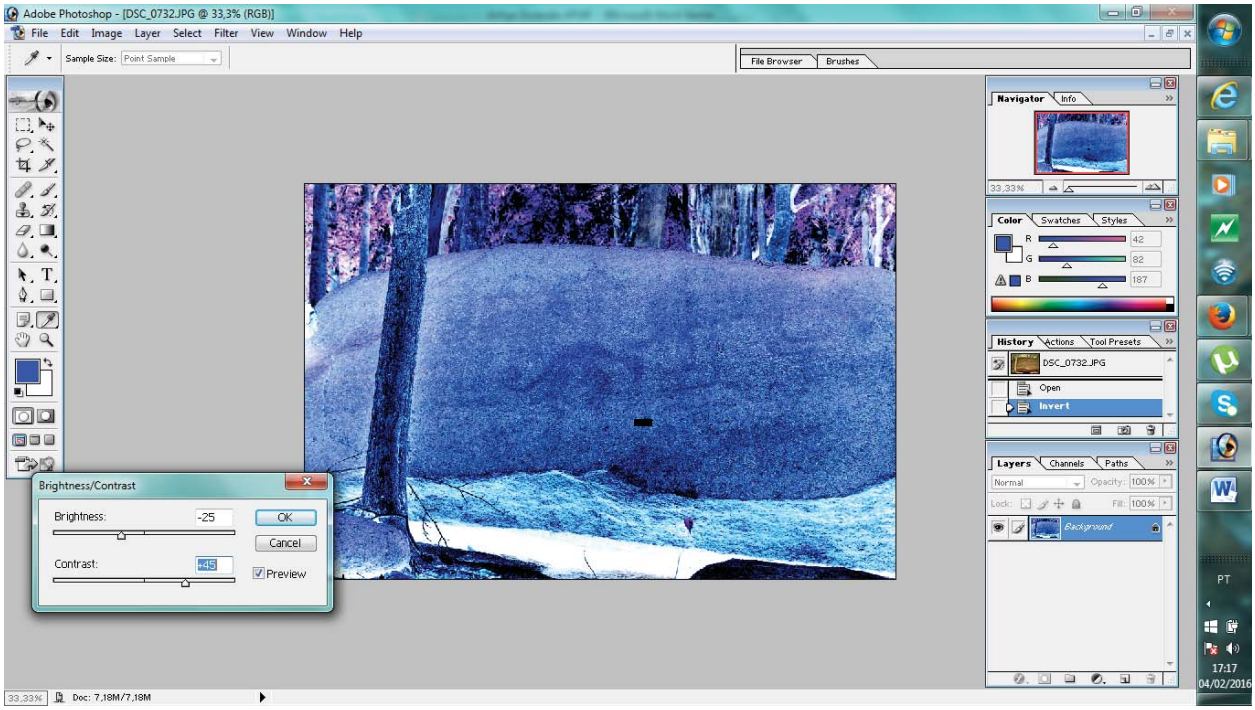


Figure 7. Calibration is in action. Image configuration was reset to value -25 in brightness and +45 in contrast.

top right corner of the panel, that can be regarded as an intermediary moment, the second graphic moment of the panel's construction; (3) a posterior, third, centralized and smaller zoomorphic element, also a quadruped, with distinctive graphic solutions for tail, head and general humped back outline. Although, it is not possible to assess the amount of time elapsed between each graphic moment, it can be stated with confidence that this panel was not made in a single moment, and that a minimum of three developmental stages with different graphic actions were necessary to stablish its sequencing and actual appearance (Figs. 8 and 9).

However, what is considered to be the last graphic moment in the panel not necessarily means the moment of the zoomorph's original fabrication. Instead, what is visible on that area of the rock surface could have resulted from a retouch action; a posterior renewal of that graphic unit. This phenomenon is widely verifiable in rock art around the world (e.g., Lorblanchet 1980) and poses some ambiguity to the indexical association between different repatination rates and different ages for the creation of the figures. Indeed, it is possible that each of these figures have several ages and (re) creations in terms of technical actions that over time intervened in the structuration, maintenance and transformation of that rock art imagery.

Finally, it is also perceptible that previously unseen figures, strongly weathered ones, became barely observable, in top left and bottom right corners of the panel. Actually, this application constitutes another goal of the procedure, that is, to reveal faded graphic presences hidden in normal day light image.

Other results – The Pedra da Vovó site case study.

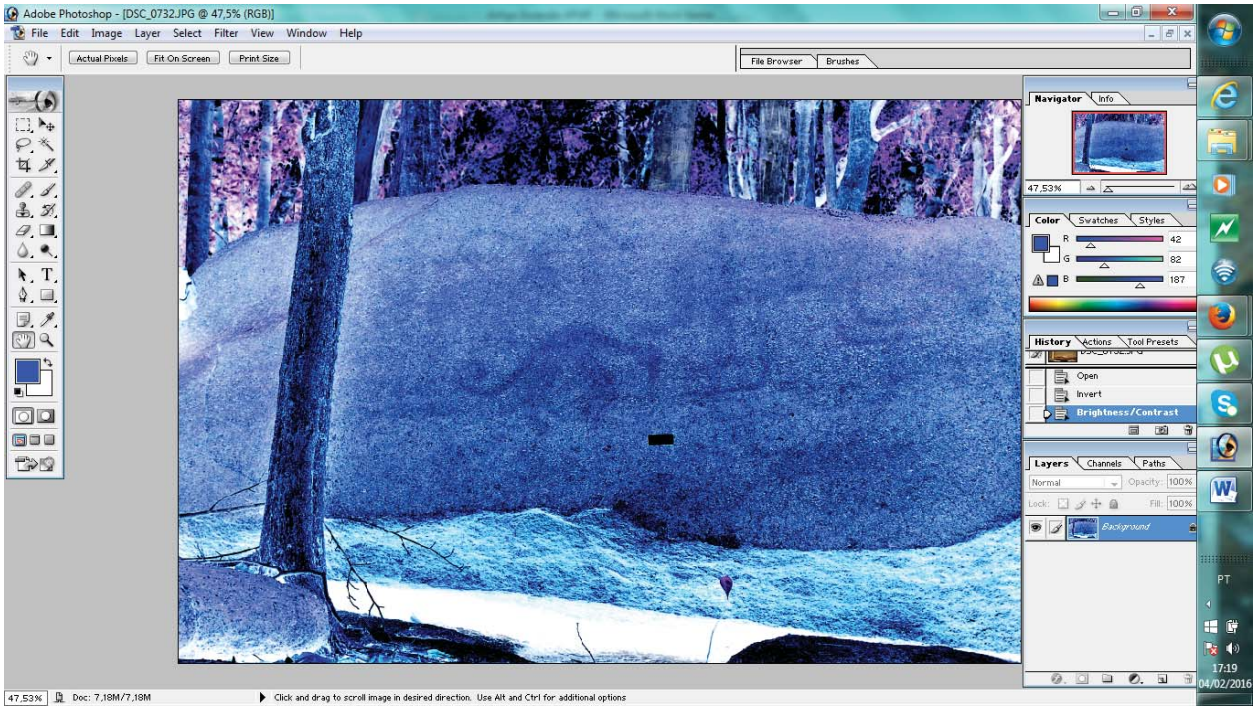
Pedra da Vovó site (PV [Figs. 10 to 14]) is a rocky island located at the mouth of the Jauaperi River, a northern tributary of the Lower Negro Basin. The rock 1 panel presents important superimpositions and differential weathering rates among its figures, which turns it into an interesting study object to understand diachronic changes in that rock art. This identification can offer evidences to broadly understand the internal historical chronology of rock art beyond the panel, which may enable further comparisons and testing inside and outside the sample.

In the analysis of rock 1 panel, of Pedra da Vovó site (Figs. 10 -14), it was possible to separate six (6) distinct graphic moments (GM) based on differences in the repatination rates (weathering states) of each figure in the panel. These states were taken as a proxy for their internal chronological sequence.

The principle involved is almost intuitive: as closer the appearance of the internal surface of a petroglyph is to the external cortex of surrounding rock surface, the older its technical actions might be. This is due to the fact that rock (re) patination is a geological phenomenon that can occur progressively, among other factors, as a function of time (e.g., Bednarik 1979/80; Mulvaney 2011).

Furthermore, it was better evidenced a radical formal change that is initially observable between GM 3 and 4, and remarkably between GM 4 and 5. GM 4 is characterized by an intentional overlap of an ambiguous geometric shape on a preexisting less ambiguous zoomorphic figure (GM 3); the intention to overlap was clear, to superimpose the ancient shape by a new and different one, based on the fact that GM 3 was highly visible during the execution of the GM 4.

The GM 5 is totally different from previous iconography on the site, zoomorphic in its rationale, indicating that it may represent a rupture between graphic systems. At this point, geometric and abstract imagery takes control of the panel's scenography as



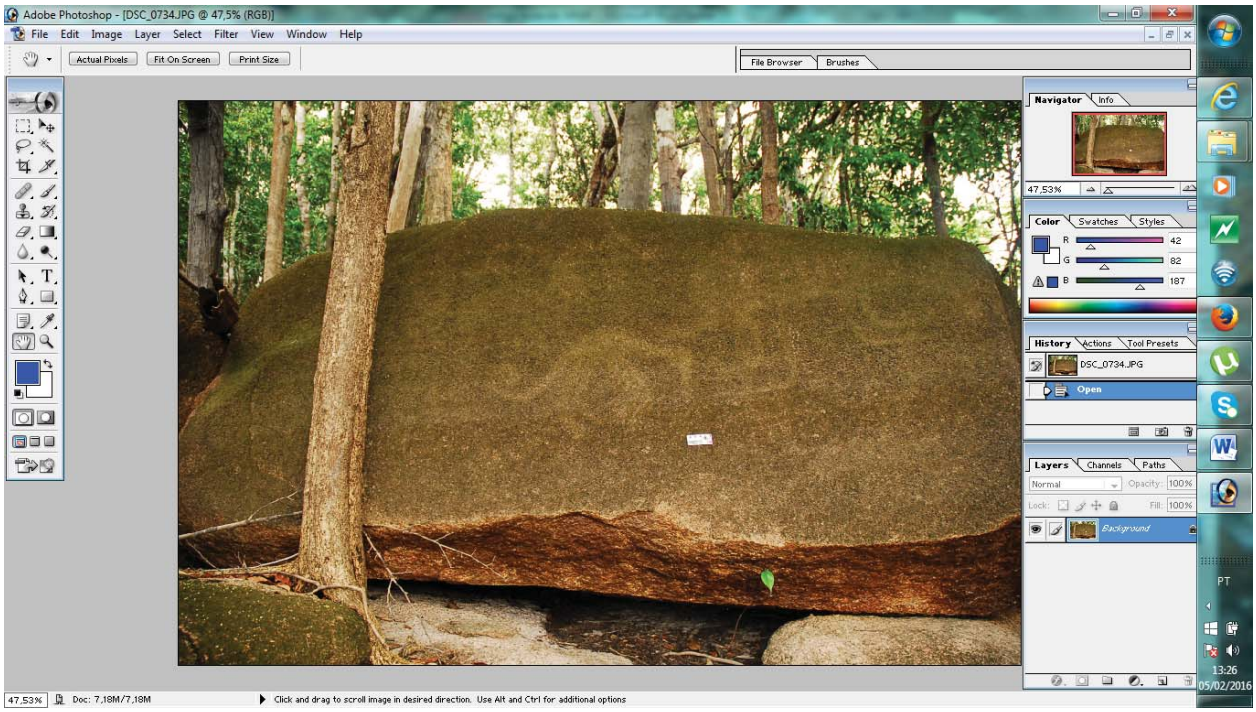


Figure 8 and 9. Inverted and calibrated image on top and its natural lightning version on bottom.

Figure 10. Rock 1, Pedra da Vovó Site, Jauaperi River, Negro Basin, Brazilian Amazonia. Photo: R. Valle, 2010.

Figure 11. The Rock 1 Panel. Pedra da Vovó Site in natural light view. Photo: R. Valle, 2010.

Figure 12. The same image after inversion and calibration in brightness and contrast levels. Basically, what is lighter is older (after Valle 2012).

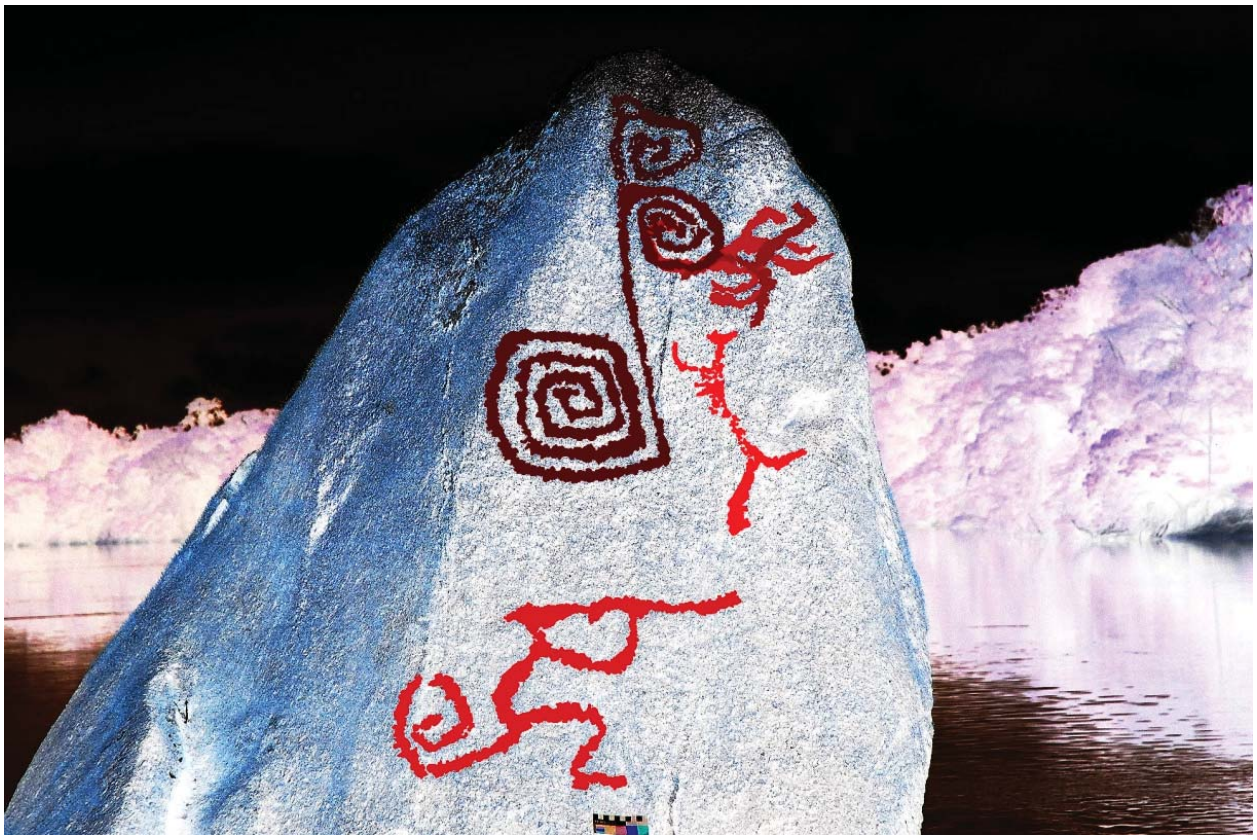


Figure 13. Using distinct color patterns (red variations) to identify and separate discrete graphical moments as suggested by differential repatination rates among the figures. (After Valle 2012).

Figure 14. Visual hypothesis concerning chronological sequencing of Rock 1, Pedra da Vovó Site, divided into six (6) graphic moments (after Valle 2012).

it becomes the most visible graphic action. From that moment on, a set of two connected and inverted semi-quadrangular spirals stayed imprinted in landscape, visually dominating the panel and not fitting in any recognizable zoomorphic canon[1]. So, it suggests social, political and ideological changes, and possibly also in belief system, that is, changes in form and content of rock art are taken to represent changes in society (Schaafsma, 1985). Consequently, it gives support to the hypothesis of a meaningful historical rupture and change taking place in that transition between GM 3 and GM 5; the kind of transformation that may be evidenced in correlated cases elsewhere in the sample, outside it, and among other archaeological variables in Amazonia. This hypothesis is currently under investigation (see note 1).

Thus, it is clear the importance of tracing (or tracking) the diachronic construction of the panels to formulate hypothesis on the chronological sequencing and morphological transformations of different patterns of rock art in sampled graphic spaces. Such procedure performs similarly to what has been known as chrono-stylistic analysis (e.g., Isnardis 2009).The understanding of such transformations of form and space over time carries some important clues to understand broader socio-political-ideological changes in Amazonian Indigenous ancient histories.

Final comments

In general, this very simple two-folded technique can be suited for building hypothesis on problems concerning visual disambiguation of morphological structures and features of rock art motifs. More specifically, it can help to understand the diachronic development of rock art panels, that is, their internal chronological sequencing. It also improves the chance to identify poorly visible/invisible figures or marks that were previously unnoticed.

However, it does not offer much help in many cases of advanced weathering states, and remains

[1] This was the case until the emergence of GM 6. This moment seems to [re]introduce an ambiguous zoomorphic component by duplicating the upper spiral of the moment 5 shape and adding a circular appendix on its top. So, in terms of a life history, or biographical account, of the panel it is observable a thematic stasis regarding zoomorphism in the three (3) first graphic moments. Then, a superimposition is introduced which acts as an obliteration of a previous zoomorph (GM 3), but also introduces a new ambiguous non-zoomorphic component over it (GM 4). After that, a clear thematic and formal rupture is introduced by the geometric motif of the connected spirals (GM 5). Then, after this thematic rupture, what initially seemed to be a simple continuation of geometric behavior (duplication of the upper spiral), actually appears to be a restoration of a zoomorphic thematic, but in a totally different style, or graphic conceptualization of the animal form. Basically, it took advantage of the formal properties of the previous geometric shape becoming just an appendix to it. The addition of this appendix seems to have converted the entire form in a sophisticated zoomorphic-like vertical shape, in which former spirals became the posterior limbs and the tail of the latter figure (GM 6). Describing this transformational trajectory opens up possibilities for interpretation regarding social and formal changes in a wider archaeological record in Amazonia. It is possible to assume that this trajectory of varied graphic transformations represent the visual history of different kinds of transformations in past Amazonian Indigenous Societies. Currently, this preliminary understanding of how these graphic and social changes are expressed by the Rock 1 of Pedra da Vovó site constitutes a working hypothesis.

dependent upon the rock art technique and the rock type. Particularly, the results are disappointing in deep marks with discernible volumetric differences and projection of shadows inside the grooves. It seems to perform better in colorimetric and textural variations than in volumetric ones. On rock surfaces more rapidly suitable to hydraulic erosion in fluvial ecosystems, like sandstones, experiences have shown that the results are not so useful and the actual enhancement is insufficient.

It was observed that weathering patterns characterized by accretionary processes are more suitable to be visually enhanced using this procedure than those characterized by erosive processes. Enhancement process depends on the survival of residual marks from the technical fabrication, left by taphonomy, slowly being covered by (re) patination phenomena in different rates. Nonetheless, something has to remain there in order to separate past technical action from the older natural cortex, as a residual informational difference. Erosion in general eradicates both surfaces: petroglyph and ancient cortex, resetting the patination clock.

Nevertheless, to some petroglyph techniques and some types of geological surfaces, this procedure, although limited in scope, is useful as a simple and preliminary device to visually disambiguate shapes, superimpositions, differential weathering and rock art diachronic development related to these two last indexes. To some extent, it offers a good starting point to non-invasive digital tracing processes of rock art panels (e.g., Pereira, Rubio & Barbosa 2013). So, it must be acknowledged that it is not a form of digital documentation of rock art *per se* (e.g., Mark and Billo 2002; Harmon 2008), just a preliminary step, a technical device that can be attached to digital documentation processes, if it is needed.

Its simplicity and ease of use coupled with rapid response allows it to be checked during field documentation, which is indeed the ideal scenario. Some cameras already come with built-in inversion dispositive. However it does not exclude later post-processing after field work. Its main purpose is to enhance conditions of visual analysis of rock art motifs and panels, not to produce a final analytical piece of evidence, but to help in the formal understanding of the evidence. Therefore, it has to be conceived as just an initial step in the process of visual disambiguation.

For the study of a specific conjunction of technology of rock art and geological and environmental factors in a Negro River sample, Brazilian Amazonia, the procedure described here has permitted some advance. Particularly, it improved the morphological identification and the discernment of slightly distinct weathering states among figures and marks, suggestive elements of their chronological sequencing. Hence, conditions for hypothesis building and testing on these fields of enquiry (morphology and chronology) were also optimized.

Digital tools to invert and control brightness and contrast in digital imaging are wide, easy and openly available. It's not necessary to depend on an expensive, private, image post-processing software to obtain results such those described here. In that sense, by no means, the use of Adobe Photoshop is a *sine qua non* condition.

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