New Procedures for Tracing Paleolithic Rock Paintings: Digital Photography

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Introduction

A fundamental part of rock art documentation work is the tracing of artistic manifestations. This consists in the reproduction of decorated sets, including artistic manifestations, as well as the reproduction of natural accidents to supports (splits, reliefs, stalagmite layers, etc.), so that their reading is facilitated (Lorblanchet, M. 1995: 113). Traces generally imply a certain degree of subjectivity, caused by several factors. In the first place, and inevitably, the perception of the researcher is always subjective. This can be seen in some zoomorphic pictures, that have been classified as different animals, by several researchers. The second factor, that contributes to the subjectivity of traces is the utilization of non-accurate reproduction systems, based sometimes on the artistic ability of the researcher.

Since the discovery of Altamira, researchers have used different procedures to accomplish tracings. The first published trace was that of the ceiling of Altamira Cave. This trace was accomplished by copying representations free hand (SANZ DE SAUTUOLA, M., 1880: Pl. 3). In the first years of this century, a technique, combining freehand drawing scaled sketching was used (BREUIL, H., OBERMAIER drawing, Hd with the s. 1935: 26).

An other frequently used system was direct tracing. For this, a transparent, plastic sheet was adhered to the wall, where the researcher reproduced the outlines. This procedure, however, could not be used on badly preserved paintings and engravings, or be accomplished on exfoliated surfaces. To avoid destruction of the representations, new systems were developed, that permited the execution of similar tracings, by keeping the sheet separated from the wall.

In a cave in Bara Bahau, A. Glory (1955: 11, cit. in.:(Lorblanchet, M. 1984: 47), used a system with transparent sheet fixed by a plate, kept separated from the wall. This kind of tracing is not destructive to the original, but it does not maintain a constant distance from the representation, and consequent deformations of the original are the result.

The use of photograph was first employed in 1893 in Chabot Cave, and researchers continued to use them, although many technical limitations, in their use, prevented the execution of acourate tracings. Photographic methods become essential in paleolithic rock art projects, with the beginning of colour photograph use. In the last decades, the most commonly used reproduction system is tracing from photographs or slides. Where paintings present defective conservation, that hinders perception, researchers can use non-visible spectrum photographic methods, such as infrared or ultraviolet photography. Tracings accomplished from photograph are much more exact than these based on traditional procedures, though they continue to depend on the artistic ability of the researcher and his collaborators.

The appearance of digital photograph techniques, opens a new route in documentation work of parietal paintings, facilitating their reproduction. Results obtained through this procedure should not be considered tracings, *sensu stricto*, because they are concentrated only on representing color dispersion. Natural accidents to the supports, that also form part of the traces, can be reproduced in a simpler way, by using vectorial drawing software, which also permits inclusion of a graphic scale.

From cave to computer: digitizing the image.

Digital vs. conventional cameras

The first phase is to take the photographs, inside the cave. The quality of the photographs will influence the following phases of the process: the greater the quality of the photo, the simpler and the faster it will be to make the tracing.

The first decision is what kind of camera to use: digital or conventional. Both kinds of cameras have advantages and disadventages. There is a wide range of digital camera models, that can be grouped to two categories: compact and reflex cameras. Digital cameras present, as an advantage, the characteristic of storing images in digital format, which permits the transfer of images directly to the computer, without previous scanning. A second advantage is the possibility of seeing the photograph, at the moment it is taken, allowing immediate evaluation of the results of the exposition, and allowing repetition of the shooting, when the photograph is bad. However, it still presents some limitations. Compact cameras don't allow the use of

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different lenses, only the built-in lens, that used to be a 35 mm. Also, it's not possible to use compensatory filters. The main problem is the low resolution of the images, that don't exceed 800x600 dots. Reflex digital cameras do not present the problems of compact cameras: they can take photographs of medium resolution (1280x960 dots), sufficient for our purposes, and the sensitivity of some models is similar to ISO-800 films. The problem that these cameras present is their high cost these days.

Conventional reflex cameras have, as their only advantage, greater resolution of the images, and the possibility of using different lenses, but it is necessary to digitize the images, using a scanner, or by storing them in a Kodak Photo-CD, which allows a maximum resolution of 3072x2048 dots.

Shooting inside the cave[3].

The results obtained, after the digital manipulation of the images, depend to a great extent on the quality of the photographs, taken inside the cave. The principal difficulty, that we encounterd, was the lighting of the objects, we wanted to photograph. Bad lighting can distort colors, because of the use of a yellow or blue-light lamps, or because the surface is not lit by a homogeneous lighting.

The use of a flash can give good results, when shooting individual pictures, located on concave or flat walls, and when the whole frame can be illuminated by the flash device. When shooting large areas, from several meters of distance, the flash is not sufficient, since it will create dark zones. This causes similar colors, that have received different quantities of light, to be recognized by the computer as different colors. In such case, it is necessary to use several white-light lamps that produce homogeneous lighting, and that do not modify the color of the photographed object.

An other problem sometimes encountered, is the presence of splits or reliefs in the wall, that can produce shadows, with lateral light. These shadows are read by the computer as dark colors, that can be confused with black pigments. In this case, it is better to use a frontal light, that produces the smallest number of shadows.

The image in the computer: optimization of photographs and execution of tracing

Used equipment: hardware and software

The work, that we will describe below, was done on a PC computer, with the Windows 95 operating system; other equipment and configurations also permit this kind of work to be done. Traditionally, Macintosh computers were most used in these labors, due to their multimedia capacity, earlier missing in computers based on MS-DOS system. The appearance of new PC equipment, with new graphic cards and, especially, new operating systems, have made the incorporation of this platform to the multimedia world possible. With regard to software, there are on the market several photographic, retouching programs, the Adobe PhotoShop™ and the Corel PhotoPaint™ being the two, most well-known. Both can acomplish most of the operations, that we will describe below.

Optimization of the image

Optimization of the image constitutes the first stage, in the manipulation of the photograph, and consists in the obtainment of a new image, where the painting appears clearly contrasted, upon the wall, and even upon stalagmitic crusts. The steps to follow, to optimize the original image, depend on its quality, but mainly, on the colors of the painting and the supporting rock. In black paintings, accomplished on a clear wall (for example, the paintings of Las Chimeneas Cave), modifying parameters, such as brightness, contrast, or intensity is sufficient. These changes can be accomplished in a general way, for all of the image, or in a selective way, in some of the color channels. This system is limited, since it is necessary to begin with a high quality image, with high contrast, while for figures with conservation problems (where it is very difficult to see the pigment), this procedure practically lacks usefulness.

On images, without much contrast, we experimented with the manipulation of one or more color channels. This procedure consisted in dividing the original image to several channels, in one of which the pigment appeared clearly contrasted. This function presented some differences in the programs, that we handled. Adobe PhotoShop™ worked with images in three color modes: RGB (red, green and blue), CMYK (cyan, magenta, yellow and black) and Lab (luminosity, green to red component and blue to yellow component). Corel PhotoPaint™, in addition to the two first color modes, worked also with the modes HSB (hue, saturation and value), HLS (hue, luminosity and saturation) and YIQ (fig. 1).

The main factor, that determined the way we worked was the color of the painting. Generally, the red paintings appeared very contrasted, in the magenta channel of the CMYK mode, and in the channel "a" (green to red component) of the Lab mode. The example, in figure 2, is a deer, painted in red. The best preserved lines are the croup, buttocks, and the back of the stomach. The rest of the figure is badly preserved, and difficult to see.

To accomplish the tracing, we proceeded, firstly, to optimize the original image. For this, we converted the image into Lab mode, and selected the channel "a", where there appeared an image, in gray scale, with the red pigment indicated by a clear gray tone, on a dark background, which coresponded to the zones of the wall, where there was no red pigment (fig. 3).

To increase the contrast of this image it was necessary to adjust the levels, darken the shadows, and clarify the highlight zones. This generated a new, much more contrasted image, that could be inverted, to create a distribution map of the color. In this new image, we could see clearly other

[3] Some of the ideas and conclussions we show below about shooting inside the caves, were born during our collaboration with Takeo Fukazawa and his team of Texnai, Inc. (Tokyo), while we were shooting for the "Photo-VR Iconoteque. Paleolithic Arts in Spain" project in 22 caves in the north of Spain, under the direction of César González Sainz. The photographs we include in this article were shooted by Takeo Fukazawa, to who we want to thank his collaboration.

outlines, that in the original image were difficult to see: the complete back, the antlers, almost all of the stomach, the beginning of the front train, and traces of what might have belonged to the head. Also, there was a red outline above the animal, that could be interpreted as an arrow (fig. 4).

The proccess, for optimizing images inblack paintings, presents some problems that are not presented in the process for red paintings. The main problem is lighting. The appearance of shadows in the image, due to the presence of splits or reliefs in the wall, produce dark zones, that the computer is not able to differentiate and that don't permit the executing of a tracing, in an automatic way.

Optimization, of black painting photographs, is not usually as complicated as is the case with red paintings. Generally, in very contrasted paintings it is sufficient to increase the brightness and the contrast, after which, it is possible to select a color range, that includes all the black tones that appear in the painting.

If manipulating the brightness and the contrast of the image is not sufficient, it's then possible to work on color channels. Black paintings appear very contrasted on the black and cyan channels in the CMYK mode. They can be manipulated on one or both channels, to obtain a new image (with not-real color), where the pigment of the support is emphasized (fig. 5).

Tracing Execution

When optimum quality of the image was obtained, we made a tracing of the painting from the optimized image. The process consisted, simply, in converting an image, that could have had up to 256 gray tones, to 16 million colors, into a new black and white image, or bitmap. All the programs, that we used had this command. However, its utilization, with the kind of images we were handling, was not possible for our purposes, since the process can convert many zones of the image, that do not contain painting, to black.

To heighten the paintings against the color of the wall, we experimented with several procedures: substituting the color of the painting with black, duplicating zones into a new image, retracing painted zones with the color black, and creating a new image, by selecting the painted areas, using the "magic wand" tool. However, none of those procedures gave acceptable results. The two best tools, which gave the best results, were "Treshold" and "Color Range".

Using the "Threshold" tool

The Threshold tool allowed us to increase the contrast in one, gray scale image, creating a new image in black and white. This tool permited us to specify what tones we wanted to convert to black, or to white, while defining the threshold among both. All the pixels above this limit were converted into black, and those below, were converted into white.

In this way, from a gray scale image, where the pigment was contrasted, it was possible to obtain a reproduction of the painting in black and white, erasing the pixels, corresponding to the support. In this new image there appeared, in addition to the painting, remains of shadow zones, that could be erased manually, with the "Eraser" tool. In this way, we obtained a tracing from the deer of El Castillo Cave, where some details appeared difficult to see in the original image (fig. 6).

Using the "Color Range" tool.

The "Color Range" tool allowed selection of one, or several, color ranges, in two ways. One of them offered different, defined ranges in the program: highlights, midtones and shadows, for the images in gray scale, and colors of the RGB and CMYK palettes for the 16M color images. In the second procedure, the user defined a range, by choosing a central color, that had to be selected with the "Eyedropper", and indicating the range to be defined by this color, adjusting the "Fuzziness" value. This, second way, is useful for true color images, when the "Threshold" tool cannot be used (fig. 7).

After we selected the color range, we could copy it onto the wallpaper, and paste it into a new layer of the same file, or into a new image. This system was very useful in photographs, where the painting was strongly contrasted to the color of the rock. The advantage of this method, compared to the previous, was that it permited us to accomplish a tracing that showed the different tonalities of the pigment.

Afterwards, we could convert the image to white and black, or to gray scale. The zones that did not belong to the painting, and that also appeared in black, could be easily erased. We recomend that this operation be executed while having the original image on the screen (fig. 8).

Conclusions

From the obtained results, we reached some conclusions. This procedure allowed the execution of very accurate tracings of the paintings, on which we worked. This means that these tracings could be used, for example, in the stylistic and authorship analysis. We think it's not useful to use in this kind of studies traces, performed through traditional methods, because these procedures have a certain degree of distortion. In the second place, it is possible to make a tracing in less time, than it takes using traditional methods.

We must be conscious, however, of the limitations of the procedure. The interpretation of the archaeologist is indispensable, and, from that point of view, a subjectivity factor is introduced. However, this factor is less than with other procedures, since some subjectivity factors are eliminated, especially with regard to the artistic ability" of the researcher.

With this article, we intended to introduce the numerous possibilities offered by digital techniques of photographic manipulation, in the research of rock art. The method of working, which we have described, should not be considered the only method, nor the best, but onlu one example of the advantages offered by this procedure. In fact, other researchers on rock art are getting similar results, using different procedures. We do not propose, therefore, a single way work, but we intended to show a new methodology that, doubtless, will be highly employed in rock art studies in the coming years.

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