

Application of GIS to images and their processing: the Chiribiquete Mountains Project

1 Introduction

The Department of Prehistory and Archaeology of the Universidad Autónoma de Madrid was invited to take part in the expedition to the Chiribiquete Mountains (Colombia) in 1993 in collaboration with the Royal Botanical Garden of Spain and the Inderena (Carlos Castaño) and the TROPEN-BOS (Thomas van der Hammen) of Colombia. The territories studied in the course of this expedition are located in the states of Guaviare-Caqueta in southern Colombia. The area lies at the confluence of the rivers Apaporis and Ajaju, in a mountain range comprising high plateaus of enormous biological and archaeological richness which break the monotony of the jungle landscape. The archaeological evidence consists primarily of the remains of dwellings and in particular, of over 34 caves with traces of paintings.

2 Documentation work

On this expedition in addition to surveying the mountain range as a whole, we started documenting the pictorial remains in a number of caves. This work was carried out under very severe conditions which meant that the study needed to include the most appropriate systems (photogrammetry, transparencies, etc.). The material we used for documentation had to be carried over long distances and sometimes to sites which were difficult to reach. For this reason we restricted ourselves to photographic and videographic materials. Mosaics of the panels were recorded photographically on slides and high definition paper, and several sweeps were made with a VHS video camera. The work covered a total of five caves.

In addition to the pictorial remains a number of test pits were cut in different caves in order to discover, as far as possible, the type of occupation and its chronology.

The evidence provided by these test pits indicated that the caves were occupied intensively over the course of time, but in no case for prolonged periods. Of the dates obtained by Professor Van der Hammen for the surface levels of the Abrigo del Arco cave, in which a sequence of datings was documented which included datings from 1375 BP at 10 cm from the surface, the most important one is of 5560 BP on a hearth structure and 23,650 BP at a depth of 35 cm, although these fire levels may relate to fortuitous fires.

Despite the data obtained, we share the opinion of various authors who are working in more southerly contexts, who do not put occupation of the area before 8-10,000 BP (Ms María Pinto Nolla and Mr Gonzalo Correal *pers. comm.*).

3 Description of the pattern of sites and the significance of the pictorial evidence

It would seem that the work aimed at documenting the possible areas of population will not be very fruitful, given the pattern of settlement adopted by these very nomadic groups with a hunting-gathering economy.

Furthermore, the areas in which the pictorial remains are found do not appear to present sufficient resources to support a population, even a small one, with a way of life that was at all sedentary. However, the documentation of a possible occupation of the located caves would seem to be a virtually essential task in that it might bring to light remains which would enable the paintings to be associated with particular remains or levels.

Let us analyse some of the characteristics of this art. The paintings usually appear in wide-mouthed caves that are not very deep but that are difficult to reach as they are high on the plateaus. Moreover, the motifs usually appear in groups, isolated images being very rare. Finally, and in the absence of subsequent analyses, the pictorial remains seem to point towards corridors or broad watercourses going through the mountain range.

As far as an analysis of the style and subject matter is concerned, the most significant features can be summarised in the following points:

1. The subject matter and scenes are very crowded together and superimposed on each other in some of the caves, as in the present case. The distribution of the pictorial motifs in each cave displays a degree of intensity related with height. The subjects become scarcer at a height of more than 2 m, and are much more abundant lower down. There are, however, caves in which the pictorial density is low.
2. In a first assessment of *style*, the existence of many different styles and qualities can be seen within similar

technical processes. So far the basic characteristics display the predominant use of flat monochrome colours, around which a line has normally been drawn with the figure coloured in (normally associated with paintings of jaguars). The motifs are painted in styles which range from the entirely naturalistic, through the semi-naturalistic, to more infrequently found abstract images or symbols.

3. The subject matter is of a very varied nature. The most notable subjects include:
 - Naturalistic/semi-naturalistic pictures of animals. Amongst these the following species are most frequently depicted: jaguars, deer, tapirs, snakes, birds, porcupines, monkeys, insects, etc. In some cases it is possible to see that scenes have been depicted.
 - Semi-naturalistic schematic depictions of anthropomorphic characters. In general these are not isolated figures but are depicted in very varied narrative associations. Prominent amongst the scenes created are hunting scenes and those which show collecting fruit of the palm tree, carrying food, dancing, fighting and motifs related to fertility.
 - Naturalistic and semi-naturalistic paintings of plants. Normally the paintings allude to the palm tree, either on its own or as the seed in germination, a clear reference to the idea of fruitfulness or fertility.
 - Symbolic images of different kinds. Dominant here is the appearance of hand prints, in some cases in clear association with examples of fauna (a number of hand prints around naturalistic figures of animals). Another type of element is a serpentine shape, drawn with a point technique, in this case very close to the idea of enclosures or nets.

4 Application of GIS to the study of evidence from the Chiribiquete Mountain range

As we said in the introduction, there are two fundamental problems in carrying out a study of the pictorial remains found in the Chiribiquete mountains. The first is the lack of cartographic information relating to the area which would enable a proper spatial study of the evidence found to be made. Our intention in this respect is to create a Geographic Information System in which we will integrate the altimetric restitution of the area on the basis of existing radar bands, or from satellite photographs. Once we have maps we can integrate the archaeological information into a system which would allow an analysis of the spatial relationships of the data to be made, including the subject matter, style, etc. of each cave.

This brings us to a second problem, and that is the enormous quantity of pictorial data in each of these caves.

As we have said, there is a style common to all of them, which demonstrates a simplified technique that uses a single type of pigment existing in the surrounding area. With the passage of time an enormous variation of tones has been generated in the pictorial remains.

In this paper we shall describe the methodology currently being developed to try and analyse and order the registers obtained in each of the caves, concentrating on the specific example of the main panel in one of the caves: the Abrigo del Arco cave (fig. 1).

5 Work process

The work of integrating and processing the evidence was carried out within the ARC/INFO program (particularly its GRID module), because this was the program we were already using for integrating the spatial information relating to the sites. The work is being carried out on an IBM RISC 6000 workstation, an IBM 486DX2 and an HP ScanJet IIC scanner.

As we said earlier, the documentation at our disposal consisted of a photographic mosaic on slides and paper, which, including a size scale, took in most of the pictorial evidence in each cave. The work of recording began with the organization and assembly of a continuous image. To do this, all the photograms on paper were integrated using a scanner. At the same time the images were married up and distortions corrected. It was possible to carry out this task using the Geographic Information System itself.

These operations were carried out by assigning control points and defining 'links' that would enable them to be combined, and a single integrated image was obtained in the system. The next step consisted of producing vectorial information for each of the elements represented. To do this we initiated the process of digitalization from the screen.

We have opted for the process of manual digitalization (fig. 2), as the automatic processes, in our case, did not produce satisfactory results because of the crowded nature of the elements in particular areas of the panels and the state of the material on which they had been painted.

At the end of this process we had two data bases: a raster graphic data base in the form of separate integrated photograms, and a graphic data base of the same material in a vectorial format. The process of creating a topology using this latter base was carried out with the following fields:

1. subject – subject matter divided into options (animal, vegetable, human, symbolic or unknown).
2. style (naturalistic, semi-naturalistic, schematic).
3. green (component of green of the red-green-blue (RGB) of the image).
4. stgreen (standard deviation of the values relating to green).



Figure 1. The main panel in the Abrigo del Arco cave.

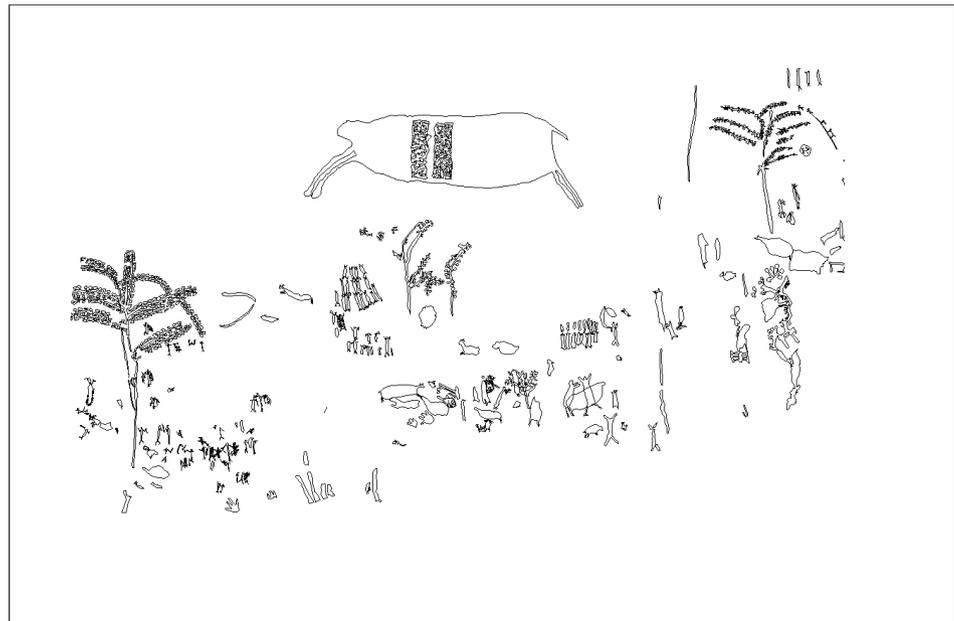


Figure 2. Manual digitalization of the main panel in the Abrigo del Arco cave.

5. red (component of red of the RGB of the image).
6. stred (standard deviation of the values relating to red).
7. blue (component of blue of the RGB of the image).
8. stblue (standard deviation of the values relating to blue).

Next we cut out the image (raster format) using each of the elements represented in the polygon overlay (vectorial

format). To do this it is necessary to isolate each of the polygons present (fig. 3), convert it to raster, and cut it out using that grid, the one of the original panel. The use of AML language macros within ARC/INFO proved indispensable to us.

Having cut out the images, they were broken down into the basic colours present in each of the figures. To do this

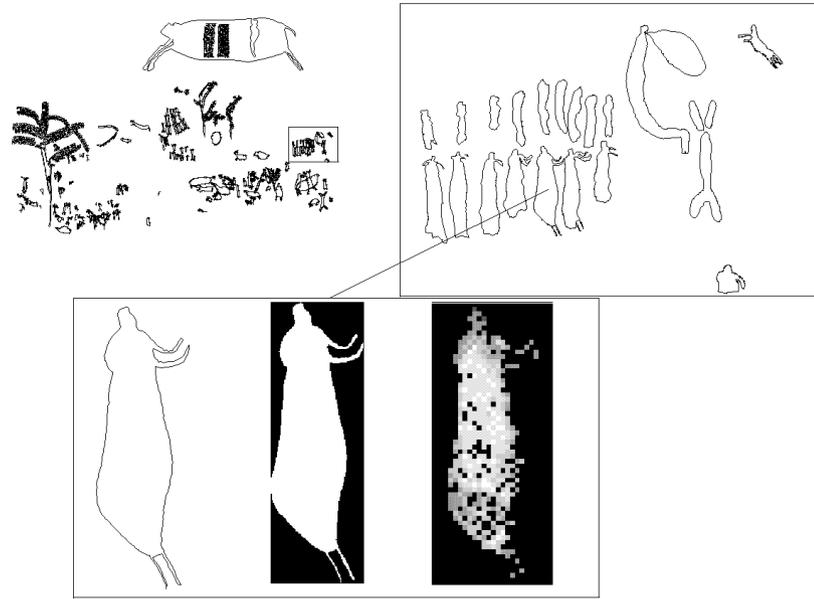


Figure 3. Cutting out the images (raster format).



Figure 4. The polygons resulting from the selection of different value intervals for three colours (red-green-blue).

the program averaged out the general values of the cut out whole element. The values taken apart are expressed in averages and deviations in each of the basic colours. These values are entered into the data base of the overlay with vectorial information.

Once this information has been recorded, analysis of the motifs represented begins. The choice of intervals and different statistical procedures will make it possible to

establish distinctions between the figures depicted and the consistent nature or otherwise of some of the groups. The answers obtained can be defined as follows:

1. The system enables the existence or otherwise of stylistically and thematically homogeneous groups to be confirmed by statistical analysis, yet to be carried out, of the chromatic value. As an example we will show some



Figure 5. In addition to the complete group, selections can be seen corresponding to animal, human and vegetable figures respectively.

preliminary results. In figure 4 we show the polygons resulting from the selection of different value intervals for the three colours (red-green-blue). It can be seen how the thematic groups are broadly differentiated in each of the selections.

2. It also enables the existence of different phases in the analysed panels to be evaluated. A relative chronology can also be established (the parts painted earlier and the parts painted later) in the groups, although this ordering should be seen purely as a guide.
3. Because it is part of a GIS, the program facilitates the analysis of the spatial relationship between different groups or phases and the discrimination of the chromatic values in each of the subjects. In figure 5, in addition to the complete group, selections can be seen corresponding to animal, human and vegetable figures respectively.

6 Discussion

We cannot deny that the system used presents enormous difficulties, both of interpretation and of realisation. Firstly it is a system designed for the particular case we are dealing with, in which the pigments always seem to be

obtained from nearby areas, and the painting is monochrome.

One of the most important aspects consists of the need for perfect control of the process by which the images are recorded, and their integration into the system. Differences in the incidence of light in each photogram, or in the resolution of recording, can distort the subsequent process of analysis.

Likewise we have to consider with the greatest care aspects such as superimposed subject matter, which produces changes in pigmentation in the polygons common to both images, or the existence of pigment which has been partially dissolved in certain areas of the panel.

However, despite these difficulties, the procedure described can be an extremely useful tool for analysing the pictorial evidence we have presented.

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