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Portable X-ray fluorescence (pXRF) analysis of Cave Paintings in Alto Vale do Jequitinhonha

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1. Introduction

The Southern Espinhaço Mountain Range (SdEM) is a place where has been intensively researched by archaeologists, producing a significant knowledge of the regional indigenous history. Being of great relevance, the elementary analysis of the paints used in cave paintings in that region **[1, 2]**. The pXRF technique was chosen for its ability for multi-elemental chemical detection, and also for using equipment that is easy to transport and handle, which results in fast and accurate data collection to obtain information about the chemical elements present in cave paintings.

In this work, the *in situ* analysis of cave paintings from two sites in *Alto Vale do Jequitinhonha - MG* called *Cabeças* I and V, and *Três Fronteiras* I, III, IV and V will be presented. The approximate location of this region can be seen in Figure 01.

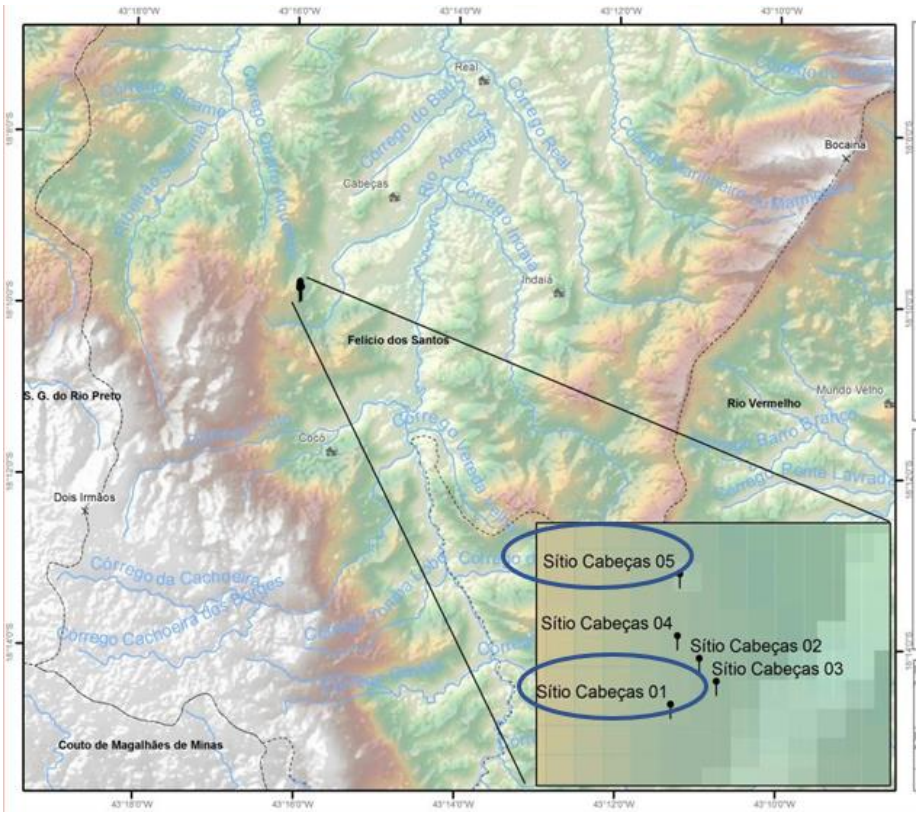

Figure 01: Location of the archaeological complex *Cabeças*.

The objective of this work is to characterize the chemical elements present in the paintings. For this, 12 paintings representing deer, fish, wings, tridactyl and geometric figures were analyzed. Some of these images are represented in Figure 02.

Figure 02. A representation of animals and geometric figures painted on stone.

The analyzed pigments were three shades of red and three shades of yellow.

2. Methodology

The analytical method used was Portable Energy Dispersion X-Ray Fluorescence (pXRF) using the Tracer 5i (Bruker) handheld device, which consists of an X-ray tube (Rh target), a Si Drift detector and 8 mm

diameter collimator. Measurement conditions were 50 kV, 35 μA and 10 seconds. For each rock and color area an average of at least three measurements were performed. Bruker Artax software was used to analyze the spectra **[2]**.

Figure 3. Portable EDXRF Tracer 5i system positioned for measurement on a rock painting.

3. Results and Discussion

In the analyses, it was identified that the red pigments presented a higher concentration of the elements Al, P, S, K, Ti, and Fe than in unpainted rock. The yellow pigments had a higher concentration of Al, P, S, Ca, Ti, Mn, Fe, and Ni compared to unpainted rock. In addition to the Fe element, red is characterized by a high concentration of P, S and K, and yellow is also characterized by a high concentration of Si, Ca, and Ti. The graphs below in Figure 04 show the presence of the elements of yellow paint measured at the location. The expected historical result is to understand the composition, raw materials and technique used in the paints of the cave paintings, which will reveal important cultural aspects about the natives technology of that region.

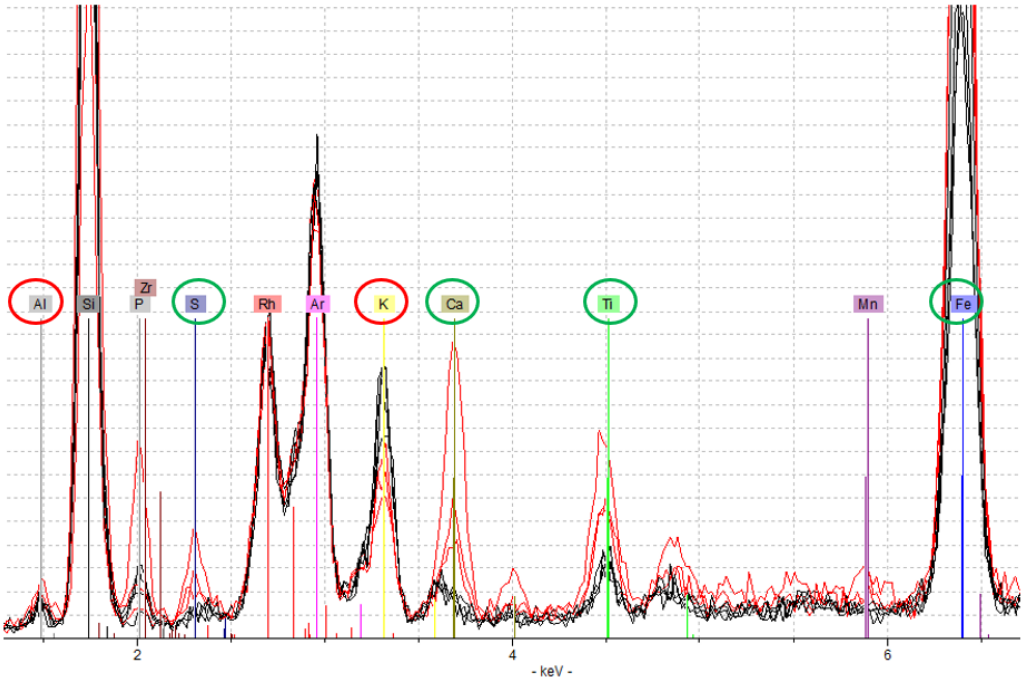

Figure 04. Black line spectrum corresponding to the rock. Red line spectrum corresponding the yellow paint. Highest concentration: Al, P, S, Ca, K, Ti, Fe, and Mn (lower concentration).

4. Conclusions

These preliminary analyzes show two types of red earth-type pigments, Fe oxide ocher, one of them darker because of the clear presence of Mn oxide. The other elements are typical of the land but vary in number and concentration, indicating different land origins. Quali-quantitative analyzes will be carried out to deepen this issue.

The shade variations may be due to different mixtures of hematite and goethite and/or limonite in the soils (Laterites? the presence of Al indicates) that molecular analysis will be able to verify. Multivariate analysis (PCA, HCA) will also be performed with the spectra to statistically determine the differences and similarities between the different pigments.

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