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| ESRF | **Experiment title:**<br>A microdiffraction characterization of ancient Mexican blue pigments | **Experiment number**:<br>**HS-2407** |
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| **Shifts:**<br>9 | **Local contact(s)**:<br>Remi TUCOULOU TACHOUERES (e-mail: tucoulou@esrf.fr) | *Received at ESRF:* |


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## Report:

The experiment was succesful in two ways :

1) It is demonstrated that it is possible to detect the phases in a thin pigment layer on top of a thick substrate (like a wall piece, in a mural paint) using grazing incidence microdiffraction. A test sample was done by painting a thin layer of hematite with a small brush on top of a lime pellet. It was possible to detect both the substrate and pigment in the diffraction image.

2) A large quantity of diffraction images (and complementary XRF spectra) were measured in 5 samples. The huge amount of data (filling 6 DVDs) requires the development of new scientific software tools

After a first analysis of some images, we found very interesting results:

1) The samples from Jiutepec convent (Morelos, Mexico) show many phases including elements like Ba, Zn, and S. The existence of some synthetic phases (like barium sulphate) indicates that the mural was probably restorated, because these pigments were not used in the XVI century. In a recent visit to Jiutepec convent we found that the chaptel from where these samples were obtained (in 1985) is completely destroyed. No rests of the original murals are found. However, in the clauster of the convent a friso has been discovered. Microdiffraction analysis from this new samples demonstrated that it is Maya blue, and no Ba and Zn are found. This fact also suggest that the use of the pigment with Ba and Zn was not general in the convent, thus supporting the hypothesis of a restoration product. See Fig. 1 for an example of diffractogram from this sample.

2) A sample of green pigment from the Bonampak (Chiapas, Mexico) site has been studied. This is an important sample because it comes from the most famous site with murals in Mesoamerica, where the greenish-blue and green tonalities are dominant. It has been suggested that this green was obtained by mixing Maya blue with other minerals (like malaquite), or it could be obtained by a variation of the Maya blue (using other clays instead of palygorskite, or other colorants, instead of indigo). Our results are quite unexpected: No Cu nor Co are found, indicating the absence of a Cu-based colouring mineral. It has been found pure palygorskite in some points of the sample (Fig. 2). Therefore, it indicates that the green is made with the same ingredients as Maya blue. Unfortunately, this finding is insufficient for a publication, because we still need to detect the indigo (some work is in progress to detect it by microRaman) and because the study is done on a single sample. We are currently applying for the permission to obtain new samples from Bonampak, and a new proposal will be submitted for their measurements.

The mechanism for extracting the phases from tens or hundreds of images poses a real challenge in the development of scientific software. In this context, a project within the scientific software at ESRF for obtaining on-line calibrated images and perform quickly the phase identification has started. Other experiments at ESRF for pigment characterization will benefit for such tools. These tools will be able to identify special features in the images (damaged surfaces, grains, microcrystallites) and will be of great help for defining on-line the zones, sometimes of a micrometer size, to be mapped.

These results, among others, have been presented in a contributed talk in the “Synchrotron Radiation in Art and Archaeology” ESRF-CNRS joint workshop, 9-11 Fwbruary 2005 in Grenoble. A full analysis of the data is in progress.

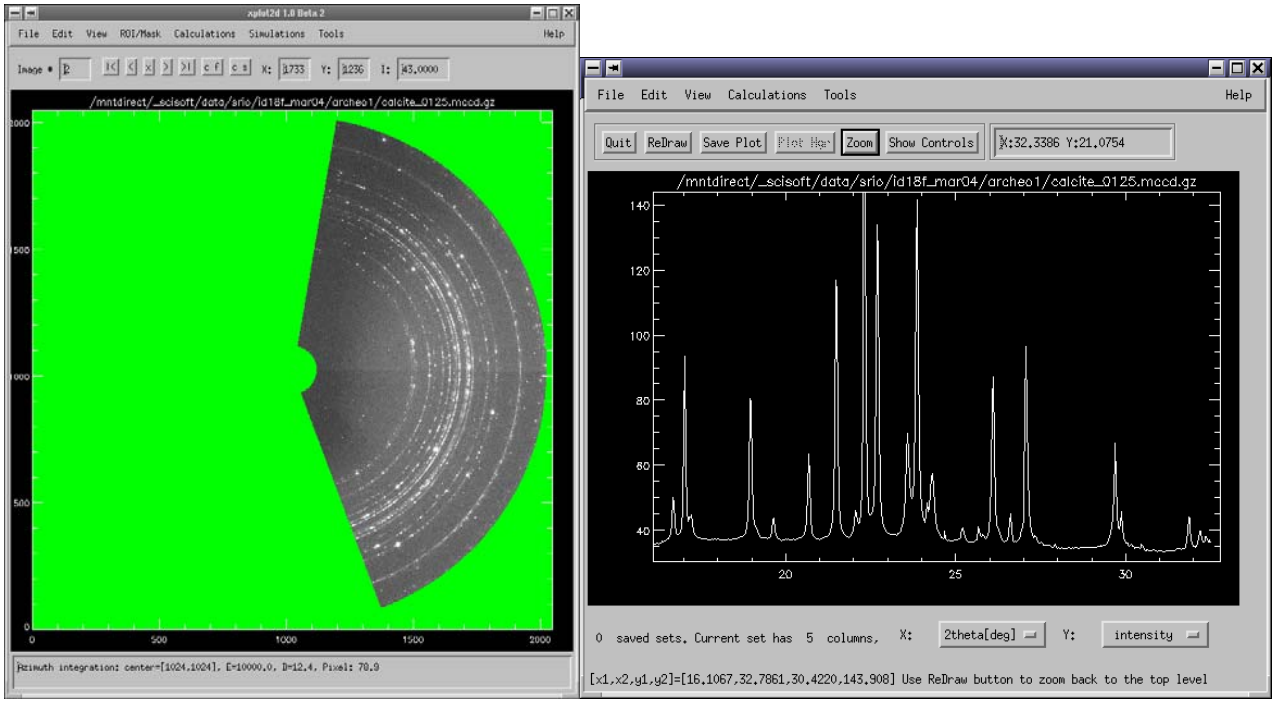

Fig. 1 Left: microdiffraction image from Jiutepec blue sample. Right: diffraction profile

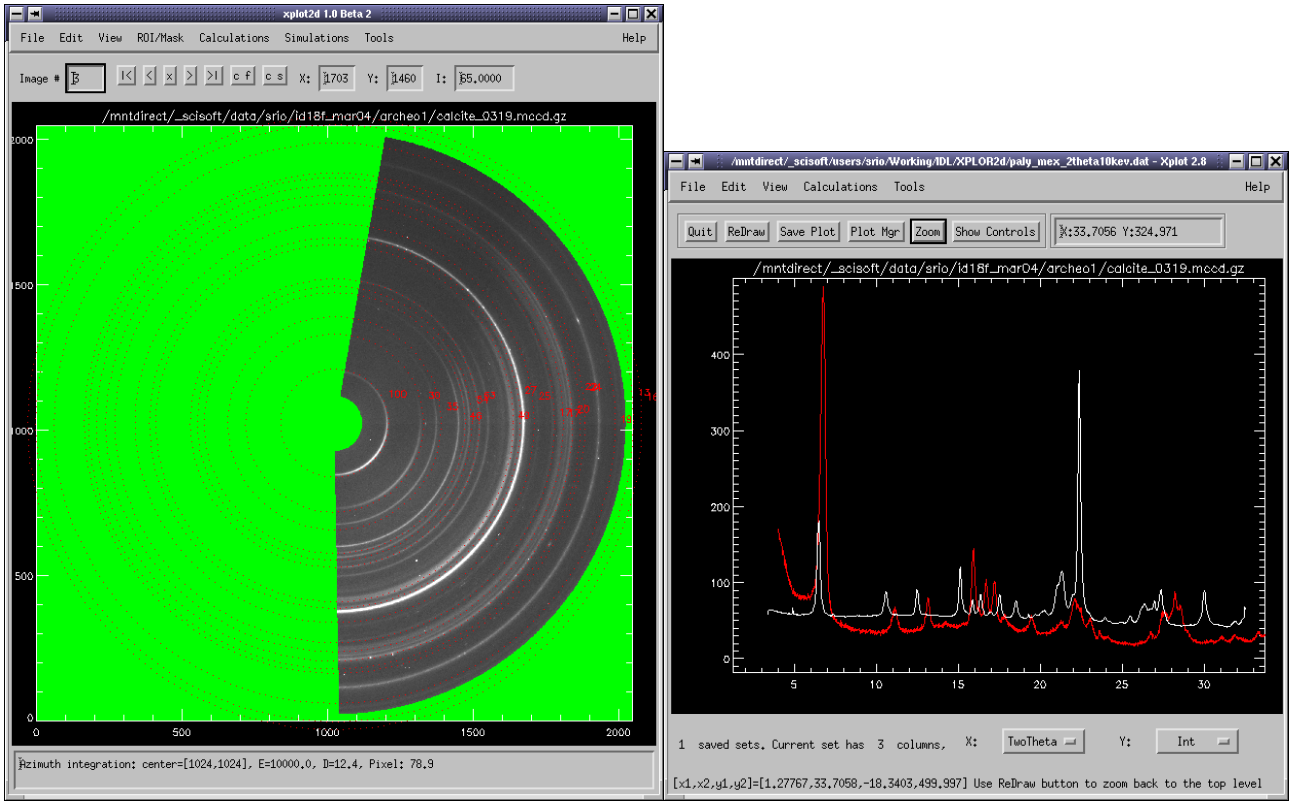


Fig. 2 Left: microdiffraction image from Bonampak blue sample. Right: diffraction profile. In red it is overplotted in both figures a reference of palygorskite from Mexico measured in a laboratory diffractometer. It can be observed that all structures found in Bonampak's diffractogram (except a narrow peak of quartz) agree with the palygorskite reference.