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ESRF

Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office using the **Electronic Report Submission Application:**

http://193.49.43.2:8080/smis/servlet/UserUtils?start

Reports supporting requests for additional beam time

Reports can now be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** **Pigments and clays used on the elaboration of the Nazca pottery. Analysis by High Resolution Powder Diffraction**	**Experiment number**: Ref.: 18017 Final: **25-01-673**
Beamline:	**Date of experiment**: From: 09/07/2008 to: 15/07/2008	**Date of report**: 24/02/2009
Shifts: 24	**Local contact(s)**: Ana Gutierrez León, Germán R. Castro	*Received at ESRF:*

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Report:

We analyzed thirty pigment samples extracted from pottery fragments recovered at sites located in the Nazca and Ica valleys, once occupied by the ancient nasca (100 B.C to 650 A.D). The fragments were divided in two groups, the first group (group A) coming from La Muña, Hanap Pacha and Lucriche, and the second group (group B) found in Cahuachi, PAP 73 and Los Molinos.

Ornamental nasca pottery is characterized by the fine finish and polychrome drawings representing flowers or animals like birds, fish and mammals as well as human beings. The basic colors used in nasca pottery are: red, orange, brown and white, and different shades of them. The color samples were obtained by mechanical means, scratching the clean surface using a bistoury blade. The operation was performed under a zoom binocular microscope (x10), to avoid scratching the clay or "clay + color" surface under the pigment.

In this experiment we run the samples in angular ranges from 1 to 40 degrees, each run took four hours.

We analyzed six samples of white color: two from group A, two from group B, plus a sample from got from a chancay pottery fragment and a sample obtained from a fake nasca piece.

We analyzed six samples of red: three from group A, two from group B and one from a fake.

We also analyzed four brown samples: three from group A and one from group B; five clay samples: two of each group A and B plus one from the chancay pottery.

The other samples were from mixed colors (black, grey and light red from the pottery inner surfaces).

The diffraction patterns are analyzed using the powder diffraction file program PCPDFWIN version 1.30 from the JPDS-ICDD, including set form 1 to 47.

The common features in all the diffraction patterns, independent of the color, provenance or kind of sample (outer or inner surface) are a large quartz peak and several peaks with large *dhkl* (> 5 and < 10) values, coming from clay minerals. The clay mineral peaks are interpreted as coming from clays mixed with the pigments by the pottery makers, in order to make easier the application of the color on the surface of the piece. Although several authors report kaolin, for us it is not possible to identify the clay minerals because the color was applied before firing the piece, so the longest *dhkl* spacings generally used to differentiate the clay mineral are disturbed.

The diffraction patterns of the white samples (Fig 1) coming from group A do not show carbonates, while the samples from group B do. We also did not identify carbonates in the sample from chancay and in the fake.

The red colors (Fig 2) are almost pure hematite (α-Fe_2O_3), mixed with very little clay. The presence of hematite is not surprising, if we consider that this is the most stable iron oxide and almost all the other oxides and the common oxide-hydroxides (goethite, lepidocrocite, etc.) transform to hematite during firing in high temperatures.

The identification of maghemite (γ-Fe_2O_3) in brown shades is also compatible with the fact that this red-brown iron phase occurs as the product of heating other iron oxides.

Our findings fit well with the results of the XRF (x ray fluorescence) analysis performed at the laboratory of the Instituto Peruano de Energía Nuclear (IPEN).

References:

- Donald A. Proulx, “The Nasca Culture: An Introduction”. Originally published in German in: *Nasca: Geheimnisvolle Zeichen im Alten Peru*, Edited by Judith Rickenbach, Pp. 59-77. Zürich: Museum Rietberg Zürich, 1999.
- Kevin J. Vaughn et al., “Ceramic production in ancient Nasca: provenance analysis of pottery from the Early Nasca and Tiza cultures through INAA”, *Journal of Archaeological Science* 33 (2006).
- R.M Cornell, U. Schwertmann, *The iron oxides*, VCH Publishers, New York (1996).
- Prudence M. Rice, *Pottery Analysis A Sourcebook*, The University of Chicago Press (1987).
- PCPDFWIN version 1.3, PDF-2 Database for Windows Sets 1 – 47. The International Centre for Diffraction Data (1997).

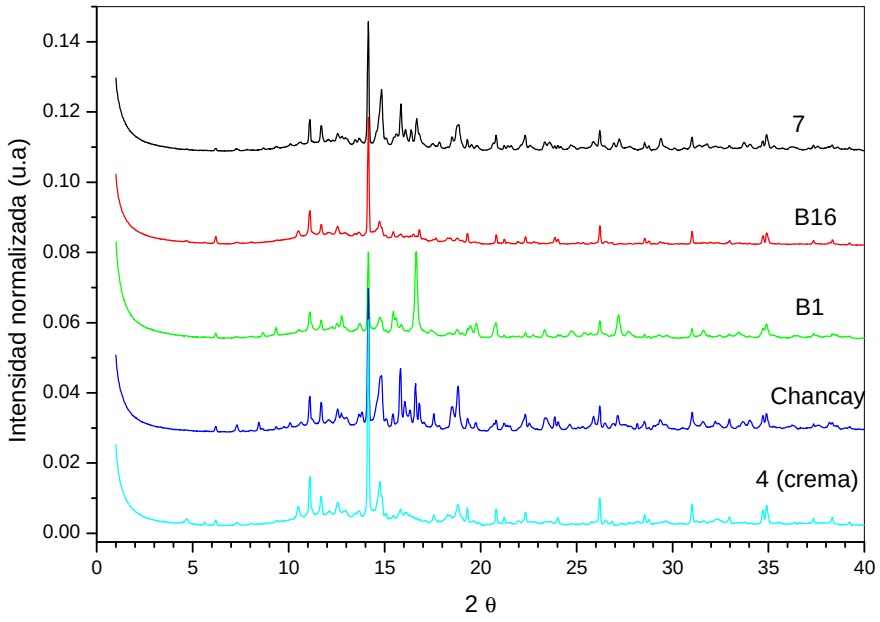

Figure 1.- Normalized diffraction patterns of the white color samples.

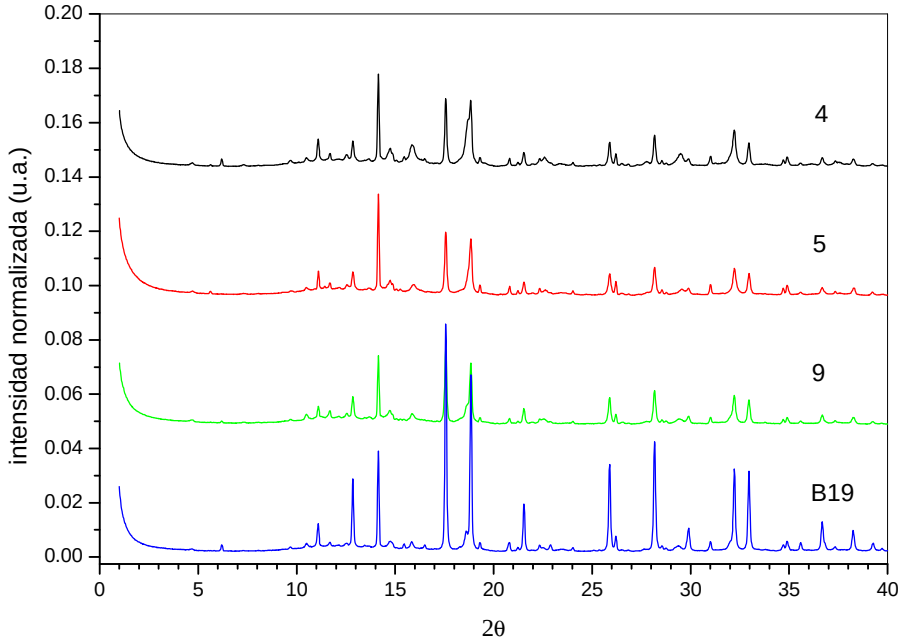

Figure 2.- Normalized diffraction patterns of the brown color samples