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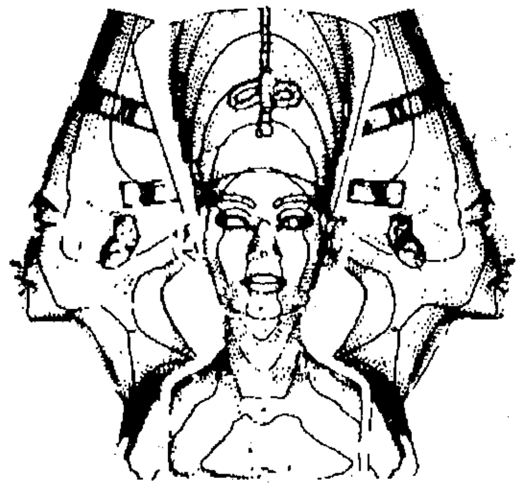

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4. Internationale Konferenz Zerstörungsfreie Untersuchungen an Kunst- und Kulturgütern

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4. Internationale Konferenz Zerstörungsfreie Untersuchungen an Kunst- und Kulturgütern
4th International Conference on Non-Destructive Testing of Works of Art

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A gamma-ray study of Indian ceramics from southern Brazil

Eine Gammastrahlenuntersuchung an indianischer Keramik aus Südbrasilien

1. Introduction

Until now the brazilian pottery has been usually investigated only by means of the traditional methods, essentially employing visual and macroscopic classifications such as shape, size, thickness, hardness, characteristics of the paste, plastic decoration and so on. Besides dating methods, no other archaeometric non-destructive technique has been currently used for the pottery studies. The aim of this work is to apply the gamma-ray transmission method to the pottery study.

2. Investigated objects

The investigated objects were nine indian brazilian pottery fragments from the region of Londrina city, at the north of Paraná state, south of Brazil. The fragments belong to the archaeological collection of the "Padre Carlos Weiss" Historical Museum (State University of Londrina) at Londrina. Each one of these fragments came from a distinct ceramic recipient and all of them belong to the Caingângue tradiction [1].

Table 1 shows the number code of the ceramic fragments, theirs sizes and thickness, the place where they were found and type of the plastic decoration, according to the brazilian pottery terminology [2,3]. These fragments are very similar to those discovered at the Iberá Farm (near Londrina) and José Vieira sites (near Apucarana city), both of them at the north of Paraná state and reported by Laming and Emperaire [4].

Figures 1 to 3 present the photographs of the fragments C-67, C-35 and C-84d, respectively.

3. Experimental arrangement

The experimental set-up consisted of:

- gamma-ray sources : 100mCi , ^{241}Am (59.5keV line) and 150mCi , ^{153}Gd (44 and 99.8keV lines);
- standard gamma spectrometry electronic chain;
- 2" diameter NaI(Tl) scintillation detector;
- holder for the samples, with vertical and horizontal movement (1mm step);
- lead collimators at the source out-put and detector entrance.

The statistical deviations in countrate remained in the range of 0.2 - 0.8%.

Collimation and distances between source, sample and detector were optimally arranged in order to achieve a good geometry condition [5,6].

4.Methods

4.1 Gamma-ray attenuation coefficient

The gamma-ray attenuation coefficient is an important physical characteristic of the paste [7,8]. It reflects the paste composition and it's knowledge is necessary for the absolute density determination.

As the samples have an irregular shape and thickness, the two medium method was used in order to avoid the problem of the fragments thickness determination. The ceramic fragments and the medium were put in an acrilic box. The two medium alternately used for the transmission measurements were mica and sawdust, because theirs attenuation coefficients are very different from each other and from the ceramics values.

4.2 Gammagraphy

In order to inspect the internal structure and homogeneity of the pottery fragments, each one of them were put in a special holder and transmission measurements were carried out employing the ^{241}Am gamma-ray source. The scanning was performed with a 1mm translational step, at three different levels of the sample (6.5mm spacing) far from the borders.

5. Results and discussion

Table 2 presents the gravimetric global density determination of the fragments. The deviation in each measurement is about 1%.

Table 3 presents the measured attenuation coefficients of the fragments. Considering included all physical deviations in the error propagation, the deviation is about 5%. From the mass attenuation coefficient values of this table it is possibly to conclude that the composition of the pottery pastes differ considerably. Taking the results for the 44keV gamma-ray line, there is a factor of 3.5 between the smallest (C-152) and higher (C-84d) μ(mass) values. At this energy value the photoelectric effect is still dominant and the atomic number (Z) dependence of the interaction is like Z^4 [7,8]. This means that the mean atomic number of the C-84d fragment paste is 36% greater than the C-152 one.

Figures 4 to 8 show the gammagraphies of the pottery fragments code number C-84d, C-35, C-152, C-67 and C-151, respectively. The total deviation in these experimental points is about 1%.

The C-84d gammagraphy (Fig.4) shows clearly the deformation at the center of this fragment, which should correspond to a contracting-tapering or cambered rim. In this fragment the density slowly decreases as it goes to the region of the fold, falling by 38%.

The C-35 gammagraphy (Fig.5) presents an almost homogeneous density pattern in great part of the fragment, except for the borders, where the density increases 62% and 137% at the left and right sides, respectively.

The C-152 and C-67 fragments (Fig. 6 and 7) presented an almost homogeneous pattern.

The C-151 gammagraphy (Fig.8) shows very small density variations (~ 4%) in the whole fragment and a small region of about 3mm where the density is about 8% smaller, indicating the presence of some different lower density material.

We pretend to continue this investigation performing more gammagraphies with other fragments of this collection, improving the attenuation coefficient measurements, obtaining the pastes chemical composition and calculating the theoretical attenuation coefficients of the pastes.

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7. Aknowledgments

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Table 1 - Investigated pottery fragments

Fragment number code	Size (mm)	Thickness (mm)	Place of discovery in the state of Paraná	Plastic decoration
61	71.9x52.15	11.7	near Tibagi River; ancient Luppi Farm; at 10/8/70	brushed
67	38.15x49.4	9.85	the same as number 61	incised
35	70.7x62.15	8.58	Assaí city	fingernail marked
116e	91.15x55.9	13.9	Nossa Senhora das Graças Farm Guaravera city	slip, nicked and painted; internal and external - pale ocher
146	66.95x69.1	8.85	unknow	slip, polished and painted; internal red, external pale ocher
152	25.85x70.0	9.61	Jaguapitã city at 8/5/76	plain
377	80.95x64.85	8.9	unknow	plain
84d	54.45x51.9	11.28	Londrina city	fingernail marked
151	69.9x121.6	23.31	unknow	plain

Table 2 - Measured global density of the pottery fragments

Fragment code number	Global density (g/cm^3)
C-67	2.46
C-377	2.45
C-61	1.23
C-84d	1.84
C-152	3.32
C-151	1.79
C-35	1.04
C-146	0.97
C-116e	2.01

Table 3 - Gamma-ray attenuation coefficients (μ) of the pottery fragments

Energy (keV)	Fragments code number	μ (linear) (cm^{-1})	μ (mass) (cm^2 / g)
44.0	67	0.375	0.152
	377	0.460	0.188
	61	0.567	0.461
	84d	0.962	0.523
	152	0.502	0.151
	151	0.571	0.319
59.5	67	0.284	0.115
	61	0.241	0.196
	35	0.191	0.183
	116e	0.519	0.258
99.8	67	0.115	0.047
	377	0.128	0.052
	61	0.176	0.143
	84d	0.428	0.232
	152	0.172	0.052
	151	0.151	0.084

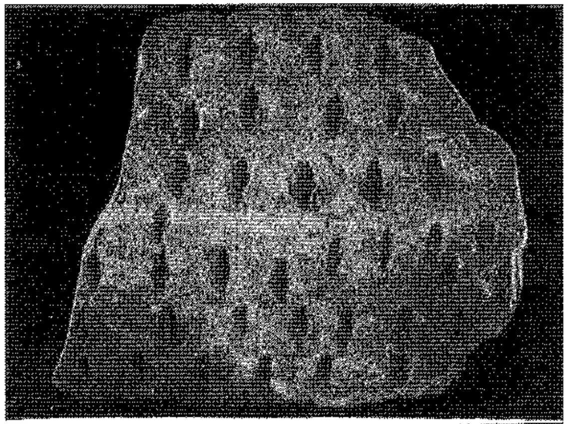


Fig. 3 - Photography of the fragment code number C-84d

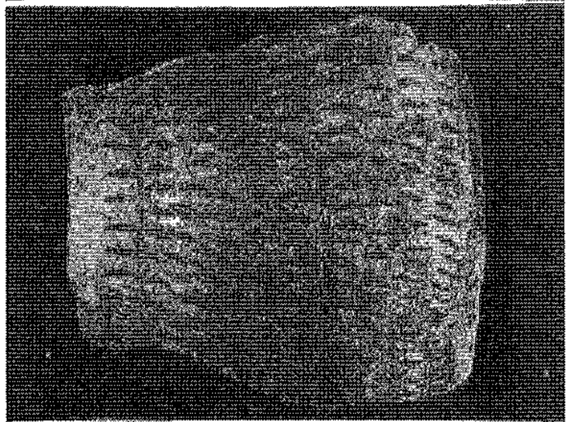


Fig. 2 - Photography of the fragment code number C-35

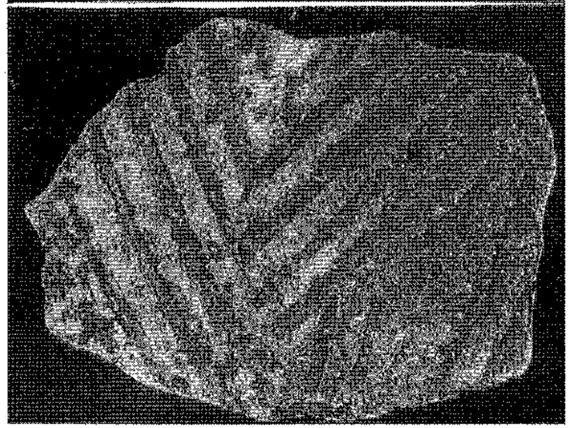


Fig. 1 - Photography of the fragment code number C-67

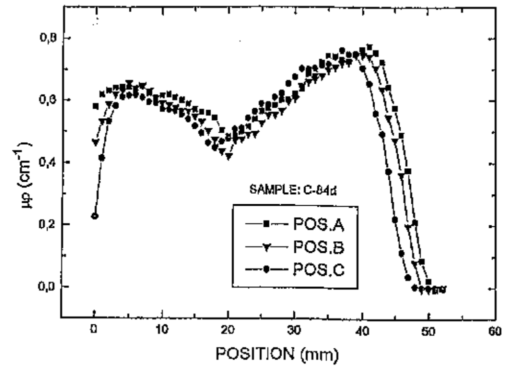
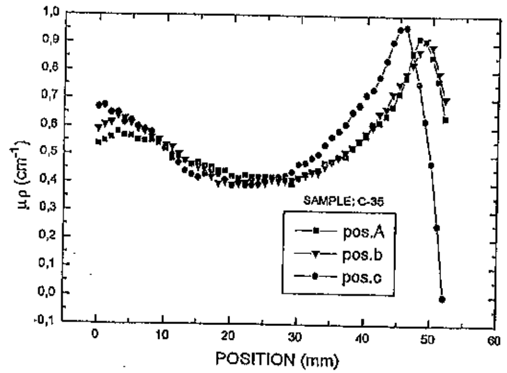


Fig. 4 - Gammagraphy of the fragment code number C-84d

Fig. 5 - Gammagraphy of the fragment code number C-35



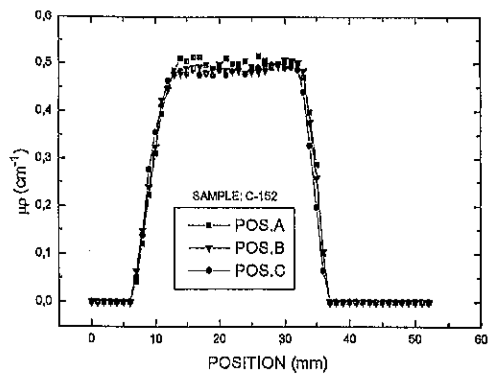


Fig. 6 - Gammagraphy of the fragment code number C-152

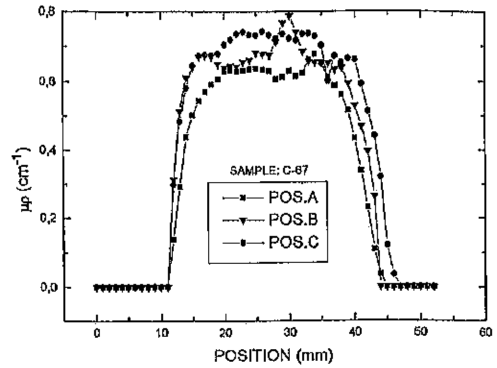


Fig. 7 - Gammagraphy of the fragment code number C-67

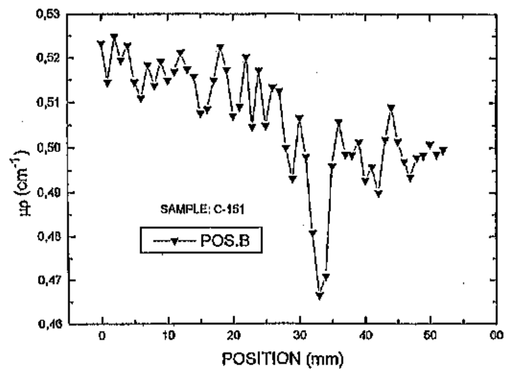


Fig. 8 - Gammagraphy of the fragment code number C-151