Journal of Molecular Structure 993 (2011) 142–146

Contents lists available at ScienceDirect

Journal of Molecular Structure

journal homepage: www.elsevier.com/locate/molstruc

Characterisation of archaeological pottery: The case of "Ionian Cups"

G. Barone [a], V. Crupi [b], F. Longo [b,*], D. Majolino [b], P. Mazzoleni [a], V. Venuti [b]

[a] *Dipartimento di Scienze Geologiche, Università di Catania, Corso Italia 57, 95129 Catania, Italy*
[b] *Dipartimento di Fisica, Università di Messina, V.le Ferdinando Stagno d'Alcontres 31, 98166 Messina, Italy*

ARTICLE INFO

Article history:
Available online 23 January 2011

Keywords:
FT-IR
SANS
Ceramics
Firing temperature

ABSTRACT

The aim of this study was the microscopic and mesoscopic characterisation of archaeological pottery findings addressed to the identification of the manufacturing techniques.

The samples under study were "Ionian Cups" sherds, coming from Poira, an archaeological site in eastern Sicily (South-Italy). These cups represent a ceramic typology widely diffused in the Mediterranean Area in archaic age (VI–V century BC). The identification of the production sites of these materials, originally manufactured in Greek-Eastern area and then largely diffused in Magna Graecia, is still an open question.

Here, the microscopic structural characterisation was obtained by Fourier Transform Infrared absorption (FT-IR) measurements, which permitted us to determine the mineralogical phases present in the artefacts. Furthermore, Small Angle Neutron Scattering (SANS) measurements permitted the characterisation of the size distribution and surface characteristics of the mesoscopic aggregates formed by the minerals.

1. Introduction

Ceramic findings are among the best preserved and the most important materials testimonies of ancient human cultures. In fact, the study of a ceramic fragment allows to obtain information concerning the artistic choices, trade pathways, cultural and technological evolution of the ancient human communities [1,2].

As is well known, the characterisation of archaeological ceramics is very complex due to the heterogeneity of the materials on different scales and to the presence of both crystalline and amorphous phases in the ceramic bodies and in the outer decorations (glaze, pigments). So the use of different analytical techniques is required to characterise the ceramic findings [2–7]. In particular, manufacture technology involves several aspects of pottery making, such as the type of raw materials used, their processing to prepare the clay paste, the surface treatment, decoration and firing to obtain the finished item.

Here, we present the employment of Fourier Transform Infrared absorption (FT-IR) and Small Angle Neutron Scattering (SANS) measurements to obtain the microscopic and mesoscopic characterisation of archaeological pottery.

FTIR and SANS techniques have been performed on "Ionian Cups" sherds, a ceramic typology widely diffused in the Mediterranean Area in archaic age (VI–V century BC). In particular, the investigated samples coming from Poira, an archaeological site near Catania (Sicily, Italy). The production of "Ionian Cups" started in about 580 BC in eastern areas of Greece and was then continued in Magna Graecia until about 540 BC [8]. The presence of various production centres in the Greek colonies have been hypothesised and represents a hotly debated question. Information on the manufacture, such as the raw materials and the estimation of firing temperature of this ceramic typology, could be useful to identify the production centres.

2. Experimental

2.1. Materials

The investigated samples include seven fragments of Ionian cups of type B2, labelled as POI 1, 3, 5, 13, 17, 19, 20 from the Poira necropolis (Sicily, Southern Italy) and dated back to VI–early V centuries BC. An example of this ceramic typology, together with the pictures of two investigated samples, are reported in Fig. 1. These samples belong to a large set of Ionian cups from five archaeological sites in eastern Sicily ("Mendolito, Monte Castellaccio, Poira-Poggio Cocola, Piano Casazzi, Francavilla di Sicilia"). Petrographic thin-section analyses and chemical investigations by X-ray fluorescence spectrometry (XRF) have been already performed on all these Ionian cups [8]. This study indicated that a peculiar character of Ionian cups from these archaeological sites in eastern Sicily is due to their highly homogeneous petrographic and geochemical features. This may indicate a single centre of production, characterised

* Corresponding author. Address: University of Messina, Department of Physics, V.le Ferdinando Stagno d'Alcontres 31, 98166 Messina, Italy. Tel.: +39 0906765463; fax: +39 090395004.

E-mail address: longof@unime.it (F. Longo).

0022-2860/$ - see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.molstruc.2011.01.028

Fig. 1. An example of (a) Ionian cup of type B2, together with the pictures of (b) POI 17 and (c) POI 19 fragments.

by abundant production and an extensive distribution of products, or an extremely specialised technique that was known to several workshops. Hence, the microscopic and mesoscopic characterisation could support one among the hypotheses above mentioned.

2.2. FT-IR

FT-IR measurements were performed by means of a BOMEM DA8 FT-IR spectrometer. This apparatus was equipped with a Globar lamp as source and a suitable beamsplitter and detector, depending on the part of the spectral range under study. In particular, a Hyper beamsplitter and a DTGS/FIR detector were used to collect the spectra in 200–600 cm^{-1} range, while we used a KBr beamsplitter and a DTGS/MIR detector to register the spectra from 450 to 4000 cm^{-1}. The two measurements were combined to obtain the spectra in the range from 200 to 4000 cm^{-1}. In such configurations it was possible to use a resolution of 4 cm^{-1}. The investigated samples were prepared in pellets, about 0.5 mm thick, using small quantities ($\sim$2 mg) of bulk sample dispersed in $\sim$200 mg of powdered CsI, that is transparent in the investigated IR frequency range. We remark that from each shard, about 2 mg of material was drawn from non-significant parts of the ceramic body, in order to avoid damages that could be affect the integrity and artistic content of the finding. The measurements were performed in dry atmosphere to avoid dirty contributions, 32 repetitive scans were automatically added to obtain a good signal-to-noise ratio (SNR) and a spectra reproducibility of high quality as well. The experimental spectra were compared with those of standard minerals and clays (Sadtler database "Minerals and Clays" [9]) and with data reported on different sources [10–12] for a reliable assignment of the bands.

2.3. SANS

SANS measurements were carried out by using the PAXE spectrometer at the ORPHEE reactor of the Laboratoire Léon Brillouin (LLB, Saclay, France). The two configurations used at large and small *Q* (scattering vector) range were summarised in Table 1. For a more detailed description of SANS technique the reader can refer to literature [3,13]. The investigated samples were cut in thin sections (thickness <1 mm) and therefore multiple scattering effects were minimised. No appreciable neutron activation of the samples was found after the SANS experiment.

We used standard LLB SANS routines to correct the two-dimensional intensity distributions for instrumental background and to normalise them to absolute cross section per unit volume of the sample (cm^{-1}) by measuring the incident beam intensity, transmission and thickness of each sample.

The structure of some samples under study turned out to be anisotropic. This may be either connected to preferential directions of the texture of mineral aggregates or to pressure effects. In such cases, *Q* must be treated as a vector and the *xy* pattern of the scattered intensity has the shape of more or less elongated ellipsoids. In this case, a longitudinal axis (Lo) along the major axis of the ellipse and, in the perpendicular direction, a transversal axis (Tr) along the minor axis, can be defined. The first corresponds to correlations in real space over shorter distances than the second. Numerical analysis is done in each direction, yielding distinct parameters.

Table 1
Instrumental characteristics for SANS measurements performed by the PAXE spectrometer.

Large Q	
Wavelength (λ)	6 Å
Sample–detector distance	2 m
Collimation	2 m
Q range	5×10^{-3}–2×10^{-1} Å^{-1}
Small Q	
Wavelength (λ)	15 Å
Sample–detector distance	4.5 m
Collimation	4.5 m
Q range	3×10^{-3}–3×10^{-2} Å^{-1}