Synchrotron X-ray fluorescence study of 'Chocolate-on-White Ware'

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Introduction

Chocolate-on-White (CoW) is a distinctive white slipped, burnished and decorated ceramic ware dated to ca. 1575-1450 BCE. It is found across the southern Levant; in modern Jordan, Palestine, and Israel. First classified by W.M.F Petrie at Tel el-'Ajjul (Gaza) in the 1930s, its forms and decorative nature suggest it was used for the consumption of food and beverages. This ware has been the subject of interest since the late 1960s due to a combination of its stylistic distinctiveness, relative rarity, and time of manufacture during a politically tense period of increasing Egyptian rule over the region. Nevertheless, relatively little is known about the ware and despite many attempts, it has proved consistently difficult for scholars to identify where the ceramics were produced.

Working mainly from the large corpus of Chocolate-on-White ware from Pella (Tabaqat Fahil) in Jordan, and 6 other archaeological sites, the approach of the present study includes the identification of sub-groups within the ware based upon differences in fabric that often correlate with form types and decorative motifs. The particular question that this paper addresses concerns the elemental nature of the pigments and slip used in the decoration of the ware.

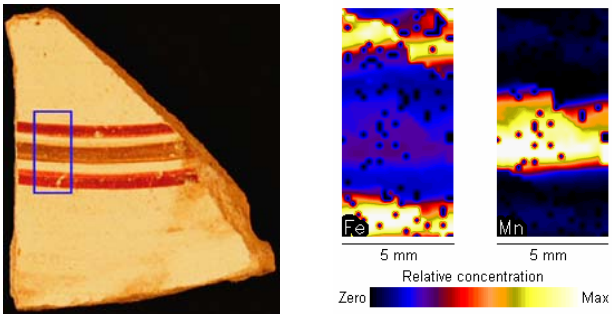
Methods and Materials

The ceramic sherds were made available to us from museum and archaeological collections on the condition that we would not physically sample them by drilling, cutting, or scraping. Thus, we turned to SRIXE or synchrotron-radiation induced x-ray emission. SRIXE is a fast, non-destructive technique for acquiring data on the chemical character of the sherds: the clay body (unembellished surface), slip, and pigments utilized by the ancient potters.

X-ray fluorescence data was collected at both 6.7keV and 19 keV on beamline 2-BM at the Advanced Photon Source. In addition, several SRIXE 2D elemental maps were obtained on selected samples to act as a 'proof of concept' of this technique as a useful tool for archaeological material. Full spectra were acquired at each pixel for the 2D data sets allowing the use of GEOPIXE II software [1,2], which uses the dynamic analysis method to project quantitative elemental images of the sherd's surface.

Results

Fluorescence spectra were taken and analysed for a number of points on the paint, slip and clay regions of 22 sherds. Selected 2D elemental images from one of the CoW sherds are shown in Fig. 1. The outer red or "chocolate" paint stripes on this sherd are primarily composed of Fe with other minor elements, while the middle or "black" stripe has Mn as a major constituent. These results were compared with complimentary elemental analyses such as NAA.



(a) (b)

Fig. 1: (a) image of a CoW sherd from Pella, with the approximate x-ray fluorescence scan region marked; (b) Fe and Mn fluroescence maps.

Discussion

SRIXE analysis of the CoW sherds inform us about the composition of the slips and pigments. The main consitutent of the slip is calcium, probably from a calcium carbonate clay native to the region (The Jordan Valley). The red paint is composed of Fe (iron oxide) distinct from the Mn-based black paint. The source of the iron oxide red 'chocolate' paint could have been crushed lumps of haematite or red ochre [3]. To obtain a contrasting black colour, the manganese pigment was used (see Fig. 1). Although carbon monoxide can produce a black colour (FeO) in a neutral kiln[3], when black and red are seen together it was necessary to use another element rather than control colour through oxygen in the kiln. The manganese would remain black during firing whereas the hematite would oxidize and become red – thus producing the bi-chrome effect [4]. The present study confirms Franken's suspicions [3] that manganese dioxide (MnO_2) was used for this purpose.

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