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# BLACK-ON-RED PAINTED POTTERY PRODUCTION AND DISTRIBUTION IN LATE NEOLITHIC MACEDONIA

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Black-on-red painted pottery is one of the most distinctive ceramic categories of the Neolithic Aegean. Particularly attractive, thanks to its vivid dark-on-light contrast frequently combined with an elaborate motif design (Fig. 1), this pottery is also remarkable for its high technical quality, witnessed by the fineness of the fabric,

the uniformity of the surface colours, the regularity of shapes, the density and hardness of the vessels' walls. Pottery of this kind is found at settlements in Northern Greece (Thessaly, Macedonia and Thrace), dated to an advanced stage of the Late Neolithic period, roughly between 4800/4700-3900/3800 BC. Although it was early recognised as a diagnostic ware for that period in the areas of its occurrence (Welch 1918-19, p. 44-46; Heurtley 1939, p. 74-75; French 1961, p. 114-116; Deshayes and Garašanin 1964), no previous attempt was made to construct a systematic classification or to study its production technology and distribution patterns.

In this paper, we summarise the main results of a series of studies carried out between 2000 and 2004, within the framework of a multidisciplinary research program supported by the French School at Athens (ÉFA) and the French National Centre for Scientific Research (CNRS).<sup>1</sup> The main body of the analytical results, concerning the production areas and distribution of the pottery, has been presented in detail elsewhere (Malamidou *et al.* 2006; for the NAA analyses, see also Kilikoglou *et al.* 2007). Here emphasis is given to the scanning electron microscopy examination for the technological characterisation of this pottery class.

## ARCHAEOLOGICAL AND CHEMICAL GROUPS: REGIONAL DISTRIBUTION AND POTTERY TRADITIONS

Preliminary macroscopical analysis of archaeological ceramics from more than one hundred Neolithic settlements, according to technological (fabric, surface treatment, paint consistency) and morphological criteria (vessel shapes, decoration), resulted in their classification into four main varieties which also correspond to different

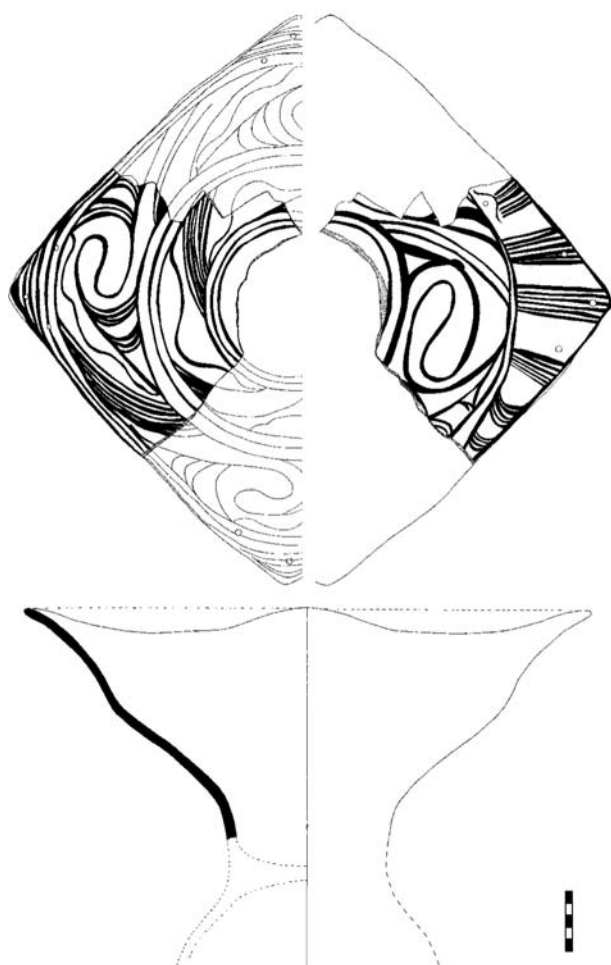


Fig. 1 – Black-on-red painted open vessel from Kryoneri (drawing D. Malamidou).

1 – We express our thanks to the two successive directors of the ÉFA, Roland Étienne and Dominique Mulliez, for financing this program within the frame of the ÉFA-CNRS conventions. Besides the authors, P. Yiouni and A. Tsolakidou have contributed to some parts of the analytical program.

geographical distributions (Malamidou 2005). The distribution areas of varieties 1, 3 and 4 coincide roughly with the physical subdivisions of Greek Macedonia into eastern, central and western regions, whereas variety 2 is limited to the middle and upper Struma valley, across the Greek-Bulgarian border.

The overall presence of black-on-red decorated pottery in Late Neolithic Northern Greece reveals the existence of some common technical standards beyond common aesthetic preferences, such as the use of iron-rich clays for the vessels, firing to high temperatures under oxidising conditions, and the use of manganese-based paints. Most of these features have a long history, at least in Eastern Macedonia, where sophisticated dark-on-light painted pottery was produced as early as 5200/5000 BC. (Tsirtsoni 2000, sp. p. 13-18; Yiouni 2000; Yiouni 2001, sp. p. 5-11). On the other hand, the existence of at least four regional varieties suggests an equal number of local pottery traditions, that is, different “recipes” resulting in similar, but not identical, products. These “recipes” differ from one another in several aspects (clay choice and preparation, surface treatments, paints, etc.), reflecting variations in the production processes from one centre to another. Certainly, this variability is related to environmental factors, namely local resources, but the role of tradition should not be underestimated.

Further research focused on the Eastern Macedonian variety 1, which is by far the most abundant and best documented. It is also the most widely distributed, since

it is also found (in small quantities) in many other parts of Northern Greece, including Aegean Thrace to the east, the Axios valley to the west and Thessaly to the south, as well as in SW Bulgaria to the north.

Neutron activation analysis (NAA) of some 200 ceramic samples from 14 settlements allowed us to distinguish four main chemical groups (A-D) for the black-on-red ceramics. A fifth group (E) corresponds to samples of the so-called brown-on-cream painted pottery, which is contemporaneous with and technically similar to the black-on-red, but features a light grey-brown decoration on a yellowish background. The distribution pattern of the four black-on-red ceramic groups (Fig. 2) suggests that pottery production took place in at least four separate production centres in Eastern Macedonia. Each production centre could include more than one workshop, exploiting the same, or mineralogically very similar, clay sources.

Extensive geological survey revealed a substantial number (more than 50) possible clay sources, all in strata dated to the Plio-Pleistocene period. However, none of the analysed samples matched the composition of the ceramics found in the same area. Although a straightforward chemical match between clays and ceramics is very rare, the great differences observed lead to the conclusion that the Neolithic clay sources were either exhausted or covered by younger formations. Future survey should take into consideration not only the general geological features, on a regional scale, but the particular characteristics of each valley.



Fig. 2 – Geographical distribution of the chemical groups A-D in Eastern Macedonia, suggesting black-on-red pottery production in at least four separate centres.

## MICROMORPHOLOGICAL ANALYSIS AND TECHNOLOGICAL EVALUATION

A representative number of 14 samples was examined under the scanning electron microscope (SEM). The examination of the micromorphology of the ceramic body and surface along with their chemical compositions provided information about the selection and manipulation of the raw materials, as well as the pyrotechnology (Maniatis and Tite 1981). This information provided the necessary evidence to reconstruct the production process of the ceramic ware under study. The main question generated by the results of the previous chemical analysis was whether the selection of raw materials and firing parameters were the same in all the production centres. The answer should provide evidence about the level of standardisation in black-on-red pottery production during the Late Neolithic period in Eastern Macedonia.

As far as the clay is concerned, analysis shows a definite preference for non-calcareous clays of a fine nature containing moderate amounts of quartz. Twelve of the fourteen samples studied were found to have been manufactured with clays containing low amounts of CaO (2-6%) (Table 1). Actually, the two samples which are clearly calcareous (CaO up to 12%) do not belong to black-on-red, but to brown-on-cream ceramics (*supra*). The low calcareous (that is, the true black-on-red) group can be further subdivided into two: a virtually non-calcareous sub-group (CaO around 2%), fitting almost perfectly with the chemical group A, which is mainly found in settlements along the Angitis and in the lower part of the Strymon valley, and a second group with CaO between 5-6%, which agrees quite well with the group B, typical of coastal sites.

Sample	Chemical group	CaO content(%)	Vitrification stage	Paint
KRY 01/06	A	1.6	V	med+Mn
KRY 01/16	A	2.6	V	med+Mn
DIM 01/142	A	1.9	V	med+Mn
LUE 01/91	B	5.4	V	fine+Mn
GAL 01/80	B	5.6	V	fine+Mn
AKR 01/72	B	5.6	V	fine+Mn
DT 01/160	D	3.6	V	fine+Mn
KRY 01/64	E	11.5	V	
KRY 01/63	E	11.9	V	
FID 01/101	C	2.0	IV	med+Mn
KRY 01/08	A	2.0	IV	med+Mn
DT 01/161	D	5.9	V+	
KRY 01/09	A	2.7	TV	
KRY 01/02	A	3.9	V+	

Table 1 – Main results of the SEM examination of black-on-red and brown-on-cream ceramic samples; the second column shows correspondence with the chemical groups identified by NAA analysis.

The majority of the samples examined showed vitrification of the clay minerals in their microstructure, in most cases well developed, as evidenced by the extensive networks of glass filaments present. This applies to ceramics coming from both A and B chemical groups, in other words, to samples produced in different production areas. In most cases the glass network is composed of fine filaments (Fig. 3), as a result of the small grain size of the original clay particles, while the firing temperature suggested, for this type of microstructure, is between 900 and 1000 °C. Extensively vitrified microstructure was also developed in the ceramic bodies of the calcareous group E, but the microstructure here is cellular due to the decomposition of calcium carbonate during firing (Fig. 4).

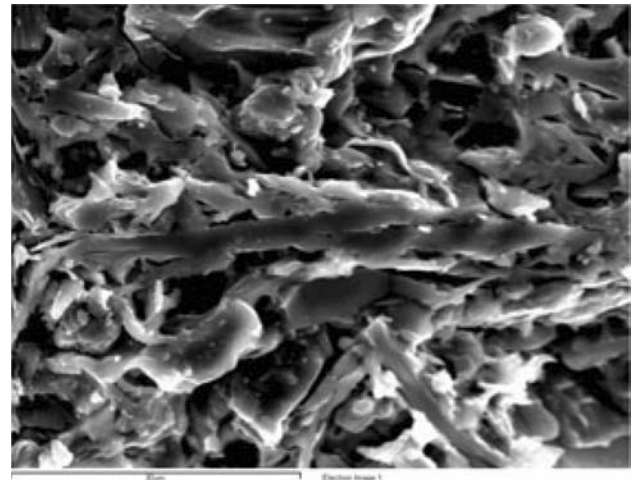


Fig. 3 – SEM microphotograph of a black-on-red pottery sample (DIM 01/142) with a well-developed microstructure, containing an extensive network of fine glass filaments; the estimated firing temperature lies between 900 and 1000 °C. Photo width = 60 µm.

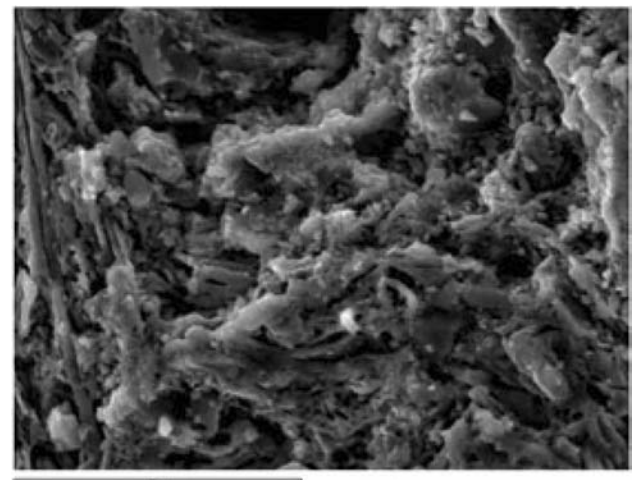


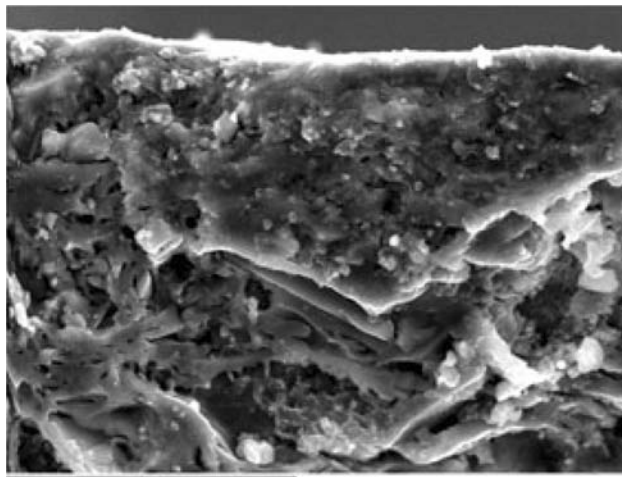
Fig. 4 – SEM microphotograph of a brown-on-cream pottery sample (KRY 01/63): the extensively vitrified cellular microstructure is due to the decomposition of calcium carbonate during firing at high temperatures (900-1000 °C). Photo width = 60 µm.



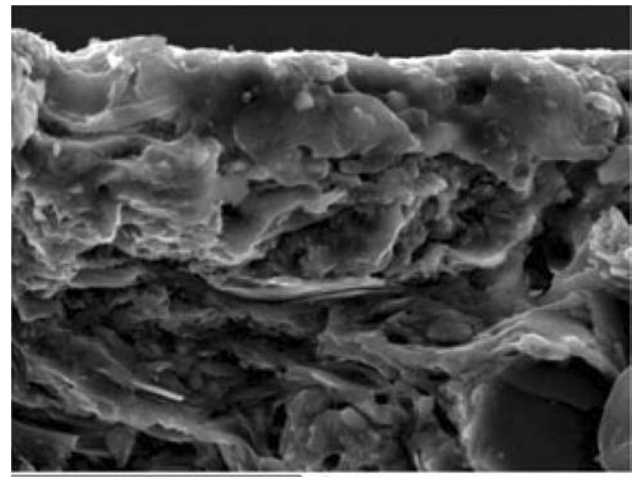
This microstructure is consistent with firing temperatures of more-or-less the same range (900-1000 °C). Slightly lower firing temperatures are assumed for two samples whose microstructures did not exhibit such an extensive state of vitrification as the others.

In all cases the black decoration was obtained by the addition of manganese oxide to a clay suspension and its application prior to firing. This resulted in a paint layer less than 10  $\mu\text{m}$  thick, which does not appear vitrified

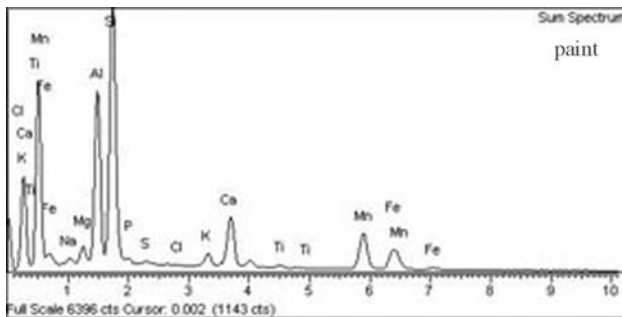
in the SEM examination, although, as mentioned above, the firing temperatures were relatively high (Fig. 5a, b). A closer look at the semi-quantitative analytical data obtained by SEM (especially the Al to Si ratio) reveals two patterns: one with the clay suspension of the paint layer (Fig. 5c) being very fine compared to the clay of the body (Fig. 5e), and one with the clay chemistry being the same in both the paint layer (Fig. 5d) and the body (Fig. 5f). In the first case, a fine suspension of the clay used for the body was obviously prepared, then mixed with Mn-oxide



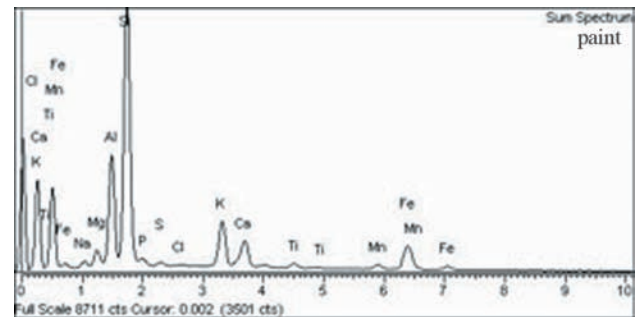
a



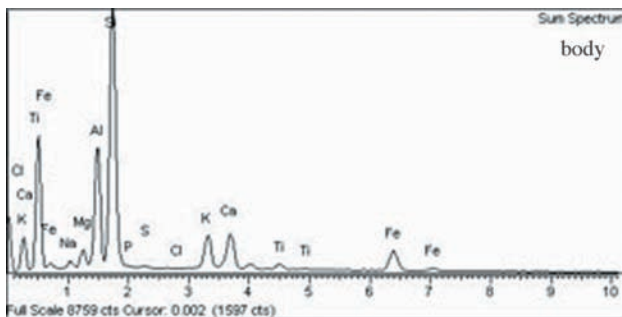
b



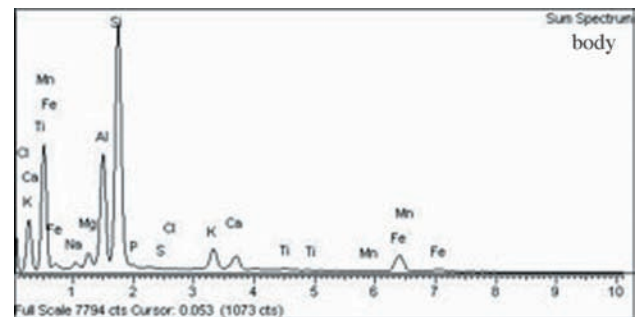
c



d



e



f

Fig. 5 – SEM microphotographs and comparative spectra of two black-on-red pottery samples (LUE 01/91, KRY 01/16). a-b: paint layers on top of the vitrified body. Photo width = 60  $\mu\text{m}$ ; c-f: comparison of the chemical compositions of the paint and body (especially the Al/Si ratio) suggests differences in the preparation of the paint mixtures for the two samples.

to produce the paint, whereas in the second, clay was mixed with water and Mn-oxide, then applied to the body, without prior refinement. It is important to note that the fine suspension pattern is only found in samples coming from the coastal group B, while the untreated one is typical for group A. These differences also had a visual effect, with the black decoration of the “fine” paints being brighter and more durable than the others.

One of the questions that SEM analysis tried to resolve was that of “black” paints that appear grey or white, a feature observed in many specimens of the variety 1 (Fig. 6). Actually, in these cases, the paint does not appear white everywhere, but only in patches—most commonly on the outer surface of the vessel. White motifs are usually surrounded by a black outline, forming a sort of contour. Close examination of samples with such decoration revealed that they had been originally exposed to very high temperatures, well over 1000 °C, as attested by their microstructures (Fig. 7). Another characteristic of these paint layers is that they are low in alkalis and Mg, but rich in Ca, although in the surrounding black lines the situation is exactly the opposite. One possible explanation is that the whitish colour is a result of the effect of the burial environment on the high temperature phases developed in the paint layers: the latter being unstable, they could undergo leaching of K, Na and enrichment of Ca. This is very similar to what happens in glass where a whitish corrosion layer is also formed during burial (Douglas and El-Shamy 1967; Grambow 1992).



Fig. 6 – Black-on-red vessel from Dikili Tash (h. ca 11 cm): the black paint appears white in some parts of the vessel's exterior (photo: Ph. Collet/ÉFA).

Whether these high temperatures were reached during the original firing or during the destruction of the settlement, is not known for certain. It seems however more probable that it happened during the original firing, as suggested by the extent of the white zones on whole vessels.

To summarise, it is obvious that there is essentially one technological tradition all over Eastern Macedonia. However, two variations exist in paint preparation : the first, observed mainly in settlements close to the coast, uses a very fine suspension taken from the same clay as the body, whereas the second one uses this same clay, but without prior refinement. Everywhere there is very good control of firing conditions and high temperatures are applied (usually between 900-1000 °C), in order to obtain hard-fired fabrics with bright, uniform colours. Accidents do happen, however, since we find vessels that have been exposed locally to temperatures above 1000 °C. This should certainly not lead to a depreciation of the Neolithic potters' skill, but rather to a re-evaluation of the constraints with which they had to deal, and to extra appreciation of the overall quality of their products.

Black-on-red vases feature, indeed, a remarkably standardised quality in all stages of the *chaîne opératoire*. Cases like this invite us to reconsider our way of thinking about Neolithic pottery production and Neolithic society in general, which may have been less “unspecialised” and less “self-sufficient” than usually thought.

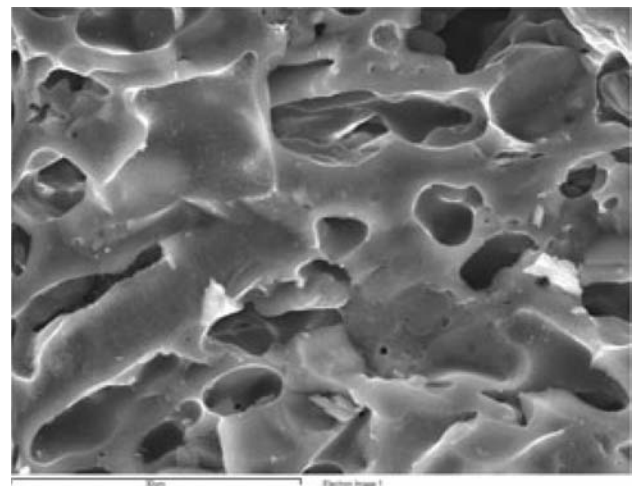


Fig. 7 – SEM microphotograph of a pottery sample with “white-painted” decoration (KRY 01/09): its microstructure suggests firing well above 1000 °C. Photo width = 60 µm.

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