Metallurgical Ceramics from Seriphos (Greece)
Technological Characterization in view of Early Cycladic Metallurgy

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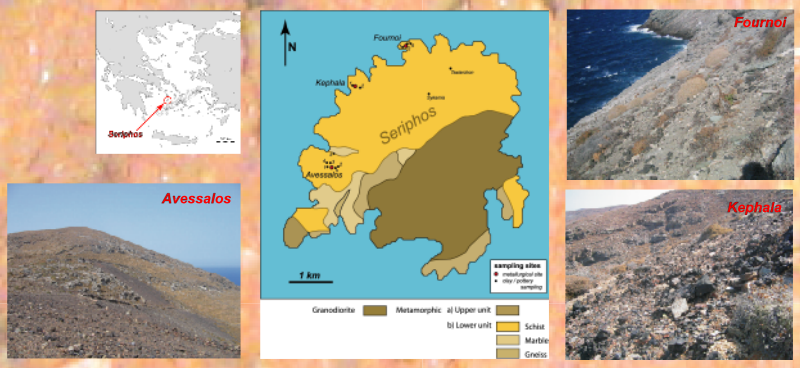

Figure 1 - Map of Seriphos with photographs of the three examined sites

INTRODUCTION

Ongoing archaeometallurgical work in the Cyclades continuously brings forward important evidence for the existence of indigenous copper, lead, and silver production during the Early Bronze Age. Seriphos, together with the neighbouring western Cycladic islands of Kythnos and Siphnos, has been shown to occupy a prominent role in these activities. Thorough technological understanding of the individual metallurgical processes is fundamental in assessing the organisation and role of early Aegean metal production within the corresponding communities. In this context the present project focused on the study of a particular type of material, the metallurgical ceramics, abundant on early Aegean metal production sites, but often neglected in corresponding analytical studies. Three copper slag heaps have been studied all of them situated in north-western Seriphos: Kephala, Fournoi and Avessalos (Fig.1).

EXAMINED FURNACE FRAGMENTS

An assemblage of 54 furnace fragments from the three examined sites was selected for the present study. Most of the fragments presented clear indications to their use in metallurgical processes, in terms of slag traces on the surface, colour variations due to the varying redox conditions and visible bloating pores in areas, which were exposed to extreme temperatures. In general the ceramic matrix gave a rather coarse impression, with frequent and large inclusions. The furnace wall fragments presented commonly a thickness between 20mm and 30mm. Some thicker fragments of the collection (> 40mm) were probably parts of furnace bases. On the basis of large wall fragments with obvious curvature the average inner diameter of the furnaces could be estimated with approximately 320-340mm. Several samples presented a second curvature (Fig. 2a), indicating possibly that the inner diameter of the furnaces was decreasing towards the top. The upper part of the furnace wall was probably freestanding, which was indicated by a furnace wall fragment with defined rim (Figure 2b). Other parts of the furnace, however, appeared to have been placed as kind of a furnace lining against a stone structure. Finally, at the sites of Avessalos and Kephala, a small number of furnace fragments with holes can be found (Figure 2c).

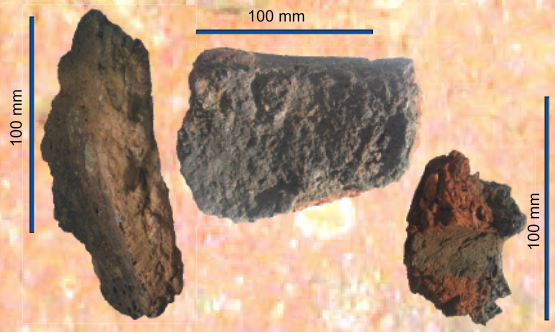

Figure 2 - Funace fragments: a) wall b) rim c) wall fragment with hole

	Fou A8		Fou A9		Fou A10		Kef A9		Kef A11	
	mean	stdev	mean	stdev	mean	stdev	mean	stdev	mean	stdev
Na2O	8.29	3.01	10.67	0.39	7.26	0.73	5.51	2.33	4.11	0.74
MgO	0.60	0.26	0.37	0.17	0.46	0.18	3.63	2.10	3.52	0.98
Al2O3	18.9	1.6	19.3	0.2	18.0	0.3	18.5	2.4	19.1	0.9
SiO2	66.0	2.8	66.4	1.1	67.1	1.0	61.6	3.1	60.6	2.7
SO3	0.24	0.06	0.56	0.02	0.53	0.14	0.20	0.07	0.52	0.09
Cl2O	0.06	0.06	0.21	0.02	0.20	0.06	0.01	0.02	2.36	0.37
K2O	2.69	3.47	1.00	0.36	3.85	0.96	1.97	0.87	2.56	0.96
CaO	1.11	0.36	0.27	0.02	0.26	0.06	3.03	1.60	0.75	0.32
TiO2	0.22	0.11	0.23	0.06	0.29	0.13	0.56	0.33	0.26	0.06
MnO	0.09	0.03	0.10	0.05	0.12	0.04	0.12	0.05	5.34	1.18
Fe2O3	1.36	0.37	0.78	0.64	1.34	0.51	4.38	1.67	0.26	0.09
CuO	0.17	0.04	0.12	0.02	0.32	0.09	0.19	0.11	0.17	0.06

Table 1 - SEM-EDS analyses of the base material in samples from Fournoi and Kephala

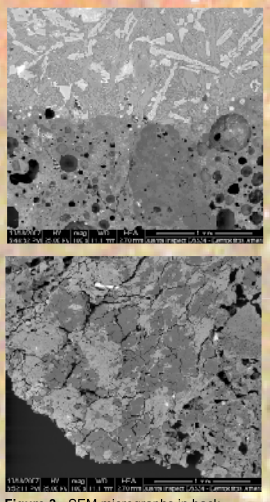

Figure 3 - SEM micrographs in back-scattering mode of a polished section of a furnace wall fragment from Fournoi: a) surface with slag layer b) clay mixture

ANALYTICAL RESULTS

Examination of samples by SEM supported the observation of a coarse and inhomogeneous ceramic body with large inclusions (Fig. 3). The ceramic structure was extremely affected by the heat, especially at the inner surface of the furnace which was in contact with the smelting load (Fig. 3 a, Fig. 4 a). The samples presented evidence of clay mixing (Fig 3 b). The base material according to SEM-EDS analysis was low-calcarteous but showed comparably high concentrations of Na, Mg and K (Tab. 1), which is an indication for the expected use of raw materials deriving from the local schists. The examination of raw materials collected in the vicinity of the sites is still in progress.

By the examination of the degree of vitrification in layers of a furnace base in different distance from the furnace inside a kind of temperature gradient can be estimated for the operation of the furnace [1]. Considering this information it is principally possible to estimate the process temperaturean operation time of the smelting furnace [1][2].

With regard to the dating of the furnaces, i.e. the metallurgical activities in Seriphos, luminescence dating was applied to selected furnace fragments. Following the protocol developed within previous studies [3][4] the samples were sliced almost parallel to the surface based on the visually observed colour variations, thus providing two to three layers from the each specimen. For D_e estimation (equivalent dosis, aliquots consisting of pure quartz grains were used. In every sub-sample, both TL and OSL examination applied for cross-checking of the techniques and in order to provide highest information about sensitivity changes and signal growth. Dose rate was based on the results of chemical and dosimetry studies (PIPS α-counting for U and Th estimation).

The Luminescence examination of samples fom Fournoi and Kephala provided a mean age at the first half of the third millennium BC, which corresponds to the Aegean Early Bronze Age (EBA) I-II periods [4].

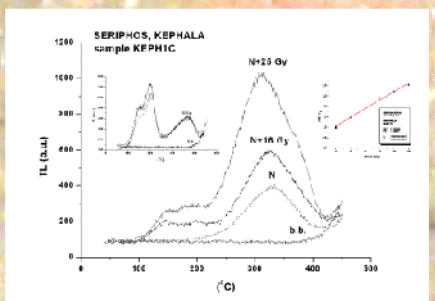

Figure 5 - Natural and natural+laboratory irradiated glow curves for quartz aliquots of sample KEPH1C. Left inset provides the 2nd glows of the same aliquots (for inter-aliquot normalization). Right inset: the resulting growth curves for D_e estimation (test-dose ρ = 12 Gy). b.b. stands for black body irradiation.

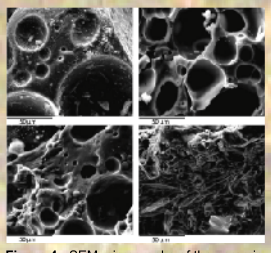

Figure 4 - SEM micrographs of the ceramic microstructure in layers from a furnace base fragment from Avessalos of approximately 40 mm thickness.

CONCLUSIONS

The hiterto results already provide considerable information concerning the metallurgical activities in Seriphos during the Early Bronze Age. The smelting technology at the three sites, at least in terms of the furnaces, was generally the same as the sites are situeted in a common geological environment with very similar raw materials available for furnace construction. The dating of furnace fragments from Avessalos, however, still has to be finalized in order to have a complete picture about chronological relation and a possible development in smelting technology.

On the basis of the studied furnace fragments the typical configuration of the smelting furnaces can be reconstructed. The air supply, however, still remains an open question as no remains of tuyeres were recovered until now and the number of perforated furnace wall fragments is quite small.

References

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[4] Zacharias, N., Michael, C.T., Georgakopoulou, M., Kilikoglou, V. and Bassiakos, Y. (2006) 'Quartz TL dating on selected layers from archaeometallurgical kiln f ragments: A proposed procedure to overcome age dispersion', Geochronometria, 25, 29-35.

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