Association of Metallurgical Engineers of Serbia *Scientific paper*
AMES *UDC: 902.2:669(497.11)*

PHYSICO-CHEMICAL CHARACTERIZATION OF ARCHAEOMETALLURGICAL FINDINGS FROM TWO LOCALITIES NEAR BOR (SERBIA)

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Received 19.01.2012
Accepted 20.02.2012

Abstract

Bor and its surroundings are well known for long and rich tradition in mining and metallurgical activities, as well as by numerous archaeometallurgical localities. The results of investigation of archaeometallurgical findings from Šetaće and Paulešti localities near Bor are presented in this paper. Research of slag samples was done using chemical analysis, DTA, XRD and EDXRF in order to confirm early metallurgical works at mentioned two localities.
Keywords: archaeometallurgy, slags, Bor (Serbia)

Introduction

A surrounding of Bor is typical for numerous archaeometallurgical localities, having in mind continuous development of mining and metallurgy in this area from prehistory up to nowadays [1-4]. Nevertheless, no systematic research of these localities has been done until now, except occasional physicochemical investigations of some artifacts from only a few, main localities [5-10].

Šetaće presents an antic locality in the area Smolnica, village Zlot, on the right bank of Vinogradarski stream at 12km from Bor by new road Bor-Zlot. Museum of Mining and Metallurgy in Bor performed probe archaeological investigations at a small-scale level and Šetaće locality was determined to be a late-antic fortification from the end of IV and beginning of V century A.D. Based on collected archaeological material

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and slag findings, it can be concluded that there was a metal processing activity, but most probably not so large, because greater quantities of slag, which could indicate to a larger metallurgical object, were missing and mentioned fortification was assumed to be of a military-strategic importance [11].

Concerning Paulešti locality, village Luka, there are just a few data. The slag findings are originated from the place called Grindu Goleš and they were firstly brought to the Museum of Mining and Metallurgy by an land-owner, together with some fragments of prehistoric ceramics, most probably from Eneolithic period (IV millennium B.C.). The quantity of material was not enough for more precise archaeological dating, and no organized probe archaeological investigations were done at mentioned locality.

The results of investigation of archaeometallurgical slag findings by using adequate analytical methods are presented in this work, in order to confirm early metallurgical activities at two less known localities – Šetaće and Paulešti.

Experimental procedure

Following research methods were used for experimental investigations in this work: chemical analysis, differential thermal analysis (DTA), X-ray diffraction (XRD) method and Energy-Dispersive X-Ray Fluorescence (EDXRF) spectroscopy.

Chemical analysis was done using optical emission spectrograph apparatus Jarrell-Ash with microphotograph, model 70.000.

DTA was performed for analysis of investigated samples by apparatus NETSCH STA 409EP. The experiments were done at a heating rate of 10^{o}/min, in an air atmosphere up to a maximum temperature of 1000^{o}C, using Al_2O_3 as a referent material.

XRD method was used for determination of phase composition of investigated samples by apparatus PHILIPS, model PW-1710, with curved graphite monochromator and scintillating counter, at a voltage if 40kV and electric current of 30mA. The intensities of diffracted CuKα radiation λ=1.54178Å were measured at room temperatures in the intervals $0.02^{o}2\theta$ within the range of 4-65 $^{o}2\theta$.

EDXRF spectroscopy was done at apparatus Canberra with radio isotopes for excitation Cd-109 (22.1keV).

Results and discussion

Among numerous investigated slag samples from mentioned archaeological localities, results for two chosen samples – sample Z1 (Šetaće) and sample P1 (Paulešti) are presented in this paper.

The results of chemical analysis are presented in Table 1, while thermograms obtained by differential thermal analysis are given in Figs.1 and 2.

Table 1. Chemical composition of investigated sample P1 and Z1

Composition, %	Sample P1	Sample Z1
SiO_2	52,32	65,38
Fe	4,58	4,00
Al_2O_3	15,29	14,45
K_2O	1,28	3,59
Na_2O	2,01	2,47
S	ø	ø
CaO	7,70	6,59
Cu	0,031	0,009
MgO	10,77	4,02
TiO_2	0,58	0,52
FeO	0,81	0,30
Fe_2O_3	4,06	2,25
Fe_3O_4	1,54	3,04

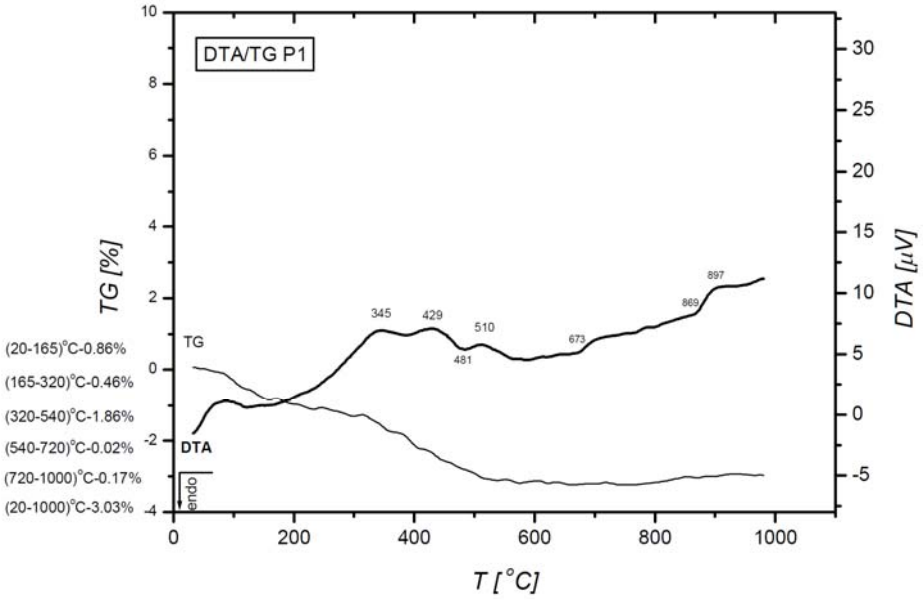

Fig.1. DTA/TG curves for the sample P1

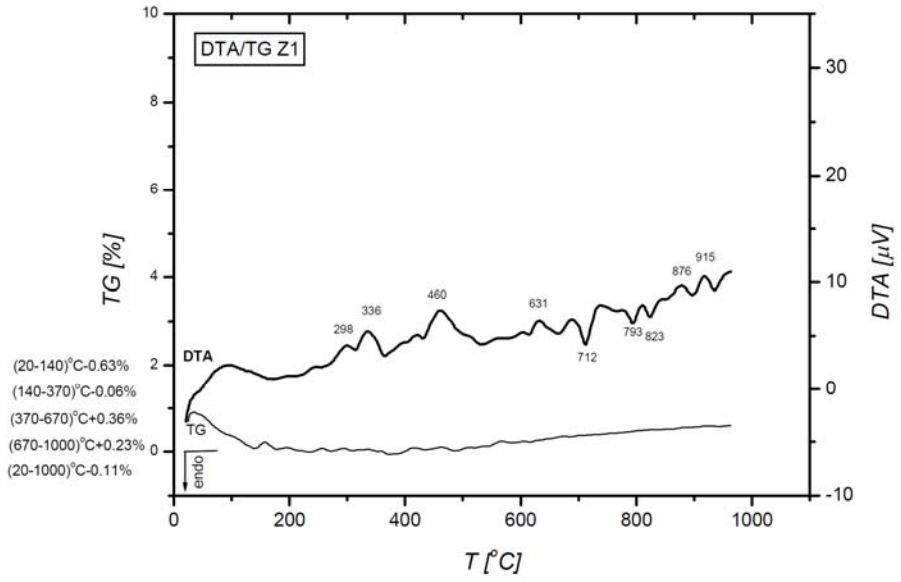

Fig.2. DTA/TG curves for the sample Z1

The presence of following minerals have been determined in investigated samples: a) feldspar (plagioclase), quartz, maghemite, carbonates (calcite, dolomite, syderite), chalcopyrite, smectite, illite, amphibole in sample P1; and b) feldspar, quartz, maghemit, carbonates in sample Z1, similarly.

The results of EDXRF spectroscopy are shown in Figs.3 and 4.

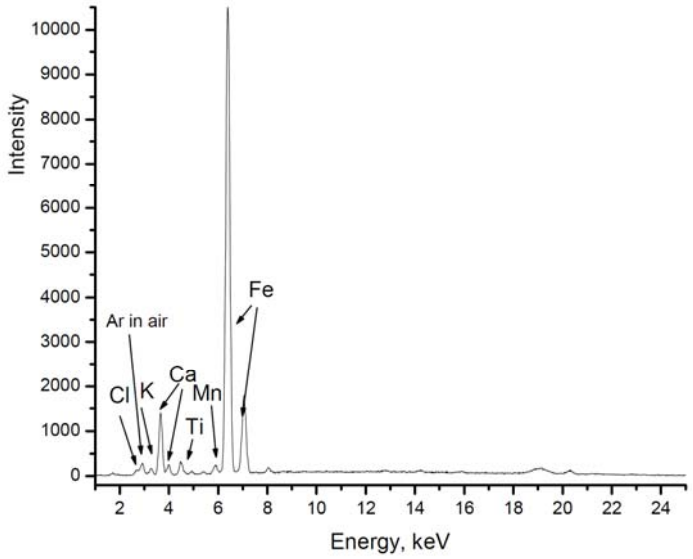

Fig.3. EDXRF spectra for sample P1

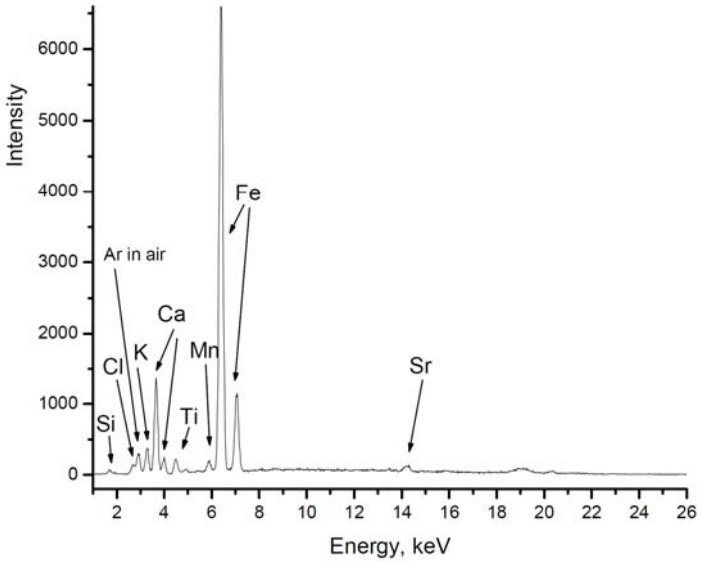

Fig.4. EDXRF spectra for sample Z1

Obtained results shows similarity between investigated two slag samples and indicates to early metal processing activities at archaeological localities Šetaće and Paulešti near Bor. Determined content of iron and iron oxides, as well as present content of SiO_2, CaO, MgO, Al_2O_3 and low copper percentage, lead to the traces of ferrous metallurgy, which was already confirmed at other archaeological localities in the region [4,5,8].

Having in mind that archaeological studies proved presence of late-antic fortification IV-V century A.D. at Šetaće locality, it is clear that at least weapons production or their repair existed there. It is a little bit more difficult to make more definite conclusions about Paulešti locality, which is typical for lack of artifact-material and which is much older than previous considered locality. Especially, if one takes into account that Paulešti locality is dated to Eneolithic, when metallurgical activities in copper production were more expected than in ferrous metallurgy. But, the historical development of metallurgy in Bor surroundings is a fact, and every locality possesses more time-defined layers, which points out on the continuity of the metallurgy in the region.

Conclusion

The results obtained by chemical analysis, DTA, XRD and EDXRF of investigated samples from archaeological localities Šetaće and Paulešti near Bor, indicating to early metallurgical activities at these two localities, are presented in this paper.

Acknowledgement

The authors of the paper acknowledge the support of the Ministry of Education and Science, Republic of Serbia under the projects OI172037 and TR34023.

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