

Characterization of iron slags from the Brâncovenești, Călugăreni and Vătava sites of the *Limes Dacicus Orientalis* (Mureș County, Romania)

E. Bitay¹, Gh. Borodi², D. Toloman², C. Tănăsolia³, I. Kacsó², D. Nyulas⁴, Sz. Pánczél^{4,5}, E. Veress^{6*}

¹*Sapientia Hungarian University of Transylvania, Faculty of Technical and Human Sciences, Tg. Mureș, RO*

²*National Institute for Research and Development of Isotopic and Molecular Technologies, Cluj-Napoca, RO*

³*INCDO-INOE 2000 Research Institute for Analytical Instrumentation, Cluj-Napoca, RO*

⁴*Babeș-Bolyai University, Faculty of History, Cluj-Napoca, RO*

⁵*Mureș County Museum, Tg. Mureș, RO*

⁶*Transylvanian Museum Society, Cluj-Napoca, RO*
veresserzsebet@gmail.com

The study focuses on iron slag samples from three important sites of the eastern frontier (*limes*) of Roman Dacia: the well known Roman auxiliary forts of Brâncovenești and Călugăreni (linked by the eastern *limes* road) and the recently discovered Roman watchtower from Vătava (all in Mureș County, Romania). Relying on the natural defence offered by the nearby mountains and hills combined with a built defensive structure and a watchtower system (like that of Vătava), the two forts controlled the border sections leading towards east around the upper Mureș Valley (Brâncovenești) and around the upper Niraj Valley (Călugăreni), representing the ancient traffic routes towards the *barbaricum*. According to the syntheses on the military history of Roman Dacia, in the II-III centuries AD both forts were among the strategically most important sites of the eastern border of the Dacian provinces.

During the research excavations carried out inside and in the vicinity of the two military forts and at the Vătava watchtower site rich Roman material was recovered, consisting mostly of ceramic pottery and ceramic building materials, but marble, stone, worked **bone**, glass, iron, bronze artifacts as well. Rich iron slag deposits were also unearthed at the Brâncovenești and Călugăreni sites. At Vătava besides the slag remains several iron-working tools have been found too. Smelting-zones or furnace remains in the area were not yet discovered.

After a preliminary characterization of numerous iron slag probes unearthed at the three sites prospected, two sample sets (4 from Brâncovenești and 6 from Călugăreni) completed with a representative sample from Vătava were selected for further study in an attempt to assess the slag types. In this purpose the samples were analysed using XRF (INNOV-X Alpha-6500) and ICP-MS (Elan DRC II, Perkin Elmer), with the aim to determine the major and micro-elemental composition; XRD (Bruker D8 Advance, CuK α 1) and FTIR spectroscopy (JASCO 6100 FTIR), with regard to their mineralogical-structural characteristics. The Fe²⁺/Fe³⁺ rate was determined by EPR spectroscopy performed at room temperature in the X-band (9.46 GHz) on the samples, firstly untreated and then thermally treated at 300 C (Bruker ELEXSYS E500).

The composition data obtained suggest different provenance for the raw materials, while the mineralogical data indicate several slag types, the main mineral phases being, as expected, fayalite, hematite and/or magnetite.

The EPR spectra evidenced properly the presence of Fe³⁺ ions in the samples, and the method used permitted the quantitative determination of the Fe²⁺/Fe³⁺ rate in good concordance with the XRD and chemical analysis data.