

# MULTI-ANALYTICAL PROCEDURE FOR THE INVESTIGATION OF THREE BYZANTINE SEALS

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During the Roman period and in the Middle Ages, lead was widely used since it was easily extracted from common minerals, such as galena and cerussite, as well as being a by-product of silver production [1].

In this work, three Byzantine lead seals from the archaeological site of San Pietro in Castello (VE) were studied. In the case of lead artefacts buried for many centuries, various coloured compounds can form on the surface, such as red PbO [2] or grey-white PbCO<sub>3</sub> and PbSO<sub>4</sub>. These are stable compounds that do not affect the lead matrix of ancient artefacts, while volatile organic compounds (VOCs) can cause active corrosion of lead [3]. A multi-analytical approach combining non-destructive and micro-invasive techniques was adopted for the analysis of the three seals. First, ED- $\mu$ XRF analysis was performed. The acquired spectra highlighted the presence of Pb, Cu, Sn, Sr and Fe. To identify the compounds that constituted the surface patina of the seals, a few mg of material was taken and analysed by ATR-FTIR. To obtain the composition of the alloy, micro-destructive analyses were required: a few mg of material was taken from each seal and dissolved in HNO<sub>3</sub>. Subsequently, ICP-AES and ICP-MS analyses were carried out to quantify Pb, Sn, Cu, Ag, P, Fe, Sb, S, As, Bi and Zn. This multi-analytical approach allowed us to identify PbSO<sub>4</sub> on the surface and to determine that seals were mainly composed of Pb (>99 wt%), with smaller percentages of Sn, Cu, Ag and Fe. The analyses performed may be preparatory to any possible consolidation and conservative restoration of the lead seals when subject to corrosion/mineralization processes.

[1] O. Karagiorgou, S. Merkel, M. Wołoszyn, *Byzantinische Z.* 114 (2021) 1161.

[2] M. Wołoszyn et al., *Archeologia Polski LX* (2015) 123-152.

[3] S. Msallamova, M. Kouril, K. C. Strachotova, J. Stoulil, K. Popova, P. Dvorakov, *Herit. Sci.* 76 (2019) 7.