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Dipartimento di Scienze della Terra
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Ancient to modern metallurgical slags: evolving smelting techniques and their interaction with the environment

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OUTLINE

- Three millennia of mining and smelting in Southern Tuscany
- Several archaeological remains
- Mining waste and slags abandoned without confinement nor supervision

OBJECTIVES

- Reconstruct the ore exploitation carried out in the last 3000 years
- Investigate the extractive metallurgy process from a petrological perspective
- Characterize the impact on the environment of abandoned slag heaps

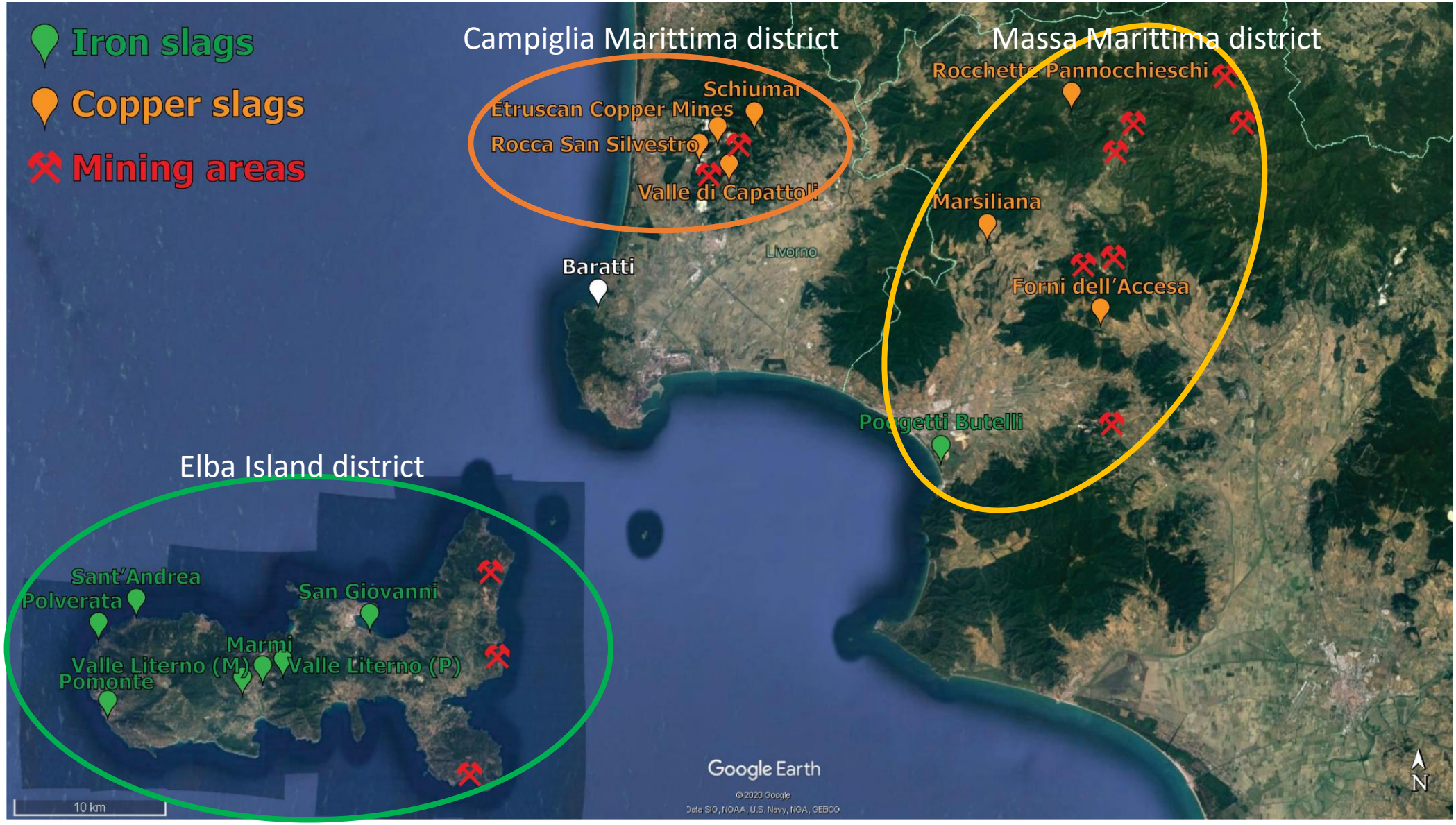
SLAGS

- By-products useful to optimise smelting processes
- Enhance metal separation from the gangue
- Specific properties concerning density and fusion temperature
- Different chemical composition related to charge, flux and process efficiency

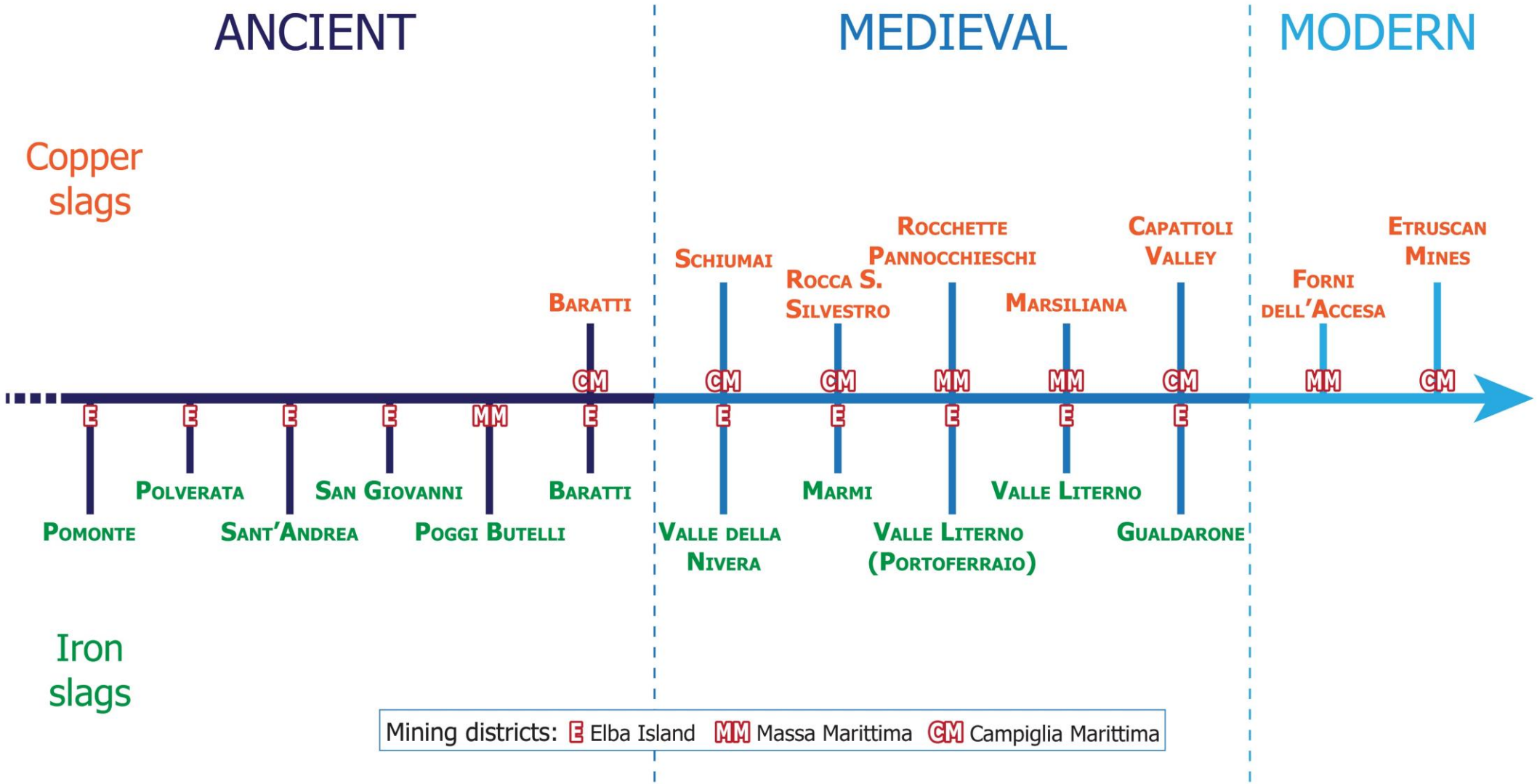
METHODS

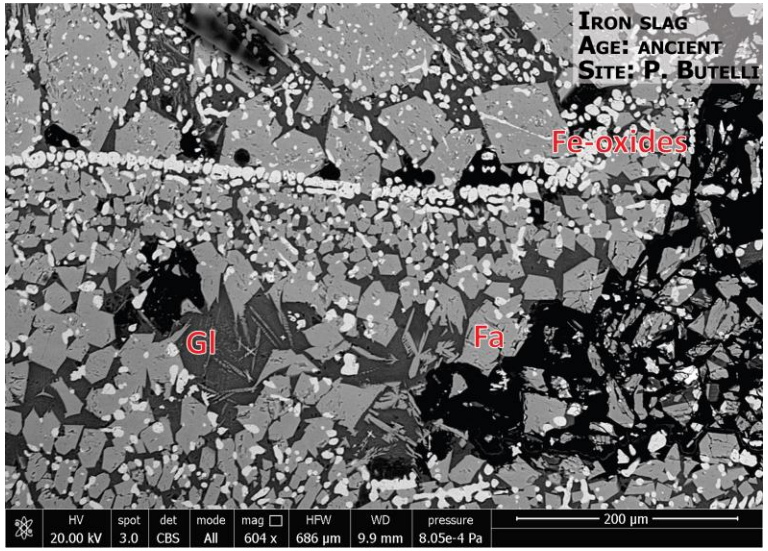
- Optical microscopy (transmitted and reflected light)
- Scanning electron microscopy (SEM)
- Major and trace element analyses (ICP-OES, ICP-MS)
- Handheld X-ray Fluorescence (XRF)
- X-ray powder diffraction (XRD)
- Melting/smelting experiments
- Leaching experiments (@University of Wrocław)

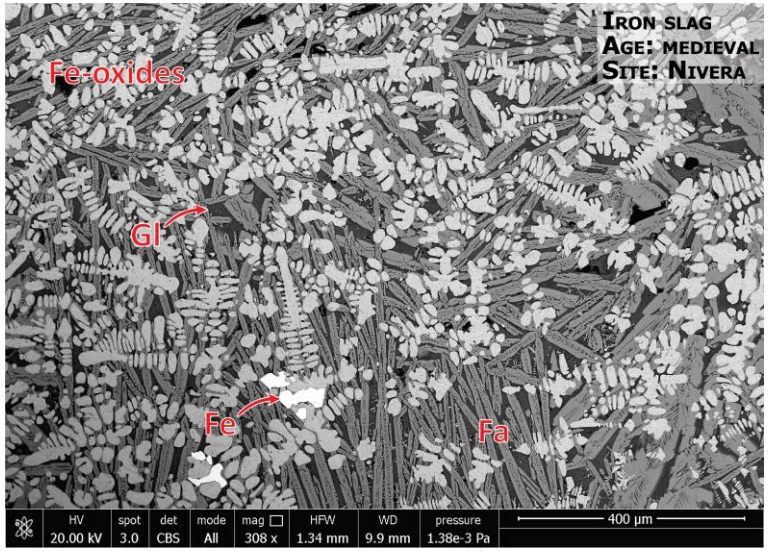
SAMPLING SITES



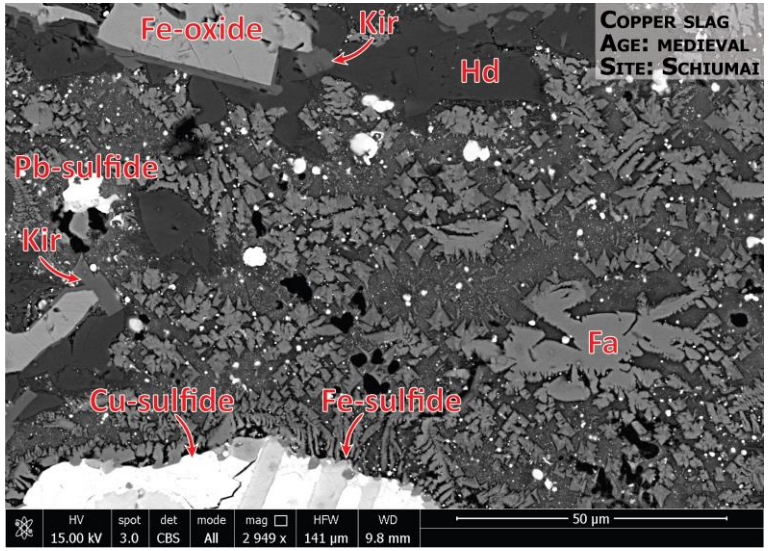
GENERAL TIMELINE

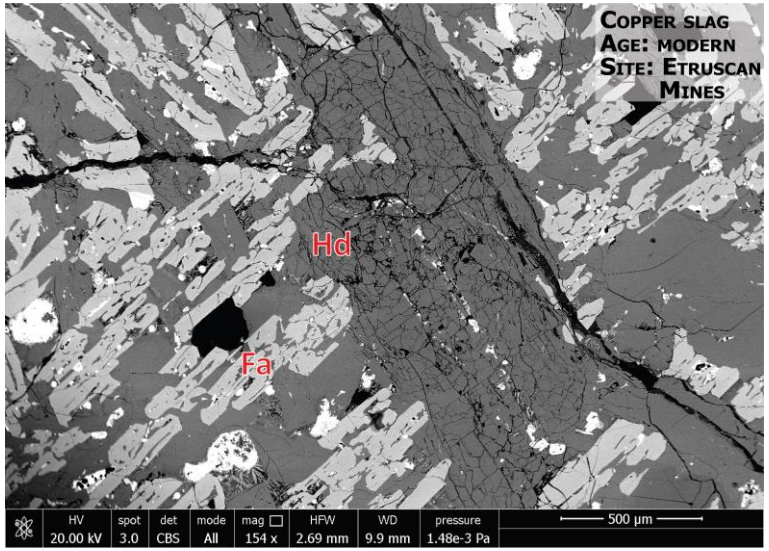






Examples of IRON SLAGS:
macroscopic image of a medieval sample; two backscattered electron images of an ancient and a medieval slag sample.



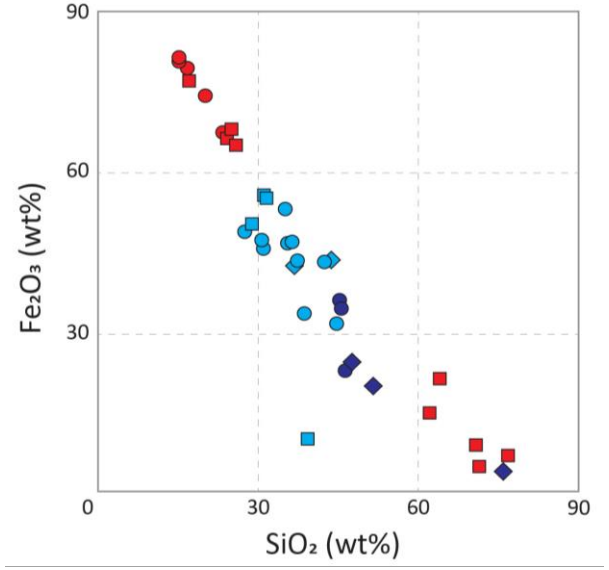


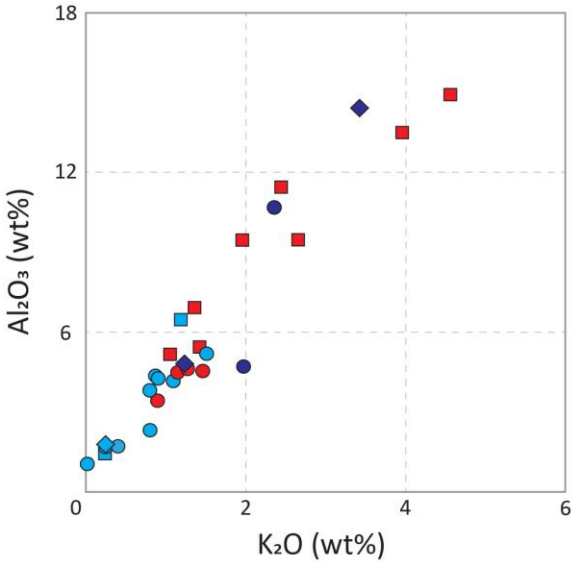
Examples of COPPER SLAGS:
macroscopic image of a modern sample; two backscattered electron images of a medieval and a modern slag sample.

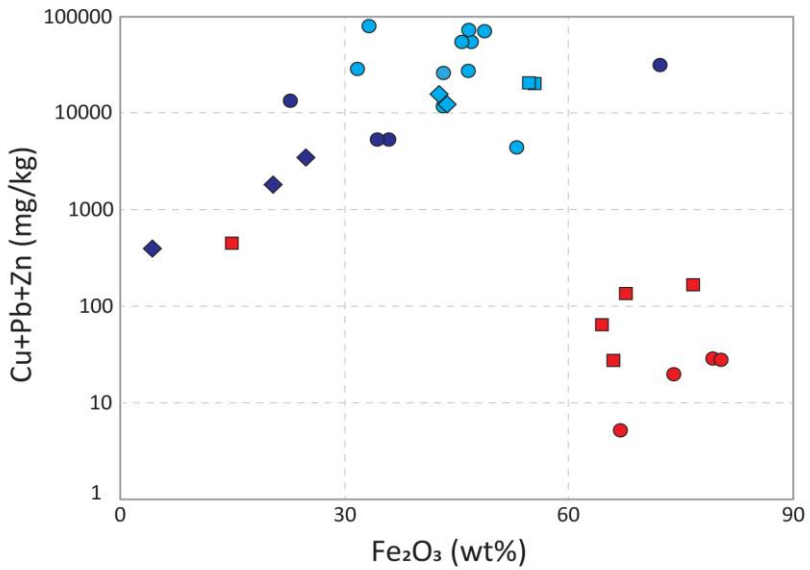
MINERALOGICAL AND CHEMICAL PRELIMINARY RESULTS

Legend:

- Fe Roman
- Fe Medieval
- Cu Roman
- Cu Medieval (CM)
- Cu Medieval (MM)
- Cu Modern (CM)
- Cu Modern (MM)

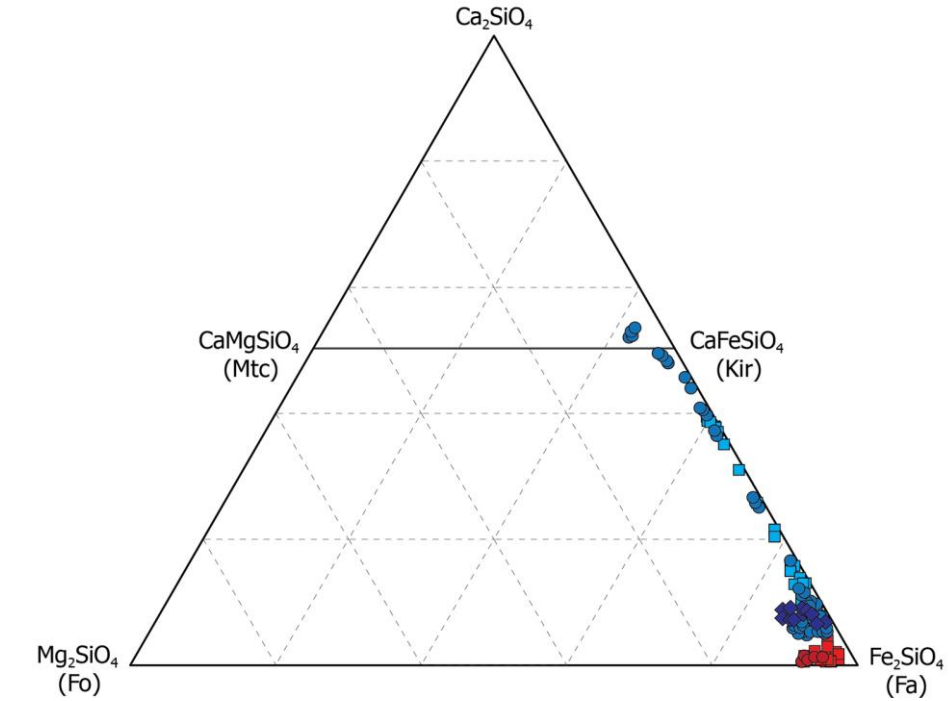






Legend:

- Fe Roman
- Fe Medieval
- Cu Roman
- Cu Medieval
- Cu Modern



Top: Dispersion diagrams of major and trace elements from bulk chemistry analyses of slag samples.

The trace elements concentrations are reported in mg/kg and the corresponding axes are set as a logarithmic scale.

Left: Classification diagrams for the main silicate phase (olivine) observed in some selected samples.

CONCLUSIONS

Important information are directly obtained or inferred from the analysed slag samples:

- Mineralogical and chemical characterisation of slags deriving from different smelting processes
- Characterisation of furnace conditions and metal extraction efficiency in different epochs - experimental petrology tests
- Assessing release of potentially toxic elements from slag heaps - leaching tests