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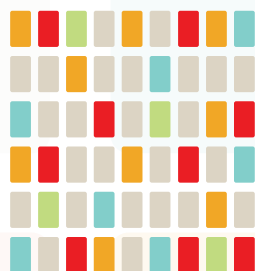
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Lecture

New Insights into Early Iron Age Iron Production in the SE Alpine area: Case Studies from Cvinger near Dolenjske Toplice and Pungrt above Ig

Iron metallurgy undoubtedly played an important role in the wide range of changes that occurred in the Early Iron Age, far beyond the Eastern Hallstatt Area. A key to its better understanding are interdisciplinary studies, which offer new data and can significantly supplement our previous knowledge about smelting of iron ore as well as smithing of iron objects.

The prehistoric complex of Cvinger near Dolenjske Toplice occupies a strategic position between the regions of Dolenjska and Bela krajina. It has yielded important finds for understanding the Late Hallstatt period (6th–4th century BC) and contains the largest known iron-smelting area in the region. Interdisciplinary research campaigns at Cvinger have combined modern remote sensing techniques, such as airborne laser scanning, multimethod geophysical surveys and geochemical mapping, with established archaeological methods. The results have provided new insights into the entire complex, including the chronological refinement of the iron-smelting area.

At the Pungrt Hillfort—an early urban settlement in central Slovenia inhabited from the 8th/7th century BC to the 2nd century AD—the abundant macro-remains of iron slag, found primarily in secondary refuse contexts, provide clear evidence that iron metallurgy played a significant role in the settlement's economy. However, only an integrated geoarchaeological approach allows reliable identification of the primary locations of metallurgical production within the site. Scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS)

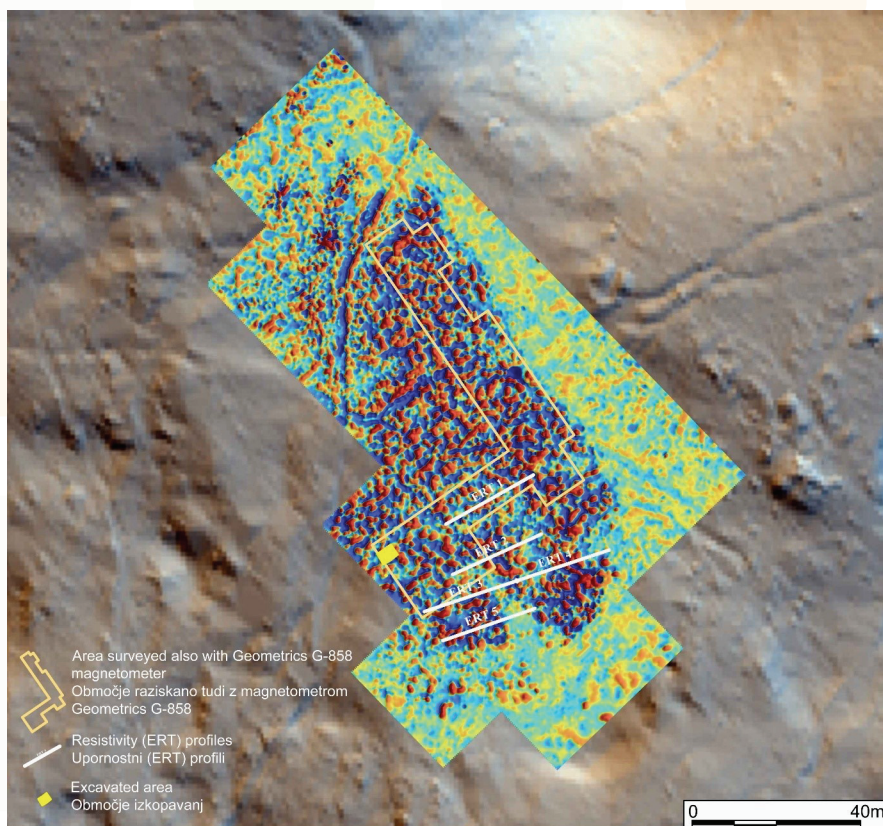


Figure 1 Branževce iron ore smelting site below the Cvinger hillfort near Dolenjske Toplice: Results of the magnetic prospecting (figure by: B. Mušič; see Mušič & Orengo, 1998, and Črešnar et al., 2020)

examination of the iron-working debris (hammerscale and slag) provided what is believed to be the earliest clear evidence for the use of flux in iron welding during the Early Iron Age. In addition, the full range of micro-refuse discovered allows us to infer that the blacksmith was probably involved in the entire chaîne opératoire, from ore procurement and processing to the final shaping of the iron objects.

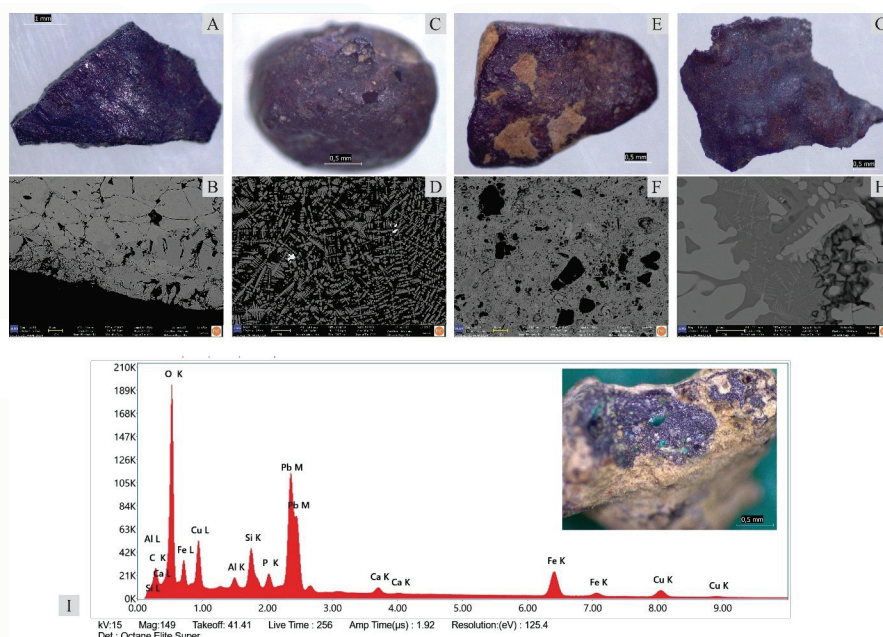


Figure 2 Pungrt hillfort. SEM-EDS analysis of micro-refuse from Building 24 in Ilb2 phase. Flake hammerscale (A) photograph and (B) SEM image showing hammerscale with various ferrous oxides. Spheroid hammerscale (C) photograph and (D) SEM image showing dendritic microstructure typical for solidification. Miscellaneous hammerscale (E) photograph and (F) SEM image showing hammerscale, different ferrous oxides with flux. Slag (G) photograph and (H) SEM image showing solidification microstructure of slag. (I) Photograph of slag and EDS spectra showing presence of Pb and Cu, typical for copper smelting (figure by L. Gruškovnjak, J. Burja & B. Šetina Batič; see Gruškovnjak et al., 2025).

Acknowledgements

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