„Life and Work at the Bronze Age Mine of Prigglitz"

FWF – Austrian Science Fund Stand-alone Project No. P30289-G25
Final Project Report by Peter Trebsche
University of Innsbruck, 25.01.2022
Updated bibliography, 07.11.2022

Project aims and specific objectives

At the site of Prigglitz-Gasteil, located at the easternmost fringe of the Alps, the excellently preserved remains of the Late Bronze Age copper mining site were excavated from 2010 to 2014. The aims of the subsequent research project (2017–2021) were to investigate the organisation and the operation of an Alpine copper mine in order to improve our knowledge of prehistoric miners' work and life in relation to the networks of communication and exchange. The **micro-regional case study** included the **multi-disciplinary study** of plant remains, animal bones, metallurgical finds, micro-debris and soil chemistry, combined with **minimally invasive fieldwork** in the form of core drillings and non-destructive geophysical prospection methods.

Most important results

The chaîne opératoire: from copper extraction to the production of bronze objects

1. Reconstruction of mines and mining technique

Ingrid Schlögel (Zentralanstalt für Meteorologie und Geodynamik) and Adrian Flores-Orozco (TU Wien) carried out electrical imaging techniques, namely electrical resistivity and induced polarization tomography, combined with seismic refraction tomography. As a result, it was possible to **reconstruct an open-pit copper-ore mine** of the Late Bronze Age, that developed in three phases (Pit A, B and C) and reached a maximum depth of 33 m below the present surface (Trebsche/Schlögel/Flores-Orozco, submitted).

Decisive for the interpretation of the geophysical measurements was the availability of materials recovered from **two deep drilling cores**. The use of geophysical measurements and deep drilling is rare in archaeological studies, making our study a possible standard for future investigations. Organic finds from the cores allowed the open pits to be radiocarbon dated to the Late Bronze Age (11th-9th century BC). The cores also provided evidence that the mining process was interrupted by a **mining subsidence event,** that can be dated **shortly after ca. 920 BC** (Trebsche/Weixelberger 2022).

2. Characterization of the ore deposits

15 copper ore samples were selected from Late Bronze Age layers and analysed for their trace elements and lead isotope signatures at the Curt-Engelhorn-Zentrum für Archäometrie (CEZA) in Mannheim (Germany). **Chalcopyrite** was the main sort of copper ore exploited at Prigglitz-Gasteil. With the data at hand, it can be characterized as a highly pure copper, containing very little trace elements and almost completely **lacking lead**. Consequently, lead isotope analyses are not appropriate for tracing the Prigglitz-Gasteil chalcopyrite copper. Thus, our study has considerable **implications for further provenancing studies**: At the Prigglitz-Gasteil mine, a type of raw copper was produced that cannot be detected neither by trace elements nor by lead isotope analyses once it has been mixed/diluted/alloyed with different ores (Mödlinger/Trebsche/Sabatini 2021).

3. Investigation of fine plate slags

The excavated slags from the Prigglitz-Gasteil site form a very homogeneous assemblage, consisting almost exclusively of fine plate slags (thickness < 5 mm). During the project, a sample of 10 plate slags was chosen for bulk chemical analyses (XRF) and local analyses of metallographic samples (SEM-EDX), conducted by Roland Haubner and Susanne Strobl at the Institute of Chemistry (Technical University of Vienna). Remarkably, some of the investigated plate slags contained tin as a trace element which most likely came into the slag through contamination from the nearby bronze processing. In line with previous archaeometallurgical investigations, the analysis of plate slags confirms that **primary and secondary metallurgy** were carried out **in immediate vicinity** at the Prigglitz-Gasteil site (Haubner/Strobl/Trebsche 2019; 2021; submitted).

4. Mixing and recycling

34 copper and copper alloy artefacts from Prigglitz-Gasteil plus 76 artefacts from contemporary contexts within an ~ 15 km radius around the site were analysed for their elemental composition by XRF and partially by lead isotope analyses at the CEZA laboratory. Our analyses indicate that the objects produced at Prigglitz-Gasteil with **locally available chalcopyrite were likely mixed** with materials from external origins. In the Late Urnfield Period (mid-11th to 9th century BC), when almost all copper-based alloys in circulation were highly impure (i.e., with high percentages of Sb and As), the fresh, pure chalcopyrite-based copper from Prigglitz-Gasteil may have been recognized as important in controlling the concentration of alloying elements (Mödlinger/Trebsche 2020; Mödlinger/Trebsche/Sabatini 2021).

5. Metallurgical traditions

Metallographic analyses of 30 cutting tools and jewelry items from Prigglitz-Gasteil and six contemporaneous sites in the surrounding region provide insights into the **post-casting treatment of different kinds of bronze objects**. Objects with a cutting edge were worked to achieve higher hardness compared with jewellery artefacts that showed higher flexibility. In sum, there was no distinct difference in quantity and quality of post-casting treatments, suggesting that the Prigglitz region's bronze production was not standardized (Mödlinger/Trebsche 2020; Mödlinger/Trebsche 2021).

6. Metal flow and regional distribution networks

Despite the interpretive difficulties mentioned above, we found evidence that **Prigglitz-Gasteil sourced metal were exchanged in the Schwarza Valley's micro-region** at least as far as c. 11.5 km away. Regarding the distribution networks, we were able to reconstruct a **detailed picture of metal flows**, demonstrating that several different copper alloy types circulated contemporaneously in the region (Trebsche/Fehlmann/Konrad 2019; Mödlinger/Trebsche/Sabatini 2021).

Chronology, formation processes and intra-site activity patterns

With a series of 24 new radiocarbon dates, measured by Accelerated Mass Spectrometry at the Poznan Radiocarbon Laboratory, it is now possible to **date the occupation of the two terraces T3 and T4** excavated from 2010-2014 much more precisely than it was possible with the small number of chronologically significant archaeological finds. According to the Bayesian calibration model, the occupation of Terrace T4 lasted from 946–906 BC (1 sigma) to 910-851 BC (1 sigma), and Terrace T3 from 972–908 BC (1 sigma) to 796-764 BC (1 sigma).

Importantly, the radiocarbon dates also contributed to the **reconstruction of formation processes**. A number of earlier outliers indicate that major re-depositions of sediments containing animal bones took place, thus creating a 'reverse stratigraphy' that would have been impossible to recognize without scientific dating (Trebsche, in press).

Detailed insights into the **spatial organisation** of the mining camp were provided by the **analysis of micro-refuse**, sorted out from sediment samples. The micro-finds (2-10 mm) allowed for a detailed reconstruction of activity patterns (butchering, meat processing, plant processing, textile, bone, antler and metal working). The **geochemical analyses** (multi-element ICP-OES of 300 soil samples) did not show interpretable spatial patterns, because the excavated area on each terrace was too restricted (max. 100 m^2). However, in principle, the adopted method was proven to be useful for further excavations involving larger areas (Salisbury, in press). Overall, the combined investigation of radiocarbon dates, micro-debris and geochemical patterns did offer insights not so much into spatial activity patterns, but into the temporal variation and **succession of different activities at a high chronological resolution**.

Food and fuel supply

1. Plant-based nutrition

The archaeobotanical analyses performed by Andreas G. Heiss, Thorsten Jakobitsch and Silvia Wiesinger (Austrian Archaeological Institute, Austrian Academy of Sciences) make Prigglitz-Gasteil one of the most intensively studied **Bronze Age mining sites** in the Eastern Alps. Barley and foxtail millet are documented as **components of cereal preparations**. These two could made up the major components of a miners' dish, a simple unfermented cereal mush. At Prigglitz-Gasteil, cereals were likely brought from outside in the form of ready-to-cook grains and ground meal to sustain the workers. Some food may even have been delivered in pre-cooked state. Furthermore, the distribution patterns of plant finds indicate **functional intra-site differentiation**, e. g. a possible small cereal stock in SE 1047; plant spectra differing between terraces T3 and T4 (Heiss/Jakobitsch/Wiesinger/Trebsche 2021).

2. Animal-based nutrition

Archaeozoologist Erich Pucher (Natural History Museum, Vienna) analysed 16.261 bones with a total weight of 176,384 g. The **vast majority** (55.9 %) of the bones **derived from pigs**, followed by 23.2 % cattle bones and 20.4 % sheep bones. Hence it becomes obvious that the mining site was supplied almost exclusively by domestic animals, among which pigs dominated. The skeletal part representation led to the conclusion that in all species **slaughtering refuse dominated**. Obviously, the excavation captured the slaughtering place of the site, not the place of meat consumption. The location and direction of cut marks reveal a **highly organised and professional butchering technique** (Trebsche/Pucher 2013; Pucher, in press).

3. Timber and fuel supply

This aspect was studied on the basis of **anthrocological analyses of fuel wood** from the settlement contexts. This approach was augmented by the **discovery of preserved wooden artefacts** in the drilling cores in 2017 and by the **discovery of a pollen archive** in the nearby Saubachgraben mire in 2018. The complementary information from these different contexts allowed a reconstruction of the **impact of settlement and mining activities** on the natural mixed forest around the site, chiefly composed of beech, spruce, and fir. Forest clearing affected mainly spruce. The investigated wood and charcoal finds indicate a **systematic and selective use of the wood species** occurring in the surrounding forest. At the current stage of the investigations, there is no evidence for any scarcity or shortage in the wood supply (Jakobitsch et al. 2022).

Organisational model of copper production

As a result of our project, the Late Bronze Age site of Prigglitz-Gasteil can be characterized **a regional centre of copper production and bronze working** based on the evidence of an openwork copper ore

mine and nearby bronze casting workshops. The copper ore mine was in operation from ca. 1050 BC to 780 BC. Its main product was very pure copper, smelted from chalcopyrite, which must have been sought after in the Late Urnfield Period, when high-impurity copper alloys dominated in Central Europe. The **Prigglitz copper was distributed in the surrounding micro-region**, where several casting cake hoards with a corresponding chemical composition were discovered. Due to the high purity and the lack of lead in the Prigglitz ores, it is difficult to trace the Prigglitz metal further after alloying or mixing. These methodical challenges make it difficult to assess the role of Prigglitz among several other copper production and metal working sites in the Easternmost Alps (Prein an der Rax, Grünbach am Schneeberg) and the Köszeg-Güns region (Stadtschlaining, Velem-Szentvid).

Shortly after 920 BC, a **mining subsidence** occurred and destroyed one part of the large opencast. This catastrophe did not interrupt mining activities but led to a **change in the spatial layout** of the workshops and dwellings associated with the mine that reflects a different mode of work organisation. During the **early period at Prigglitz (ca. 1050 to 920 BC)**, the mine had been operated continuously, the different work steps in copper production **followed a strict spatial pattern**. **After the subsidence event (ca. 920 BC)**, all attested activities – like copper beneficiation, bronze working, butchering, food processing, textile, bone and antler working – alternated in rapid succession, at least on the two working terraces excavated, thus provoking the picture of a rather **loose, uncoordinated organisation** of the mine.

With the intense geophysical, archaeobotanical, archaeozoological and archaeometallurgical investigations performed during the project, the site of Prigglitz-Gasteil now provides abundant data for comparison with other interdisciplinary studies of copper mining sites in the Eastern Alps, like the Mitterberg, Kitzbühel and Schwaz-Brixlegg districts, and the salt mine at Hallstatt. As regards the mining technique, Prigglitz represents the **first prehistoric large-scale opencast mine** in the Eastern Alps that can be reconstructed thanks to the intensive geophysical surveys, complemented with deep core drillings for ground-truthing. Despite the differences in mining technique and mined resources, the organisation of meat supply is very similar across all Late Bronze Age sites. Thanks to intensive sampling, Prigglitz provided **a wealth of charred plant remains**, including processed food stuffs that were probably delivered to the mining site. Thus, for the first time, the **plant-based cuisine and consumption practices** of Bronze Age miners were investigated in detail, with a great future potential for the application of recently developed methods like organic content and proteomics analyses of charred food remains.

As opposed to the mentioned underground copper mines, the Prigglitz opencast mine is directly associated with a settlement area and bronze workshops. For the late operation period (ca. 920 to 780 BC), **bronze casting and recycling of scrap metal** of different sources is evidenced by archaeometallurgical analyses. The dwellings and workshops corresponding with the early period (ca. 1050 to 920 BC) have not yet been discovered as they are covered by 10-20 m thick layers of mining debris and the mentioned landslide. These buried layers – partially with organic finds preserved under wet conditions – should be further investigated by deep core drillings and microarchaeological methods (micromorphological, geochemical and aDNA analyses) in the future.

Project publications

Haubner/Strobl/Trebsche 2019: R. Haubner/S. Strobl/P. Trebsche, Metallographic analyses from the late Urnfield period copper mining settlement at Prigglitz-Gasteil in Lower Austria. In: R. Turck/T. Stöllner/G. Goldenberg (Hrsg.), Alpine Copper II - Alpenkupfer II - Rame delle Alpi II -

Cuivre des Alpes II. New Results and Perspectives on Prehistoric Copper Production. Der Anschnitt Beiheft 42 (Bochum 2019) 323–332. PDF on Academia

Haubner/Strobl/Trebsche 2021: R. Haubner/S. Strobl/P. Trebsche, Analytical investigations on plate slags from the late Urnfield Period copper mining settlement at Prigglitz-Gasteil (Lower Austria). In: B. Török/A. Giumlia-Mair (Hrsg.), Proceedings of the 5th International Conference "Archaeometallurgy in Europe", 19-21 June 2019, Miskolc, Hungary. Monographies Instrumentum 73 (Drémil-Lafage 2021) 205–218. PDF on Academia

Haubner/Strobl/Trebsche submitted: R. Haubner/S. Strobl/P. Trebsche, Materialographic investigations on plate slags from the Late Bronze Age copper production site of Prigglitz-Gasteil (Lower Austria). Journal of Archaeological Science – Reports, submitted 9.8.2022.

Heiss/Jakobitsch/Wiesinger/Trebsche 2021: A. G. Heiss/Th. Jakobitsch/S. Wiesinger/P. Trebsche, Dig Out, Dig In! Plant-based diet at the Late Bronze Age copper production site of Prigglitz-Gasteil (Lower Austria) and the relevance of processed foodstuffs for the supply of Alpine Bronze Age miners. PLoS ONE 16, 3, 2021, e0248287. https://doi.org/10.1371/journal.pone.0248287 open access; PDF on Academia

Jakobitsch/Wiesinger/Heiss/Faltner/Oeggl/Grabner/Trebsche 2022: Th. Jakobitsch/S. Wiesinger/A. G. Heiss/F. Faltner/K. Oeggl/M. Grabner/P. Trebsche, Wood use and forest management at the Late Bronze Age copper mining site of Prigglitz-Gasteil in the Eastern Alps – A combined anthracological, archaeological, and palynological approach. Journal of Archaeological Science: Reports 46, 2022, 103673. https://doi.org/10.1016/j.jasrep.2022.103673 open access; PDF on Academia

Mödlinger/Trebsche 2020: M. Mödlinger/P. Trebsche, Archaeometallurgical investigation of a Late Bronze Age hoard from Mahrersdorf in Lower Austria. Journal of Archaeological Science: Reports 33, 2020, 102476. https://doi.org/10.1016/j.jasrep.2020.102476 open access; PDF on Academia

Mödlinger/Trebsche 2021: M. Mödlinger/P. Trebsche, Work on the cutting edge: metallographic investigation of Late Bronze Age tools in southeastern Lower Austria. Archaeological and Anthropological Sciences 13, 2021, article 125. https://doi.org/10.1007/s12520-021-01378-1 open access; PDF on Academia

Mödlinger/Trebsche/Sabatini 2021: M. Mödlinger/P. Trebsche/B. Sabatini, Melting, smelting, and recycling: A regional study around the Late Bronze Age mining site of Prigglitz-Gasteil, Lower Austria. PLoS One 16(7), 2021, e0254096. https://doi.org/10.1371/journal.pone.0254096 open access; PDF on Academia

Trebsche/Fehlmann/Konrad 2019: P. Trebsche/D. Fehlmann/M. Konrad, 12 urnenfelderzeitliche Bronzefunde = 1 Depot vom „Gelände" bei Grünbach am Schneeberg? In: S. Hye/U. Töchterle (Hrsg.), UPIKU:TAUKE. Festschrift für Gerhard Tomedi zum 65. Geburtstag. Universitätsforschungen zur Prähistorischen Archäologie 339 (Bonn 2019) 559–569. PDF on Academia

Trebsche/Schlögel/Flores-Orozco 2022: P. Trebsche/I. Schlögel/A. Flores-Orozco, Combining geophysical prospection and core drilling: Reconstruction of a Late Bronze Age copper mine at Prigglitz-Gasteil in the Eastern Alps (Austria). Archaeological Prospection 2022, 1-21. https://doi.org/10.1002/arp.1872 open access; PDF on Academia

Trebsche/Weixelberger 2022: P. Trebsche/G. Weixelberger, A mining subsidence event around 920 BC in the Late Bronze Age copper mine of Prigglitz-Gasteil (Lower Austria). Archäologisches Korrespondenzblatt 52/1, 2022, 41–64. Open access; PDF on Academia

Further Publications

P. Trebsche/E. Pucher, Urnenfelderzeitliche Kupfergewinnung am Rande der Ostalpen. Erste Ergebnisse zu Ernährung und Wirtschaftsweise in der Bergbausiedlung von Prigglitz-Gasteil (Niederösterreich). Prähistorische Zeitschrift 88, 1–2, 2013, 114–151. DOI 10.1515/pz-2013-0004; PDF on Academia

P. Trebsche, Resources and nutrition in the Urnfield period mining site of Prigglitz-Gasteil in Lower Austria – Preliminary report on the excavations from 2010 to 2012. In: P. Anreiter u. a. (Hrsg.), Mining in European History and its Impact on Environment and Human Societies – Proceedings for the 2nd Mining in European History Conference of the FZ HiMAT, 7.-10. November 2012 (Innsbruck 2013) 33–37. PDF on Academia

P. Trebsche, Urnenfelderzeitlicher Kupferbergbau in Niederösterreich. In: T. Stöllner/K. Oeggl (Hrsg.), Bergauf Bergab. 10.000 Jahre Bergbau in den Ostalpen. Wissenschaftlicher Beiband zur Ausstellung im Deutschen Bergbau-Museum Bochum vom 31.10.2015–24.04.2016. Im vorarlberg museum Bregenz vom 11.06.2016–26.10.2016 (Bochum 2015) 209–214. PDF on Academia

P. Trebsche, Zur Absolutdatierung der urnenfelderzeitlichen Kupfergewinnung im südöstlichen Niederösterreich. Archäologisches Korrespondenzblatt 45/1, 2015, 41–60. https://doi.org/10.11588/ak.2015.1.34520; PDF on Academia