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Prehistoric copper production in Lower Austria – A new assessment

ABSTRACT: *The prehistoric copper mining area of Lower Austria is situated at the eastern edge of the Austrian Alps. This region of south-eastern Lower Austria is known for the medieval and modern mining of iron and copper ore. The copper ore deposits belong to three geological units: the Greywacke Zone, the base of the Northern Limestone Alps (or Northern Calcareous Alps) of the eastern alpine Mesozoic and the crystalline nappes of the Austroalpine Unit of the Central Alps. Of further interest for the study of prehistoric copper production are the ore deposits in the area of the orthoriebeckite gneiss belonging to the Greywacke Zone west of Gloggnitz. Ten prehistoric mining districts can be distinguished based on the structure of the landscape. Nine of these are situated north of the River Schwarza and its tributaries. Only one mining district is known south of the River Schwarza, although several copper ore deposits have been recorded there.*

Research on prehistoric copper production in Lower Austria started in the early 1930s by the speleologist Franz Mühlhofer and was continued in the 1950s with the recording and the archaeological investigation of sites of prehistoric copper smelting by the archaeologist and ethnologist Franz Hampl and the geologist Robert J. Mayrhofer. Since then up to 50 archaeological sites related to prehistoric copper production have become known. Only a few of these smelting sites can be dated to the Late Bronze Age. The remains of furnaces and roasting hearths were described by Hampl at the Prein sites, their construction details differing from smelting sites in Switzerland, the Tyrol, Salzburg and Styria. In the 1970s another type of furnace was found in the mining district of Kulm-Hafning, south-east of all the other mining districts. More recently, a number of sites with mining pits and other findings have been discovered which now widen the base for future research.

KEYWORDS: COPPER PRODUCTION, MINING, SMELTING, PREHISTORY, LOWER AUSTRIA

Introduction

The prehistoric copper mining area of Lower Austria is situated in the south-east of Lower Austria at the eastern edge of the Austrian Alps. Archaeological research started in the early 1930s, when the speleologist Franz Mühlhofer discovered mining pits of unknown date. Research was continued in the early 1950s with the recording and investigation of prehistoric copper smelting sites by the archaeologist and ethnologist Franz Hampl and the geologist Robert J. Mayrhofer from Lower Austria. Since then up to 50 archaeological sites related to prehistoric copper production have become known.

The majority of the archaeological sites, mainly slag sites and slag dumps from copper smelting sites, were discovered in the course of road construction works in the woodlands. Mining sites and sites of ore beneficiation are still a rarity, although new mining sites of unknown date have been recorded. The results of the archaeological investigations carried out by Franz Hampl, Helga Kerchler and others as well as the chronological framework of prehistoric copper production and its potential for future research in Lower Austria will be discussed. A physiographical division of the archaeological sites into 10 prehistoric mining districts is presented based on their distribution, setting in the landscape and the location of the known copper ore deposits. This study aims to identify the potential for future research on prehistoric copper mining and smelting in Lower Austria.

The landscape

This Eastern Alpine mining area of Lower Austria is situated in the areas south and east of the mountain ranges of Rax, Schneeberg, Hohe Wand, Semmering and Wechsel and reaches east as far as the lower mountain range called

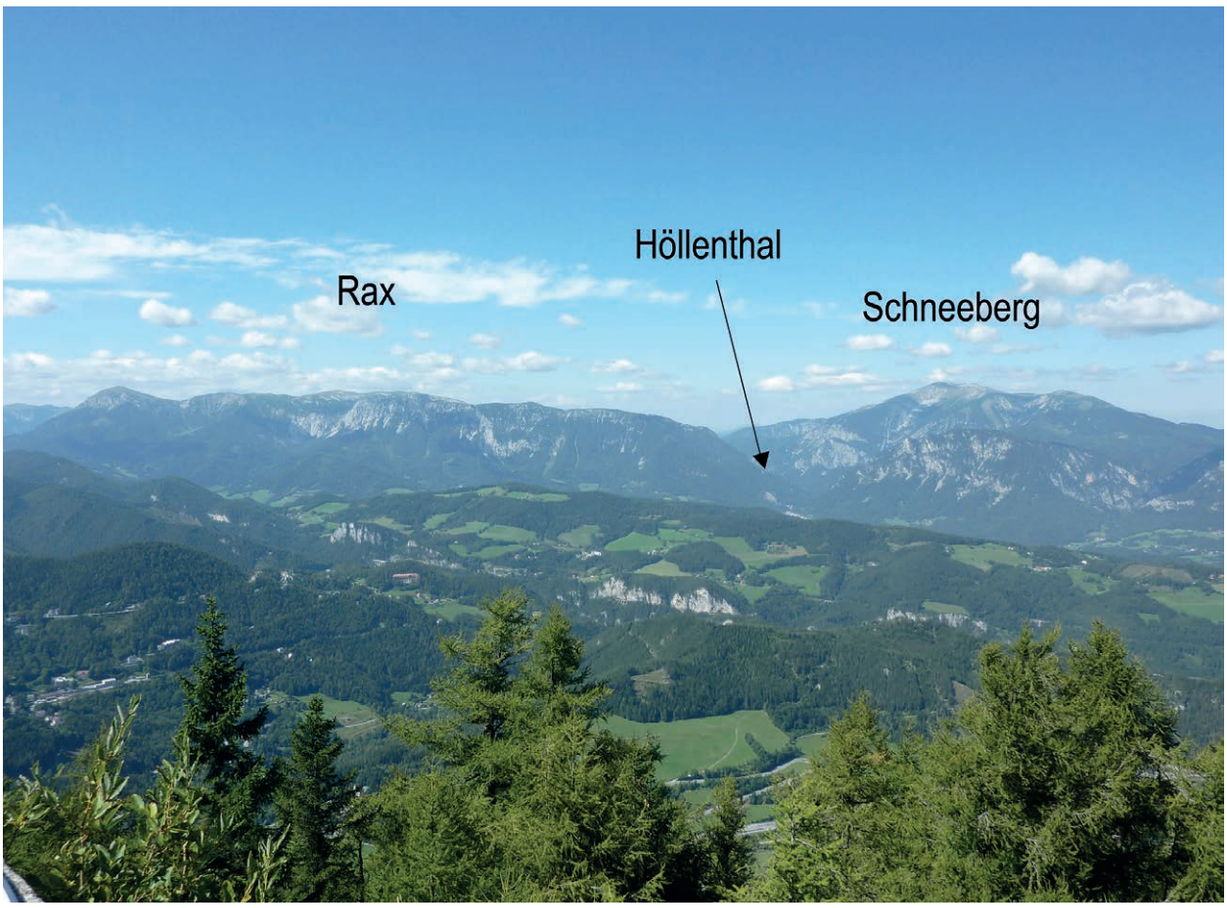

Fig. 1: The north-western prehistoric copper mining area at the foot of the Rax and Schneeberg mountain range. Photo taken from Pinkenkogel/Semmering from the south-west (photo: S. Klemm).

Bucklige Welt (Figs. 1, 2). The highest mountains, Rax (Heukuppe 2007 m a.s.l.), Schneeberg (Klosterwappen 2078 m a.s.l.) and Hohe Wand (Große Kanzel 1052 m a.s.l.) confine the prehistoric mining area to the north, while the Semmering/Wechsel region with Sonnwendstein (1523 m a.s.l.) and Hochwechsel (1743 m a.s.l.) at the border of Lower Austria to Styria confine the area to the west. The most important passages to cross these mountains to the western regions in Styria are Preiner Gscheid, south of Rax (1070 m a.s.l.), the Semmering Pass (984 m a.s.l.), and the Feistritz Sattel (1290 m a.s.l.). The archaeological sites of the mining districts 1-9 were discovered in areas at about 500-1030 m a.s.l. at the foot of these mountains or in the lower mountain range with heights from 450-1100 m a.s.l.

West of the Semmering/Wechsel region is the lower mountain range of Bucklige Welt, reaching a height of almost 1400 m a.s.l. in the west and 1000 m a.s.l. in the east, with mining district 10 in its northern part. The archaeological sites in this mining district are situated at 490-570 m a.s.l.

The rivers Schwarza, Preiner-Bach, Haidbach/Heidbach and Auebach drain the mountain region in the north, the rivers Feistritz and Pitten in the south.

In the north-east of these mountain ranges, the countryside opens out to a much lower, open and flat area, the most southern part of the Wiener Becken. At its north-western edge the hills of the Fischauer Vorberge separate a broad valley, called Neue Welt, at the foot of the Hohe Wand mountain, from the plain of the Wiener Becken.

The copper ore deposits

The copper ore deposits in Lower Austria are rather small in comparison with those of other prehistoric mining areas in the Eastern Alps (Fig. 2). Our knowledge of these ore deposits derives from the remains of medieval and modern mining, frequently from iron ore mines, from historical sources about these historical mines and from local findings of minerals (Hackenberg, 2003).[1] It is presumed that medieval and modern mines destroyed or were superimposed upon prehistoric mines, with the most recent mines having closed only as recently as the early 20th century.

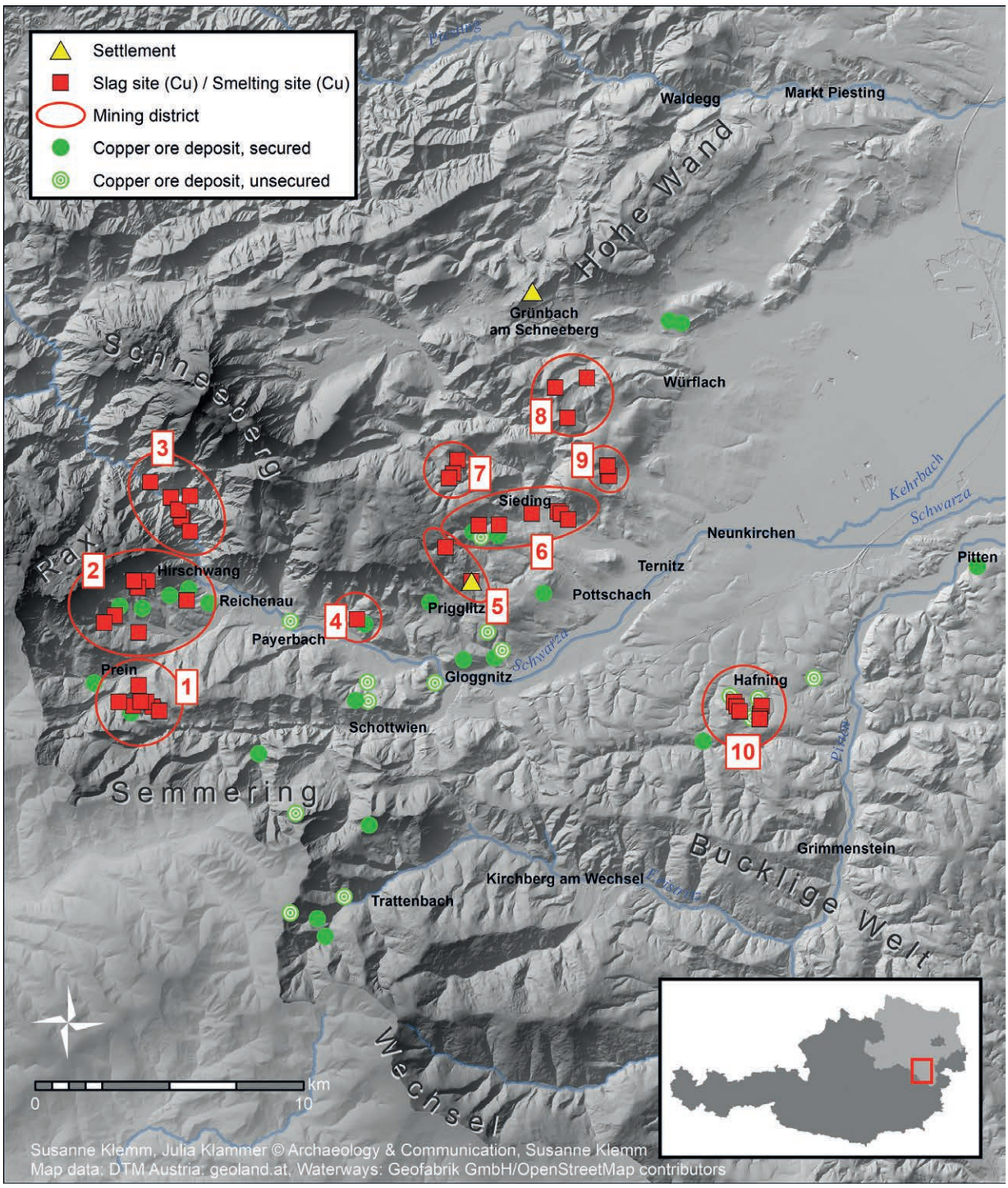

Fig. 2: Distribution of copper ore deposits and prehistoric copper mining districts in Lower Austria (graphics: S. Klemm, J. Klammer; © Susanne Klemm). 1 Prein-Breitenstein. – 2 Kleinau-Großau-. – 3 Kaiserbrunn-Höllental. – 4 Payerbach-Grillenberg. – 5 Prigglitz-Gasteil. – 6 Sieding. – 7 Gadenweith. – 8 Schrattenbach-Stixenstein. – 9 Flatz. – 10 Hafning-Kulm.

The copper ore deposits belong to three geological units: the Greywacke Zone, the base of the Northern Limestone Alps (or Northern Calcareous Alps) of the eastern alpine Mesozoic and the crystalline nappes of the Austroalpine Unit of the Central Alps. These units are situated in various geological positions. Most of the recorded sites of prehistoric copper production were found in the Greywacke Zone and at the base of the Northern Limestone Alps, where iron ore and chalcopyrite were mined. So far, only one group of sites is known from the crystalline nappes of the Austroalpine Unit. Also of interest for the study of prehistoric copper production are the ore

deposits in the area of the orthoriebeckite gneiss belonging to the Greywacke Zone west of Gloggnitz (Heinrich, 2006).

The copper ore deposits of the Greywacke Zone – copper sulphides, mainly chalcopyrite but also fahlore, rarely native copper – are part of the siderite deposits, the copper ore being associated with quartz veins. Contents of arsenic and antimony are characteristic for chalcopyrite deposits in the eastern Greywacke Zone (Hampl & Mayrhofer, 1958, pp.46-51). Most prehistoric mining districts are situated in this geological zone, namely the mining districts 1-9 in the region of Rax and Schneeberg reaching as far as Hohe Wand (see Figs. 1, 2).

South of the River Schwarza and west of Gloggnitz, in the area of the Eichberg-Kreuzberg mountain range, there are copper ore deposits within the orthoriebeckite gneiss belonging to the Greywacke Zone. Archaeological finds and other findings indicate a mining area west of Gloggnitz (Hackenberg, 2003, pp.53-54, no. 69).

In the western part of Bucklige Welt, south of Neunkirchen, mining district 10 is situated in the area of Hafning and Kulm where copper ore deposits (chalcopyrite) in the crystalline nappes of the Austroalpine Unit are known. West of this area, in the region of the Semmering/Wechsel mountain range, also in the crystalline nappes of the Austroalpine Unit, further copper ore deposits were recorded as well as copper ore mining from the 16th-20th cent. AD, with its largest mine at Trattenbach (Hackenberg, 2003, pp.66-68, nos. 95, 97, 99, 100; Inventory of Abandoned Mine Sites in Austria, GBA Vienna/Austria). No prehistoric mining sites are yet known in this area.

The prehistoric copper mining districts

History of archaeological research

Meanwhile, around 50 archaeological sites directly connected with prehistoric mining and the smelting of copper ore are recorded in the region. No site or mining district yet represents all the features that cover the whole *chaîne opératoire* or metallurgical chain, such as mining, ore processing, roasting and smelting of the copper ore, the alloying with tin and the production of bronze artefacts. It is only at the large site of Gasteil-Sandriegel (Prigglitz I/Cu)[2] in the mining district of Prigglitz-Gasteil (district 5) that several of these steps have been identified (Trebsche, 2013; Trebsche & Pucher, 2013; Haubner, et al., 2015; Haubner, Strobl & Trebsche, 2017). As this is the case, our knowledge of early copper production is derived mainly from slag sites and slag dumps rather than from complete smelting sites as will be shown later.[3] So far no mining sites have yet been successfully investigated (see Fig. 2).

Excavation at the prehistoric settlement Grünbach 'Am Gelände', west of the Hohe Wand mountain, by Mühlhofer (1952, p.82) in 1935-1937 produced the first information about prehistoric copper production in Lower Austria in the form of copper ingots, a variety of copper slags, amongst the latter also thin plate slag, stone hammers, and grinding stones with single rilling. The mining pits at Rothengrub-Zweierwald and Netting, on the northern slope of the Kienberg, discovered by Mühlhofer (1930; Inventory of Abandoned Mine Sites in Austria, GBA Vienna, ÖK 75/1003) are still undated; copper ore deposits are known from Rothengrub-Zweierswald.

In 1951 the archaeologist and ethnologist Franz Hampl, Museum of Lower Austria, now called MAMUZ Schloss Asparn/Zaya, was notified by the school teacher Johann Danzer about the find of a bronze knife dating to the Urnfield Period as well as some copper slags in Prein (mining district 2) that had already been found in 1938. Hampl then started intensive interdisciplinary research on prehistoric copper and medieval iron production in the area in cooperation with the geologist Robert J. Mayrhofer, combining archaeology and geology with geophysics, archaeobotany, archaeozoology as well as spectral analyses of ore and copper matte (Hampl, 1953; 1976; Mayrhofer, 1953; Hampl & Mayrhofer, 1958; 1963; Mayrhofer & Hampl, 1958; Hampl & Fritsch, 1959).

Fieldwork in Prein, south of the Rax mountain range (mining district 1), from 1951-1953 by Hampl and Mayrhofer was followed by an investigation of the Stixenstein-Siebentannen I/Cu site (mining district 8), where Ernst Preuschen, the well-known mining engineer, who discovered most of the prehistoric mining areas in the Eastern Alps, had found some prehistoric copper slag in 1949 (Hampl & Mayrhofer, 1963, p.77). Since 1954 further fieldwork has been done on the southern foot of the Rax mountain in Kleinau, Großau, Thonberg/Hirschwang (mining district 2) and east of Kaiserbrunn (mining district 3). From 1955 to 1959 their research concentrated on the site of Prigglitz-Gasteil (mining district 5), while more investigations were done in 1959 at the Grillenberg in Payerbach (mining district 4). Also in 1959, another small excavation to the north-east of the Hohe Wand mountain took place where thin plate slag and some post-medieval pottery were found (Hampl & Mayrhofer 1963, p.77, tab. 1).

Research on the prehistoric copper mining area in Lower Austria came to a standstill with the early death of Mayrhofer in 1959. In the 1970s Michael Puhr, Neunkirchen, started investigations in mining district 10, Hafning-Kulm, which were continued by Helga Kerchler from the University of Vienna (Puhr, 1972; Kerchler, 1976). Kerchler also continued research by recording sites in the mining districts 3, 6, 7 and 10, these being Höllental-Kaiserbrunn, Sieding, Gadenweith and Hafning-Kulm respectively (Kerchler, 1976). Wolfgang Haider-Berky, Neunkirchen, recorded some slag sites in Sieding, Gadenweith, Schrattenbach-Stixenstein and Flatz (mining districts 6-9) as well as some potential mining sites (Haider, 1975a; 1975b; 1977; Haider-Berky, 2013).

The most recent and important investigations were carried out by Peter Trebsche, Danube University Krems, at

the huge settlement and mining site of Gasteil-Sandriegel in the mining district Prigglitz-Gasteil in 2010-2014 (Trebsche, 2013; 2015; Trebsche & Pucher, 2013).

The mining districts of Lower Austria

The mining district Prein-Breitenstein

South of the Prein river, eight sites of copper smelting were recorded in Prein-Breitenstein (mining district 1). The sites were discovered at 680-820 m a.s.l. All of these sites, just like the sites of Kleinau-Großau (mining district 2), were found on slopes and in proximity to streams, as it is typical with most sites of this type in the Eastern Alps (Klemm, 2003).

Characteristic findings such as metallurgical slag, furnace stones, charcoals, fragments of technical and settlement pottery as well as animal bones with green patina were found in the layers of the slag dumps from the sites Prein I/Cu, Prein II/Cu, Prein V/Cu and Prein VII/Cu in mining district 1, Prein-Breitenstein (Hampl, 1953; Hampl & Mayrhofer, 1963).

At one site – Prein III/Cu – extensive excavations were carried out in 1952 and 1953 (Hampl, 1953; Hampl and Mayrhofer, 1963). Several features were discovered and interpreted as installations for the smelting of copper ore such as round, oval, and trapezoid stone settings and small rectangular or square stone structures as well as two slag dumps. Unfortunately, the 1950s' records of the excavation do not give clear and detailed information about these features, which were interpreted as the remains of roasting hearths and furnaces. Three single furnaces were described. From the excavation results of copper smelting sites in other regions of the Eastern Alps in Styria, Salzburg or the Tyrol, we know only of rectangular roasting hearths and shaft furnaces in a typical setting (e.g. Zschocke & Preuschen, 1932, pp.76-79, tab. III-VIII; Presslinger & Eibner, 1993, pp.28-31; Klemm, 2010; 2015; Goldenberg, et al., 2011, pp.74-76). Recent excavations in the Oberhalbstein Valley in eastern Switzerland uncovered the same type of rectangular roasting hearths and two shaft furnaces (Della Casa, Naef & Turck, 2015; see also Turck, in this volume). For his experimental reconstruction of the Bronze Age copper smelting furnaces, Hampl (1976) used the medieval bloomery furnaces as prototypes, thus suggesting that the shafts of the Bronze Age copper smelting furnaces were also free-standing and not built into the slope as archaeological evidence from all Bronze Age copper smelting furnaces in the Eastern Alps showed. As the published report by Hampl and Mayrhofer (1963) as well as the original excavation report[4] suggest that the site was not completely excavated, any evidence of twin furnaces might not have been recorded. Prein III/Cu is a complex multi-phase site and the short excavation campaigns as well as the excavation methods in the 1950s might have been insufficient to recognise and interpret the evidence as expected nowadays. No radiocarbon dates are available for this large and complex site. The site can be dated to the Late Bronze Age (Ha B) on the basis of late Urnfield pottery and a bronze pin, a type in use from the younger Urnfield Period (Ha B) to the early Hallstatt Period (Ha C); no typical Hallstatt C pottery has been found so far.

The only radiocarbon date from this mining district derives from site Prein II/Cu and dates the site to the 10th cent. BC (995 BC-925 BC, calibrated 2σ 95.4%) (Trebsche, 2015, p.44, tab. 2). All settlement pottery found at the Prein sites belongs to the Urnfield Period, mainly to its later phase.

The geologist Robert Mayrhofer (Mayrhofer, 1953; Hampl & Mayrhofer, 1963, p.54) recorded a recent pit for limonite on the western slope of the Fuchsgraben at 900 m a.s.l., and it is doubtful that prehistoric miners would have reached the necessary depth to reach the copper veins. Results of a geoelectrical survey near the sites Prein VII/Cu and Prein III/Cu were interpreted as a mining site; unfortunately, this could not be proved by excavation (Hampl & Fritsch, 1959; Hampl & Mayrhofer, 1963, p.92, fig. 10).

West of the Prein sites, in the Hollersbachgraben, an undated mining site is known. Mayrhofer (Hampl & Mayrhofer, 1963, pp.55-56) mentioned that copper ore from the Hollersbachgraben could have been smelted at the Prein sites. Though macroscopic description and spectral analyses of copper ore samples suggest that copper ore from the ore deposits north of Prein at the southern foot of the Rax mountain range (mining district 2) was used for copper production in Prein (Mayrhofer, 1953, pp.91-95). Further investigations are mandatory because of the distance between the ore deposits in mining district 2 and the smelting sites in mining district 1; water and wood for fuel for roasting and smelting were available in Prein as well as in the region of the Kleinau-Großau sites.

The mining district Kleinau-Großau

The prehistoric sites of the mining district Kleinau-Großau (no. 2) are situated at the southern foot of the Rax mountain range where copper ore was mined within the intensive mining of iron ore in the medieval and modern periods. This modern mining district stretched from Schwarzkogel, Schendlegg/Schendleck, Knappenberg, Kleinau, Hirschwang as far as Trautenberg and Thonhof. Copper ore was still mined in the early 20th cent. AD at Schendlegg. The ore deposits belong to the Greywacke Zone, the base of the Northern Limestone Alps also known as the Northern Calcareous Alps (Hackenberg, 2003, pp.32-37; Heinrich, 2006, p.287, tab. 18). The sites in the mining district Kleinau-Großau are situated at about 840-1030 m a.s.l.; copper slag was found at six sites and a copper ingot was discovered at another site.

Two of the seven sites demonstrate that natural erosion and massive deposits of rock waste as well as medieval and modern mining destroyed or covered

older traces of mining, ore beneficiation and smelting. Prehistoric pottery, two animal teeth and three pieces of thin plate slag, a copper droplet, and some copper ore (Hirschwang I/Cu; Haubner, et al., 2015, p.31, figs. 2 and 3) were found 1.62 m below the surface on the site of a badly destroyed medieval iron smelting site and were enclosed in layers of fine quartz as known from ore beneficiation sites (Hampl & Mayrhofer, 1963, p.76). At the second site in Großau a copper ingot was discovered 1-1.8 m below the surface while a pit was being dug for a fishpond in 1967.[5]

Heavy erosion in the area of the Schwarzkogel was also proven by the unsuccessful search for smelting furnaces and roasting hearths at the Großau I/Cu site (Hampl & Mayrhofer, 1963, pp.53-54).

The mining district Höllental-Kaiserbrunn

In the narrow valley of Höllental between the Rax and Schneeberg mountains, north of the Kleinau-Großau mining district, eight sites with prehistoric copper slags were discovered in mining district 3, Höllental-Kaiserbrunn (Kerchler, 1976, p.96; Cech & Walach, 1995). These sites cannot be more exactly dated. The seven sites near the River Schwarza at about 510-530 m a.s.l. were badly destroyed by road works. A small excavation at one site only revealed smaller slag deposits (Kerchler, 1976, p.96). A geophysical survey in 1994 proved atypical anomalies that cannot be successfully interpreted without excavation (Cech & Walach, 1995). The site in the Krummbachgraben is situated at about 560 m a.s.l.

The mining district Payerbach-Grillenberg

Further east, copper ore was mined in the large iron ore mine at Grillenberg (Hackenberg, 2003, pp.25-29, no. 9). A small slag dump was excavated in 1959 at a prehistoric site in mining district 4, Payerbach-Grillenberg. Typical copper slags, though only a few thin plate slags, were found in the slag deposit of 0.2-0.25 m thickness. The search for roasting hearths and furnaces was unsuccessful (Hampl and Mayrhofer, 1963, pp.75-76).

The mining district Prigglitz-Gasteil

The first excavations by Hampl (Hampl & Mayrhofer 1963, pp.56-74) in the mining district Prigglitz-Gasteil (no. 5), north-east of Payerbach, were followed by new research by Trebsche (2013) from 2010-2014. The excavations at the complex site of Prigglitz-Gasteil I/Cu (also called Gasteil-Sandriegel) by Trebsche[6] confirmed and immensely broadened our knowledge of this large and exceptional mining centre. A vast settlement with an extensive production of bone tools, metal working and metallurgical activities of the Late Bronze Age was recorded (Trebsche, 2013; Trebsche & Pucher, 2013). The settlement layers of several phases of the later Urnfield Period, dating to a period from 1063-961 BC to 957-857 BC (phase calibration 68.2 %), describe activities that cover at least one century (Trebsche, 2015, p.53). Metal objects confirm these radiocarbon dating results. The settlement terraces were superimposed by debris from mining and ore beneficiation. Below these layers of the Urnfield settlement deposits, several meters thick remains of ore beneficiation demonstrate that copper ore mining at this mining district has a long tradition. Only when Trebsche and his team fully present their excavation results, will a full assessment of this mining centre be provided.

Mining pits are known but not yet dated. Copper and iron ore deposits are mapped in the Prigglitz area (Hackenberg 2003, p.30). North of the site at Gasteil-Sandriegel, slag sand, a Bronze Age socketed axehead as well as a Neolithic copper axehead were found (Hampl & Mayrhofer, 1963, pp.54-56; Hottwagner, 2000; Lang, 2000).

The mining districts Sieding and Gadenweith

Slag sites were recorded in the 1970s in the mining districts of Sieding (no. 6) and Gadenweith (no. 7): six sites in Sieding, three more sites at Gadenweith, all of them quite possibly of prehistoric date (Kerchler, 1976, pp.92-95; Haider, 1977, p.352; Haider-Berky, 2013, p.113[7]). There has been no archaeological investigation. The Sieding sites were situated at about 440-560 m a.s.l. while the Gadenweith sites were found at 650-770 m a.s.l.

Hampl (Hampl & Mayrhofer, 1963, pp.54-56, 81-82) had already recorded some mining pits of unknown date. Ore deposits at Florianikogel (Bürg/Vöstenhof) and an iron ore mine from the beginning of the 20th century in the Ambachgraben, also called Saubachgraben, are also known (Hackenberg, 2003, pp.23-24, no. 2 and 4; Inventory of Abandoned Mine Sites in Austria, GBA Vienna/Austria, ÖK 50/105).

The mining districts Schrattenbach-Stixenstein and Flatz

The slag site Stixenstein-Siebentannen I/Cu in the mining district of Schrattenbach-Stixenstein (no. 8) was discovered by Ernst Preuschen in 1948 and archaeologically investigated in 1953 (Hampl & Mayrhofer, 1963, pp.77-78). Wolfgang Haider-Berky (2013) recorded mining pits at the Hochberg near Gutenmann and two more slag sites in this district as well as another three slag sites in mining district no. 9 in Flatz. Leopold Neff (1985/86, p.242) recorded another slag site in mining district no. 8. The sites are situated at 600-760 m a.s.l. and are quite possibly prehistoric.

The mining district Hafning-Kulm

In 1969-1971 Puhr (1972) discovered six sites south of the town of Neunkirchen, in the mining district of Hafning-Kulm (no. 10); they were situated at 490-570 m a.s.l. Three of these were partly excavated in cooperation with Hampl (1976, tab. 1). The copper ore deposits are part of the

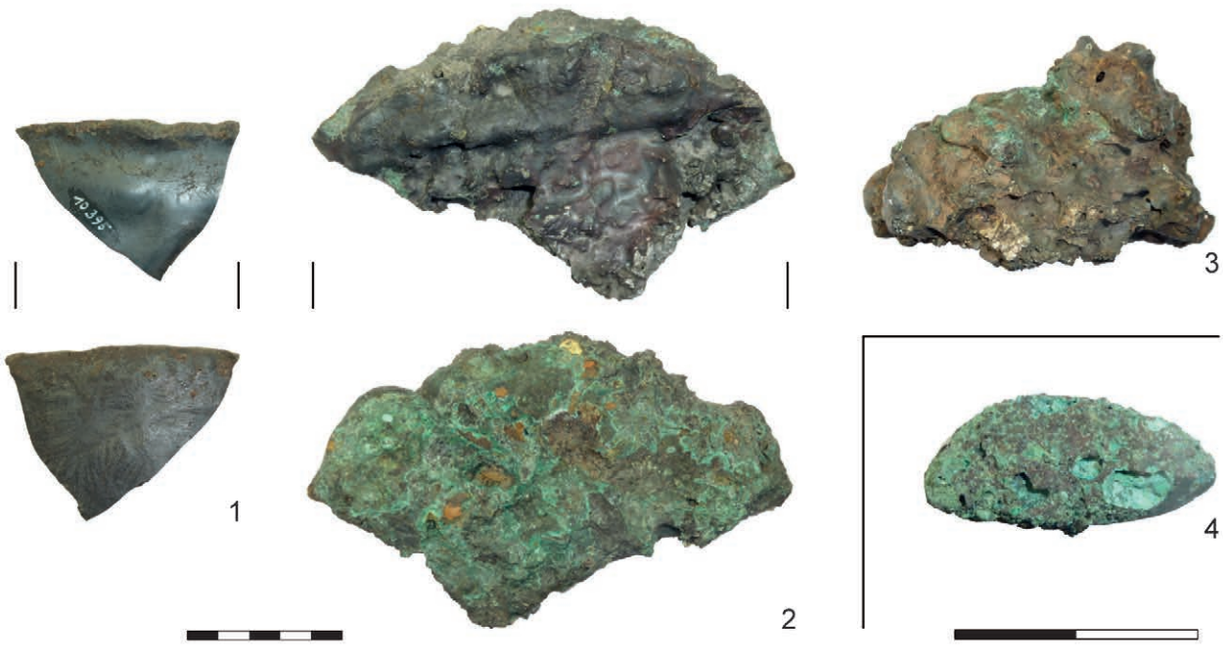

Fig. 3: Typical slag types from prehistoric copper production in Lower Austria (Photos: S. Klemm). 1 – thin plate slag, Hirschwang I/Cu, 2 – fragment of slag cake with rim, Prein VII/Cu, 3 – coarse slag, Payerbach I/Cu, 4 – copper droplet, Hirschwang I/Cu (Landessammlungen Niederösterreich).

crystalline nappes of the Austroalpine Unit unlike all the sites in the mining districts 1-9.

At the sites Hafning I/Cu, Hafning II/Cu and Kulm I/Cu, reoccurring features – small pits with a diameter of 0.15-0.17 and 0.29-0.35 m with canals at their sides – were recorded. While at the site Hafning I/Cu two pits with the same depth and size were found beside each other; a larger and one smaller pit were found at the site Hafning II/Cu. At the site Kulm I/Cu a feature with only one pit was excavated. It was argued that these features were remains of smelting furnaces. If so, no comparable features have been found elsewhere in the region so far. Roasting hearths, typical structures on Bronze Age copper smelting sites in the Eastern Alps, were absent. Both coarse as well as thin plate slag were found, although there were no tuyère fragments (Puhr, 1972).

During excavations in 1973, Kerchler (1976, pp.89-91) ascertained that the sites Hafning III/Cu and IV/Cu were, in fact, part of one large, multi-phase copper smelting site. Its slag dump seemed to have slipped off on the steep slope. At the working platform a small pit, 0.27-0.30 m in diameter and 0.13 m in depth, reddened at the base, was revealed; its function remains unclear. At another large smelting site, Weibnitz I/Cu, a characteristic slag dump, with vegetation absent, 11 m in length and 4.5 m in width with a slag deposit of 0.20-0.30 m thickness was investigated (Kerchler, 1976, pp.91-92).

Prehistoric pottery from the Late Bronze Age, the Urnfield period, besides the typical slags already mentioned, was found at all sites in this mining district. Settlement pottery at Hafning II/Cu dates this site to the latest phase of the Urnfield Period (Ha B3) (Puhr, 1972, p.197, fig. 8)[8]. The described remaining structures, pits with one or two canals, are reminiscent of features found at the medieval copper smelting sites in the Harz region, Germany (Asmus, 2012, pp.124-142, fig. 6.10). There are no historical documents on copper mining and smelting in the area of the mining district of Hafning-Kulm. Only future research will be able to reveal more evidence on the technology as well as the chronology and the dating of the described features.

Potential mining districts

Further indications of prehistoric mining are mining pits discovered in the 1930s, the 1970s and later in areas where no historical information on mining exists.

Mining pits of unknown date were discovered by Mühlhofer (1930; see also Mühlhofer & Pittioni, 1934) in the Hohe Wand region at Rothengrub and on the northern slope of the Kienberg, near Netting, in the early 1930s. Haider-Berky (2013, pp.106-108, fig. 11, 14, 15) mentioned more mining pits of unknown date at Pfenningbach-Grünbacher Sattel and at Sonnleiten-Neusiedl am Walde. These sites are situated to the north of mining district 8; no smelting sites were recorded in their vicinity.

Other mining pits of unknown date were identified near Gloggnitz; prehistoric mining activities are suggested (Hackenberg, 2003; Haider-Berky, 2013). Just north of Gloggnitz, and east and south of mining district 5, Prigglitz-Gasteil, there are mining pits of unknown

date at Kohlberg near Pottschach and at Weißjacklberg. Copper ores such as chalcopyrite and fahlore deposits are known (Haider, 1975a; 1975b; Hackenberg, 2003, pp.29-30, no. 12, 13; 32, no. 16-18; Haider-Berky, 2013, pp.107-108, fig. 11-17). These copper ores were also mined in the Stuppachgraben on the north-eastern side of the Silbersberg from the 17th-20th cent. AD (Hackenberg, 2003, pp.30-32, no. 15).

West of Gloggnitz between the rivers Schwarza and Auebach, mining pits of unknown date were found in an area where copper ore deposits within the orthoriebeckite gneiss belonging to the Greywacke Zone are known. A hoard of seven small copper ingots of unknown date was discovered at a distance of only 50 m from these mining pits (Lang, 2001; Hackenberg, 2003, p.54, no. 70, fig. 65)[9]. In this area copper mining from the 16th-20th cent. AD is known at Gloggnitz, Pettenbach and Eichberg, though mainly magnesite was mined there (Hackenberg, 2003, pp.53-55, no. 69-71).

Archaeometallurgical analyses

Coarse copper slag, thin plate slag as well as some thick plate slag and copper droplets were found at slag dumps and smelting sites (Fig. 3). The samples taken at the excavations such as Prein, Payerbach, Hirschwang or other sites are typical for Bronze Age copper smelting sites in the Eastern Alps; chalcopyrite was used for smelting (Mayrhofer, 1953; e.g., Kraus, et al., 2015). Recent archaeometallurgical analyses of copper slags and a copper droplet from the Lower Austrian sites confirm that ore containing chalcopyrite was used for copper production at these smelting sites (Hackenberg, 2003; Haubner, et al. 2015, pp.28-32, figs. 2-4; Haubner, Strobl & Klemm, 2017). Large pieces of quartz are regularly found in the coarse slag while the thin plate slag is macroscopically more homogenous.

On the other hand, thin plate slags with maximal contents of about 0.5 wt.% tin were found during the excavation of the settlement at Prigglitz-Sandriegel. Additionally, corroded bronze droplets from this settlement contained tin; a content of 9 wt.% and 35 wt.% was measured. The thin plate slags and the bronze droplets from the settlement can be related to the production of bronze (Haubner, et al. 2015, p.32, fig. 1, fig. 2, g-l, fig. 3, f-h; Haubner, Strobl & Trebsche, 2017).

Further archaeological evidence: settlements, single findings, hoards

Hampl & Mayrhofer (1963, pp.82-85, fig. 24a-e) suggested in their study on prehistoric copper and medieval iron mining that the process of settlement formation in this mountainous region of south-eastern Lower Austria is firmly connected with the search for minerals, especially copper ore. Hampl interpreted single findings of polished stone hammers and axeheads as well as bronze axeheads as tools used for ore prospection since the Late Neolithic. Also, Late Neolithic findings from settlements and new findings of copper axeheads of the Altheim type and other single findings of bronze tools discovered in woodlands since the publication of Hampl and Mayrhofer (1963, pp.82-85, fig. 24a-e) underline this theory (e.g., Daim & Ruttkay, 1981; Neff, 1985/86; Haider, 1990; Klemm 1992, vol. 1, pp.274-276; Lauermann, 1998; Hottwagner, 2000; Lang, 2000).

The importance of large settlements as regards the organisation of mining and smelting of copper ore as well as the production of bronze in Late Bronze Age (Ha B) settlements is indisputable. The findings at the mining settlement at Gasteil-Sandriegel confirms this. Moreover, archaeological evidence, such as moulds for the casting of bronze objects and thin plate slags, presumably from the production of bronze, is known from other large Late Bronze Age/Early Iron Age settlements in the region, for example ‘Am Gelände’ near Grünbach, Kienberg, and Malleiten near Bad Fischau (Mühlhofer, 1952; Kaus, 1992; Klemm, 1992, vol. 1, p.265). The well-known hoard from Mahrersdorf, including a copper ingot and a pickaxe, and other findings of copper ingots in the region are further indications of mining and copper production in the region (Hampl, 1976, p.62; Lang, 2001; Haider-Berky, 2004, p.9; Lauermann & Rammer, 2013, pp.125, 128-133).

Conclusions

A division of 10 prehistoric copper mining districts in Lower Austria has been discussed based on the physiographical position of the archaeological evidence as well as the evidence of copper ore deposits. Evidence of undated mining pits situated near prehistoric settlements as well as archaeological findings close to copper ore deposits suggest further small mining districts in the region. So far, only the Late Bronze Age (Ha B) copper production can be assumed on the basis of copper smelting sites, slag dumps or singular slag findings and the large mining settlement at Gasteil-Sandriegel in the region.

At Gasteil-Sandriegel, the huge deposits of material from mining and ore beneficiation below the Late Bronze Age settlement layers suggest extensive mining over a long period. The actual research carried out by Trebsche and his team can be seen as the first major step to investigate this area of prehistoric copper production in the Eastern Alps since the research by Hampl & Mayrhofer in the 1950s.

A priority of future research should be the investigations of undated mining sites, for example, in one of the smaller mining districts or in one of the new potential mining districts. Future research should also aim at dating as many sites as possible with all available methods, especially as, so far, only Late Bronze Age sites have been

identified. Also, new excavations of small smelting sites are necessary to achieve a clear picture of the construction of roasting hearths and smelting furnaces in this area of the Eastern Alps. New investigations in mining district 10, Hafning-Kulm, seem equally important, as the type of furnaces described is unusual for the Late Bronze Age.

Notes

1 An extensive bibliography and a comprehensive summary on the geological background, the copper ore deposits and the historic mining in the area: Hackenberg, 2003.

2 The site names follow the system of nomination by Franz Hampl.

3 For more information on the terminology of the type of sites see Klemm, 2003, pp.19-23, 28-36: Slag sites are sites with singular slags with no further evidence of a smelting site (for example, Hirschwang I/Cu). Those sites where slag dumps were identified but without further evidence of smelting (roasting hearths, furnaces) in close vicinity are referred to as slag dumps (for example, Prein II/Cu). Smelting sites are identified either by excavation or by geophysical survey showing the typical features of smelting sites (for example, Prein III/Cu).

4 MAMUZ, Schloss Asparn an der Zaya, archive, file Prein 1952 and Prein 1953. The author thanks Dr. Ernst Lauermann for the right of access to study the files.

5 MAMUZ, Schloss Asparn an der Zaya, archive, file Groß-Au.

6 Research project financed by the Austrian Science Fund FWF, P 30289.

7 The sites Thann 1-3 (Haider-Berky, 2013, p.113) are identical with the sites Sieding I/Cu–III/Cu listed by F. Hampl and H. Kerchler in Hampl, 1976, tab. 1 and Kerchler, 1976, p.95.

8 The pottery sherd shown in Puhr, 1972, fig. 8, was erroneously assigned to Hafning I/Cu in the publication (Inv.-No. 10196, Städtisches Museum Neunkirchen).

9 In Hackenberg, 2003, p.53 described as slag. See also Lang, 2001.

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