Medieval Mining Centre of Buchberg in the Bohemian-Moravian Highlands

Metal Production in the Kingdom of Bohemia (13th–14th Centuries)

Středověké důlní středisko Buchberg na Českomoravské vrchovině

Produkce kovů v Českém království (13.–14. století)

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Příspěvek představí výsledky metodicky širokého spektra průzkumů zaniklého důlního centra Buchberg na Havlíčkobrodsku zapojeného ve 13. a 14. století do produkce stříbra. Toto středisko je výjimečné svou rozlohou i rozvinutou komunitní infrastrukturou. Tomu odpovídá i odraz tohoto komplexu v písemných pramenech. Průzkumy a sondáže se zaměřily na obytný areál, a především na navazující metalurgická pracoviště. Ta poskytují jedinečné prostorové informace i množství cenných údajů z analýz archeometalurgických nálezů, reprezentujících články operačního řetězce od těžby surové rudniny k finální produkci žádaných kovů. Aktuální odlesnění montánních terénních reliktů umožnilo trojrozměrné zaměření, přinášející dosud nepoznaný pohled na prostorovou strukturu historické důlní činnosti.

Českomoravská vrchovina, těžba rud, archeometrie, 13. století

The study presents the results of a wide range of research approaches and surveys of the defunct mining centre at Buchberg in the region of Havlíčkův Brod, which was involved in silver production in the 13th and 14th centuries. Burchberg is exceptional in its size and well-advanced community infrastructure. Its significance is also reflected in written sources. Surveys and trial diggings focused on the residential area, and especially on the adjoining metallurgical facilities providing unique spatial information, as well as a wealth of valuable data obtained by analysing archaeometallurgical materials, representing the links in the operational chain, staring with the raw ore extraction and ending with the final production of the desired metals. The current deforestation of mining field relics enabled their three-dimensional survey, and, thus, providing a hitherto unknown view of the spatial structure of historical mining activities.

Bohemian-Moravian Highlands, ore mining, archaeometry, 13th century

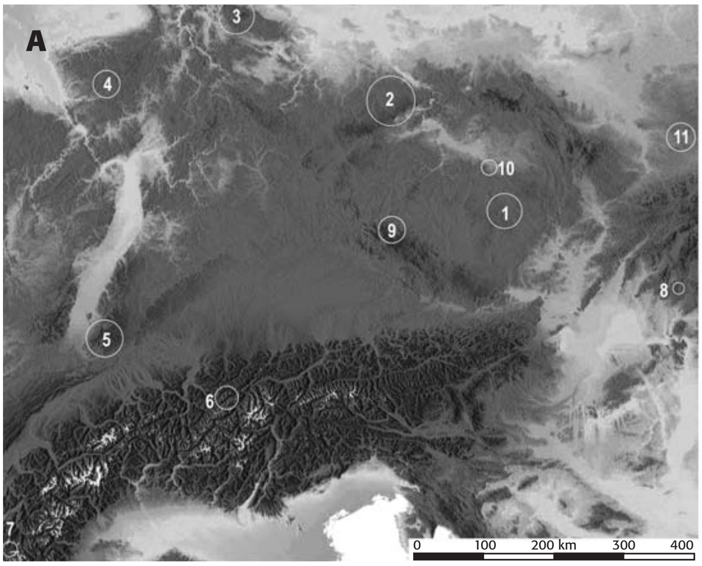
1. Introduction

1.1. Historical context of the earliest medieval mining of silver ores in the region of Havlíčkův Brod

Following the mid-13th century, the Přemyslid domain experienced the earliest boom of the production of non-ferrous metals, especially lead, silver and copper even before the opening of the mines located between Kolín and Čáslav and the establishment of Kutná Hora, mainly thanks to mining centres in the Bohemian-Moravian Highlands (*Fig. 1A: 1*; *1B*). The Bohemian-Moravian Highlands landscape underwent a dynamic transformation during a short time, and the transformation process was partly motivated also by the prospection and exploitation of precious metal ores (*Hrubý 2014*; *Hrubý et al. 2019*; *Kaiser et al. 2019*).

Probably already at the end of the 1230s, mining activities started in Jihlava, at least according to the archaeological finds (*Hrubý 2019*, 42–44, 48, Tab. 2). In 1252, a mint master Henry (*Heinricus magister monetae*) is mentioned in the town of Humpolec (*CDB IV/1*, No. 256, pp. 436–437) in a deed of the Vyšehrad Chapter, and it can be considered as an indicator of mining activities in the area with the attested occurrence of gold and polymetallic ores. Such activities are also corroborated by a sequence of dendrochronological data indicating the years 1252/1253 and 1257/1258 that was obtained during archaeological fieldwork conducted at the site of ore processing facility near Kaječín, located between Humpolec and Brod (*Hrubý et al. 2019*). The development of several mining sites in the Havlíčkův Brod region is also attested by the deed of Smil of Lichtenburg dated November 5th, 1257 listing a tithe from silver mines (*de argenti fodinis*) situated near the sites of Brod, Bělá, Přibyslav, and Šlapanov (*CDB V/1*, No. 138, p. 223).

One of the centres of polymetallic ore mining at that time was located near the village of Utín near Přibyslav (*Fig. 2: 10*). The site was called *Buchberg* (or *Mons Fagus*) and had a well-developed community infrastruc-



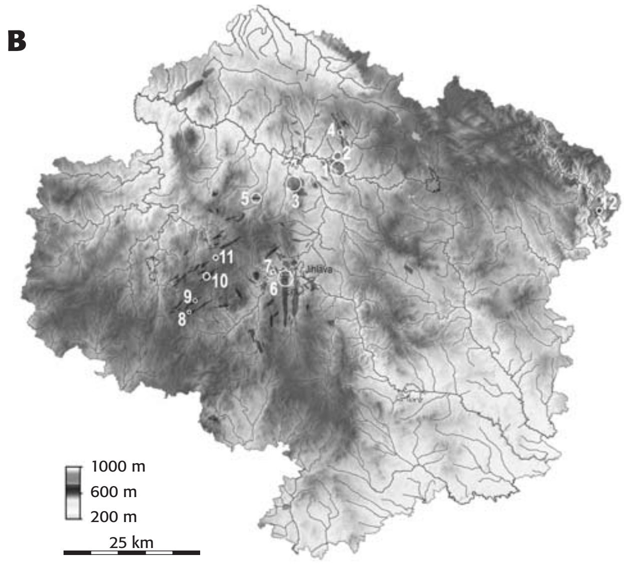


Fig. 1A. *Archaeologically investigated medieval mining regions in Central Europe. **1:** Českomoravská vrchovina (Bohemian-Moravian Highlands), **2:** Krušné hory (Ore mountains, Erzgebirge), **3:** Harz, **4:** Siegerland and Sauerland, **5:** Schwarzwald, **6:** Silbertal (Tirol), **7:** Alpe d'Huez, **8:** Banská Štiavnica in Štiavnické vrchy (Štiavnica Mountains), **9:** Kašperské Hory (Šumava Mountains), **10:** Kutná Hora, **11:** Dąbrowa Górnicza. — **Obr. 1A.** Archeologicky zkoumaný důlní region ve střední Evropě. **1:** Českomoravská vrchovina, **2:** Krušné hory, **3:** Harz, **4:** Siegerland and Sauerland, **5:** Schwarzwald, **6:** Silbertal (Tirol), **7:** Alpe d'Huez, **8:** Banská Štiavnica, Štiavnické vrchy, **9:** Kašperské Hory, **10:** Kutná Hora, **11:** Dąbrowa Górnicza.*

Fig. 1B. *Archaeologically investigated medieval mining sites in the Bohemian-Moravian Highlands (Vysočina Region). **1:** Utín (Mons Fagus, Buchberg), **2:** Stříbrné Hory (Mons Herliwini, Herliwinberg), **3:** Sv. Kříž (Mons Medium, Mittelberg), **4:** Česká Bělá, **5:** Koječín, **6:** Jihlava (Antiquus Mons, Altenberg), **7:** Bělokamenský potok, **8:** Cvilínek site by Černov and Chrástov, **9:** Čejkov, **10:** Vyskytná, **11:** Opatov, **12:** Havírna site at Štěpánov nad Svratkou. — **Obr. 1B.** Archeologicky zkoumané středověké hornické areály na Českomoravské vrchovině v kraji Vysočina. **1:** Utín (Mons Fagus, Buchberg), **2:** Stříbrné Hory (Mons Herliwini, Herliwinberg), **3:** Sv. Kříž (Mons Medium, Mittelberg), **4:** Česká Bělá, **5:** Koječín, **6:** Jihlava (Antiquus Mons, Altenberg), **7:** Bělokamenský potok, **8:** Cvilínek, u Černova a Chrástova, **9:** Čejkov, **10:** Vyskytná, **11:** Opatov, **12:** Havírna u Štěpánova nad Svratkou.*

ture including settlement, a sacral building and a public house (*hospicium*). We have been able to partially reconstruct the appearance of this site by combining historical documents and means of remote, as well as direct non-destructive, prospection that was verified by trial excavations. The prospection methods applied have been more commonly used in surveys of prehistoric and protohistoric settlement areas such as open or hill-top settlements and strongholds. In this respect, the high medieval mining complex is archaeologicaly fully preserved in agricultural and forest areas with anthropogenic relief relics shares some features with the sites mentioned in the previous sentence.

Geochemical analyses of a broad spectrum of archaeometallurgical materials form part of the research of such operational-production complex. It consists mainly of metallurgical and blacksmith slags, lead drips and castings of cupriferous alloys, a unique silver bar and scalings. Xylotomy analyses of the carbonised fuel from filling and the working surroundings of furnaces completed the obtained picture. Analyses of these groups of finds represent the key to our understanding of the production and technical infrastructure of the complex and are probably more important in the research of mining areas than the study of community infrastructure. Fieldwork and surveys conducted near Utín fit well into the concept of long-term research in medieval ore mining and metal production in the Bohemian-Moravian Highlands (*Crkal et al. 2019*; *Derner – Hrubý 2018*; *Hrubý – Hejhal – Malý 2007*; *Hrubý et al. 2012*; *Hrubý – Malý – Milo 2016*; *Hrubý et al. 2019*; *Hrubý – Derner – Skořepová 2019*).

1.2. Mining in the region of Přibyslav and at Buchberg as seen in the 13th and 14th century-deeds

Silver mining near Utín is corroborated by a deed issued in Šlapanov on October 25th, 1258 (*CDB V/1*, No. 167, p. 267). It specified a tenancy provided by the mintmaster at the silver mines in Brod and Bohemia Eberhard (*magister monetae super argenti fodinas*), the deed itself was written by another Mint master *Heinricus dictus Avis* (Henry the Bird). In addition to the names of royal mining officials forming the consortium, we also know the names of mining entrepreneurs to whom the facilities were lent – *Theodoricus dictus Vriberch*, probably from Freiberg, a significant silver production centre in the Meissen region, and *Gernot dictus Niger*. The deed contains a list of mines and galleries/adits corroborating the extraordinary scope of mining activities: *Iegerberch, Vberschar, Hertwigesberch, Breitbartesberch, Scubelerberch, Helmerichesberch,* ***Buchberch Juvenis et Buchberch Antiquus****, Lettenberch, Clophurberch, Hohalde, Haberberch, stollo Vribergeri, stollo Cunradi* and *Gotesgabe.* The so-called Freiberg's adit was lent to Freiberg, Gernot and their heirs irrevocably and forever (*irrevocalibiter et perpetuo*); thus, it is a so-called hereditary adit. The tenancy deed also mentioned a pub (*hos-*

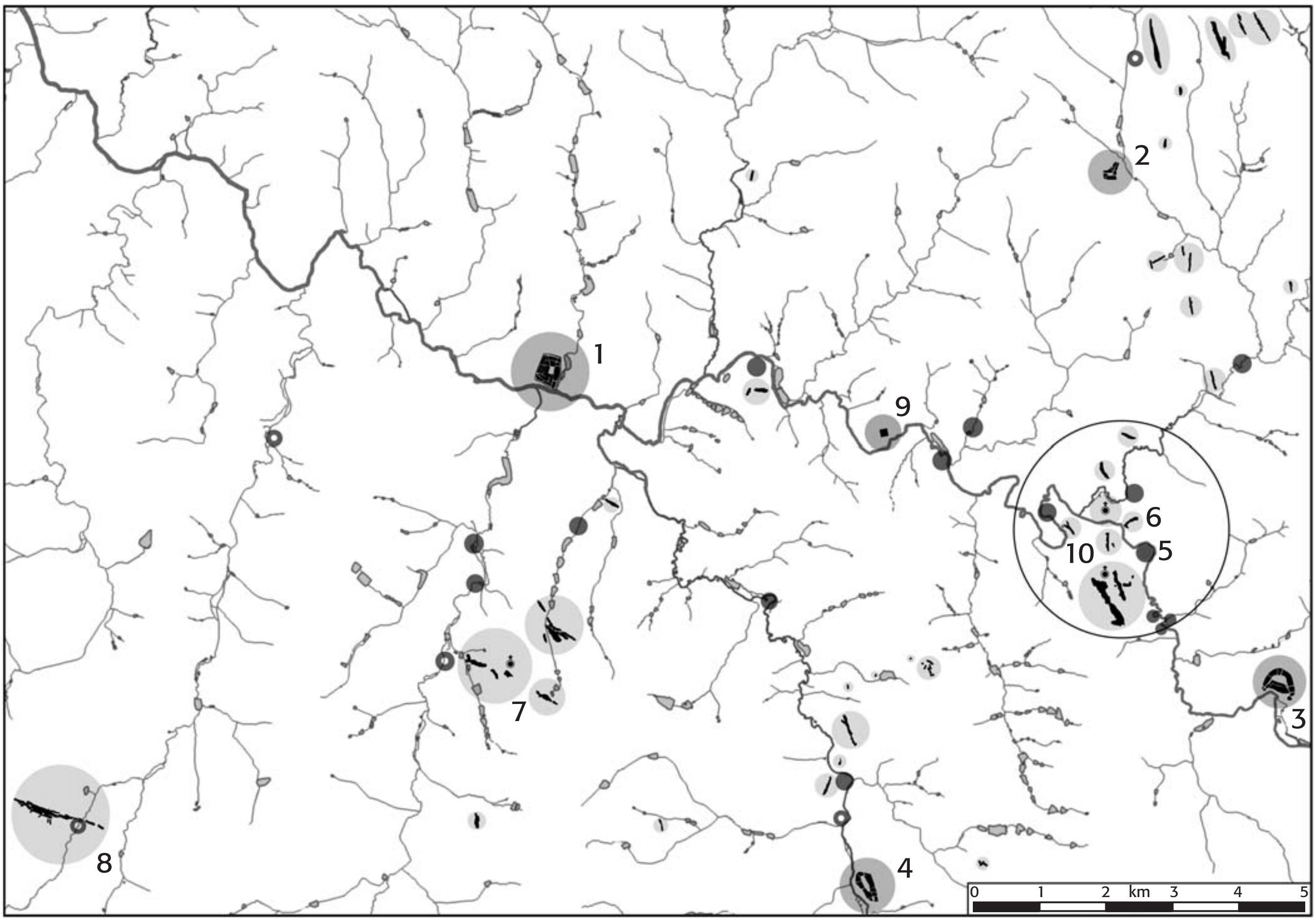


Fig. 2. *Medieval mining sites and urban settlement in the region of Havlíčkův Brod.* ***1:*** *Town of Havlíčkův Brod,* ***2:*** *Town of Česká Bělá,* ***3:*** *Town of Přibyslav,* ***4:*** *Town of Šlapanov,* ***5:*** *Smelting site under Buchberg,* ***6:*** *Mons Herliwini (Herliwinberg),* ***7:*** *Mons Medium (Mittelberg),* ***8:*** *Koječín site,* ***9:*** *Monastery of Pohled (Frauental),* ***10:*** *Mons Fagus (Buchberg). —* ***Obr. 2.*** *Středověké hornické a městské areály na Havlíčkobrodsku.* ***1:*** *město Havlíčkův Brod,* ***2:*** *městečko Česká Bělá,* ***3:*** *město Přibyslav,* ***4:*** *městečko Šlapanov,* ***5:*** *Zpracovatelský areál pod lokalitou Buchberg,* ***6:*** *Mons Herliwini (Herliwinberg),* ***7:*** *Mons Medium (Mittelberg),* ***8:*** *Koječín,* ***9:*** *klášter Pohled (Frauental),* ***10:*** *Mons Fagus (Buchberg).*

picium) at the road leading to Utín. Smil of Lichtenburg confirmed the tenancy on January 1st, 1259 (*CDB V/1*, p. 281, No. 175).

The *Buchberg* mine (*Puchperch*) is subsequently mentioned in the Brod deed issued by King Ottokar II of Bohemia of January 9th, 1261 excluding the Freiberg's mines of from the competence of the Mint master for Moravia (*CDB V/1*, p. 385, No. 252). Another mention can be found in a deed dated June 13th, 1265 settling the dispute over income from the local chapel (*CDB V/1*, pp. 661–662, No. 447). The chapel dispute (*capella de Buchberch*) also appears in the mandate charter of the Prague bishop Jan of August 27th, 1272 (*CDB V/2*, pp. 307–308, No. 673).

Primizl de Monte Vagi (*RBM II*, p. 865, No. 2001) is mentioned among witnesses in the Brod deed of February 27th, 1304 issued for the monastery in Fraunthal. The deed by John of Luxembourg for Henry of Lipa (Jindřich z Lipé) of June 18th, 1321 (*RBM III*, p. 288, No. 692) also mentions the site (*in Monte Fago, qui in volgari Puchberk dicitur*). The mine is also discussed in a charter dated December 7th, 1327, containing the decision of Hynek of Lichtenburg and Žleby in the long-running dispute over the chapel (*RBM III*, p. 548, No. 1399). The *Buchberg* (*Puchberch*) mine is mentioned for the last time in 1351 (*CIM II*, p. 575, No. 1362). *Puchberk* was also mentioned as a village in 1500; however, it could probably refer to a village of Utín, not the mine (*Rous 2001a*, 69).

1.3. Topography of Buchberg

The area is situated on an extensive flat ridge between the villages of Hesov and Utín (*Fig. 10*) within the cadastral district of Utín (775649). Its highest point is situated in the southern part of the magnetically prospected area **G** with an altitude of about 520 m above the sea level; the lowest point is the foot of the dumps in the north-eastern part of the area located on the slope towards the river Sázava with an altitude of 472 m above the sea level. *Buchberg* lies 2.6 km to the north-west of the medieval core of the town of Přibyslav, and about 9.3 km to the south-east of Havlíčkův Brod. The site lies 5.4 km north-east of Šlapanov, which was a mining town of regional importance in the 13th century (*Fig. 2: 3, 4*). The nearest contemporary mining area was

Fig. 3. Orthophoto map of the surroundings of Utín, including a layer of shaded relief, based on Lidar scanning. ***1:*** *Mining areas on the Poperek site, identified as the Buchberg enterprise.* ***2:*** *One of the defunct central smelting areas.* ***3:*** *Church of St. Catherine in the area of the historical Herliwinberg (Mons Herliwini) mines.* ***4–6:*** *Another smelting places. Based on the map server of the Czech Office for Surveying, Mapping and Cadastre (CUZK), edited by author. Supplemented with magnetograms from surveys conducted by the Department of Archaeology and Museology, Faculty of Arts, Masaryk University. —* ***Obr. 3.*** *Reliéfní LiDAR mapa důlního areálu u Utína.* ***1:*** *lokalita Poperek ztotožňovaná s historickým důlním podnikem Buchberg.* ***2:*** *jedno z centrálních struskovišť.* ***3:*** *kostel sv. Kateřiny v místě středověkého dolu Herliwinberg (Mons Herliwini).* ***4–6:*** *Další hutniště. Mapový podklad převzat ze serveru ČÚZK, magnetické měření ÚAM.*

Herliwinberg (*Mons Herliwini*) with the Church of St. Cathrine in the cadastral district of Stříbrné Hory on the opposite, i. e. northern, bank of the Sázava River at a distance of 1.2 km to the north of the evaluated area (*Havlíček 2018*). On the southern bank of the Sázava River, at a distance of about 900 m to the north-east, there is also an extensive slag dump (*Fig. 3: 2*), probably directly connected with *Buchberg* (*Hrubý – Malý – Milo 2016*). The eastern part of the area, which is closer to the upper edge of the slope above the Sázava valley, slopes further to the north-east and the landscape there can be characterised by notches, which can even contain a seasonal smaller watercourse. Otherwise, there is currently no water source at the site. In the higher parts of the site, there are mesobasic cambisols, and on the slopes dystric cambisols (Soil map 1 : 10 000, sheet no. 23-21-23).

Relics of historical mining activities in the form of funnel-shaped shaft openings with spoil-banks can be observed on two ore-bearing structures of the extensive dislocation zone running in the NNW–SSE direction (*Figs. 2, 9* and *10*). The spoil-banks reach up to 890 m length in the primary striking (*Fig. 9: L, M*), and 370 m in the eastern draft (*Fig. 9: O*). However, the original extent of mining work can be estimated at an indicative length of up to 2000 m (*Pokorný 1963*). The total area of the currently visible ore mining relics reaches around 13.8 ha, which makes *Buchberg* one of the most extensive historic mining areas of its time in the region (*Fig. 2, 3, 9, 11* and *12*).

1.4. Geological and mineralogical conditions

The site forms part of the so-called Havlíčkův Brod ore district, including several dozens of sites with occurrences of polymetallic mineralisation. These are classified as the so-called k-pol type or the so-called Lower Perm Fe-Zn-Pb-Ag mineralisation of the Kutná Hora type according to the new classification (*Dobeš – Malý 2001*). Such mineralisations are characterized by the abundant presence of pyrite, pyrrhotite, sphalerite and arsenopyrite; quartz and Fe-Mg-Mn carbonates predominate the vein content, while barite is generally wholly missing. The mineralisation is well advanced in the form of veins and mineralised dislocation zones. The veins are up to tens of cm thick and have a striking length of only a few hundreds of meters. On the other hand, dislocation zones are more distinct. The surrounding rocks are mostly Moldanubian pararules, migmatised to varying degrees. The rocks in the vicinity of the dislocation zones are tectonically affected and transformed by hydrothermal alterations: feldspar decomposition, crystallisation, the formation of sericite, sometimes also chlorides, pyritisation, limonitisation are typical, and graphite is relatively standard.

Ore minerals do not form continuous bodies in the dislocation zone near Utín, but rather occur in veins, ore columns, discontinuous veins and impregnations. Pyrite, pyrrhotite, arsenopyrite and dark sphalerite (with a Fe content of up to about 10% by weight) have been attested in the *Buchberg* area. The ores form either granular aggregates up to several centimetres in size or crystals in the vein up to 1 cm (pyrite and arsenopyrite). The occurrence of macroscopic galena, with its largest aggregates of about 5 cm in size, is relatively rare (*Fig. 13: samples 2* and *6*). Chalcopyrite has been detected microscopically in the form of small inclusions in sphalerite. The occurrence of pyrargyrite creating inclusions in pyrite and galena up to 10 micrometres in size (*Fig. 14: 2, 3*) is sporadic.

The gangue consists mainly of hydrothermally altered rocks and quartz that usually has a white colour and is massive only exceptionally forms crystals up to 0.5 cm in size in cavities. Carbonates are exceptional, but they can relate to the long-term weathering in the acidic environment of the heaps (*Fig. 13: sample 8*). Dolomite-ankerites with increased manganese content and siderites with increased manganese content are also present among the samples. Secondary minerals are represented by limonite, which is mainly formed by weathering of iron sulphides, especially pyrite and pyrrhotite, or Fe carbonates. Black manganese hydroxides usually accompany limonite. So far, cerussite and anglesite have only been confirmed microscopically. Secondary calcite and as yet undetermined secondary arsenic minerals have been attested in coatings. Ore samples have been obtained from mine heaps, i. e. they represent unusable waste. Therefore, they are not a representative example of textural and structural types of the presumed quality ore, which was further processed by medieval miners.

1.5. Investigation, mapping, surveys and fieldwork conducted at the medieval mining centre of Buchberg

Since the 1880s, the identification of the medieval mines at *Buchberg* – a site that was mentioned in a surprisingly significant number of the 13th and 14th century-documents, has relied on its resemblance to the local name *Poperek*. It is considered a folk version of the original German name *Buchberg*, or *Puchberk* or *Puchberch* (*Feyfar 1876*, 6; *Petr 1897*, 21; *Kořan 1954*, 4; *Cigánek – Keclík 1976*). The name *Puperneck* is also mentioned on the oldest mine district map from 1773 (*Fig. 4*) drawn by the royal Mining master Johann Christian Fischer, who, on behalf of the authorities, reviewed the remains of ancient ore mining in the Havlíčkův Brod region (*Fischer 1773*).

Finds related to historical mining activities in the Přibyslav region were recorded as early as the 1870s when the mining engineer Johann Höniger (1804–1892) carried out experimental mining work there. They found old mine-timbers, picks and other tools. These artefacts are lost today. Moreover, it is not clear whether they came from Utín or more probably from the northern bank of the Sázava River from Stříbrné Hory where they mined in 1873–1888 (*Kutílek 1884*, 269–271; *Rous 1998a*, 107). In 1872, Höniger drew several mining maps (*Figs. 5* and *6*) showing relics of historical mining activities (*Höniger 1872*; *1872/1879*; *Anonymous Uibersichts-Gangkarte*). Rudolf Helmhacker (1841–1915), a Czech geologist and mining engineer of German origin, also took part in the survey and mapping and drew an even more accurate map of the abandoned mining works in 1876 (*Helmhacker 1876*). Last but not least, the most accurate map of old mining works near Utín, and Stříbrné Hory from 1875 (*Fig. 5*) also seems to be drawn by Helmhacker, but his authorship is not absolute (*Anonymous 1875*).

Modern geological inspections and surveying of old mining works date back to the 1960s and can be predominantly attributed to the activities of the geologist Joel Pokorný (*Fig. 6*). In the years 1963–1964, he carried out exploratory and mapping drillings near Stříbrné Hory, Utín and Dlouhá Ves, just to mention a few of them. He also created a card-index of old mining works kept at the Czech Geological Institute in Prague. At that time, geological maps were created at a scale of 1 : 25,000 to 1 : 50,000 (*Pokorný 1963*; *Holub 2005*, 396; *Špaček et al. 1963*; *Bartášek – Martinek 1973*). In the following decade, Svatopluk Cigánek and Ivo Keclík provided a topographic and mining-historical description of the site (*Cigánek – Keclík 1976*, 28, 31, 36–37).

Archaeologist Pavel Rous, who had been active in the Havlíčkův Brod region, introduced *Buchberg* as an archaeological topic and conducted the first field survey of relics of historical mining there in 1989 (*Rous – Zborovská 1989*). Above all, he evaluated numerous finds obtained by the amateur researcher and de facto discoverer of the site Jiří Berky during systematic surface pottery collectings at the site in 1981–1991 (*Berky 1992*; *Rous 1998a*, 107). During his research, he managed to identify locations **A–F** with higher concentrations of pottery fragments and determine the different spatial distribution of earlier and later pottery sherds (*Rous 1998a*, 107–108, 114). Rous has followed up with further surveys since 1997 and supported his results with archival research and a critical evaluation of previously published views on topographical inaccuracies and problems (*Rous 1998a*, 107–108, 114; *1998b*; *2001a*, 69, 72, 79–81; *2004*, 50). In 1998, an isolated motte was archaeologically prospected; this feature shows some morphological characteristics of a small medieval fortification of the *motte* type (*Rous 1998a*, 107; *Fig. 11*).

The range of issues has soon expanded from the mining settlement to the production and metallurgical facilities and ore mills. Since 1999, the Jihlava Museum has started to participate in the prospection of the site and its hinterland. Surveys, including metal detectors for the first time, have focused on archaeometallurgical finds, which were systematically evaluated utilizing geochemical analyses (*Havlíček 2005*; *Havlíček 2007*; *Malý – Rous 2001*, 81–85, No. 15; *Rous 2001b*; *2005*; *2006a*; *2006b*; *2010a*; *2010b*; *2007*; *Rous – Berky 2002*; *Rous – Malý 2004*, 124, Fig. 2, 126; *AVV 1/2007*, 29).

Surveys conducted by the field office in Jihlava of ARCHAIA Brno company and the Institute of Archaeology and Museology of Masaryk University (ÚAM) drew on the previous research in 2013–2014. As part of the project "Historical use of the Bohemian-Moravian Highlands landscape in Prehistory and the Middle Ages", large-scale magnetic prospection was carried out on adjacent fields. Its results confirmed the presence of settlement structures with adjoining extensive metallurgical area (newly discovered; *Fig. 9: F* and *Fig. 15*). Magnetic prospection was also performed in the nearby metallurgical area located in the Sázava Valley (*Fig. 3: 2*). Geochemical sampling that supplemented the prospection corroborated the existence of indicators of advanced production infrastructure (*Hrubý – Malý – Milo 2016*).

At that time, *Buchberg* was already becoming a Central European topic (*Hrubý 2016*, 186–187; *Derner – Hrubý – Schubert 2016*, 226, 234, Abb. 27: 1, 237; 38, 238). The latest research has been performed as a part of the international project *VirtualArch*, which is guaranteed in the Czech Republic by the Archaeological Institute of the Czech Academy of Sciences in Prague (ÚAM co-operates in that project). Further magnetic prospection was performed in 2018 under the leader-

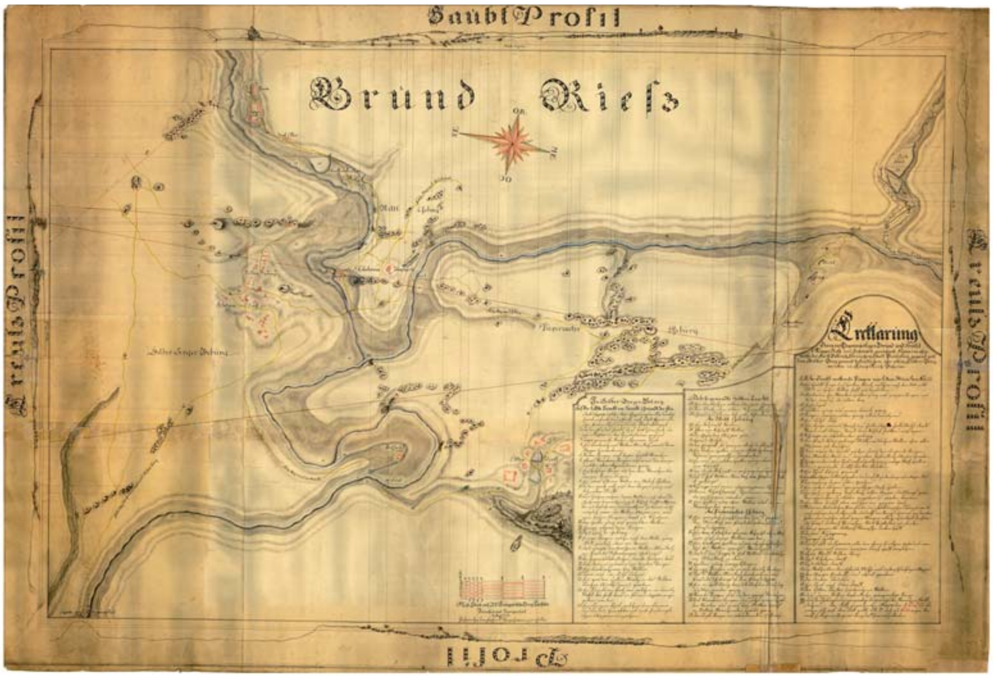


Fig. 4. *Mining map from 1773 by Johann Christian Fischer. The site of Buchberg is designated as Pupernecker Gebürg (Fischer 1773). —* ***Obr. 4.*** *Důlní mapa Johanna Christiana Fischera z roku 1773. Zájmové území je označeno jako Pupernecker Gebürg (Fischer 1773).*

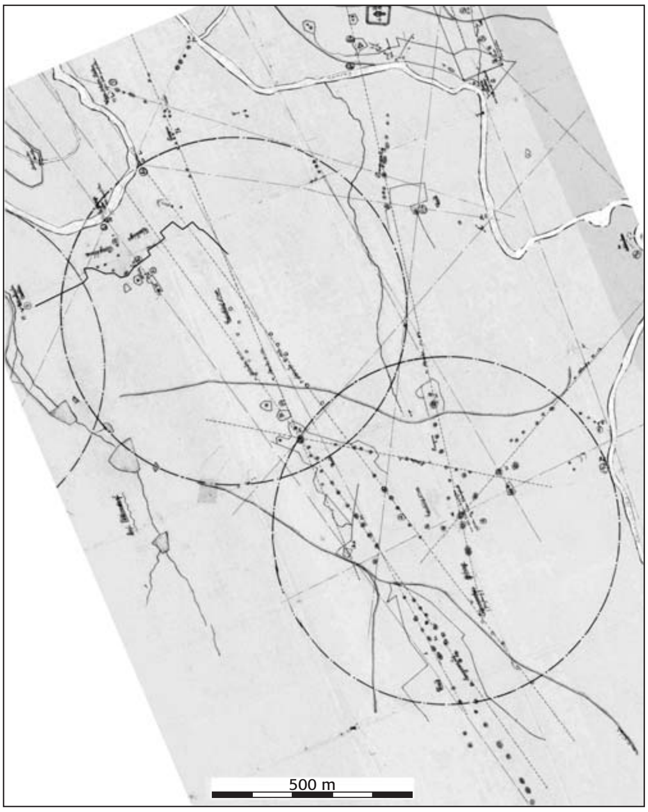


Fig. 5. *Anonymous mining map (probably by Rudolf Helmhacker) from 1875 (Anonym 1875). —* ***Obr. 5.*** *Anonymní důlní mapa (pravděpodobně Rudolf Helmhacker z roku 1875 (Anonym 1875).*

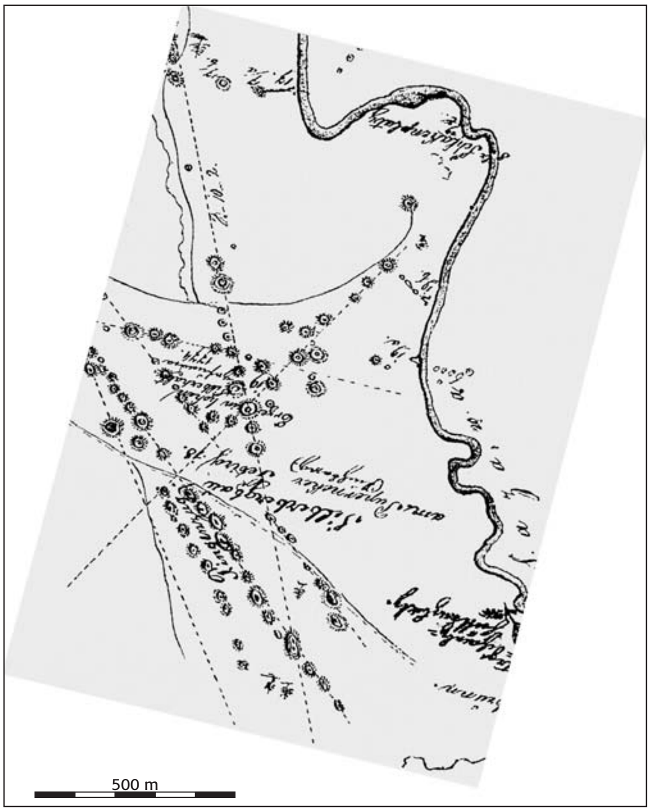


Fig. 6. *Mining prospection map with preserved remains of historical mining by Joel Pokorný (1963). —* ***Obr. 6.*** *Mapa důlního průzkumu s vynesenými relikty historické hornické činnosti od Joela Pokorného (Pokorný 1963).*

ship of experts from Masaryk University (*Milo – Tencer 2018*). The area of metallurgical facilities was subject to surface prospections in 2017–2018. This was followed in the autumn of 2018 by small-scale excavations, supplemented in the summer of 2019 by trial fieldwork at the foot of the cumulus formation (its top was archaeologically investigated in 1998). As a part of the research activities, field relics of historical mining activities have been surveyed, and their distribution has been subject to spatial analysis.

Prospection and surveys conducted in the years 2013 to 2020 have provided more detailed and accurate information about the community and technical infrastructure of the defunct mining complex. It was also urgent to survey relics of historic mining activity in areas that were forested until recently. In 2018–2020, the threat that they could be damaged or become inaccessible for documentation for some time has increased, mainly in connection with the clearing of forest stands infested with bark beetles and their subsequent reforestation (*Figs. 7, 10–12*). As a scientific discipline, as well as a heritage care factor, archaeology should be able to respond appropriately to such interventions.

2. Methodology/Research methods

2.1. Remote 3D-surveying of deforested relics of historical mining

The current deforestation of the area has enabled the application of remote digital data collection in the surveying using the multi-image photogrammetry method – *Structure from Motion* (SfM) – of primary image data processing that can provide metric, accurate and detailed 3D digital data at any scale (*Figs. 7* and *8*). This technology calculates the spatial position and shape of the evaluated feature based on the image correlation of two sub-images by identifying the position of two corresponding points of reference. The algorithm benefits from the fact that each point (pixel), together with its surroundings, is unique, and, therefore, can be identified in other images. Hardware and algorithm improvements have caused that SfM can bring results from the ground and aerial data collection and processing that are comparable to laser scanning (*Remondino – Rizzi 2010*).

The UAV (*DJI Mavic Pro*) system was chosen to photograph the site. Data collection took place during the dormant period (in January 2020). Data was captured from a height of 120 m, the total flight time reached 57 min, and 2239 photographs were obtained. An area of 0.3 sq. km was photographed with an overlap of more than nine photographs per point. Data was processed in *Agisoft Photoscan* software, and the resulting resolution was 3.01 cm/pix. The pictures were georeferenced by means of GPS coordinates corresponding to the time and place when the drone took the images. Ten GCP ground control points were incorporated in the model, and their coordinates were read from the ČUZK website (State Administration of Land Surveying and Cadastre). The measurement error values for X, Y and Z axes are only several centimetres.

The digital 3D-model was also used for a test calculation of the volume of excavated rock in suitable parts of the site. Three compact segments of the mining field **I–III** were chosen, where the elevation compared to the original plain was clearly visible (*Fig. 47*). By doing so, a geometric body representing a convex mining field can be modelled. The ideal original relief (of a mining field) was calculated to copy as much as possible the natural landscape determined by the outer edges of the spoil-banks. Based on the same points of reference, the circumferential sides of the modelled body were determined, and, thus, its lower surface could be calculated, and the body closed. The automatic volume calculation was performed in *Agisoft Photoscan* software, and its results were verified by *CloudCompare* software. At most, the calculations differed from each other in tenths of a cubic metre. If the considered body cut concave shaft orifices (such occurrence is indicated on the cross-sections below the connectors on the outer sides), their volume was automatically subtracted from the mass of the above-ground segments (it is indicated on the cross-sections above the connectors on the outer sides of the model). The calculation was the most satisfactory for the segment **I** in the northern section of the spoil-bank field **M** (parcel No. 219/1) and for segment **II**, which is located in the middle section of the spoil-bank field **O** (parcel No. 136/1, 136/2).

The use of publicly available aerial photographs on the ČÚZK (State Administration of Land Surveying and Cadastre) map server can also be considered, to some extent, a method of remote sensing. For example, cropmarks of nine settlement structures are clearly visible in the 2018 images (*Fig. 49*), and they coincide with the magnetically detected subsurface anomalies, as well as the concentrations of pottery fragments (*Fig. 9: B*). The metallurgical facility in area **F**, which was first detected by magnetic prospection and subsequently verified by trial excavations, were visible (or rather their soilmarks) in the 2013 images. The pictures were taken during ploughing (or sowing). There is a large dark soil anomaly, caused by a significant concentration of charcoals in the soil (*Fig. 16*), which roughly overlaps with the area with the highest slag density (*Fig. 15*).

2.2. Magnetic prospecting

Magnetometry is the most suitable geophysical method that can be used to locate shallow subsurface features. When surveying mining areas associated with ore extraction and metallurgical activities, the contrast detection of subsurface structures can be mainly affected by the composition of processed ores, as iron minerals (pyrite, arsenopyrite, pyrrhotite and possibly chalcopyrite) are practically always present in the ore obtained from polymetallic mineralisation bodies. As the ores present in the fillings of archaeological features have been subject to weathering processes, secondary minerals such as hydroxides, sulphates, carbonates and possibly also iron phosphates, were formed. These ferromagnetic minerals, thus, play an important role in the magnetic detection of subsurface archaeological features. In mining and metallurgical areas, the magnetograms also indicate the presence of furnaces as their constructions consisting of stones and daubs (and parts thereof) were exposed to high temperatures. Last but not least, concentrations of metallurgical waste, i. e. metallurgical and smithing slags, can also invoke the anomalous magnetic values.

During the magnetic prospection, the area **F** (5.0 ha; *Fig. 9: F*, plot No. 209/1) was surveyed in the seasons 2013 and 2014 using the fluxgate magnetometer Förster Ferex 4.032 DLG, which was designed as a gradiometer for measuring the vertical gradient of the local magnetic field, i. e. the differences in the vertical com-

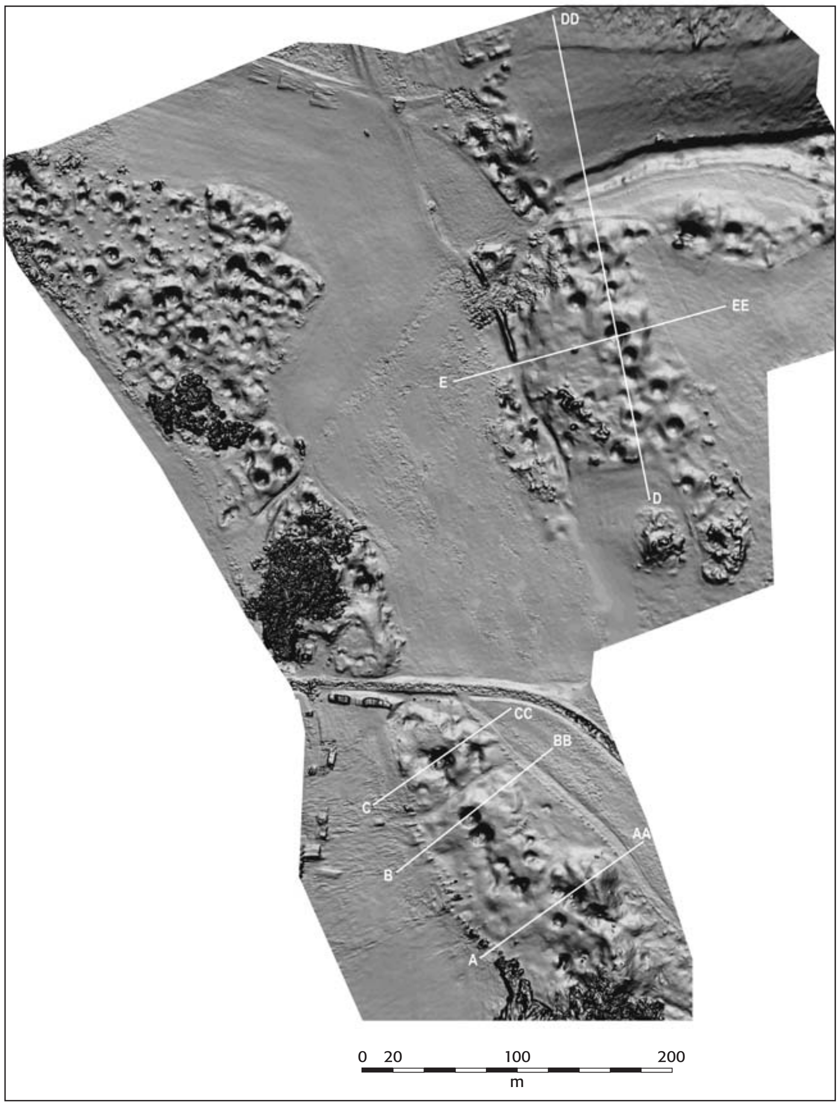


Fig. 7. 3D relief survey conducted by drone. Created by Jiří Unger. — *Obr. 7.* 3D montánní relief v areálu zaměřený dronem. Vytvořil Jiří Unger.

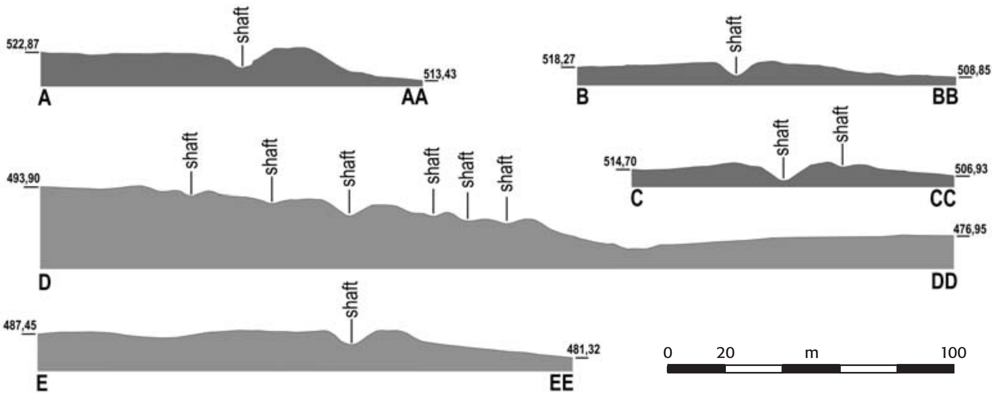


Fig. 8. Profiles of the historical mining relief. Created by Jiří Unger. — *Obr. 8.* Profily historickým montánním reliéfem. Vytvořil Jiří Unger.

ponents of the magnetic field at two various elevations from the surface. The vertical distance between both sensors in each probe is 65 cm. The density of the measured points was 0.25 × 0.5 m. The mining settlements near Vyskytná and at *Cvilínek* were also surveyed by means of this magnetometer (*Crkal et al. 2019*, 887–923).

The grassed area **G** (5.2 ha) located to the west of the mines was surveyed in 2018 (*Fig. 9: G*, plot no. 222/2, 222/3, 222/4) using the fluxgate magnetometer LEA MAX, which was also designed as a gradiometer equipped with Förster probes. At a frequency of hundreds of measurements per second, it continuously records magnetic field values with an accuracy of 0.1 nT/m and registers

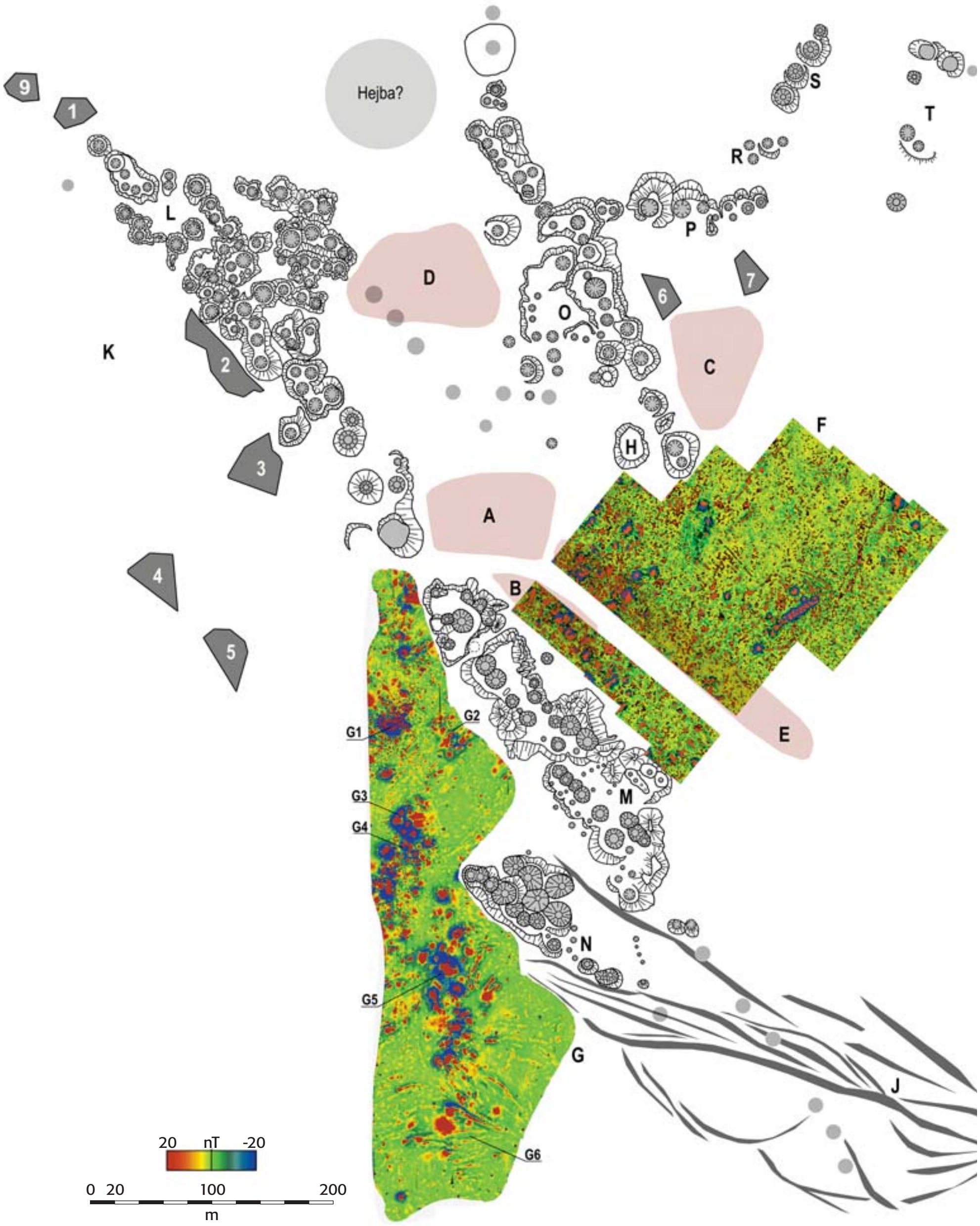


Fig. 9. *Buchberg.* ***A–E:*** *Surveyed areas with high concentrations of pottery fragments.* ***F–G:*** *Magnetic surveyed areas.* ***J:*** *Medieval and early modern trails.* ***L–T:*** *Mining fields.* ***1–9:*** *Field anomalies on the 1838 cadastral map, probably shafts, today entirely re-cultivated.* ***Grey points:*** *shafts attested on an anonymous map from 19th century (see Fig. 5).* — ***Obr. 9.*** *Buchberg.* ***A–E:*** *Plochy povrchových prospekcí s koncentracemi keramiky.* ***F–G:*** *Plochy proměřené magnetikou.* ***J:*** *Staré úvozy.* ***L–T:*** *Důlní areály s relikty ústí šachet a s haldami.* ***1–9:*** *pozemkové anomalie dle Stabilního katastru z roku 1838, hypoteticky rekultivované důlní objekty.* ***Šedé body:*** *šachty podle anonymní mapy z 19. stol. (viz obr. 5).*

them synchronously together with the spatial information obtained from a GNSS receiver. The density of the measured points was 0.25 × 0.5 m. The data were subsequently processed in the LEAD 2 software in order to obtain an area magnetogram, later on, visualised in ArcGIS Desktop 10.3 (*Milo – Tencer 2018*).

We have divided the magnetic anomalies into positive, negative and bipolar according to the measured values. Archaeological subsurface features usually appear as slightly positive anomalies while geological structures are displayed as significantly positive or negative anomalies. Bipolar magnetic anomalies with values between 100/–100 nT are mostly smaller and usually represent recent metal items; however, in the mining area, they can also indicate fragments of ores or slags. A cluster of such anomalies was identified, for example, in the northern part of area **G** (*Fig. 9: G1*) and showed the same characteristics as the magnetic indication of the slag dump (*Hrubý – Malý – Milo 2016*, 402, fig. 13). To achieve the most distinctive results of the non-destructive methods, we combined the magnetic survey with soil and crop mark analysis (*Fig. 16* and *49*), as well as with analytically processed surface collecting of archaeometallurgical materials (*Fig. 15*).

2.3. Surface prospecting and survey

In the initial phase of the survey in autumn 2017, an orthogonal network corresponding to the magnetic prospection network from 2013 and 2014 was laid out in areas **B** and **F** (*Fig. 9: F*). Altogether, 15 squares with a side length of 30 m covered a total area of 13,500 sq. m (*Fig. 15*). Entire squares were initially sampled in area **B**, i. e. in the field between the road and the forest, but the considerable high density of pottery sherds and

__Fig. 10.__ Panoramic photo depicting deforested historical mining relief taken by drone. Photo by Jiří Unger. — ***Obr. 10.*** *Panoramatické foto odlesněného montánního reliéfu s šachtami a haldami pořízené dronem. Foto Jiří Unger.*

slags forced us to abandon this method for practical reasons. A simplified and faster procedure was chosen instead. The trajectories of collectors along the boundaries of squares were determined, first in the longitudinal direction (SW–NE axis) and consecutively in the transverse direction (NW–SE axis). Thus, the interpolation and interpretation potential during later extrapolation of the data from the lines to the area significantly increased. Along these routes, collectings performed by one single person focused separately on ceramics and slags were carried out in strips 2 m wide. Initially, both categories of finds were put in bags while still in their original position; subsequently, for practical reasons (a large number of finds), they were marked with two different spray paints. In the end, the points marked in such a way with both groups of finds were surveyed using GPS RTK Leica with an average maximum deviation of up to 3 cm.

The measured data were processed in the ArcGIS environment by *Nearest Neighbor* interpolation (*Burrough 1986*) and Kriging (*Ebdon 1985*) methods, and their results were almost identical. The *Nearest Neighbour* method, with an interpolation square radius of 1 m proved to be more suitable for visualisation. The obtained values provided separate distribution spatial data for slags (*Fig. 15*) and ceramics. The method application is limited mainly due to the square size. It would be almost impossible to use the method without prior magnetic survey while maintaining such vast distances between the trajectories of collectors. Moreover, we can benefit from the fact that the trajectories can be supplemented with RTK GPS in future surveys and, subsequently, the data interpolation can be updated. With regard to the generally accepted method of surface prospections (*Kuna et al. 2004*, 324–339), we can state that sampling of large squares cannot confirm the presence of subsurface features, but can help determine the character of the site. When combined with other data layers, the surface collectings can provide the most complete picture of the surveyed area. The spatial distribution of data was compared with the data layer of subsurface magnetic anomalies. This approach contributed to a more detailed understanding of the subsurface archaeological contexts and features, and at the same time, facilitated the selection of a site for the trial excavations targeting the relics of metallurgical facilities.

2.4. Limits of the application of metal detectors

Surface collectings were supplemented by metal detector prospection, which was raised by already obtained metal finds discovered in other parts of the site in the past by various prospectors (*Figs. 35–38, 41–45*). Areas **B, E, F** were divided into working sectors according to the plots and surveyed for approximately a similar period. Three working groups moved in strips 1.5–2.5 m wide, and subsequently at the discretion of the individuals using Garrett ACE 250, XP-Gmaxx and Golden Mask GM4PRO detectors.

The Garrett ACE 250 device is a digital detector with a 9 × 12" PRO coil suitable for work at greater depths. It operates at 6.5 kHz frequency and has several programmes for searching for all targets (*all metal*), non-ferrous metals (*jewellery, coins*), iron artefacts (*relics*), etc. Its disadvantages include a rather slow response to the signal, low distinction of ferromagnetic artefacts and especially the built-in discrimination, which allows movement in different environments. However, they cannot be regulated according to soil conditions in order to gain the highest possible depth range.

The XP-Gmaxx (XP Metal detectors) device is a fully adjustable analogue detector. With a standard DD coil of 22.5 cm and a frequency of 4.6 kHz, it is a stable device for all conditions and is ideal for searching for ferromagnetic finds and targets at greater depths; it is, however, less suitable for tracing small items.

The Golden Mask GM4PRO differs in its modern design of a 12" (30 cm) 2D coil with a higher operating frequency of 18 kHz. Thus, it achieves a swift response to the smallest targets and has precise discrimination. It also has a considerable depth range. Its disadvantages include the signal interference near power lines, WI-FI networks, etc., as well as its instability on soils with high mineralisation, and the permanent presence of disturbing sounds that cannot be debugged.

Fig. 11. *Details of panoramic photo depicting deforested historical mining relief taken by drone. Photo by Jiří Unger.* — ***Obr. 11.*** *Detailní foto odlesněného montánního reliéfu s šachtami a haldami pořízené dronem. Foto Jiří Unger.*

Fig. 12. *Details of panoramic photo depicting deforested historical mining relief taken by drone. Photo by Jiří Unger.* — ***Obr. 12.*** *Detailní foto odlesněného montánního reliéfu s šachtami a haldami pořízené dronem. Foto Jiří Unger.*

Metal detector prospection proved to be problematic in effectiveness concerning XP and Goldenmask detectors with fixed parameter settings. Its effectiveness was hindered by the widespread occurrence of slags including metal phases, and such response could not be debugged. Paradoxically, the best finds were found with the Garrett beginner's device, which was the oldest of the detectors used and had no soil tuning. Thus, we found, for example, both belt ends and other finds (*Fig. 44: 7, 8*).

2.5. Analytics of archaeometallurgical and anthracological material

Slags (*Figs. 26–29*; *Tabs. 1* and *2*): Based on the relevant physical properties (porosity, morphology, colour, aggregate density), a representative group of samples was selected representing 5–10% of the entire assemblage. The elemental composition of samples was determined with a hand-held XRF analyser (pXRF – portable X-ray fluorescence). Selected representative samples were subjected to further examination based on the results. Such phased selection process allows describing large assemblages of archaeometallurgical material with minimal loss of informative value while maintaining the selection representativeness. Combined with archaeometric analytics, time, and resources can be saved significantly. The elemental composition of slags was initially determined by X-ray fluorescence using a Delta Professional hand-held spectrometer in Geochem mode and with a measurement time of 120 seconds (Department of Archaeology and Museology, Faculty of Arts, Masaryk University, analyst M. Kmošek). Altogether, 243 measurements were performed on fresh fracture surfaces of the samples. By using this approach, it is possible to provide fast and economic analyses of vast sets, already during fieldwork. In comparison with desktop XRF analysers or more advanced analytical methods (NAA, AAS), the hand-held XRF analysers suffer from the lower level of accuracy and higher detection limits. The water content, usually ranging from 0 to a few percentages by weight per slag, significantly affects the measurement accuracy of the elemental composition. The porosity and inhomogeneity of slags, as well as light-elements that cannot be determined by the device, represent other issues. Finally, the different valencies and, thus, the different oxygen content, especially in compounds with iron (FeO, Fe_2O_3, Fe_3O_4, FeOOH, etc.), also challenge the measurement accuracy.

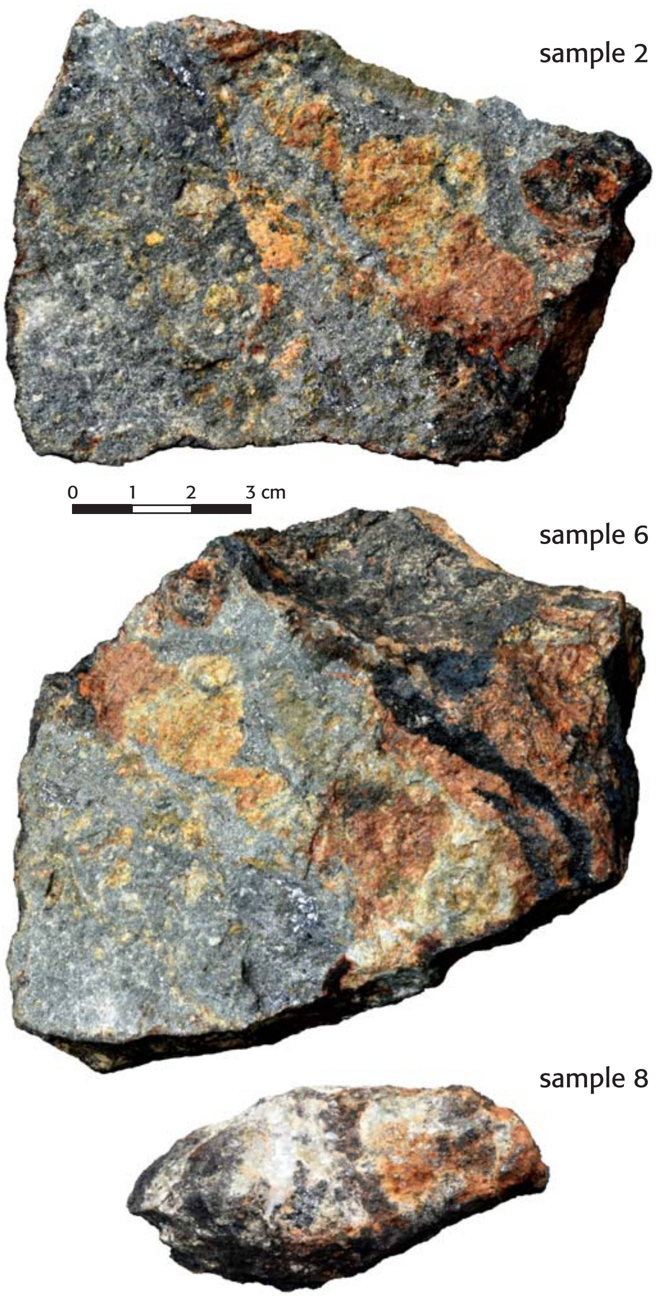


Fig. 13. Ore samples from Buchberg (by Karel Malý). ***Sample 2*** *and* ***6:*** *Galena and sphalerite in the siliceous altered rock.* ***Sample 8:*** *Mg-Fe carbonate with sphalerite and minority pyrite. Photo by Karel Malý. —* ***Obr. 13.*** *Vzorky rudniny z areálu Buchberg (sbírka Karel Malý).* ***2*** *a* ***6:*** *galenit a sfaleryt v prokřemenělé alterované hornině.* ***8:*** *Mg-Fe karbonáty se sfaleritem a minoritně pyritem. Foto Karel Malý.*

The device determines the qualitative and quantitative representation of elements automatically without the possibility to process further the measured spectra (*Nicholas – Manti 2014*). Any differences in the slag element contents can be rendered as possible errors if they are not really significant.

The magnetic susceptibility of slags was determined with a KP-5 hand cappameter (Geophysics Brno). Standard slag thin and polished sections were prepared and studied using an Olympus BX40 optical microscope. The polished sections were subsequently studied in an electron microscope with an EDX analyser (analyst K. Malý).

Spherules and scalings (*Figs. 30* and *31*; *Tab. 3*): Soil samples containing a high portion of scalings were taken from the filling of sunken parts of the furnaces. The scalings were separated from the soil by using gold pans similar to the so-called Chinese hats. The heavy phase concentrate was subsequently separated from the remaining light phase in bromoform (measured density 2.9 g/cubic cm). Heavy minerals obtained in such a way were examined under an optical microscope. Furthermore, manually separated samples were examined in an electron microscope and after preparation of their polished sections in the form of epoxy tablets in a scanning electron microscope JEOL JSM-6490LV with connected EDX analyser of Oxford Instruments with accelerating voltage of 15 kV (Institute of Geological Sciences, Faculty of Science, Masaryk University, Brno, analyst J. Štelcl).

Non-ferrous metal ***ingots*** (*Figs. 32–36*; *Tabs. 4–8*): An area of approximately 1 sq. cm was mechanically cleaned on the ingots from oxidation products. They were analysed using a hand-held XRF spectrometer Olympus Delta or Olympus Vanta in the mode for the analysis of metals and alloys, with an accelerating voltage of 40 or 50 kV and an ED spectrum reading time reaching 30 s.

Charcoal from furnace fillings and their working environment (*Tab. 10*; *Diagram 1*): An unsorted and unflushed sample of charcoals (ca. 3 l, 420.6895 g) from feature 0503 in trench 2/2018 was subjected to an anthracological analysis. The sample comes from layout 0108, which also contained a considerable amount of slags. The charcoal fragments were analysed using a light microscope adapted for observation in incident light (episcopal microscope). After gaining new fracture surfaces (transverse, radial and tangential fractures), the charcoals were viewed directly at 50×, 100× and 200× magnification.

3. 2018 and 2019 fieldwork seasons

3.1. Excavation of relics of metallurgical facilities in trench 2/2018

The metallurgical complex subject to prospecting and consequent trial fieldwork is located to the east of the central shaft zone on a field in the *Hesovské louky* parcel (parcel No. 209/1; GPS coordinates N 49.5843714: E 15.7058454, Křovák coordinates Y 658317.93: X 1110316.51). It was detected on the orthophoto map from 2013 as a soil mark with dark areas formed by a distinct admixture of charcoals (*Fig. 16*) forming the upper parts of the fillings of subsurface relics of metallurgical facilities. The altitude is about 500 m above sea level.

An area of small-scale anomalies of high values was detected there by the geomagnetic survey. The anomalies were arranged in a continuous double line running in the SW-NE direction and can be interpreted as a battery of about twenty furnaces in two rows (*Fig. 9: F*). This facility measuring approximately 8 × 50 m could be fenced off; the probable fence can be seen on the magnetogram as a line anomaly (*Fig. 15*). The analytically evaluated surface collectings corroborated the presence of enormous concentrations of slags there, which coincide with the extension of soil marks. This area also contained numerous pieces of lead ingots (*Fig. 34*). Archaeological trenches distributed over this area were to corroborate the presumed subsurface relics of metallurgical facilities. The 2/2018 trench fully met this goal, initially measuring 1.6 × 7 m, which was later on widened by 114 cm on its north side (*Figs. 17–21A, 21B*).

Topsoil, overburden and subsoil layers, and marginal features (*0101–0105, 0109, 0505*): Topsoil (0101) contained fragments of pottery, slags and charcoals corresponding to the soil marks visible on the orthophotos from 2013 (*Fig. 16*). Layers 0102 and 0103 corroborate the fact that recent agricultural activities have been disturbing the fillings of medieval archaeometallurgical structures. This level also contained a shallow circular pit 0500 with filling 0105, measuring 38–40 cm in diameter, with a depth of 15 cm (*Fig. 17: level 1*).

A complex of features 0501, 0506, 0508 and 0509 containing evidence of metallurgical activities: A relatively shallow but extensive feature 0501 with a flat bottom containing components of metallurgical activities formed the dominant element (*Figs. 17–22*). In the western part of the complex, the terrain was lowered by 20 cm in the form of the feature 0506. A smaller oval pit 0509, measuring 35 × 30 cm, with traces indicating high temperatures and fire, was discovered at its edge. The feature was filled with the layout 0130 containing a significant charcoal (*Fig. 24*). It can be interpreted as a smaller pit furnace (perhaps a crucible furnace?); however, it is also possible that this feature is not a metallurgical facility at all. After extending the trench, the feature 0508, with a diameter of 170 cm, was identified in the northern part of the complex. It was also lowered by 40 cm compared to the bottom of the structure 0501 in the same way as the feature 0506 (*Figs. 18: level 6*; *19* and *20*).

Feature 0502 containing evidence of metallurgical activities: It was a relatively shallow feature measuring approximately 190 × 190 cm. In the upper part of its filling, there was a blacksmith's hearth of a circular shape (0900), with a diameter of 55–58 cm, built of stones and especially slags (*Figs. 19* and *22*). The heath was directly connected with the accumulation of stones 0901, which could be a remnant of the heath structure or another part of the smithy.

Feature 0503 containing evidence of metallurgical activities: It was a circular feature with a diameter of 120 cm that was dug to the weathered rock outcrops (with the depth of 58 cm). The upper part of its filling consists of the layout 0108 with a significant admixture of slags and charcoal, which was sampled for anthracological analysis (*Tab. 10*; *Diagram 1*). At this level, the feature was filled with stones that may come from a destroyed furnace. The stones did not show, however, any

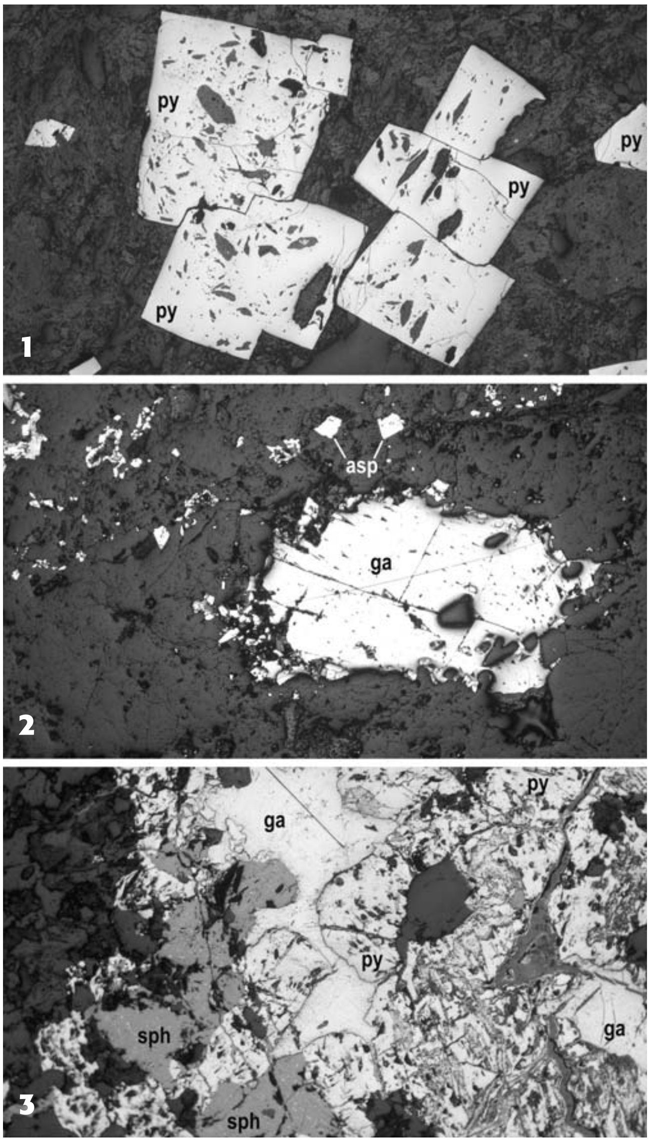


Fig. 14. *Microscopic ore samples.* ***1:*** *Pyrite. Cut, Nicol prism 1, Underside of the sample 3 mm.* ***2:*** *Galena and arsenopyrite. Cut, Nicol prism 1, Underside of the sample 1.2 mm.* ***3:*** *Galena, pyrite, sphalerite with inclusions of the chalcopyrite and pyrhotine in the quartz (dark). Cut. Nicol prism 1, Underside of the sample 1.2 mm. Photo by Jaroslav Kapusta. —* ***Obr. 14.*** *Vzorky rud pod mikroskopem.* ***1:*** *pyrit, nábrus, jeden nikol, spodní strana záběru 3 mm.* ***2:*** *galenit a arsenopyrirt, nábrus, jeden nikol, spodní strana záběru 1,2 mm.* ***3:*** *galenit, pyrit, sfalerit s inkluzemi chakopyritu a pyrhotinu, křemen, nábrus, jeden nikol, spodní strana záběru 1,2 mm. Foto Jaroslav Kapusta.*

discolouration or surface damage that would be indicative of high heat (*Figs. 17: level 3*; *23*). Compared to the features 0501 and 0502, this structure appears to be stratigraphically later.

Archaeometallurgical structures detected as features 0501, 0502, 0503, 0506, 0508 and 0509 show characteristics indicating their approximately simultaneous establishment and short existence, despite their stratigraphic sequence. The pottery assemblage contains specimens belonging to the earliest and middle horizons (*Figs. 39: 4, 5*; *40*). The final phase of the existence of this part of the metallurgical district can be dated by a silver *parvus* of John of Luxembourg (1310–

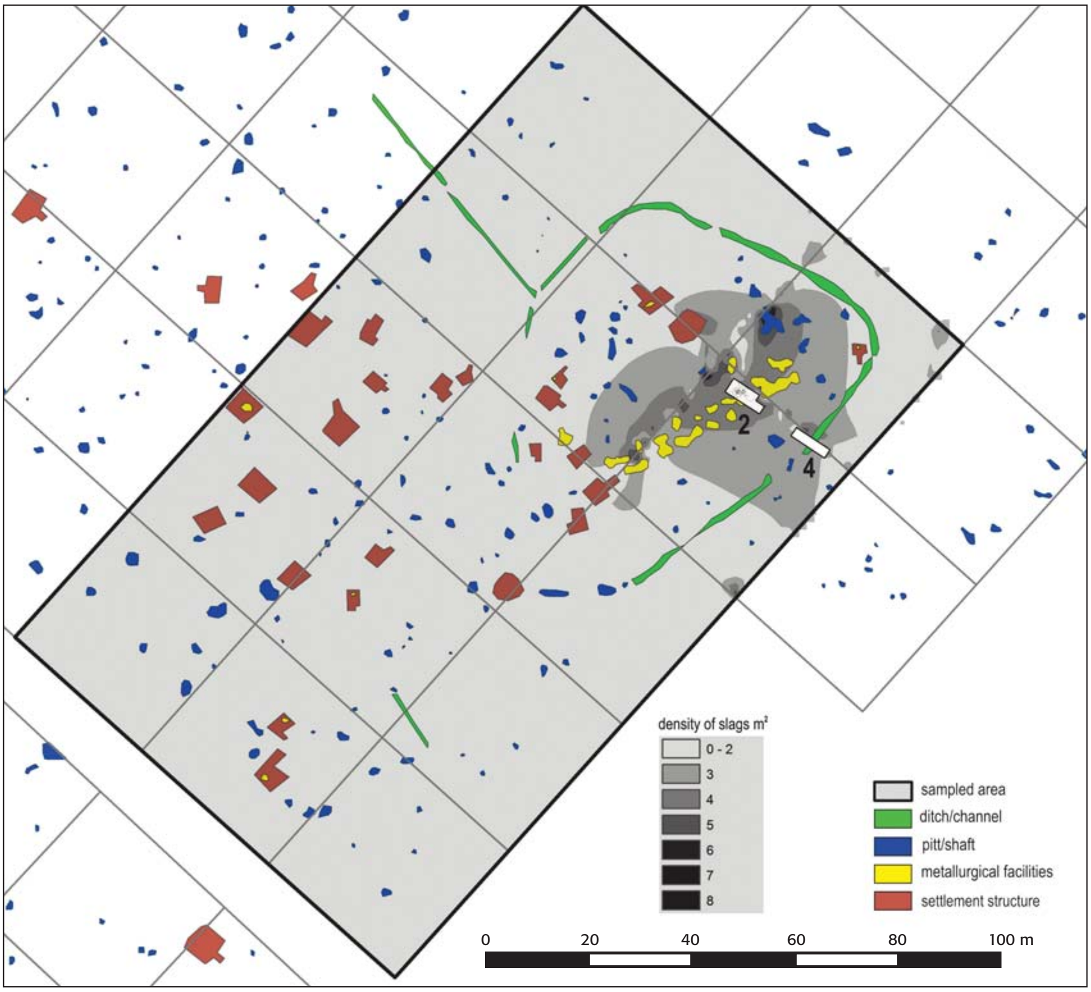


__Fig. 15.__ Metallurgical area surveyed by magnetic prospection and sampled (slags and pottery) including excavated trenches 2 and 4. — __Obr. 15.__ Plán metalurgického areálu proměřeného magnetikou a podrobeného systematické sběrové prospekci (strusky a keramika). Vyneseny sondy 2 a 4.

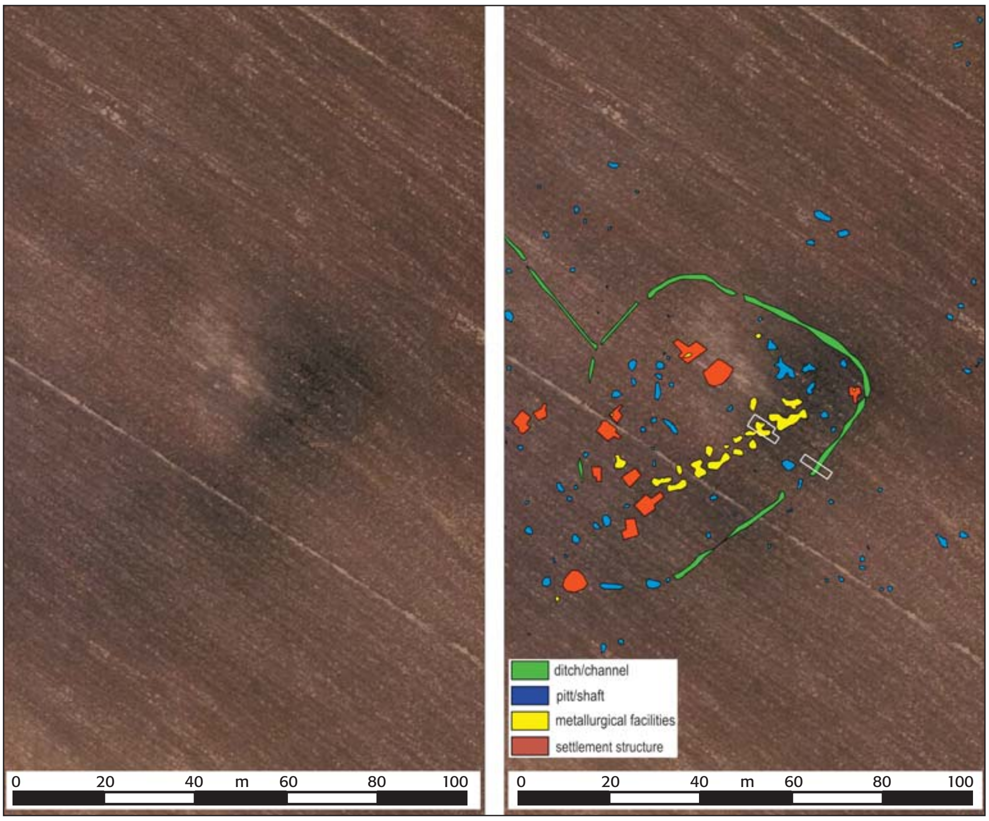


__Fig. 16.__ Comparison of the magnetic survey and soil indicators (maps from the Geoserver CUZK) in the prospected metallurgical area F. — __Fig. 16.__ Magnetickou prospekcí zjištěný metalurgický areál F na leteckém snímku s výraznou půdní anomálií, jejímž zdrojem jsou uhlíky z pecí a z jejich okolí (mapa převzata z geoserveru ČÚZK).

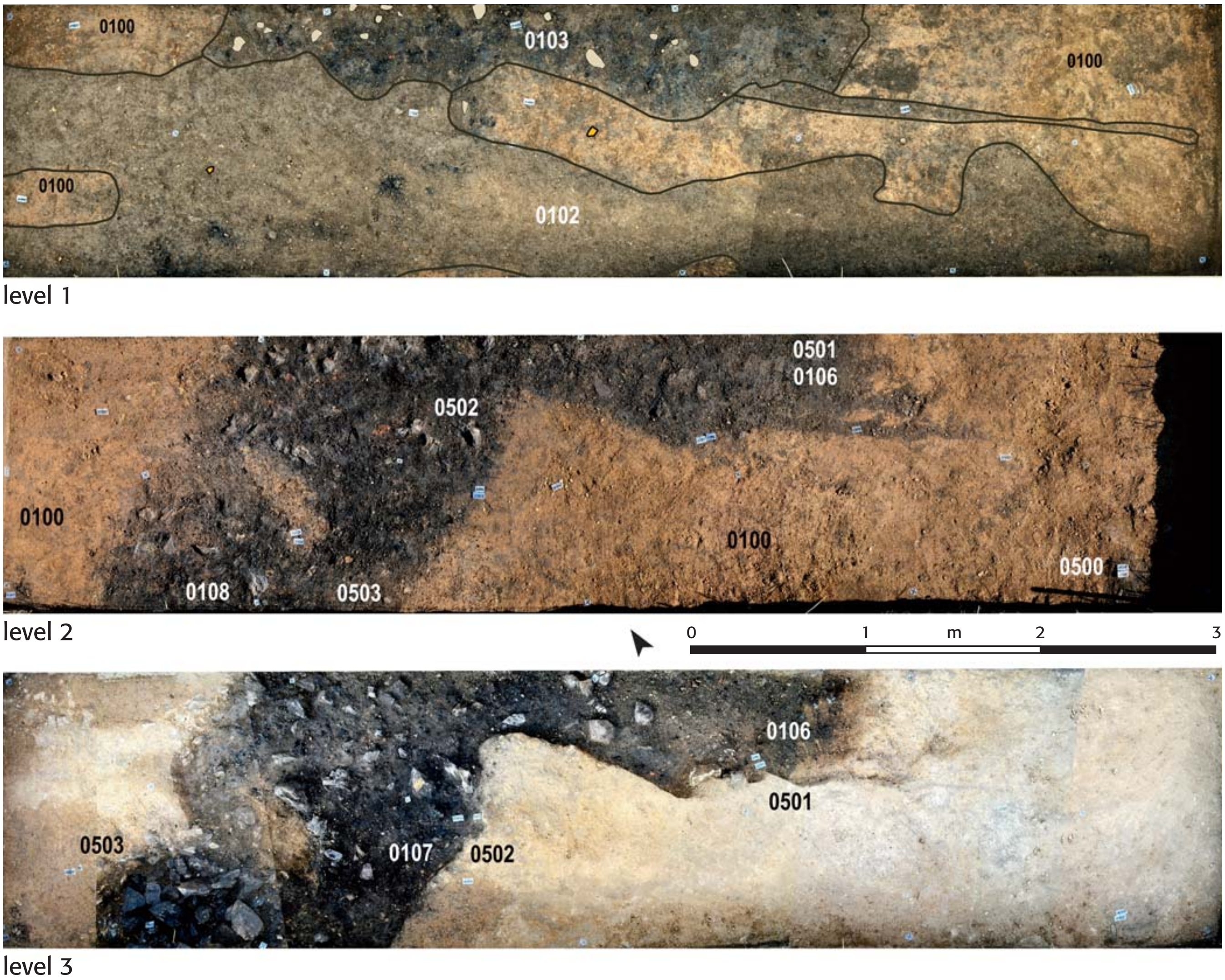


Fig. 17. *Trench 2/2018, levels 1–3. Photo by Martin Košťál.* — ***Obr. 17.*** *Sonda 2/2018, úroveň 1–3. Foto Martin Košťál.*

1346), which was found in the feature 0501 (layout 0106; *Fig. 45: 5*). The immediate vicinity does not show any traces of buildings or even residential structures. The layers were exclusively of a technogenic character (furnace debris, furnace fuels, metallurgical and operational waste). The absence of fragments of fired clay daubs and other binding material is essential as their presence would be expected around furnaces built of stones.

3.2. Trench 4/2018 and trial excavation located at the foot of the cumulus field relic H (2019)

The trench 4/2018 was laid in with the objective to corroborate the assumption whether the metallurgical area was fenced off or not, as can be seen on the surface magnetogram (*Fig. 15*). This sondage discovered the features 0504 (with fillings 0117, 0118 and 0121) and 0505 (with fillings 0115 and 0122). The trench located at the foot of the cumulus field relic **H** (parcel Nos. 145/1 and 209/7; excavation season 2019) should verify the presence of a presumed ditch, which would confirm the assumption that this relic is, in fact, a small wood-and-earth fortification of the *motte* type. The trench, however, did not contain a trace of either ditch or any archaeological subsurface structures.

4. Archaeometallurgical material

4.1. Slags with a higher iron content

Slags can be found in the entire area of the site. However, their most numerous occurrence concentrates in area **F**. Surface collectings, as well as fieldwork, provided 65 kilograms of slags, counting several hundreds of pieces. The majority of slags comes from the fillings of the features 0502 and 0503, where they formed continuous horizons (*Figs. 20, 22* and *23*). The slag size ranges from fractions of cm to a maximum of approximately 15 cm. The finds mostly comprise fragments of irregular shape, but bowl-shaped (plano-convex) “whole units” up to 10 cm in diameter are also commonly rep-

Fig. 18. *Trench 2/2018, levels 4–6. Photo by Martin Košťál. —* ***Obr. 18.*** *Sonda 2/2018, úroveň 4–6. Foto Martin Košťál.*

resented (*Figs. 26* and *27*). In addition to slags, which cannot be unambiguously classified and comprise the majority of the assemblage, two significantly different types of slags can be distinguished macroscopically:

Type 1 (*Figs. 26, 27*; *28: 2, 3, 6, 12*; *Tab. 1*): Slags with a brown, brown-black or brown-grey coloured surface, which is usually very broken and irregular. When fractured, they have grey or black colour, at most with a greasy lustre, are strongly porous and usually with a high portion of charcoals. Most often, these slags have a plano-convex shape. This slag type had also been attested during archaeological fieldwork in the *Cvilínek* area and by prospecting near *Vyskytná* in the Pelhřimov region (*Hrubý et al. 2012*, 375, Fig. 72: 2–3; *Hrubý 2019*, 142, Fig. 108: 4–6). It is also known from the mining site near Opatov to the north-west of Jihlava (*Hrubý*

Sample	Fig. No.	LE	Fe	Si	Al	Mg	Mn	K	Ca	P	S
S 001	*28: 1*	24,17	47,49	14,99	6,29	2,55	0,1259	1,0939	1,575	0,4765	0,2162
S 002	*28: 2*	21,62	60,29	9,49	4,06	<LOD	0,1184	0,5521	1,1008	0,463	<LOD
S 117	*28: 12*	34,25	41,72	12,98	6,36	1,96	0,0425	0,625	0,5928	0,9347	0,1657
S 181	–	40,33	42,28	8,27	3,88	1,72	0,0783	0,4757	0,6333	1,0564	0,1257

Tab. 1. *Elemental composition of slags, Type 1 (pXRF, %). Measured by Matěj Kmošek. —* ***Tab. 1.*** *Prvkové složení strusek typu 1 (pXRF, %). Měřil Matěj Kmošek.*

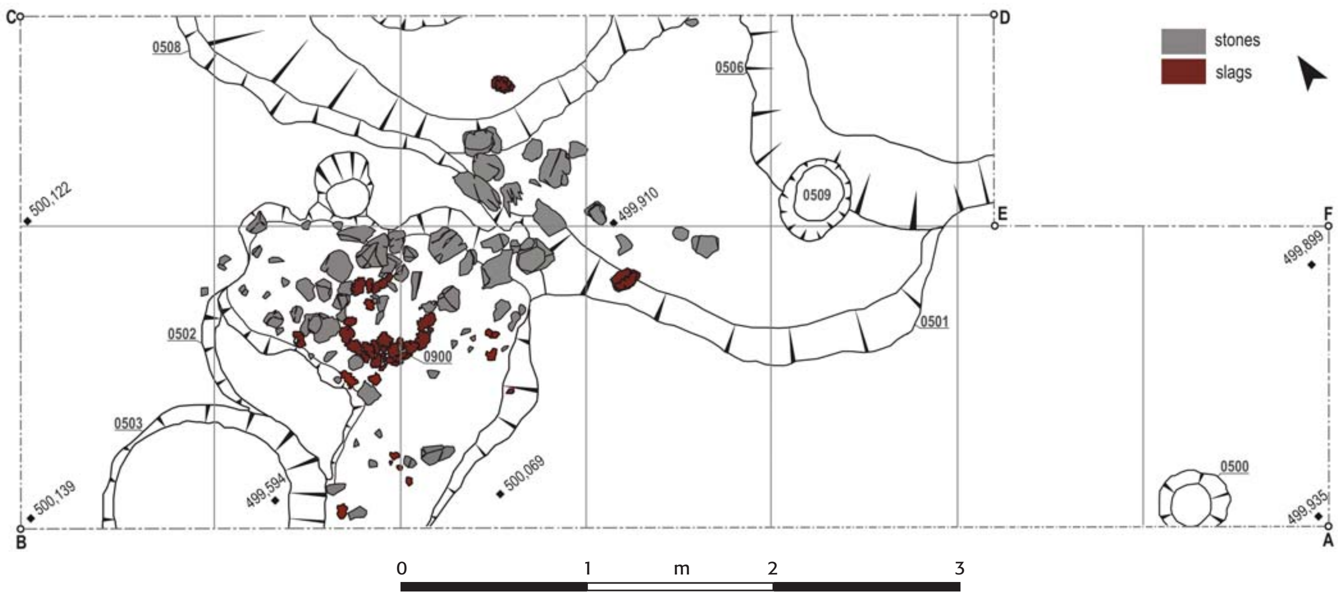


Fig. 19. Plain drawing of the trench 2/2018. Drawing by Petr Hrubý. — ***Obr. 19.*** *Výkres sondy 2/2018. Výkres Petr Hrubý.*

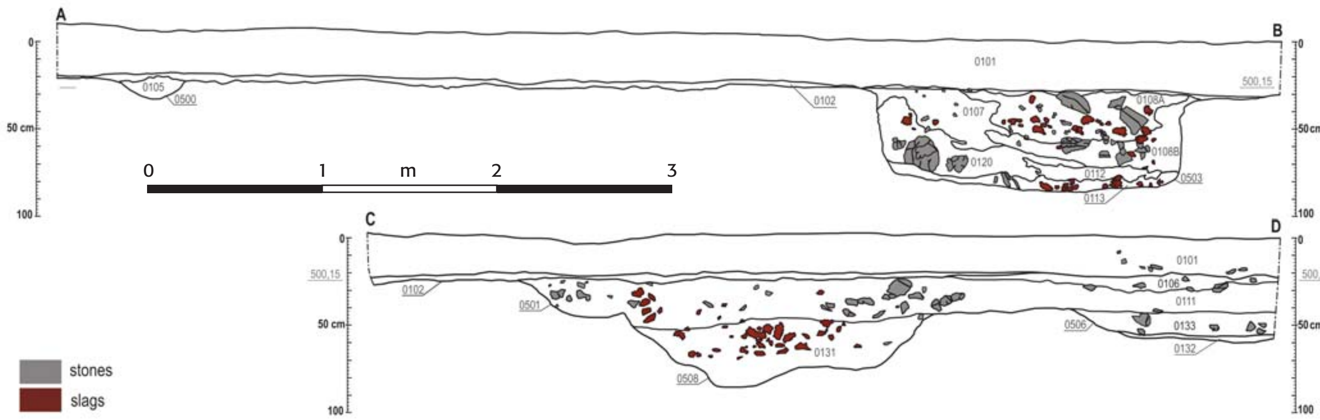


Fig. 20. Profile drawing of the trench 2/2018. Drawing by Petr Hrubý. — ***Obr. 20.*** *Výkres řezů v sondě 2/2018. Výkres Petr Hrubý.*

2019, 142, Fig. 108: 2–3), Jihlava (*Hrubý 2019*, 142, Fig. 108: 7), the site of *Kremsiger* in the Ore Mountains (*Derner 2018*, 300, Fig. 237), or from the Saxon site of *Treppenhauer* (*Schwabenicky 2009*, 154). Some more distant analogies include the *Schauinsland* mining complex in the Schwarzwald (*Straßburger 2015*, Taf. 123–129) or the metallurgical site of *Johanneser Kurhaus* in the Harz, where the slags are described as *heterogene Schlacken mit niedrigem Blei- und hohem Eisengehalt* (*Alper 2003*, 322–327).

Type 2 (*Figs. 28: 4, 5, 7, 9–11, 13*; *29*; *Tab. 2*): Slags with a usually grey or black coloured surface, sometimes containing greenish or blueish glassy sections. Small blue-green glassy fragments were also found separately. These slags are not bowl-shaped (plano-convex). Fluid structures is sometimes visible on the glassy parts. The glassy slags are only slightly porous and do not contain charcoals.

Both slag types show an increased magnetic susceptibility. The average value reaches 13.5 SI units, the highest value (77 SI units) was attested in a bowl-shaped unit. Magnetic susceptibility of the type 2 slags is less than 10 SI units. The slags are mainly composed of glass, fayalite (in the characteristically lamellar

Tab. 2. *Elemental composition of slags, Type 2 (pXRF, %). Measured by Matěj Kmošek.* — ***Tab. 2.*** *Prvkové složení strusek typu 2 (pXRF, %). Měřil Matěj Kmošek.*

Sample	Fig. No.	LE	Fe	Si	Al	Mg	Mn	K	Ca	P	S
S 006	*28: 10*	43,35	5,1174	32,78	7,27	1,61	0,1634	2,3904	6,6857	0,201	<LOD
S 041	*28: 11*	46,52	7,008	25,08	5,39	2,01	0,2867	2,8435	10,09	0,3384	<LOD
S 072	*28: 7*	38,94	5,966	27,24	7,22	2,82	0,3428	3,0501	13,27	0,5796	0,1017
S 084	*28: 13*	59,48	6,0891	24,56	5,46	<LOD	0,1291	2,2456	1,2076	0,2278	0,0765
S 137	–	51,87	4,0977	32	6,56	1,06	0,1184	2,2356	0,8979	0,434	<LOD

Fig. 21A. *Photo of the trench 2/2018 in the initial phase of fieldwork. Photo by Petr Hrubý. —* ***Obr. 21A.*** *Foto sondy 2/2018 v počáteční fázi odkryvu. Foto Petr Hrubý.*

Fig. 21B. *Photo of the trench 2/2018 in almost final phase of fieldwork. Photo by Petr Hrubý. —* ***Obr. 21B.*** *Foto sondy 2/2018 v závěrečné fázi odkryvu. Foto Petr Hrubý.*

Fig. 22. *Detailed photo of the forge excavated in the trench 2/2018. Photo by Petr Hrubý. —* ***Obr. 22.*** *Detailní foto reliktu výhně v sondě 2/2018. Foto Petr Hrubý.*

crystals) and wüstite; they commonly contain charcoals, quartz grains (cracked and partially melted), as well as secondarily created limonite, which fills pores and cracks. Pure iron is a slight but frequent mass admixture in slags, creating inclusions of circular to oval diameter, with a size of about 0.X mm, in slags of both types. It can also form irregularly shaped aggregates up to 0.5 cm, which occurs in the type 1 slags. Fe-S and Cu-Fe-S inclusions have been occasionally attested microscopically.

4.2. Slags attesting the metallurgy of polymetallic ores

Although several dozens of slag samples from the entire area were analysed using a cappameter and a hand-held XRF analyser, we have not been able to determine any significant amount of slags that could be demonstrably related to the metallurgy of polymetallic ores. Such slags are characterised by their macroscopic appearance (they are black and glassy),

Fig. 23. *Detailed photo of the stratigraphy in the feature 0503. Photo by Jiří Unger. —* ***Obr. 23.*** *Detailní foto stratigrafie objektu 0503 v sondě 2/2018. Foto Jiří Unger.*

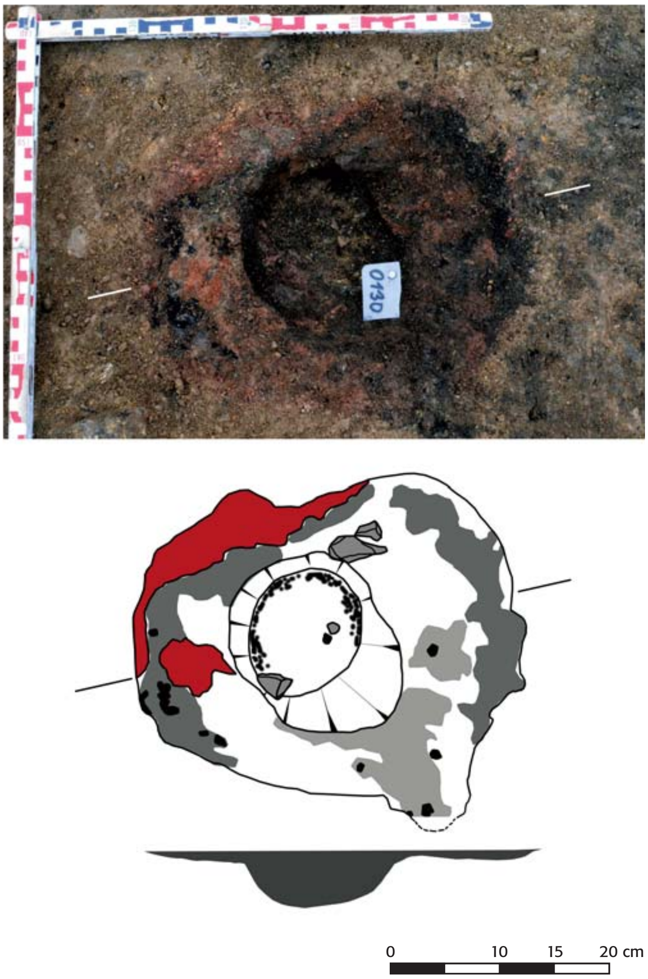


Fig. 24. *Detailed photo of the feature 0130, probably metallurgical facility. Photo and drawing by Petr Hrubý. —* ***Obr. 24.*** *Detailní foto a výkres pravděpodobně picky 0130. Foto a výkres Petr Hrubý.*

physical (including low magnetic susceptibility), and chemical properties (*Janíčková – Dolníček – Malý 2012*; *Kapusta – Dolníček – Malý 2012*; *2013*; *2015*; *Kapusta et al. 2014*; *2017*). Slags with properties corresponding to the metallurgy of polymetallic ores were found only rarely and could be, in fact, brought to the site.

4.3. Spherules and scalings

Scalings and spherules were found in the feature 0503 (layout 0108); the sediment was characterised by a substantial admixture of charcoals and slags. At its level, the feature 0503 was filled with stones that may have come from the destroyed furnace construction; even though the stones did not show any discolouration or molten surface indicating exposure to high temperatures (*Figs. 17: level 3*; *21*).

High-density phases were separated from the soil sample that had been obtained from the trench (*Fig. 30: 1*). Apparently anthropogenic, ferromagnetic particles of two different morphological types predominate: 1) Flat, crenellated particles, hereinafter referred to as "scalings"; and 2) Globular or spherical particles, hereinafter referred to as "spherules". These ferromagnetic particles constitute approximately 1–2 wt. % in the soil sample; however, they represent over 99 wt. % of the separated heavy fraction.

The scalings are flat, with the scale size of 0.X mm; the largest are up to 1.5 mm long (*Fig. 30: 5*). They significantly predominate the spherules in the ferromagnetic fraction. On the surface, they are matt to glossy, and sometimes glassy smooth with a transition to a metallic lustre. According to EDX analyses, the scalings comprise mainly of wüstite (FeO). According to the stoichiometric Fe/O ratios, part of the wüstite metamorphosed to magnetite (Fe_3O_4) or hematite (Fe_2O_3). Glass is another essential phase, while quartz is represented only rarely (*Tab. 3*).

Phase	Spherule 1	Spherule 2	Spherule 3	Spherule 4	Flake
Na_2O	0,00	0,45	0,00	0,00	0,00
MgO	8,41	0,39	0,00	0,42	0,00
Al_2O_3	24,29	0,00	0,00	2,48	2,73
SiO_2	40,11	2,27	6,15	17,14	4,01
P_2O_5	0,00	1,65	1,75	0,00	0,00
K_2O	2,83	2,19	0,64	0,79	0,45
CaO	0,69	1,58	1,83	1,27	0,00
FeO	23,67	91,46	89,63	77,90	92,81

Tab. 3. *Representative analytics of the spherules and flakes (EDX, weight %, re-calculated to 100%). Measured by Karel Malý. —* ***Tab. 3.*** *Analýzy sférulí a okují (EDX, hm. %, přepočítáno na 100 %). Měřil Karel Malý.*

Fig. 25. ***1:*** *A stone-built furnace with an open hearth. Illustration from the first half of the 16th century taken from the so-called Annaberg Altar in the Church of St. Anna in the mining town of Annaberg in Ore Mountains, Saxony.* ***2:*** *Smelting of polymetallic ores in a furnace with hand-operated bellows, around 1500, depicted in the so-called Kutná Hora Illumination (Studničková – Purš 2010, 82–83). —* ***Obr. 25. 1:*** *Z kamene stavěná hutnická pec s otevřenou výpustí na tzv. Annaberském oltáři z první poloviny 13. století, Annaberg, Krušné Hory, Sasko.* ***2:*** *Tavba polymetalických rud v peci s ručními měchy okolo roku 1500 na jednom z kutnohorských hudebních rukopisů (Studničková – Purš 2010, 82–83).*

Fig. 26. *Smithy slag from surface survey between area* ***A*** *and* ***B*** *(parcel No. 131/15). Photo by Petr Hrubý. —* ***Obr. 26.*** *Kovářské strusky z povrchových sběrů na plochách* ***A*** *a* ***B*** *(ppč. 131/15). Foto Petr Hrubý.*

On average, the spherules measure 0.3 mm, with the largest diameter of 0.95 mm. Most often, they are globular, sometimes less regular, but always close to a sphere or ellipsoid (*Figs. 30: 2, 3, 4, 7*; *31*). All analysed spherules were hollow inside or contained pores. It probably affects their low density and, thus, the observed small proportion of spherules in the heavy phase. Their surface is matte black, less often glassy, and very rarely brown. According to EDX analyses, wüstite predominates in the majority of spherules; its skeletal aggregates are characteristic. Magnetite, glass and quartz are less frequently represented (*Tab. 3*).

4.4. Lead ingots

The survey conducted in areas **A**, **B**, **E**, and **F** provided a set of more than 80 lead ingots. They share the same main property as they do not have a deliberate artefactual shape (*Figs. 32–34*). Two irregularly pyramidal pieces with rounded edges, which may be the remnants of lead casting into moulds, are, therefore, very interesting (*Figs. 32: 3* and *4*).

These lead objects form part of the standard archaeometallurgical material: they have been found during archaeological research in Jihlava (*Hrubý 2011*, 141, Fig. 155), at the Cvilínek site (*Hrubý et al. 2012*, 373, 376–377, 378, Fig. 86), and during metal detector survey at Vyskytná in the Pelhřimov region (*Hrubý*

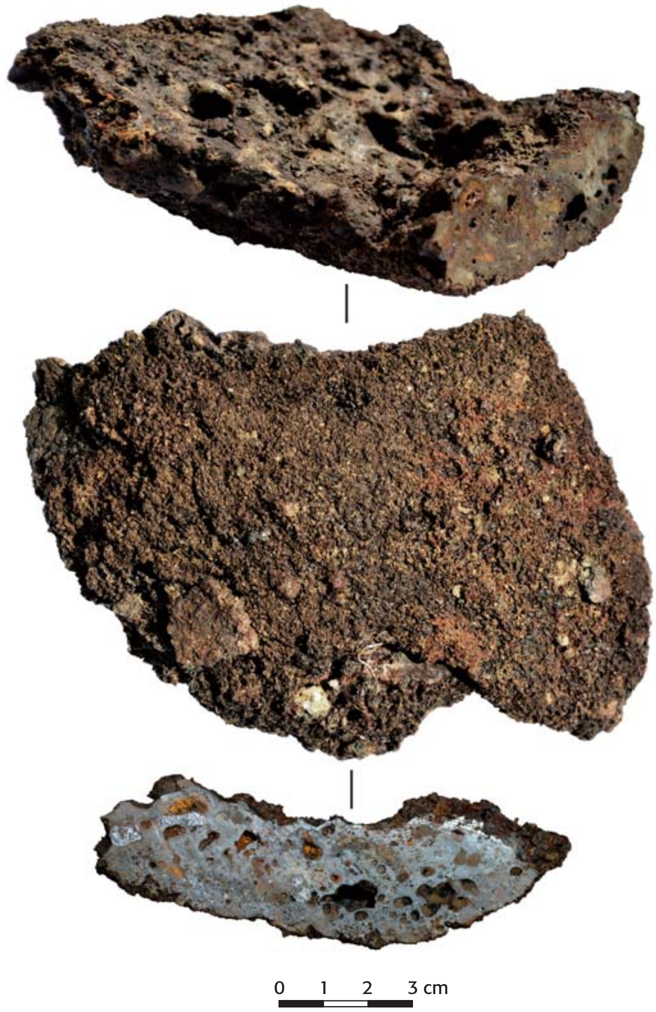


Fig. 27. *Smithy slag from the excavated feature 0503, layout 0108. Analysed by Karel Malý. Photo by Petr Hrubý. —* ***Obr. 27.*** *Kovářská struska z objektu 0503, vrstva 0108. Analyzoval Karel Malý. Foto Petr Hrubý.*

*Fig. 28. Various types of slags from the excavated features 0502–0503. **1:** S (sample) 001, **2:** S 002, **3:** S 105, **4:** S 016, **5:** S 112, **6:** S 137, **7:** S 072, **8:** S 110, **9:** S 013, **10:** S 006, **11:** S 041, **12:** S 117, **13:** S 084. Photo by Matěj Kmošek. — **Obr. 28.** Různé typy strusek ze zkoumaných objektů 0502 až 0503. **1:** S (vzorek) 001, **2:** S 002, **3:** S 105, **4:** S 016, **5:** S 112, **6:** S 137, **7:** S 072, **8:** S 110, **9:** S 013, **10:** S 006, **11:** S 041, **12:** S 117, **13:** S 084. Foto Matěj Kmošek.*

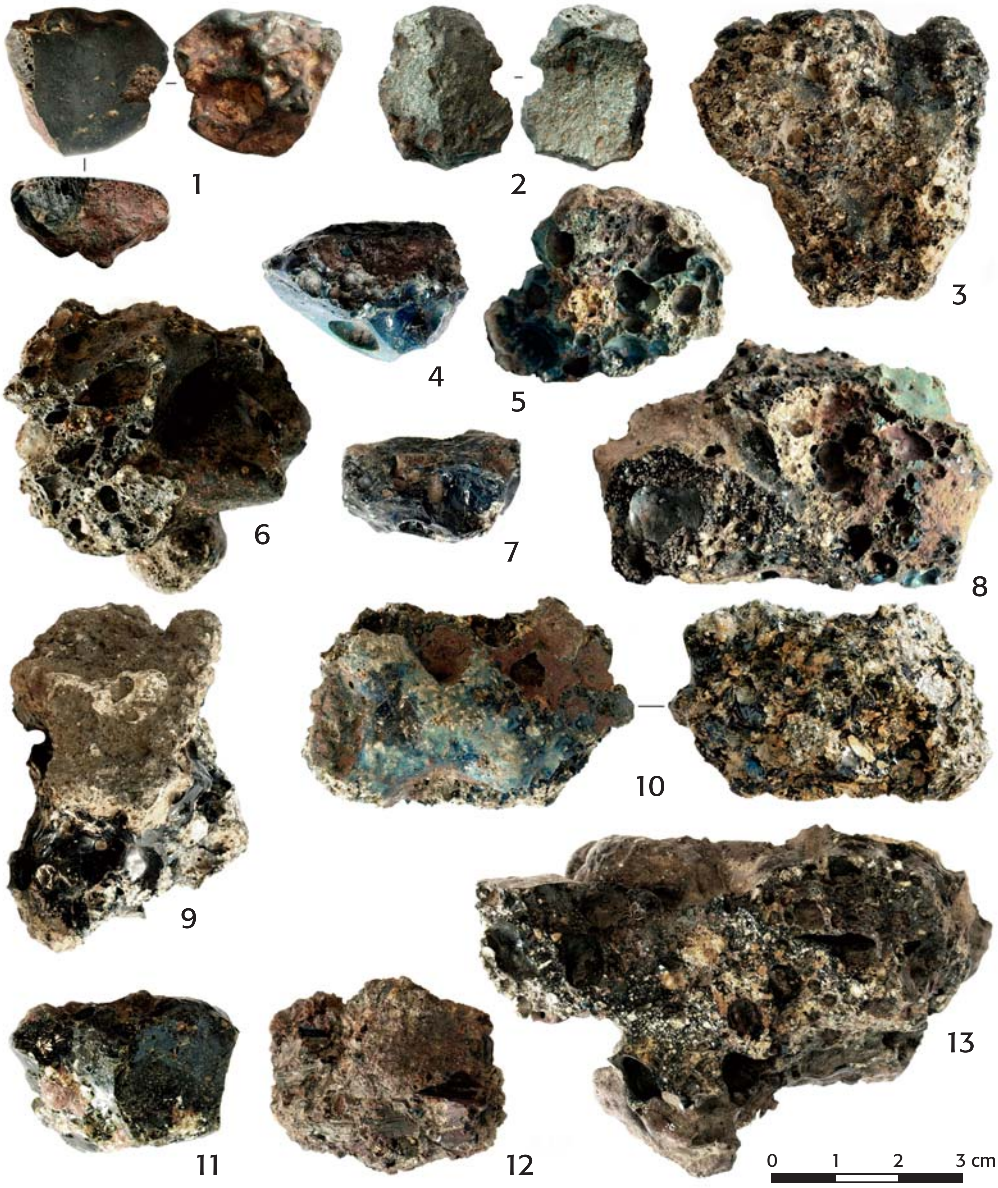
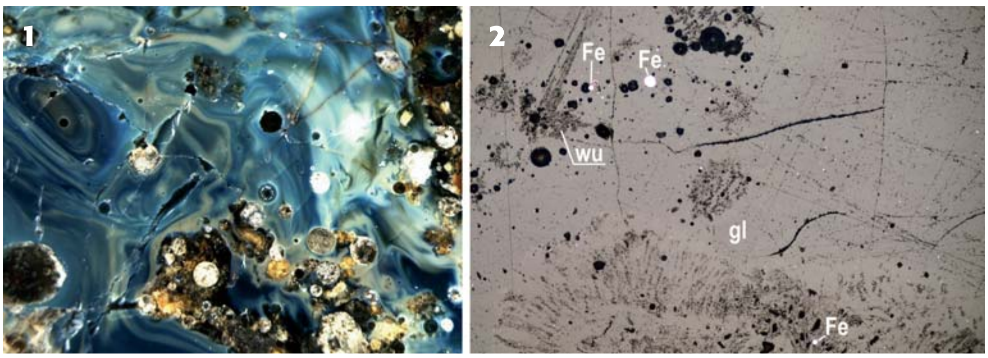


*Fig. 29. Microscopic photos of the analysed slags. **1:** Slag type 2. Fluidal glass structure. Underside of the sample 2 mm. **2:** Slag type 2. Cut, Nicol prism 1. Underside of the sample 0.35 mm. Photo by Karel Malý. — **Obr. 29.** Vzorky strusek pod mikroskopem. **1:** struska typu 2, fluidní sklovitá struktura, spodní strana záběru 2 mm. **2:** struska typu 2, nábrus, jeden nikol, spodní strana záběru 0,35 mm. Foto Karel Malý.*



2019, 146, Fig. 110: 27–38). A disc-shaped ingot of almost pure lead from Koječín can also be mentioned (*Hrubý et al. 2019*, 965, obr. 17: 2). Recently, such finds were obtained during metal detector survey conducted near Opatov, located to the north-west of Jihlava, and near Čejkov in the Pelhřimov region (unpublished surveys conducted by the Department of Archaeology and Museology, Faculty of Arts, Masaryk University and the Institute of Archaeology of the Czech Academy of Sciences, Prague in 2019).

Lead ingots are, however, well known from many other medieval mining and metallurgical centres in

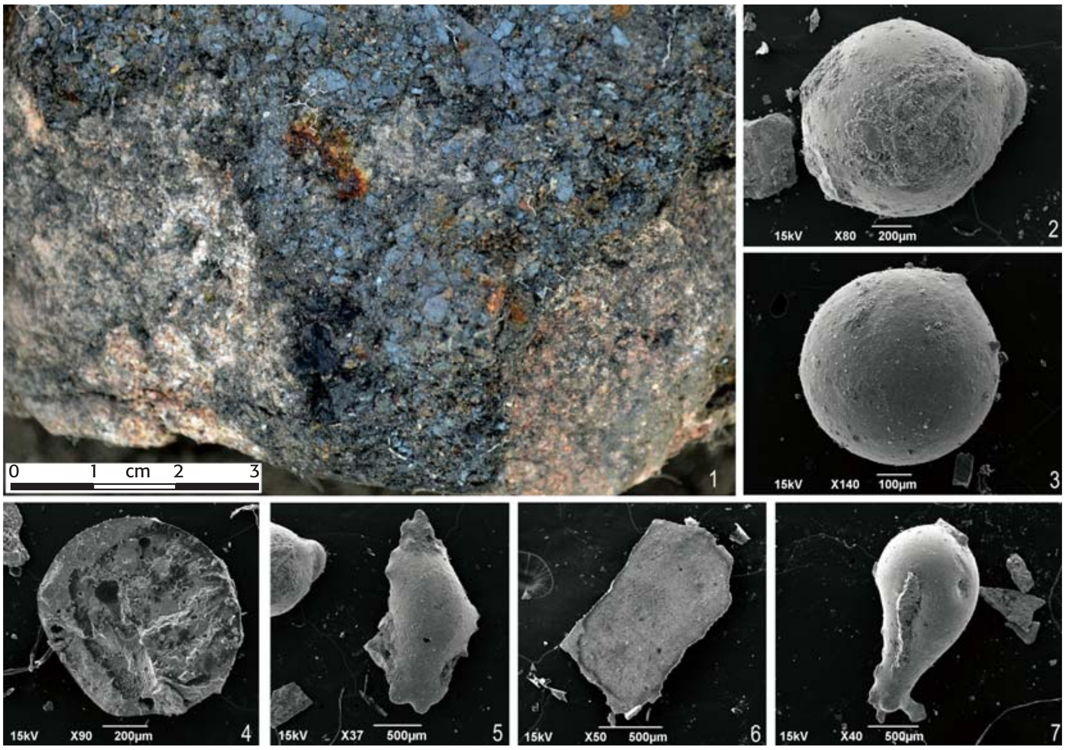


Fig. 30. *Smithy flakes from the feature 0503, layout 0108.* ***1:*** *Field photo taken during excavation. Photo Petr Hrubý.* ***2–4, 7:*** *Spherule, electron microscope, BSE. Photo Jiří Štelcl.* ***5, 6:*** *Smithy flake, electron microscope, BSE. Photo by Jiří Štelcl. —* ***Obr. 30.*** *Okuje z objektu 0503, vrstva 0108.* ***1:*** *terénní foto pořízené při exkavaci Petr Hrubý.* ***2–4, 7:*** *sférule, elektronový mikroskop, BSE. Foto Jiří Štelcl.* ***5, 6:*** *okuje, elektronový mikroskop, BSE. Foto Jiří Štelcl.*

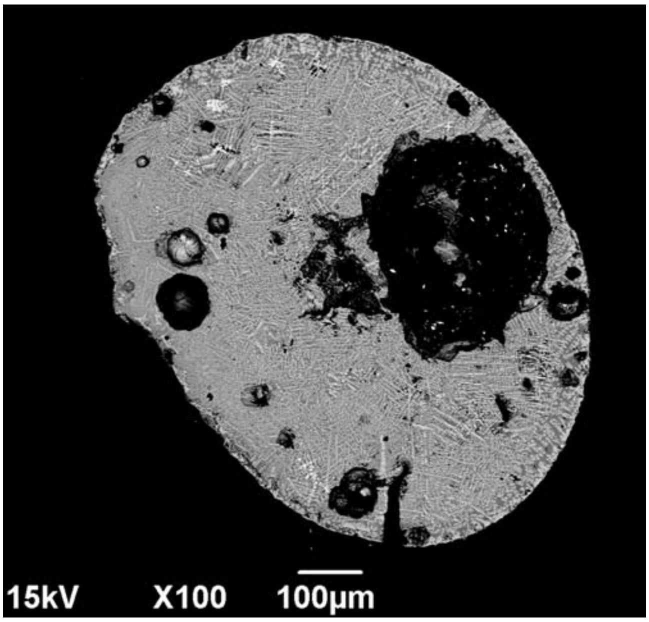


Fig. 31. *Spherule separated from iron flakes (feature 0503, layout 0108). Light skelletic crystals are the wuestite in glass. Dark: poruses and caverns. Reflected electron visualising displays the phase composition. Electron microscope, BSE. Photo by Jiří Štelcl. —* ***Obr. 31.*** *Sférule, object 0503, vrstva 0108. Světlá: kostrovité krystaly wüstitu ve skle. Tmavá: dutiny a póry. Elektronový mikroskop, BSE. Foto Jiří Štelcl.*

Europe. An example is the site of Dąbrowa Górnicza - Łosień near Katowice from the 12th century (*Rozmus – Rybak – Bodnar 2005*, 24–25). An irregularly cast lead ingot was found at the *Brandes en Oisans* site in the French Alps (*Bailly-Maître 2002*, 134–136; *Bourgarit 2008*). Lead drips and ingots have been found on the *Treppenhauer* hill in the Saxon part of the Podkrušnohoří (the foothills) region (*Schwabenicky 2009*, 138–140, 149–150). An assemblage of lead ingots dating to the 12th and 13th centuries also comes from the *Johanneser Kurhaus* site in the Harz (*Alper 2003*, 310–317). The approximately 14 cm long lead object was also found in the *Altenberg* mining centre in the Siegerland (*Weisgerber 1998*, 71, 73). From Bohemia, we can name the finds from the area *Stříbrník* nearby Plánička in the Horažďovice region (*Červený 2007*, 119).

The silver content in the analysed ingots from *Cvilínek* and Jihlava reaches 1–23 ppm, i. e. we can speak of the so-called non-argentiferous lead. There is only one example – a drip, found in Staré Hory containing 0.23% of silver (*Hrubý 2011*, 141, Fig. 155; 138–141).

4.5. Cupriferous and tin ingots

A set of other metal items without a deliberate artefactual shape was also found in the defunct mining centre at *Buchberg* (*Fig. 36*). These finds were obtained in the course of the surface survey using metal detectors, just like the lead ingots. Such a circumstance must be taken into account when critically evaluating these finds, but their connection with the medieval life of the centre is more than probable. In general, three material groups can be distinguished:

Cu-Sn alloys (Inv. Nos. Bu 24, Bu 55, Bu 49, *Fig. 36: 1–5, 7, 9*; *Tab. 5*): Finds discovered in areas **A** and **B**, which were analysed using an XRF spectrometer on their cleaned surface. It comprises bronze mass with a proportion of lead amounting to 1.51–2.05%. In two cases, silver of up to 0.13% was detected.

Cu-Pb alloys (Inv. Nos. Bu 19, Bu 54; *Fig. 36: 6*; *Tab. 6*): Finds discovered in areas **A** and **B**. XRF mea-

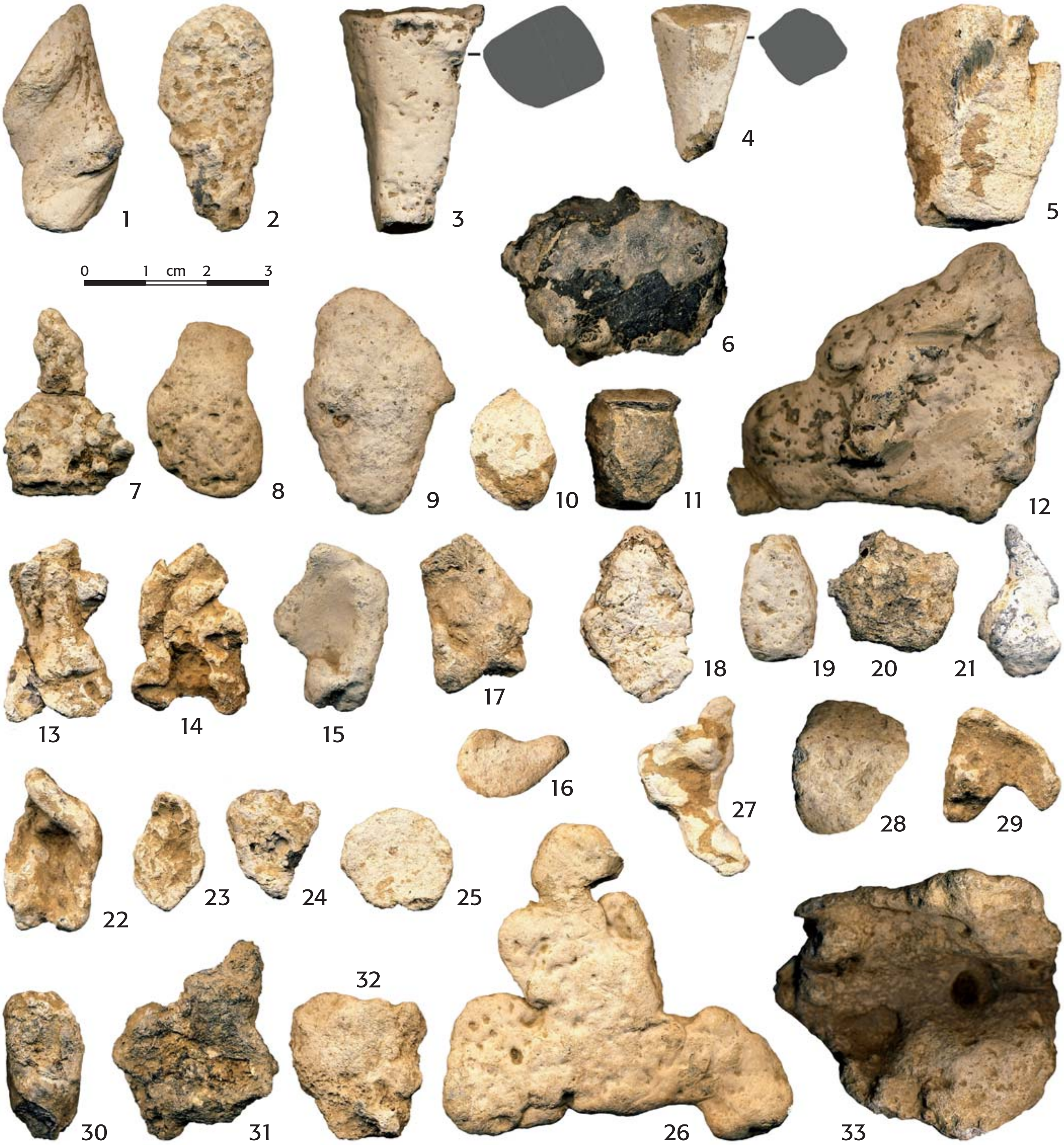


Fig. 32. *Lead objects from the prospected area B and F at the site of Buchberg. Photo by Petr Hrubý. —* ***Obr. 32.*** *Olověné slitky a úkapky ze sběrů na plochách B a F. Foto Petr Hrubý.*

surements that were taken on the cleaned surface determined the proportion of silver amounting to 2% in both artefacts.

Sn alloy (Inv. No. Bu 43, *Fig. 36: 8*; *Tab. 7*): It is the only item cast in an intentional mould. It was found in the southern part of area **D**.

More or less similar finds can be found in several contemporary mining centres in Europe. An object made of an alloy of copper and tin is known from the Staré Hory dislocation zone in Jihlava (*Hrubý 2011*, 140, 141). Traces of copper and brass casting were also detected in the *Treppenhauer* mining settlement in the Saxon part of the Podkrušnohoří (the foothills) region (*Schwabenicky 2009*, 150–153). Three finds made of an alloy of nickel and arsenic were found at the site of *Kremsiger*, located at the Czech side of Ore Mountains, showing traces of cutting off, as well as a flat copper

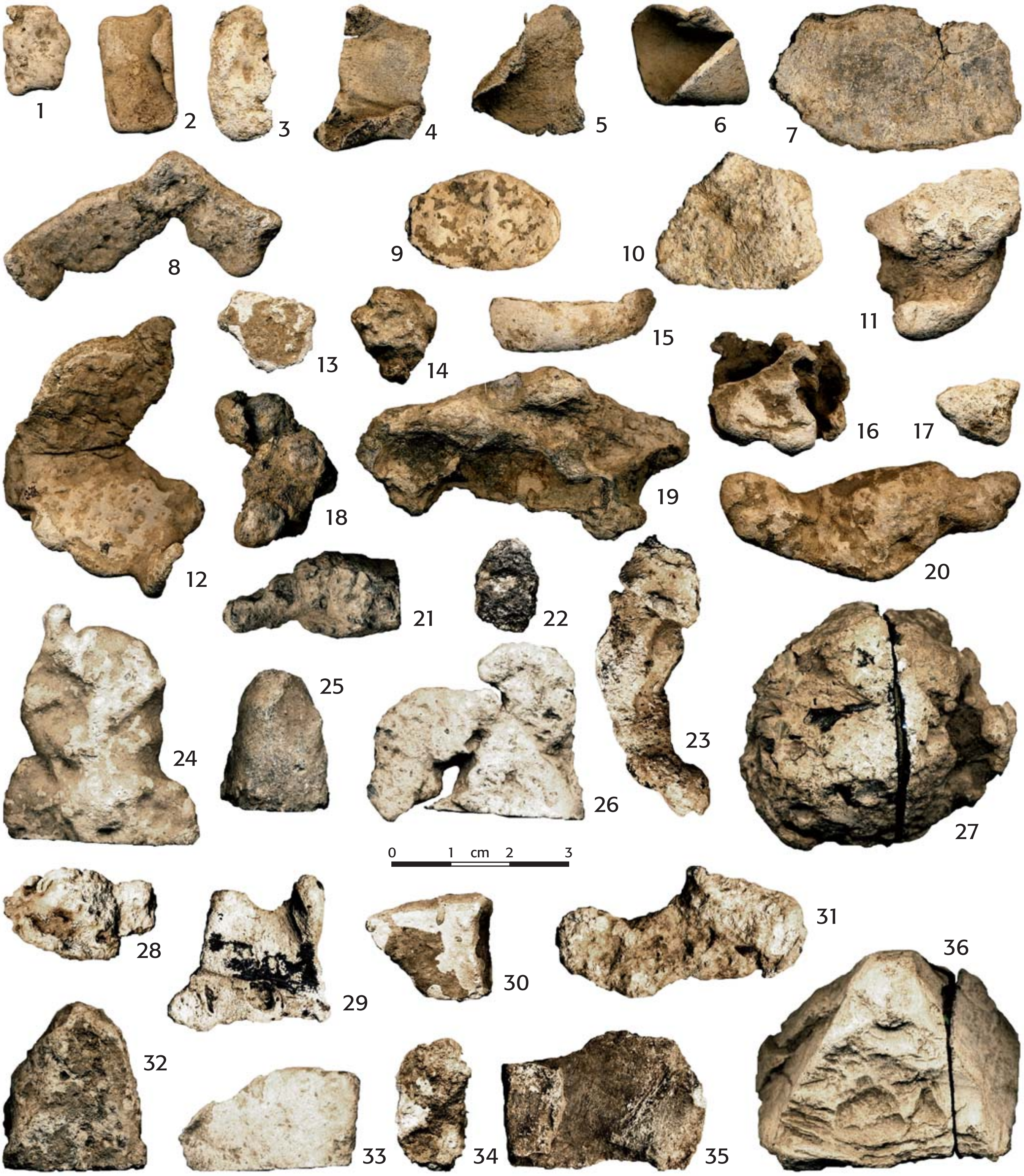


Fig. 33. *Lead objects from the prospected area B and F at the site of Buchberg. Photo by Petr Hrubý. —* ***Obr. 33.*** *Olověné slitky a úkapky ze sběrů na plochách B a F. Foto Petr Hrubý.*

casting with cobalt admixture, which may be related to metal casting or assaying (*Derner 2017*, 108–110). Evidence of copper processing in the form of crucibles and fragments of melting-pots, shards with molten bronze mass or a casting mould were also found in the area of the deserted town at the site of *Sekanka* located at the confluence of the Sázava and Vltava rivers, corroborating its connections with gold exploitation (*Richter 1982*, 169, Fig. 115: 1–4; 170, Fig. 116; 173, Fig. 119: 2–3; 210, Fig. 149; 212; 213, Fig. 151; 214).

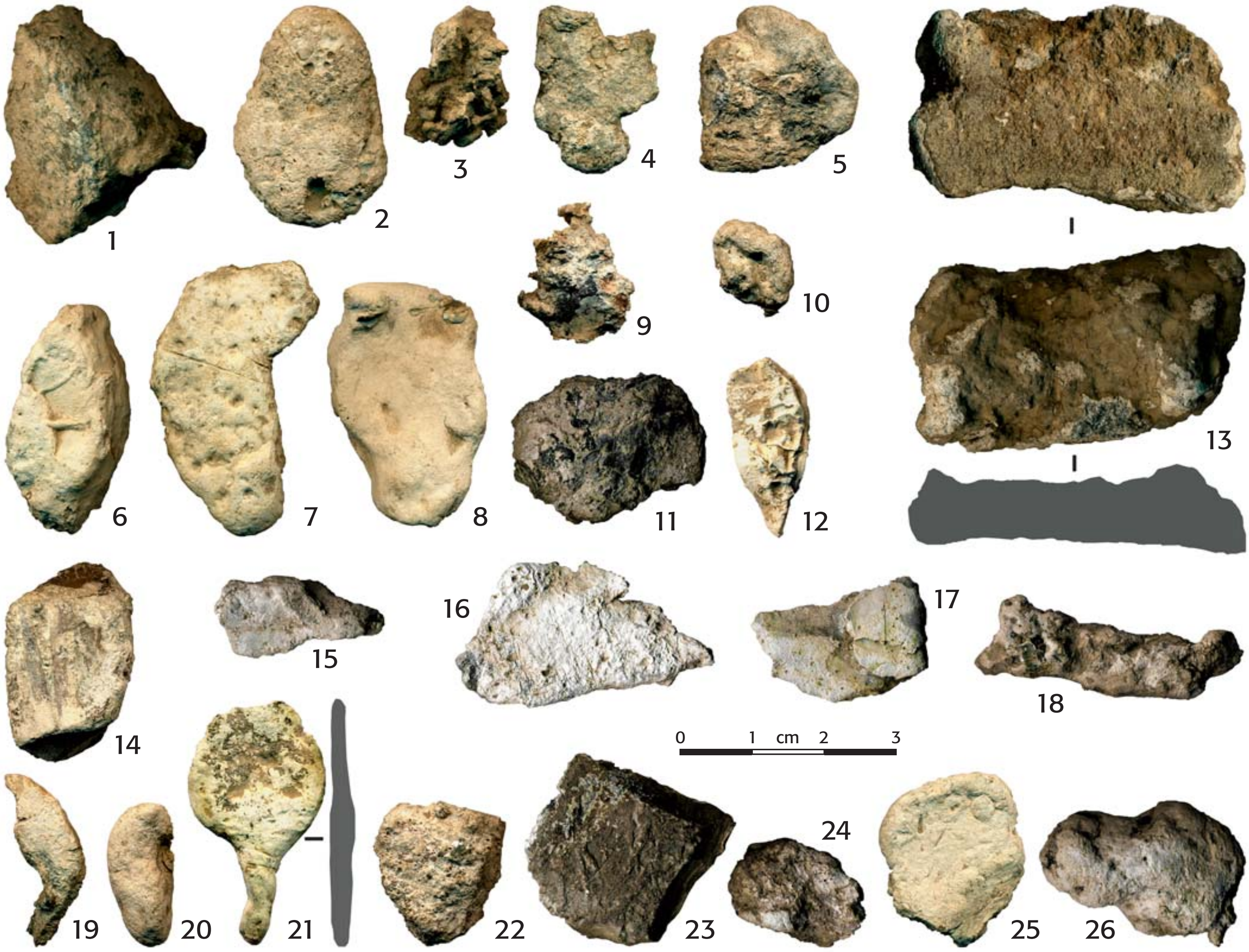


Fig. 34. *Lead objects from the prospected area B and F at the site of Buchberg. Photo by Petr Hrubý. —* ***Obr. 34.*** *Olověné slitky a úkapky ze sběrů na plochách B a F. Foto Petr Hrubý.*

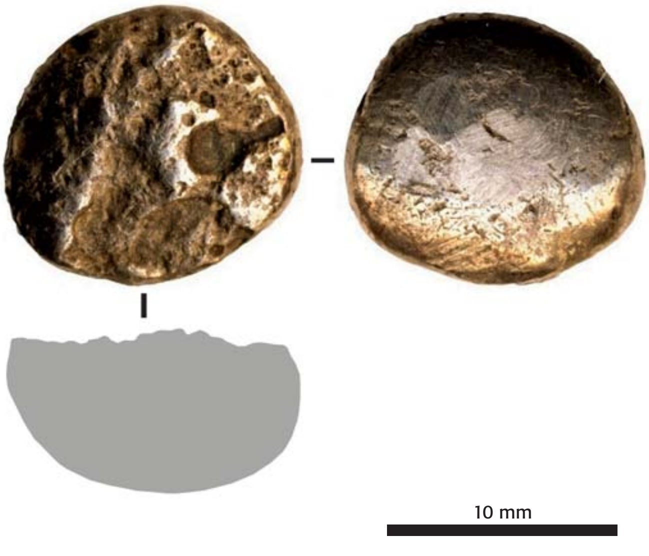


Fig. 35. *Silver object (Inv. No. Bu 29), weight 4.67 g. Photo by Pavla Starůstková. —* ***Obr. 35.*** *Stříbrný pecičkovitý slitek (i. č. Bu 29), hmotnost 4,67 g. Foto Pavla Starůstková.*

4.6. Silver ingots/hacksilver in the context of the mining sites in Bohemia

A small silver ingot/globule weighing 4.671 g (*Fig. 35*; Inv. No. Bu 29) was found during prospecting the area **A** (plot No. 131/15). The elemental composition by XRF analysis is Ag 94.50%; Pb 3.41%; Cu 2.00%; traces of Bi and Au (*Tab. 6*). The closest analogy is a silver ingot/globule weighing 4.45 g found during prospecting near the church of St. Catherine in the nearby Stříbrné Hory, is usually associated with the site of *Herliwinberg* – another historical mining centre of the Havlíčkův Brod region. According to XRF analysis, its elemental composition is Ag 86.68%; Sn 10.76%; Pb 2.22%; Cu 0.19%; Au 0.09%; As 0.03%; Zn 0.01% (*Havlíček 2018*, 43, 45). Another flat and elongated silver ingot, weighting before the XRF analysis 36.025 g, also comes from Jihlava. Its elemental composition by XRF analysis is Ag 90.89%; Pb 8.52%; Fe 0.37% and Bi 0.21% (*Hrubý 2011*, Tab. 5). A silver object of about 900/1000 purity weighing 1.5 g was found in the course of prospecting conducted by the Academy of Sciences of the Czech Republic in Brno at the site of *Havírna* (*Hrubý 2019*, Fig. 112: 8).

Fig. 36. *Non-ferrous alloy objects.* ***1:*** *Inv. No. Bu 54,* ***2–3:*** *unspecified.* ***4:*** *Inv. No. Bu 55,* ***5:*** *Inv. No. Bu 29,* ***6:*** *Inv. No. Bu 19,* ***7:*** *Inv. No. Bu 24,* ***8:*** *Inv. No. Bu 43,* ***9:*** *Inv. No. Bu 49 (see Tabs. 5–7). Photo by Petr Hrubý. —* ***Obr. 36.*** *Předměty ze slitin barevných kovů. 1: i. č. Bu 54.* ***2–3:*** *bez čísla.* ***4:*** *i. č. Bu 55,* ***5:*** *i. č. Bu 29,* ***6:*** *i. č. Bu 19,* ***7:*** *i. č. Bu 24,* ***8:*** *i. č. Bu 43,* ***9:*** *i. č. Bu 49 (viz Tab. 5–7). Foto Petr Hrubý.*

5. Other types of material culture

5.1. Pottery

The first surface prospectings of pottery were conducted between 1981 and 1998 (*Rous 1998a*; *1998b*). A total of 2,887 pottery fragments were obtained during this survey phase; they were primarily assessed by *Pavel Rous* (*2001a*, 72, Fig. 7; 80–81, Fig. 8–9). Part of the pottery was also found on heaps and dumps (*Fig. 39: 1*). Trial excavations in 2018 focusing on the metallurgical complex provided a set of only about three dozens of pottery fragments, and their quality does not, in fact, exceed the quality of shards from surface surveys (*Figs. 39: 4*; *40*). Thus, the possibilities of a comprehensive comparison of the assemblage from *Buchberg* with the pottery from other contemporary mining areas of the Havlíčkův Brod region are low. Archaeological material from surface surveys at Stříbrné Hory or near the village of Termesivy can be used (*Rous 2001a*, 71–72, Figs. 5–7). Moreover, pottery assemblages obtained from excavations in other mining areas in the region also enabled only limited comparative possibilities, as they are as unrepresentative and usually small in number as pottery finds from surface prospectings. These include finds from the ore processing facility detected near Kaječín (*Hrubý et al. 2019*, 966–968, Figs. 18 and 19), the metallurgical district near Květinov, and a small mining area near Česká Bělá (*Hrubý 2019*, 63, Fig. 28; 79, Fig. 41).

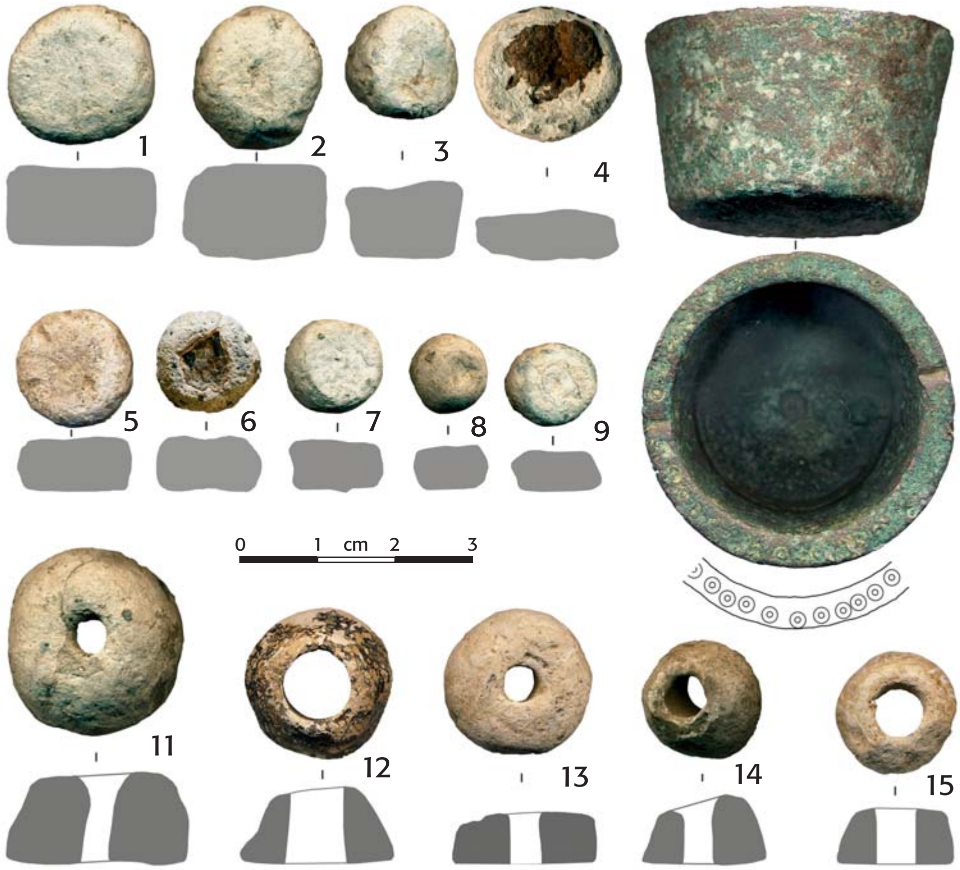


Fig. 37. *Weights of the 13th and 14th century from the Buchberg mining site.* ***1:*** *Inv. No. Bu 32;* ***2:*** *Inv. No. Bu 33;* ***3:*** *Inv. No. Bu 44;* ***4:*** *Inv. No. Bu 22;* ***5:*** *Inv. No. JiA 17/09-107;* ***6:*** *Inv. No. JiA 17/09-126;* ***7:*** *Inv. No. Bu 21;* ***8:*** *Inv. No. Bu 41;* ***9:*** *Inv. No. Bu 47;* ***10:*** *Inv. No. JiA 17/09-146;* ***11:*** *Inv. No. Bu 46;* ***12:*** *Inv. No. JiA 17/09-127;* ***13:*** *Inv. No. JiA 17/09-153;* ***14:*** *Inv. No. Bu 30;* ***15:*** *Inv. No. JiA 17/09-103. Photo by Petr Hrubý. —* ***Obr. 37.*** *Závaží ze 13.–14. století z areálu Buchberg.* ***1:*** *i. č. Bu 32;* ***2:*** *i. č. Bu 33;* ***3:*** *i. č. Bu 44;* ***4:*** *i. č. Bu 22;* ***5:*** *i. č. JiA 17/09-107;* ***6:*** *i. č. JiA 17/09-126;* ***7:*** *i. č. Bu 21;* ***8:*** *i. č. Bu 41;* ***9:*** *i. č. Bu 47;* ***10:*** *i. č. JiA 17/09-146;* ***11:*** *i. č. Bu 46;* ***12:*** *i. č. JiA 17/09-127;* ***13:*** *i. č. JiA 17/09-153;* ***14:*** *i. č. Bu 30;* ***15:*** *i. č. JiA 17/09-103. Foto Petr Hrubý.*

Fig. 38. *Deformed and burned cup-weight (find Inv. No. Bu 54, weight 13.2 g). Photo by Petr Hrubý. —* ***Obr. 38.*** *Deformované a nejspíš i spálené miskovité závaží (i. č. Bu 54, hmotnost 13,2 g). Foto Petr Hrubý.*

Based on Rous' classification, the pottery from *Buchberg* can be divided into three horizons. The earliest horizon can be characterised by mainly oxidative firing, with a proportion of graphite pottery (*Rous 2001a*, 80, Fig. 8: 1–21). The second horizon is dominated by proto-reductive firing and predominantly oval edges of several variants (*Rous 2001a*, 80, Fig. 8: 22–49; 81, Fig. 9: 1–28). Part of the assemblage consists of fragments of advanced reduction ceramics dating to the later 15th and 16th centuries (*Rous 2001a*, 81, Fig. 9: 1–28). The structure corresponds to the finds from the nearest mining centre at *Herliwinberg* (*Rous 2004*, 54–55).

Pots or bowls predominate in the pottery collection from *Buchberg*, and it is possible to distinguish lids (*Berky 1992*, Ad VII; *Rous 2001a*, 80, Fig. 8: 13, 21). Handles are quite common, usually decorated with a row of inserts, or insects evoking a cross sign or the letter W (*Figs. 40: 8, 12*). Similar handles were also found, for example, in Staré Hory near Jihlava (*Hrubý 2011*, 211, Fig. 224: 14, 16, 20). Part of the ears belongs to the kettles with the stirrup handle (*Fig. 40: 6*). A hollow shape sherd, which could have belonged to the pan, or an atypical nozzle (*Fig. 39: 3*), was found during surface prospections. A fragment of a simple conical bowl (*Fig. 39: 2*) represents the class of open bowl-like vessels. Its analogies can be found in the *Cvilínek* mining area in the Pelhřimov region (*Hrubý et al. 2012*, 391, Fig. 89). There are only a few fragments in the assemblage that could have belonged to storage jars (*Fig. 39: 14, 15*). A relatively small proportion of storage jars is a characteristic feature of Central European mining settlements (*Derner – Hrubý 2018*, 219–220).

A small lamp with a hole called palčák (called *Schalenlampe mit Griffloch* in German, *Schwabenicky 2011*) was discovered in trench 2/2018, structure 0502 (layer 0106/0107). It was manufactured by using reductive firing, and the bottom bears traces of cutting off (*Fig. 39: 4*). The lamp corresponds to the **Ia** type according to *Kateřina Doležalová* (*2012*, 219, Fig. 11).

Fig. 39. *Pottery.* ***1:*** *Surface prospection, northern part of shaft field* ***O****, parcel No. 149/1;* ***2–3, 5:*** *Surface prospection, prospected area* ***D****, parcel No. 131/15;* ***4:*** *Excavated feature 0502, layout 0107. Photo by Petr Hrubý. —* ***Obr. 39.*** *Keramické nálezy.* ***1:*** *povrchová prospekce severně od šachetního pole* ***O****, ppč. 149/1;* ***2–3, 5:*** *povrchová prospekce plochy* ***D****, ppč. 131/15;* ***4:*** *Zkoumaný objekt 0502, vrstva 0107. Foto Petr Hrubý.*

Similar lamps were very widespread in the medieval mining environment (*Hrubý 2011*, 213, Fig. 225: 2, 6, 11; 215; *Waldhauser – Daněček – Nováček 1993*, 399, Abb. 6: 9). The most numerous finds come from the Czech and Saxon regions of the Ore Mountains (*Derner 2018*, 269, Fig. 204: 3; *Schwabenicky 2009*, 101, Abb. 226: 3; 104, Abb. 229: 13, 14; 109, Abb. 237: 11; 113, Abb. 243: 3; 115, Abb. 245: 10; 117, Abb. 247: 7; 119, Abb. 249: 3, 4; 122, Abb. 252: 3, 253; 126, Abb. 257: 17; 187, Abb. 374: 3, 4; 189, Abb. 380: 1, 2).

A spindle whorl made of lightly fired fine clay discovered during surface collecting can be added as another type of material culture (*Fig. 39: 5*). Such finds also have also been found in mining settlements; we know them from Jihlava (*Hrubý 2011*, 211, Fig. 224: 3, 6; *Crkal et al. 2019*, 905, Fig. 19) or the sites of *Treppenhauer*

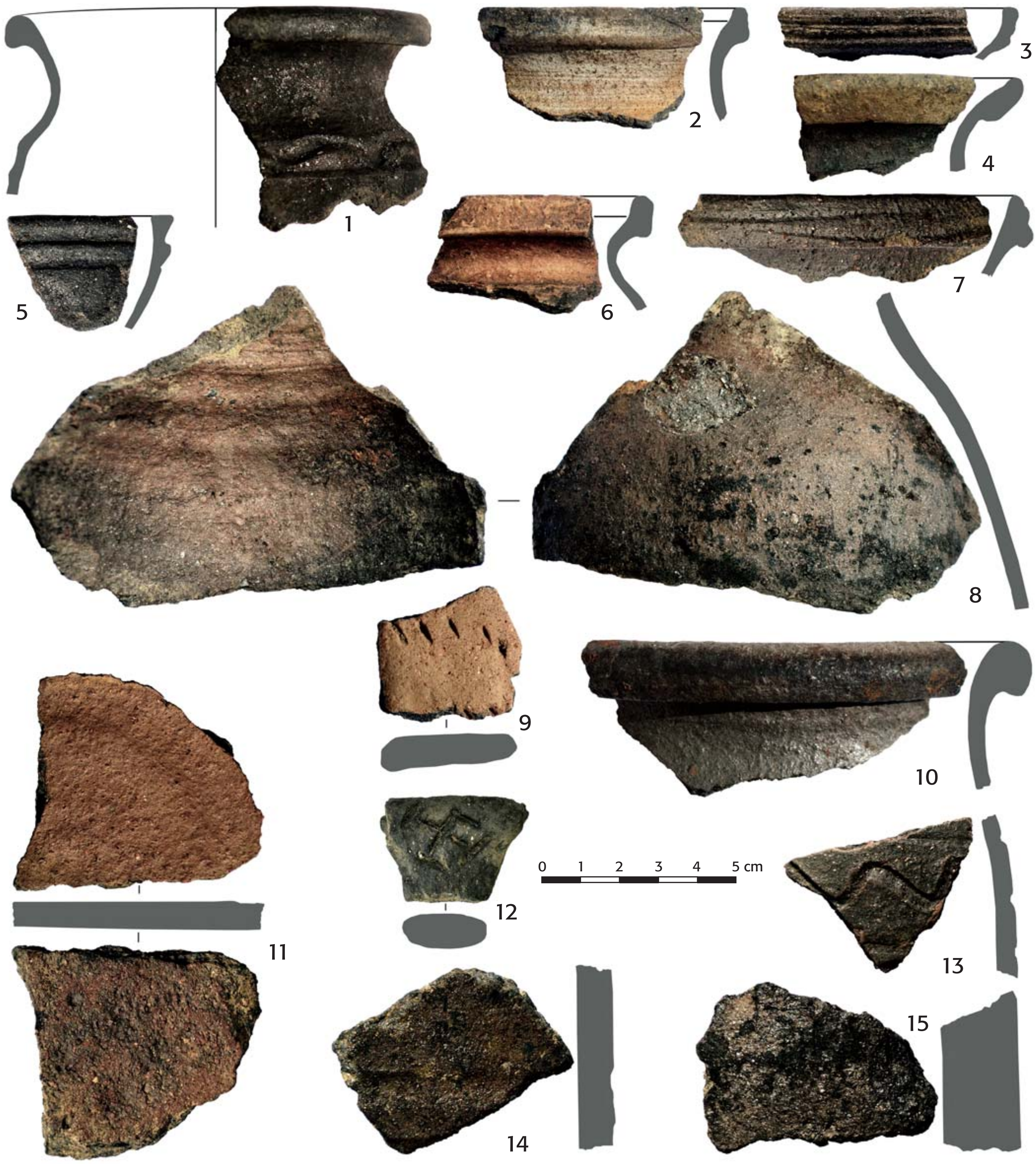


Fig. 40. *Pottery.* ***1:*** *Excavated feature 0501, layout 0106;* ***2, 5, 9, 14, 15:*** *Surface prospection 2017;* ***3, 4, 7:*** *Excavated feature 0501, layout 0111;* ***6, 8:*** *Excavated feature 0502, layout 0107;* ***10:*** *Excavated feature 0508, layout 0131;* ***11:*** *Excavated feature 0500, layout 0105;* ***12:*** *Surface prospection 2014;* ***13:*** *Excavated feature 0501, layout 0106. Photo by Petr Hrubý. —* ***Obr. 40.*** *Keramické nálezy.* ***1:*** *zkoumaný objekt 0501, vrstva 0106;* ***2, 5, 9, 14, 15:*** *povrchová prospekce 2017;* ***3, 4, 7:*** *zkoumaný objekt 0501, vrstva 0111;* ***6, 8:*** *zkoumaný objekt 0502, vrstva 0107;* ***10:*** *zkoumaný objekt 0508, vrstva 0131;* ***11:*** *zkoumaný objekt 0500, vrstva 0105;* ***12:*** *povrchová prospekce 2014;* ***13:*** *zkoumaný objekt 0501, vrstva 0106. Foto Petr Hrubý.*

in the Saxon part of the Podkrušnohoří (the foothills) region (*Schwabenicky 2009*, 136–138), *Kremsiger* on the Czech side of the Ore Mountains (*Derner 2018*, 299, Fig. 236: 1), *Havírna* (*Doležel – Sadílek 2004*, 64, Fig. 19: 13), and *Kašperské Hory* (*Waldhauser – Daněček – Nováček 1993*, 399, Abb. 6: 10, 11). One spindle whorl was found in the medieval gallery *Venetianer* in the Hochsauerland (*Straßburger 2012*, 35, Fig. 7, 8). A set of spindle whorls was also found at the sites of *Altenberg* in the Siegerland mountains (*Austermann 1998*,

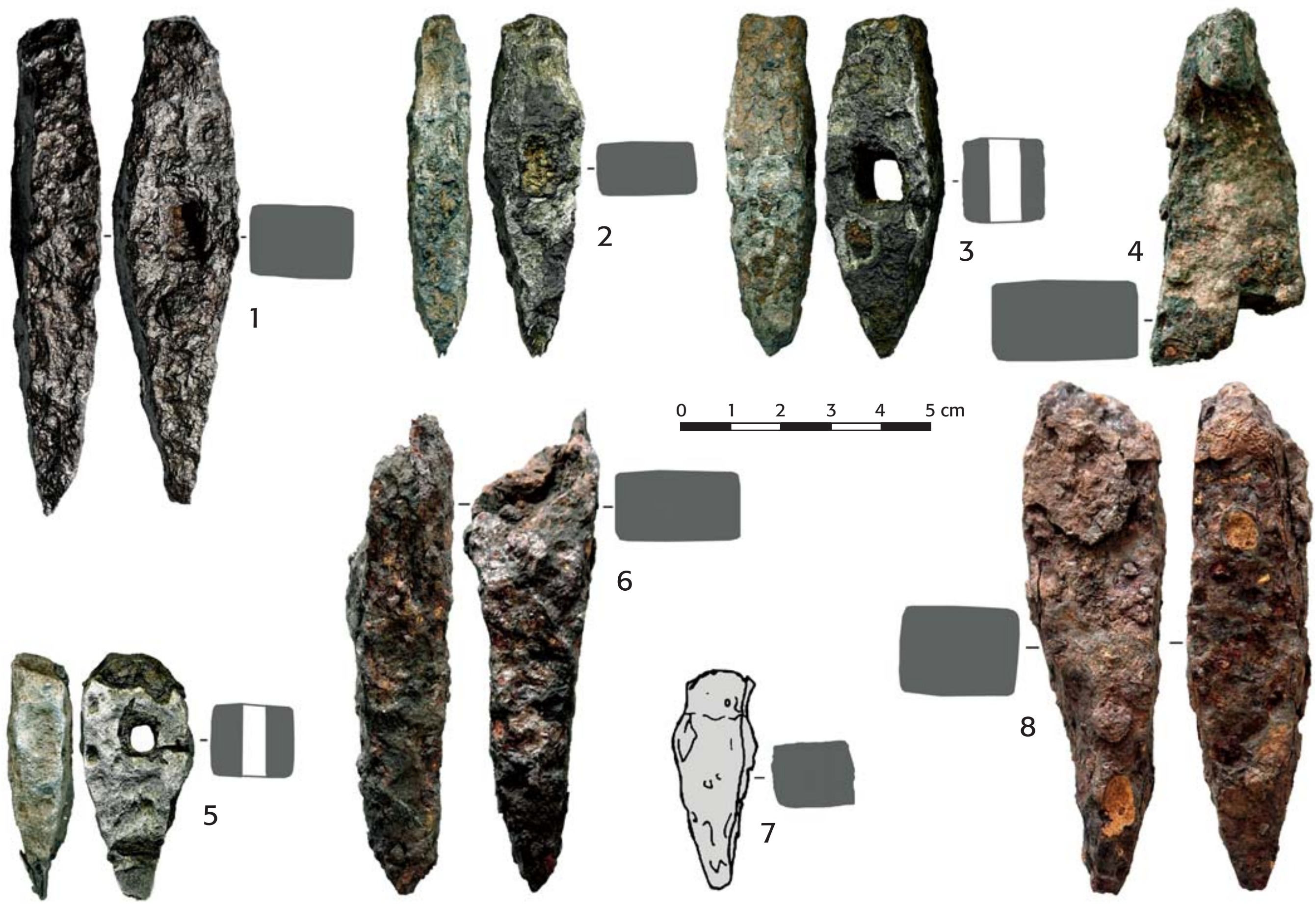


Fig. 41. 1: *Mining irons from surface prospections on shaft field **O**, parcel No. 143/2;* ***2:*** *Iron from surface prospection, undetermined;* ***3, 7:*** *Iron from surface prospection, undetermined (by Luna – Zimola 2007, 311, Fig. 29);* ***4–6, 8:*** *Iron from surface prospection, undetermined;* ***2:*** *Inv. No. J08/B/16190;* ***3:*** *Inv. No. J08/B/16189;* ***5:*** *Inv. No. JiA 17/09/116;* ***6:*** *Inv. No. JiA 17/09/121. Photo by Petr Hrubý. —* ***Obr. 41. 1:*** *Hornická želízka z povrchových průzkumů na šachetních haldách, plocha O, ppč. 143/2;* ***2:*** *nález ze starších povrchových průzkumů, neurčeno;* ***3, 7:*** *nálezy ze starších povrchových průzkumů, neurčeno (by Luna – Zimola 2007, 311, Fig. 29);* ***4–6, 8:*** *nálezy ze starších povrchových průzkumů, neurčeno;* ***2:*** *nález i. č. J08/B/16190;* ***3:*** *nález i. č. J08/B/16189;* ***5:*** *nález i. č. JiA 17/09/116;* ***6:*** *nález i. č. JiA 17/09/121. Foto Petr Hrubý.*

Taf. 1: 3; 48: 6–11) and *Johanneser Kurhaus* in the Harz (*Alper 2003*, 242, Abb. 109: 3–7).

The decoration located on the jar bodies consists of wave lines, sometimes combined with horizontal lines (*Fig. 40: 1, 13*); moreover, helix lines have been attested (*Rous 2001a*, 80, Fig. 8: 6). Helix lines also occur on the outer side of certain rim types, together with incised lines (*Figs. 39: 1*; *40: 3, 7*; *Rous 2001a*, 80, Fig. 8: 11, 12). Previous surface prospections yielded bottom sherd of a pot-shaped vessel incised with a mark (*Berky 1992*, Ad VII); another mark can be found on a lid handle, also obtained during surface collectings in the 1990s (*Rous 1998b*, sheet 1/4). The bottom detected in trench 2/2018 (structure 0505) shows traces of an underburden (*Fig. 40: 11*).

5.2. Iron artefacts

A specific type of iron artefacts characteristic for medieval mining sites stands out among various metal objects, mostly of indeterminate shape, namely mining irons. The majority of *Buchberg* mining irons comes from surface and metal detector surveys in arable land and dumps (*Fig. 41*). Therefore, irons or their fragments discovered in the stratified archaeological contexts in trench 2/2018 are very important. They were found in the working and waste fillings of structures 0503 and especially 0502, i. e. near furnaces and forges (*Fig. 42*). Such concentration in this space agrees with the idea of a blacksmith's workplace, where iron spikes were resharpened or old tools were forged into other items. The finds from *Buchberg* are very similar to irons discovered at other contemporary sites in the Bohemian-Moravian Highlands (*Hrazdil – Dočkal – Vokáč 2007*; *Luna – Zimola 2007*, 311, Fig. 7: 29, 30).

The iron finds also include a rotary key with a hollow shank and a round eye (*Fig. 43*). Keys and various types of locks belong among standard artefacts found in medieval mining settlements: the defunct mining centre at the site of *Treppenhauer* in the Saxon part of the Podkrušnohoří (the foothills) region, *Kremsiger* in the Ore Mountains (Erzgebirge), as well as the areas of the *Staré Hory* dislocation in Jihlava, or mining complex near *Vyskytná* in the Pelhřimov region (*Schwabenicky 2009*, 143, Abb. 294: 10, 4; 145, Abb. 296: 17, 20; 146, Abb. 297: 7; *Derner 2018*, 292, Fig. 230: 1, 34, 35; *Hrubý 2011*, 224, Fig. 228: 21, 26; *2019*, 175, Fig. 122: 8).

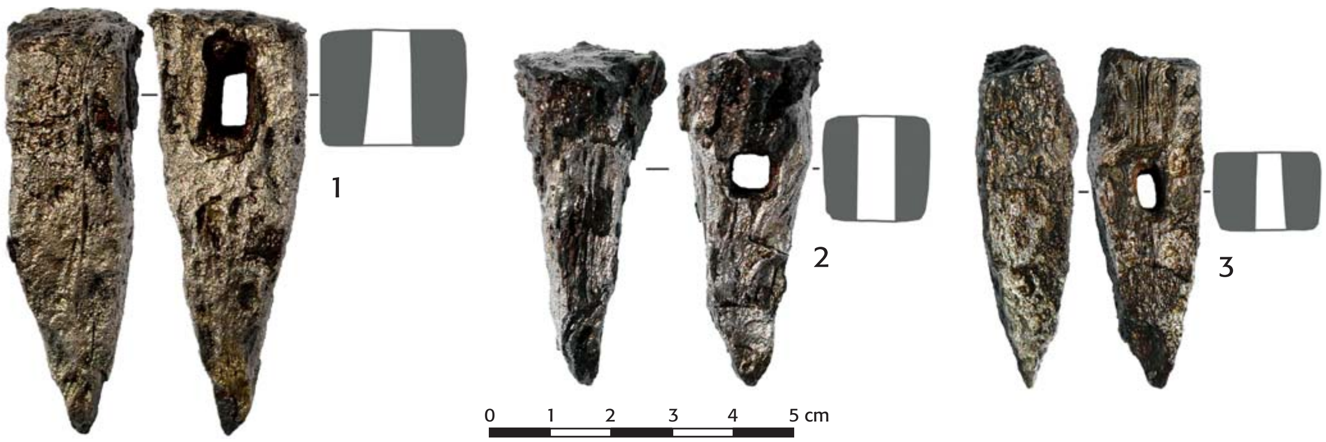


Fig. 42. *Mining irons from metallurgical feature 0502, layout 0107. Photo by Petr Hrubý. —* ***Obr. 42.*** *Hornická želízka z archeologicky zkoumaného objektu 0502, vrstva 0107. Foto Petr Hrubý.*

Fig. 43. *A key from surface prospection found in the shaft field* ***O****, parcel No. 143/2. Photo by Petr Hrubý. —* ***Obr. 43.*** *Klíč z povrchového sběru na haldách, plocha* ***O****, ppč. 143/2. Foto Petr Hrubý.*

A direct analogy to the Utín key can also be found in the mining area *Havírna* near Štěpánov nad Svratkou (*Hrubý – Malý – Lajtkepová 2015*, 32, Fig. 104). It is a relatively common key type of the 15th to 17th centuries (*Kilian 2008*, 22, 27). The find can be, therefore, also related to attempts to resume mining in the Modern Era, or represent an accidental loss.

5.3. Weights within the context of precious metal production

Weights are a common type of finds from medieval mining centres. Among other things, they can be linked to the activities of assayers (*examinatores*) and ore emptors (*emptores metalli*). By determining the weight, abrasions on touchstones and thermochemical tests, the essayers determined the composition and metallicity of ores, the proportion of specific metals in alloys, the purity of the silver, etc. Weights and scales were widely discussed in work *Das kleine Probierbuch* written by Lazar Ercker (*Vitouš 1974*, 70–81) in the mid-16th century, and *De re metallica libri XII* by Georgius *Agricola* (*Ježek – Hummel 2001*, 265–271, 424, 428).

So far, we have discovered sixteen weights at the medieval mining centre *Buchberg*. The most common type represents cylindrical to biconical lead weights (nine examples; *Fig. 37: 1–9*). Analogies are known from the nearest contemporary mining complexes, for example, from *Herliwinberg* located to the east of Stříbrné Hory (*Havlíček 2018*, 43, 44). Two pieces come from a mining settlement in Jihlava and three weights of the same type from *Cvilínek* (*Hrubý 2019*, 153, Fig. 115: 1–5), *Havírna* (*Hrubý – Malý – Lajtkepová 2015*, 31, Fig. 101). Identical items were found at the medieval mining site of *Stříbrník* in the Horažďovice region (*Červený 2007*, 119, Fig. 12). They are also known from the *Johanneser Kurhaus* site near Clausthal-Zellerfeld in the Harz (*Alper 2003*, 311–312, Abb. 142 and 143).

The second type is cup weight, usually made of bronze or brass. One example of such weight weighing 117.9 g was found in the *Buchberg* area (*Fig. 37: 10*, Inv. No. JiA 17/09/146). Another find weighing 13.2 g, which was discovered in the southern part of area **B** (plot no. 131/15), was damaged and affected by heat (*Fig. 38*). This type of weight, weighing 6.36 g, was found during archaeological research in Staré Hory near Jihlava (*Hrubý 2019*, Fig. 115: 6 and 9); and others came from sites of *Havírna* or *Městisko* (*Doležel 2008a*, 189; *2008b*, 473).

Lead circles or cones with a coaxial central hole (characteristic of a spindle whorl) represent a specific group of artefacts, which may have also been considered weights. Five pieces come from surface prospecting at *Buchberg* (*Fig. 37: 11–15*). Analogous finds from mining regions in the Přemyslid territory are known only from *Havírna* (*Hrubý – Malý – Lajtkepová 2015*, 31, Fig. 98). Such finds from Bohemia and the regions lying to

Fig. 44. *Artefacts made of the non-ferrous metals.* ***1–2:*** *Surface prospection, surveyed area* ***A****, parcel No. 131/15;* ***6–7:*** *Surface prospection, surveyed area* ***B****, parcel No. 223/1 (by Jakub Těsnohlídek);* ***10:*** *Southern part of the surveyed area* ***D****, parcel No. 131/15;* ***5:*** *Inv. No. JiA 17/09-143. Photo by Petr Hrubý. —* ***Obr. 44.*** *Nálezy z barevných kovů.* ***1–2:*** *povrchové průzkumy plochy* ***A****, ppč. 131/15;* ***6–7:*** *povrchové průzkumy plochy* ***B****, ppč. 223/1 (Jakub Těsnohlídek);* ***10:*** *povrchové průzkumy jižní části plochy* ***D****, ppč. 131/15;* ***5:*** *i. č. JiA 17/09-143. Foto Petr Hrubý.*

the north are usually dated to the 11th to 12th centuries (*Bláha – Hejhal – Skala 2013*; *Macháček – Měchura 2013*, 284–285, Figs. 6 and 7; *Rozmus 2014*, 217, Ryc. 204: 4–6; 219, Ryc. 205; 224, Ryc. 211–212).

Analyses of medieval weights usually rely on attempts to find weight systems and standards to which individual pieces can be assigned. It is rather difficult to achieve any reliable results that would withstand criticism or just different point of view based on any subsequent analyses of the same artefacts (*Doležel 2008a*, 198–201, Tab. 2). Researchers have tried to attribute the same weights to several systems, namely ounce or sometimes lot systems, etc. As far as analogies from close vicinity are concerned, a cylindrical lead weight from Stříbrné Hory can be cited (*Havlíček 2018*, 43, 44), as its weight of 61.48 g would correspond to a quarter of the *hryvnia* of Hungary, with only a small deviation of 0.10 g. The weight nominal called *ferto* can also be attested in some deeds determining amounts of various payments. For example, in 1222, the words *XX marcas argenti et fertonem ad pondus Pragens*e first appeared in The Kingdom of Bohemia (*CDB II*, No. 228, p. 214). The *ferto*, like a lot or a quent, was probably a standard nominal that had its weight.

Metrological analysis of *Buchberg* weights has shown a mass spectra ranging from 4.10 g to 117.09 g (*Tab. 9*). The individual pieces often differ in weight only by tenths of a gram or grams. Weights weighing less than 3 g have not yet been found, although the fine medieval metrology undoubtedly used sub-gram units. However, the probability of finding such artefacts is generally small, as they may not have survived to this day due to their material and conditions of archaeologisation? In the analysed set, we can see quents, half-lots, ¼-lots, lots, one and a half lots, two-lots or 2 and ¼ to ¾-lots and perhaps even half-hryvnias, in almost all supra-regional nominal systems that sometimes differed only slightly (*Tab. 9*). The presented interpretation of the weights from the *Buchberg* site and their attribution to the hryvnia (*marca*) - lot system relies on the assumption that they deviate from the ideal weight unit by 0.2 g on average, which is the assumed accuracy of common types of medieval scales determined by practical experiments with their imitations (*Hrubý 2014*, 630–631).

Fig. 45. *Coins.* ***1–4:*** *Prague groschen, John of Luxembourg (John the Blind, 1310–1346), surveyed area **D**, parcel No. 131/15. Inv. No. JiA 17/09/128 (weight 2.73 g), JiA 17/09/129 (weight 3.30 g), JiA 17/09/130 (weight 3.49 g), JiA 17/09/131 (weight 3.52 g). Photo by Pavla Lajtkepová;* ***5:*** *Silver Parvus, John of Luxembourg (John the Blind, 1310–1346), feature 0501, layout 0106 (weight 0.24 g). Photo by Petr Hrubý. —* ***Obr. 45.*** *Mince.* ***1–4:*** *pražské groše, Jan Lucemburský (1310–1346), povrchová prospekce plochy **D**, ppč. 131/15. i. č. JiA 17/09/128 (hmotnost 2,73 g), i. č. JiA 17/09/129 (hmotnost 3,30 g), ppč. JiA 17/09/130 (hmotnost 3,49 g), JiA 17/09/131 (hmotnost 3,52 g). Foto Pavla Lajtkepová;* ***5:*** *parvus, Jan Lucemburský, zkoumaný objekt 0501, vrstva 0106 (hmotnost 0,24 g). Foto Petr Hrubý.*

5.4. Non-ferrous metal artefacts, glass pearls and coins

Non-ferrous metal ingots and drips, which are evaluated in the context of the metallurgical operating chain, were excluded from this group of artefacts. These finds were exclusively obtained during metal detector prospecting.

Two copper trapezoidal plates with rivets – belt ends, were found in area **F**. They consist of a pair of plates; the visible areas of the top plates were decorated with ornamental or perhaps plant motifs and gilded (*Fig. 44: 7, 8*). A similar belt ends were discovered in the defunct medieval village of Konůvka (*Šlancarová 2016*, 152). Two copper decorative patches in the form of a stylised lily flower and with a circular hole may also have belonged among garment parts (*Fig. 44: 1, 2*). The closest analogous finds can be found in the assemblage from the *Havírna* facility (*Hrubý – Malý – Lajtkepová 2015*, 33, Figs. 105, 106). A single-wing arched buckle with slabs from *Buchberg* belongs to the standard and widely spread types of belt fasteners from the 13th and 14th centuries (*Fig. 44: 6*). Furthermore, a trapezoidal buckle was also found there (*Fig. 44: 9*). Cast round buckles represent the most numerous group of such finds (*Fig. 44: 10–12*) that occurs in many variations continuously from the Middle Ages to the Modern Age (*Šlancarová 2016*, 116–118; *Zůbek 2002*, 128).

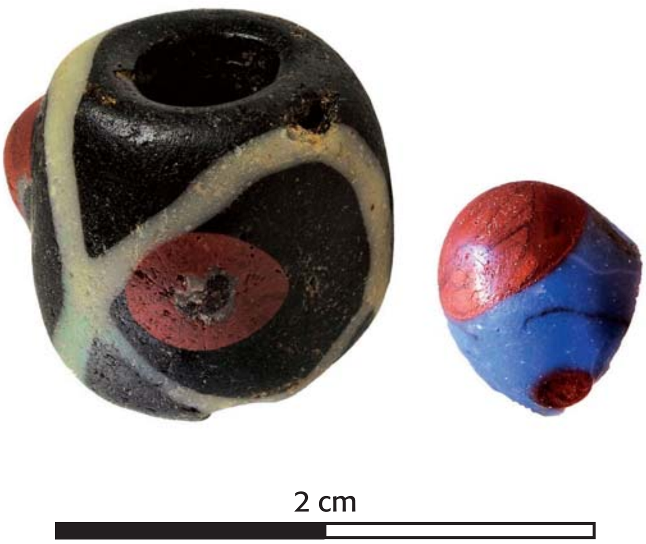


Fig. 46. *Glass pearls, Inv. No. JiA 17/09/124 and JiA 17/09/125. Photo by Pavla Starůstková. —* ***Obr. 46.*** *Skleněné korálky, i. č. JiA 17/09/124 a JiA 17/09/125. Foto Pavla Starůstková.*

A cast lead token obtained during the metal detector prospecting was found in the southern part of area **D** (plot no. 131/15). Its one side is decorated by a bow wheel with a raised centre (*Fig. 44: 5*; Inv. No. JiA 17/09/143). The most numerous set of similar tokens comes from the medieval mining centre of *Havírna* (*Hrubý – Malý – Lajtkepová 2015*, 36, Fig. 114); and a similar token was also found at the more distant site of *Treppenhauer* (*Schwabenicky 2009*, 150, Abb. 305).

A glass bead made of opaque dark black glass was found by surface prospecting in arable land. It is decorated with light strips and red target-like protrusions – eyelets. A fragment of another bead is coloured blue and red (*Fig. 46*). When found in Bohemia, these beads are considered imports and are mostly dated to the 10th to 12th century (*Krumphanzlová 1965*). However, such finds can also be dated after the year 1200, when found within the context of mining settlements dispersed across wider Central European region (*Schubert – Wegner 2015*, 233, Abb. 38: 3).

Four Prague groschen by John of Bohemia (John of Luxembourg, 1310–1346) were found during metal detector survey of area **D** in 2008 and 2009. The coins were individually lost (*Fig. 45*) and were scattered over a small area. They belonged to the common mints of the Royal Mint of Kutná Hora and can be dated to 1327–1340 (*Smíšek 2020*, No. 1–4). Thus, the *parvus* of John of Luxembourg from structure 0502 in the trench 2/2018 represents the only coin obtained during archaeological fieldwork. The coin can be most likely dated to 1320–1326 (*Smíšek 2020*, No. 5).

6. Discussion, interpretation, and conclusions. Spatial, working and community infrastructure of the *Buchberg* mining centre in the 13th and 14th centuries

6.1. Mining area

Above-ground relics illustrating the historical ore mining have been continuously disappearing from the site and its surrounding landscape. The mechanisation of agriculture has accelerated the process. Currently, the relics of old mining activities are mostly destroyed by mechanised harvesting of wood due to bark beetle outbreak and restoration of forest stands, sometimes accompanied by bulldozing of mining areas.

Remains of historical mining activities are recorded in mining maps of the 18th to 20th centuries and can be compared with the current reduced condition. Johann Höniger's drawings from the 1870s and 1880s offer relatively low content and coordinate accuracy, and it is, therefore, quite problematic to georeferenced them. The anonymous mining map (*Fig. 5*), which could be attributed to Rudolf Helmhacker (*Anonym 1875*), is more valuable.

First of all, the topic of mining galleries on the Sázava left bank has to be addressed when describing the historical mining landscape around *Buchberg* by combining the original mining maps, the mining landscape analysis and the field survey. Höniger and the anonymous author show two shaft mouths (*Fig. 5*) on the eastern side of the river above the central slag dump. The southernmost mouth can be identified with the field anomaly with the coordinates ETRS 89: B = 49° 35' 12.46" : L = 15° 42' 29.70". In its northern vicinity, there is another gallery mouth, which can be identified with the field-mark with the coordinates ETRS 89: B = 49° 35' 15.76" : L = 15° 42' 26.83". The third mouth is located to the north of the prospected slag dump. Höniger determined its direction as NE–SW. This gallery has recently been named the *Ag adit* and can be found on the coordinates ETRS 89: B = 49° 35' 33.78" : L = 15° 42' 10.40" (*Malý – Havlíček – Sobotka 2020*). The maps show another gallery mouth corresponding to the field anomaly on the coordinates ETRS 89: B = 49° 35' 44.74" : L = 15° 41' 30.80", located at the river bend called *U Groubu*, more or less opposite to the estuary of the Borovský brook. The anonymous author located another gallery, called *Weisse Ochsen Stollen* (*Pokorný 1963*, No. 44), just downstream of the river; and it can be identified with the field anomaly on ETRS coordinates 89: B = 49° 35' 37.81" : L = 15° 41' 23.16". Further downstream of the Sázava River, we find another adit, nowadays called *Nebeská*, laying just opposite the *Štukhejlský mill* (*Pokorný 1963*, No. 49a), the coordinates ETRS 89: B = 49° 35' 30.65" : L = 15° 41' 24.78". To the south-west, another adit (*Pokorný 1963*, No. 49) is indicated on the anonymous map, which can be identified with the so-called *White adit*, with the coordinates ETRS 89: B = 49° 35' 28.37": L = 15° 41' 21.70". Finally, the authors of the maps recorded the so-called *Utín gallery* on the right bank of the Utín brook (*Pokorný 1963*, No. 50), its mouth can be found on the coordinates ETRS 89: B = 49° 35' 20.90" : L = 15° 41' 15". It is the only shaft, which was drawn on the anonymous map from 1875 in the form of a mapped corridor about 690 m long predominantly running in the SW–NE direction (*Fig. 5*).

The chronology of the origin and operation of the galleries and shafts cannot be determined without corresponding dating material, mainly in the form of dendrochronological data from wooden timbering. Dating of the galleries to the 13th and 14th centuries is purely hypothetical, as almost all of them show traces of the so-called re-working in their accessible sections, which could be dated to later periods; even though the two galleries in operation (*stollo Vribergi*, *stollo Cunradi*) are already explicitly mentioned in a deed of October 25th, 1258 (*CDB V/1*, No. 167, p. 267). According to the deed of 1261, the so-called Freiberg's adit should be even located literally next to *Buchberg*: *apud montem dictum Puchberch* (*CDB V/1*, No. 252, p. 385).

Joel Pokorný summarised the topography of old mining dumps in the 1960s. In the area of interest, he discovered the following mining fields Nos. 42, 43, 45, 45b, 46, 47, 48, 49. The historically attested mining works near the neighbouring Dlouhá ves, which Pokorný registered under numbers 31b, 37–41 and 51 (*Fig. 6*), formed part of the so-called Přibyslav Mountains. However, whether or not they formed part of the historic *Buchberg* complex is debatable.

The group of mining dumps **L** and **M** in the NW–SE direction reaches a guiding length of 790 m; and two main parallel lines of shafts can be distinguished in the **M** group. The group of mining dumps **O** in the form of a single line of shafts running in the NW–SE direction reaches a guideline length of 370 m. The southernmost mining field **N**, reaching a length of 160 m, is situated separately. Despite our modern measurement possibilities, it is still challenging to identify mining or exploration length rates in the systems of shaft mouths, which are known from contemporary legal norms, especially if a substantial part of these shafts is no longer preserved in landscape. Nevertheless, for example, in the north-eastern part of the **L** mining dump field, one system of three pits measuring 60 m can be distinguished; the so-called triple-pit is considered to be a sign of the medieval measurement mining system (*Večeřa 2013*). A group of six shafts, also 60 m long, is located just to the south (*Figs. 9* and *11*). The southern part of the **N** group and the **S** pit group also show features of an individually set-up mining measure about 70–95 m long.

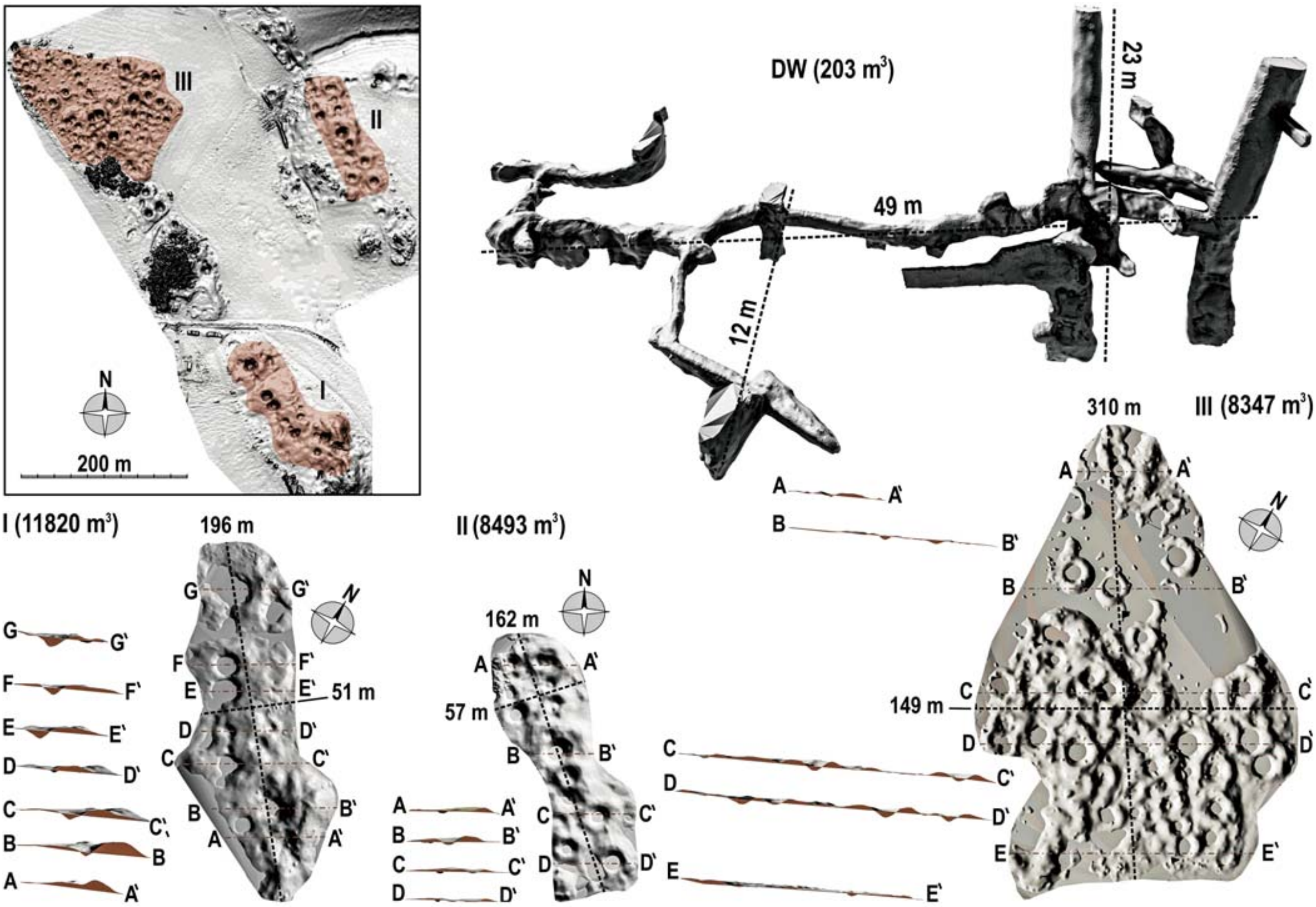


Fig. 47. *Hypothetical calculation of the mined rock volume and its comparison to a part of the medieval mines in Dippoldiswalde. Created by Jiří Unger. —* ***Obr. 47.*** *Hypotetický výpočet objemu vytěžené horniny a srovnání s úseky středověkých dolů v Dippoldiswalde. Vytvořil Jiří Unger.*

The Stable cadastre of Utín from 1838 (No. 8285-1) with clearly visible local field anomalies near the mining dump fields can also contribute to the detection of already destroyed relics of historical mining activities. These may indicate shafts with dumps that were still visible at that time (*Fig. 9: 1–7, 9*). Some of these anomalies coincide with the mining dumps on the anonymous mining map from 1875 (*Fig. 5*). Analysis of magnetic anomalies in reclaimed areas can also provide some new pieces of information. Area **G** shows circular to oval anomalies with diameters of 5 to 10 m and values of 5 to 150 nT. They can be considered as manifestations of shaft mouths, and the surrounding anomalies with negative values could indicate mining dumps. On the magnetogram, the anomalies form several clusters. One such system of four to five anomalies running in the NW–SE axis is located in the central part of the area. It reaches a length of about 40 m and is directionally connected to the southernmost system of shafts with mining dumps, which are still visible in the field (*Fig. 9: G3*). At the same time, another system of anomalies, 30 m long, adjoins it from the south, which can be interpreted as an exploratory shaft field (*Fig. 9: G4*). We do not know why some parts of the mining landscape have been entirely reclaimed after leaving the mines, while others have never been destroyed and have remained visible in the landscape to this day.

While maintaining a critical approach, as in the case of galleries, the dating of the relics of shafts with mining dumps is uncertain, although only fragments of medieval pottery were obtained from the heap material (*Fig. 39: 1*). Experimental and exploratory works in the late Middle Ages and Early Modern Times seem to have changed the previous mining landscape. The traces of mining activities from the 13th and 14th centuries were, thus, preserved in the form of the mining dump zones, parts of which (the selected exploratory shafts) were later reworked. In this regard, it is necessary to draw attention to the uncertain location of Johann Höniger's experimental mining activities from the years 1873–1888 conducted near Přibyslav (*Rous 1998a*, 107). However, it seems that his activities concentrated on the cadastre of Stříbrné Hory and not Utín.

The approximate calculation of the volume of mined material deposited on the ideal original surface has provided hypothetical but interesting results. Methodologically, the calculation was the most successful for the segments of the mining relief **I** and **II**, where the field morphology allowed the connection of the lower sides of the modelled body with a minimum deviation from the calculated original plain. The calculation determined that the volume of excavated rocks reached 11,820 cubic meters for the segment **I** covering an area of about 196 × 57 m and 8,493 cubic meters for segment **II** with an area of 196 × 51 m. In segment **III**, the outer sides of the modelled body led partly over the surface of the mining relics, which reduced the calculation accuracy, providing the result of 8,347 cubic meters.

The volumes of the shaft dumps can be estimated in hundreds of cubic meters of rock. The dump bodies surrounding the shafts have a diameter of about 30 m at their bases, and to calculate the cubic capacity of the rocks, they can be modelled as truncated cones with the subtraction of the volume of the reduction above the shaft mouths. Currently, about seventy of such bodies can be identified in the mining area of *Buchberg*. Altogether, we can estimate the volume of extracted material to 32,550 cubic meters of rock, even if the lower limit of the volume of extracted material in the amount of 465 cubic meters is taken into account. If we add the volumes of the assessed areas, the value reaches the amount of 28,860 cubic meters. Hypothetically, the total volume of the mined material could be around 30,000 cubic meters.

For comparison, the volume of a shorter section of the three-dimensionally surveyed medieval mine in Dippoldiswalde (*Hemker – Hoffmann – Scholz 2012*) with a guideline length of 49 m was calculated. The total length of the corridors, including the mines, is about 90 m, to which two shafts with depths of 23 m must be added. The total volume of this underground segment is 203 cubic meters. The ore-bearing structures at *Buchberg* were excavated in a total length of about 1330 m; the mined segment from Dippoldiswalde can fit 27.14 times there. Should the underground volume be taken into account, it would provide 5,510 cubic meters. This is, however, 5.44 times less than the estimations for *Buchberg* based on the mining field volume. Different ore-mineralogical conditions can explain the discrepancies because typical ore veins were mined in Dippoldiswalde (*Lange – Kaden 2011*), while in Utín, the miners exploited the filling of an extensive dislocation zone, tens of meters wide (*Fig. 47*).

6.2. Primary ore treatment

The absence of a natural watercourse is an unmissable feature of the *Buchberg* mining complex; thus, we must assume that the wet processes of primary ore processing took place elsewhere. Places on the banks of the Sázava River come into consideration, especially those with a direct spatial connection to metallurgical facilities. Nevertheless, concentrations of linear subsurface structures, which were detected by magnetic prospection in the southernmost part of the area **G**, and which converge in a fan-shaped manner to the southeast (*Fig. 9: G6*) should be emphasised. These structures correspond to the relief, which slopes in this direction and forms a ditch. Therefore, the linear structures may be erosion furrows in which water was collected seasonally; however, they could also be used for draining of water drawn from shafts. Based on finds from Jihlava, where water supply systems using water from shafts were found (*Hrubý 2011*, 102–129), we may hypothetically consider these relics washing facilities (German *Erzwäsche*) and gravity separation of ore. In this sense, the anthropogenic heap-like formations registered under number 66 (*alte gangartige Wash halden*) on the map of Johann Christian Fischer from 1773 located in the valley of the local watercourse to the east of this place can be seen as indications (*Fig. 4*).

6.3. Metallurgy of polymetallic ores and slag dumps in the mining complex hinterland

Due to the absence of slags associated with the smelting of polymetallic ores, we assume that the metallurgy of non-ferrous metals took place elsewhere. The nearest slag dump that could be associated with the smelting of polymetallic ores is an area about 0.75 km away on the southern bank of the Sázava River (*Fig. 3: 2*). Trial excavations corroborated the presence of crushed or ground ore, as well as layers of slags up to 80 cm thick. Based on a combination of geophysical and geochemical measurements, it is possible to assume the existence of a well-developed metallurgical facility utilising water-technical elements. The local slags are characterized by increased contents of Zn, Pb, Cu, Ag, As, Sb, which are bound to microscopic inclusions of sulphides, pure metals and phases with Sb and As less so to silicates (*Janíčková – Dolníček – Malý 2012*). The ore processing has led there to extensive contamination of soils with these elements (*Hrubý – Malý – Milo 2016*).

However, the dating of slag dumps represents the real challenge. The majority of them has been subject to either non-destructive survey or just small-scale fieldwork. Therefore, there is little or no dating material available, especially pottery sherds. The same also applies to the evaluated area of *Buchberg*. Only some slag dumps are located on arable land, where it is possible to conduct surface prospectings meaningfully. The site *V groubu*, located approximately 1500 m to the northwest of the *Buchberg* complex, is another example of metallurgical facilities near the Sázava River, which could have been prospected. However, the pottery sherds found there can be dated only to the Late Middle Ages and the Early Modern Period (*Rous 2007*). As far as the identification of possible metallurgical facilities within the *Buchberg* complex is concerned, the concentration of bipolar magnetic anomalies in the northern part of area **G** is worth mentioning (*Fig. 9: G1*), as their characters coincide with the magnetic indication of slag dumps (*Hrubý – Malý – Milo 2016*, 402, Fig. 13). Magnetic anomalies of circular to oval shape with a diameter of up to 1.5 m and with magnetic values in the range of 1–10 nT can be cautiously interpreted as unspecified metallurgical structures. They present themselves similarly to the relics of metallurgical facilities affected by high temperatures; magnetically anomalous metallurgical waste can be found in their vicinity.

6.4. Non-ferrous metallurgy: Assaying, cupellation, or even smelting of polymetallic ores?

The find of copper ingots, Cu-Sn alloys and Pb-Sn alloys are difficult to interpret (*Tabs. 5–7*). Although their number in total does not reach a dozen (*Fig. 36*), their

Sample	Fe	Cu	Zn	As	Ag	Cd	Sn	Sb	Pb	Au
BU 22	0,29	<LOD	<LOD	5,59	<LOD	0,87	1,20	<LOD	92,05	<LOD
BU 01	1,89	<LOD	0,01	4,76	<LOD	0,99	0,87	0,05	91,43	<LOD
BU 22	0,16	<LOD	<LOD	5,22	<LOD	1,03	0,88	<LOD	92,71	<LOD

Tab. 4. *Elemental composition of the lead objects (XRF, %). Measured by Karel Malý. —* ***Tab. 4.*** *Prvkové složení olověných slitků (XRF, %). Měřil Karel Malý.*

Sample	Fe	Cu	Zn	As	Ag	Cd	Sn	Sb	Pb	Au
BU 24	0,51	66,30	0,39	0,37	0,13	<LOD	30,74	0,05	1,51	<LOD
BU 55	7,34	33,66	0,63	0,21	<LOD	0,02	56,10	<LOD	2,05	<LOD
BU 49	0,23	68,90	0,36	0,25	0,10	<LOD	28,34	0,02	1,76	0,04

Tab. 5. *Elemental composition of the Cu-Sn alloy (XRF, %). Measured by Karel Malý. —* ***Tab. 5.*** *Prvkové složení Cu-Sn slitků (XRF, %). Měřil Karel Malý.*

Sample	Fe	Cu	Zn	As	Ag	Cd	Sn	Sb	Pb	Au
BU 19	0,40	77,65	0,13	1,46	1,69	<LOD	0,21	0,06	18,39	<LOD
BU 54	0,14	80,50	<LOD	1,12	1,37	<LOD	1,10	2,58	13,19	<LOD

Tab. 6. *Elemental composition of the Cu-Pb alloy (XRF, %). Measured by Karel Malý. —* ***Tab. 6.*** *Prvkové složení Cu-Pb slitků (XRF, %). Měřil Karel Malý.*

Sample	Fe	Cu	Zn	As	Ag	Cd	Sn	Sb	Pb	Au
BU 43	0,20	0,02	0,04	0,78	<LOD	0,04	78,39	<LOD	20,52	<LOD

Tab. 7. *Elemental composition of the tin ingot, Inv. No. Bu 43, Fig. 36: 8 (XRF, %). Measured by Karel Malý. —* ***Tab. 7.*** *Prvková analýza cínového slitku, i. č. Bu 43, obr. 36: 8 (XRF, %). Měřil Karel Malý.*

Sample	Fe	Cu	Zn	As	Ag	Cd	Sn	Sb	Pb	Au
BU 29	0,36	0,34	0,78	0,19	84,19	<LOD	10,62	<LOD	3,46	0,06

Tab. 8. *Elemental composition of the silver ingot/hacksilver, Inv. No. Bu 29, Fig. 35 (XRF, %). Measured by Karel Malý. —* ***Tab. 8.*** *Prvkové složení stříbrné pecičky, i. č. Bu 29, obr. 35 (XRF, %). Měřil Karel Malý.*

presence at the site is not coincidental and can be linked with the medieval metallurgy. In principle, the artefacts can be products of metallurgy of polymetallic ores, but also documents of metal casting or even metal assaying. The fact that no slags corroborating these processes have been found in the area significantly hinders the possibility of their connection with the metallurgy of polymetallic ores. We may assume the existence of a metalworking workshop, as corroborated by analogies from the *Treppenhauer* mining settlement in the Saxon part of the Podkrušnohoří (the foothills) region (*Schwabenicky 2009*, 150–153). Also, the relatively low content of tin in ores from the Přibyslav region indicates that the metal was imported from elsewhere. Any definitive hypotheses could be made only based on hitherto missing finds of corresponding metallurgical ceramics.

Numerous pieces of lead object can be definitely considered as indicators of metallurgical or, more probably, assay activities (*Figs. 32–34*; *Tab. 4*). They could be utilised as the input raw material for leading, where the pure non-argentiferous lead was melted in crucibles or sherds and was used for "dissolving" of silver ores. By doing so, unwanted elements such as S, As, Sb were removed, and the silver was reduced. The lead was consecutively separated in the molten state from the resulting alloy by oxidation and extraction, and the silver was, thus, separated. Lead ingots also might have belonged to the equipment of an assayer who used non-argentiferous lead in many tests (*Vitouš 1974*, 34–35, 41, 45). The connection with assaying can also be supposed in the case of a small pit-like silver globule (*Fig. 35*; *Tab. 8*).

6.5. Iron ore mining, its metallurgy and primary blacksmith processing

The trial excavations in 2018 clarified our ideas about the metallurgical facility located on the edge of the mining settlement in area **F**, which shows the characteristics of ironworks and forges rather than smelting facilities used for processing of precious and non-ferrous metals. Archaeological context allows the interpretation that structures 0502 and 0503 could be used as iron metallurgical furnaces in an older phase; later on, some of them were covered with metallurgical waste and transformed into blacksmith facility equipped with furnaces (structure 0502). The fact that no fragments of fired clay daubs and other binding material have been found in these structures represents a critical point of this hypothesis, as their presence would be expected in the case of shaft metallurgical furnaces (*Fig. 25*). On the other hand, no daubs or other binding material were found in the contemporary processing site of *Cvilínek* in the Pelhřimov region, where more than a dozen relics of furnaces of various types were discovered (*Hrubý et al. 2012*, 363–369).

The discovered structures in the trench 2/2018 at *Buchberg* are similar to the situation at the *Johanneser Kurhaus* metallurgical site in the Harz, where linearly arranged structures 512, 514, 541–543 were found. Their dimensions were comparable to the Utin structures 0502 and 0503, and they were also filled with charcoal and blacksmith slags. The find is interpreted as a waste slag heap located next to a forge (*Alper 2003*, 136–137, Abb. 65). The structures 0501 and 0506 are comparable with the archaeological context 1/2002 in the metallurgical complex Dąbrowa Górnicza interpreted as a metallurgical furnace (*Rozmus 2014*, 159–170, Ryc. 120).

The magnetically detected structures at Utín are regularly distributed with very close intervals; one structure more or less follows the other (*Figs. 9: F*; *15*). Due to its small size, the trial excavation cannot provide answers to the question whether all furnaces or forges were operated at the same time, which would make the complex a highly organized, large-capacity facility. Another hypothesis presumes the gradual abandonment of used furnaces and the construction of new furnaces in a continuous line.

The origin of the slags in the prospected area **F**, including trial fieldwork, represents another challenge. Some of the type 2 slags could have been formed by remelting of aluminous-sandy linings and daubs of furnaces and forges. The generally amorphous shape and glassy character of slags, low iron content and at the

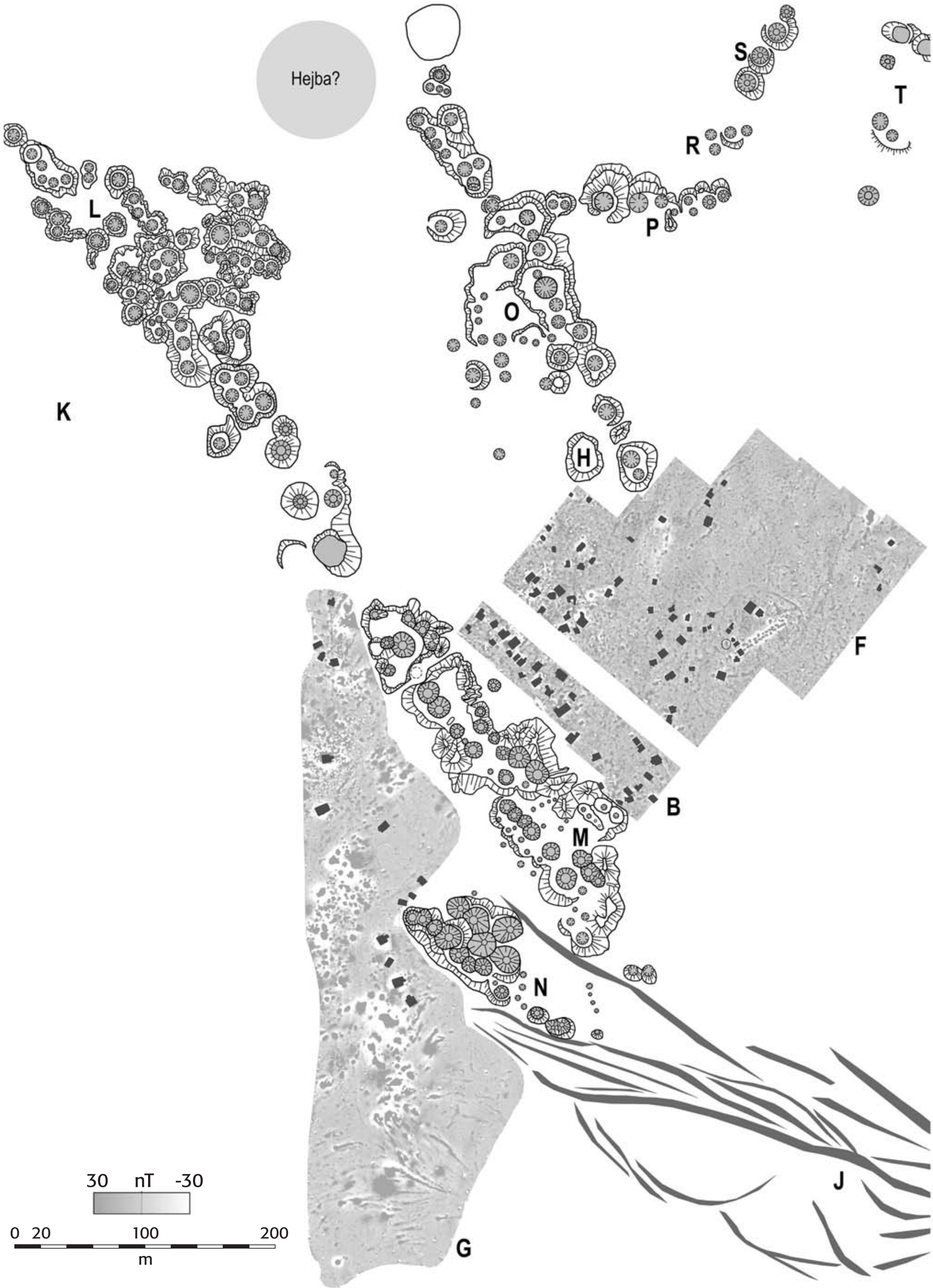


Fig. 48. Probable settlement structures. Interpretation of the magnetic survey results. — ***Obr. 48.*** *Pravděpodobně sídelní stavební struktury detekované jako magnetické anomálie.*

Fig. No.	Material	Type	Wgt. g	Resulted Marca	Hypoth. avoirdupois wgt.	Wgt. g	Lot g	Hypothet. wgt. nominal	Ideal wgt	Error g
Fig. 37: 9	Pb	cylindrical	4,10	262,400	*Marca* of Prague	253,14	15,821	¼ Loth		0,144
Fig. 37: 8	Pb	cylindrical	4,20	268,800	*Marca* of Wienna	280,70	17,543	¼ Loth		0,186
Fig. 37: 6	Pb	cylindrical	6,40	204,800	*Marca* of Poland	198,90	12,431	½ Loth		0,185
Fig. 37: 7	Pb	cylindrical	7,00	224,000	*Marca* of Leipzig	233,40	14,587	½ Loth		0,293
Fig. 37: 15	Pb	spindle-whorls	8,80	281,600	*Marca* of Wienna	280,70	17,543	½ Loth	8,771	- 0,028
Fig. 37: 14	Pb	spindle-whorls	9,50	190,000	*Marca* of Poland	198,90	12,431	¾ Loth	9,323	+ 0,177
Fig. 37: 4	Pb	cylindrical	11,50	230,000	*Marca* of Prague	253,14	15,821	¾ Loth	11,865	- 0,365
Fig. 37: 12	Pb	spindle-whorls	13,26	212,160	*Marca* of northern	210,00	13,125	1 Loth	13,125	+ 0,135
Fig. 37: 5	Pb	cylindrical	14,20	227,200	*Marca* of Leipzig	233,40	14,587	1 Loth	14,587	- 0,387
Fig. 37: 3	Pb	cylindrical	16,92	270,720	*Marca* of Wienna	280,70	17,543	1 Loth	17,543	- 0,643
Fig. 37: 13	Pb	spindle-whorls	23,13	246,720	*Marca* of Hungary	245,50	15,343	1 and ½ Loth	23,015	+ 0,116
Fig. 37: 1	Pb	cylindrical	29,70	237,600	*Marca* of northern	210,00	13,125	2 and ¼ Loth	29,174	+ 0,169
Fig. 37: 2	Pb	cylindrical	30,80	246,400	*Marca* of Hungary	245,50	15,343	2 Loth	30,686	+ 0,114
Fig. 37: 11	Pb	spindle-whorls	40,40	235,054	*Marca* of Leipzig	233,40	14,587	2 and ¾ Loth	40,114	+ 0,285
Fig. 37: 10	bronze/brass	cup-weight	117,09	234,180	*Marca* of Cologne	234,00	14,625	½ Marca	117,000	+ 0,090

Tab. 9. *Overview of hypothetical historic metrological relations of weights from the Buchberg site (historical weight standards by Hladík 1953; Hlaváček – Kašpar – Nový 1994, 129–152; Doležel 2008a, 198–201, Tab. 2; Wachowski 1974, 183–187; 2006; Witthöft 1993).* — ***Tab. 9.*** *Přehled hypotetických středověkých metrologických souvislostí závaží z areálu Buchberg (historické hmotnostní standardy podle Hladík 1953; Hlaváček – Kašpar – Nový 1994, 129–152; Doležel 2008a, 198–201, Tab. 2; Wachowski 1974, 183–187; 2006; Witthöft 1993).*

same time, high content of silicon and light elements seem to favour this hypothesis. However, the amount of this type of slags is too large to be explained exclusively in this way. Another assumption sees them as waste products from the smelting of low-quality and unsorted iron ores with a higher proportion of tailings; these ores should form an inhomogeneous furnace charge. This could be indicated by the characteristic glassiness, which cannot be produced during the smelting of high-quality ores by direct reduction, but also by the relatively higher content of silicon and alkalis in the glassy parts. Last but not least, these slags could have been produced during the very efficient iron smelting, which is achieved only in modern blast furnaces; however, this hypothesis is least likely.

A particular part of the type 2 slags does probably represent iron ore metallurgy waste. This is indicated by their structural-textural features (fluid-structure), phase composition (spherical inclusions of pure Fe), and their formation in reductive conditions (blue-green brava is a consequence of the presence of Fe^{2+} in the glass). In the vicinity of *Buchberg*, limonite ores are located in the neighbouring Dlouhá Ves (*Juráček 2011*) where they are bound to serpentinite weathered rocks. Limonites and Fe carbonates can also be found in the surface weathered parts of the ore veins at *Buchberg*. The presence of Fe-S and Cu-Fe-S inclusions in slags may have indicated their processing. However, these inclusions can also be interpreted as a consequence of the contamination of the entire area during the ore mining and processing. Suppose we assume the spatial interconnection of forges with iron metallurgy based on trial fieldwork and analyses of slags and scalings. In that case, it is possible to consider the processing of limonite and Fe carbonates from local weathered rocks, which had to be removed in the process of searching for and mining of silver-bearing sulfides anyway. Iron ore metallurgy performed in the area of medieval mining of polymetallic ores is well documented at *Havírna* in the Svratka region, where researchers assume the processing of limonitic ores from weathered parts of the deposit, as well as ores transported from the surrounding area (*Malý 2020*).

Until the 13th century, we can find evidence of iron processing in virtually all types of settlements; moreover, these settlements do not need to be directly spatially connected with the occurrence of ores or places of their mining (*Pleiner 1958*, 208–224, 233–264; *Souchopová 1995*; *Klápště 2005*, 339, 504; *Havrda – Podliska – Zavřel 2001*; *Havrda – Podliska 2011*; *Hlubek – Šlézar 2014*). The fact that the demand for iron belonged among one of the driving motifs for colonisation seems to be corroborated by the settlement of peripheral areas in northern Moravia and the Jesenice region (*Klápště 2005*, 297–299, 345–346, 487–488). The iron processing may have influenced the discovery of silver-bearing ores (*Crkal 2017*; *Schubert et al. 2020*). Some of the iron ore occurrences result from oxidation processes of primary polymetallic mineralisation, as the mixture of oxides and hydroxides of iron represented raw material that was easily extracted and metallurgically processed. Therefore, the discovery of silver-bearing ores may be seen as a consequence of the search for and mining of iron ores in these genetically and spatially linked deposits (*Houzar 1996*). The earliest archaeological evidence of iron ore metallurgy in the Bohemian-Moravian Highlands includes finds from the site of *Staré Město* located to the west of Žďár nad Sázavou. Its origins can be traced to the mid-13th century. The number and character of the relics of iron metallurgical and blacksmithing facilities can be only described as extraordinary (*Zatloukal 1999*; *Geisler – Zatloukal 1998*; *Geisler 2004*; *2005*; *2006*; *Geisler – Malý 2006*). By far, the most significant group of finds consists of large volumes of slags. These finds correspond to the occurrences of iron ore in the area (*Malý 2005*).

Part of the slags from *Buchberg* (type 1) was formed during oxidative processes, i. e. probably during forging. Forms entirely cup-shaped/plano-convex shapes, probably originating from the hearths of blacksmith furnaces (*Figs. 26* and *27*), as well as the numerous concentration of scalings and spherules, especially in the filling of structures 0503 and 0502 in the trench 2/2018 (*Fig. 30*) seem to corroborate this assumption. However, the archaeological material prevents us from deducing whether the forging processes can be connected with the initial treatment of the compacted iron sponge, or with the advanced processing of the already finished iron, or with both. Forges represented a common type of workshops present in mining centres, as is clear from the *Ius regale montanorum*, Chapter *XVI De Fabris* (*CIB I*, 310–313). Several blacksmith facilities indicated as magnetic anomalies with the occurrence of slags of the same type as in Utín were detected in the mining complex near Vyskytná in the Pelhřimov region (*Hrubý 2019*, 76–77, 142, Fig. 108: 4–6). The absence of a natural water source represents a standard feature. The site of *Cvilínek* is also worth mentioning, as the studied relics of metallurgical facilities and waste heaps indicate the existence of an integrated metallurgical and blacksmith workplace located on the banks of a stream (*Hrubý et al. 2012*, 365, Fig. 42; 375, Fig. 72: 2, 3). As far as more distant analogies are concerned, forges located on the *Riester* vein near the town of Sulzburg in the Black Forest (*Goldenberg 1999*, 21; *Goldenberg – Steuer 2004*, 54), or in Brandes in the French Alps, where remains of constructions of several smithies and tools were uncovered (*Bailly-Maître 2010b*, 228–230), can be named.

6.6. Fuels used for metallurgical processes

Anthralogical analysis of a sample of wood charcoals obtained from the structure 0503 and layer 0108 (*Tab. 10*; *Diagram 1*) provided an interesting and mostly surprising testimony regarding the quality of fuels used for metallurgical processes, as well as the selection of suitable tree species for their production. The assemblage consisted of fragments of maple (*Acer*), alder (*Alnus*), birch (*Betula*), hazel (*Corylus*), beech (*Fagus*), spruce (*Picea*), poplar (*Populus*) and poplar/willow taxon (*Populus/Salix*) charcoals, i. e. charcoals of predominantly heliophilous "successive" woody plants that grow on glades, forest clearings, and along forest edges. The assemblage is dominated by birch (67% of charcoals), followed probably by aspen (*Populus* and taxon *Populus/Salix*) - a total of 23% of the charcoal fragments. The "climax" woody plants of the main tree layer of the local forests (beech, spruce, maple) make up only 3% of the assemblage.

The fact that the working space around the furnaces or in their fillings contained fuels consisting of a mixture of less calorific trees correlates to some extent with the results of analyses performed at the contemporary mining and metallurgical site of *Cvilínek* in the Pelhřimov region. The species spectrum of charcoals enclosed in slags consisted mainly of beech, and it can be considered as evidence of the selection of calorific trees. On the other hand, the charcoal samples from furnaces and their surroundings contained a balanced proportion of conifers (fir, spruce, fir/spruce) and deciduous trees (beech, birch, alder, poplar/willow) and a small admixture of maple and elm (*Hrubý et al. 2012*, 381).

Species	***Acer* (Maple)**	***Alnus* (Alder)**	***Betula* (Birch)**	***Corylus* (Hazel)**	***Fagus* (Beech)**	***Picea* (Spruce)**	***Populus* (Poplar)**	***Populus/Salix* (Poplar/Willow)**
Wght. (g)	3,777	13,3175	306,4537	10,9181	7,1574	3,2595	63,8134	11,9929

Tab. 10. *Trench 2/2018, feature 0503, layout 0108. Charcoals. Determined by Romana Kočárová. —* ***Tab. 10.*** *Sonda 2/2018, object 0503, vrstva 0108. Uhlíky. Určovala Romana Kočárová.*

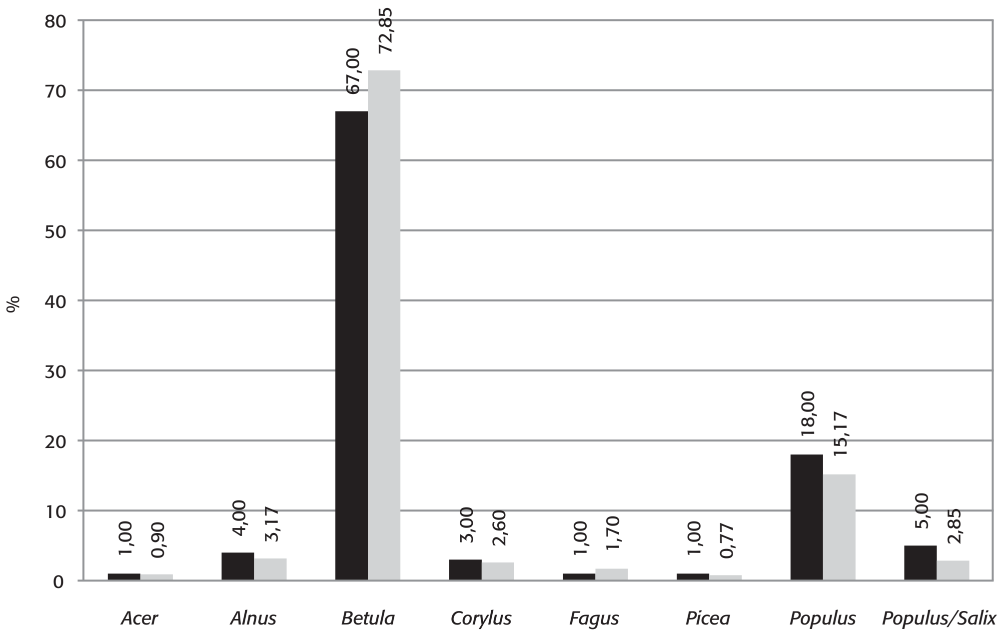


Diagram 1. *Anthracological analyses of charcoals from the feature 0503, layout 0108,* ***black:*** *quantity,* ***grey:*** *weigt (g). Determined by Romana Kočárová —* ***Graf 1.*** *Antrakologická analýza uhlíků z pece 0503, vrstva 0108,* ***černá:*** *počet,* ***šedá:*** *hmotnost (g). Určovala Romana Kočárová.*

Fig. 49. *Comparison of the magnetic survey and cropmarks (maps from the Geoserver CUZK) of the surveyed area B.* ***1–13:*** *Most probable mining settlement structures. —* ***Obr. 49.*** *Srovnání magnetických a porostových anomálií v části plochy B.* ***1–13:*** *Velmi pravděpodobně se jedná o relikty staveb (podkladové mapy z geoserveru ČÚZK).*

Such spectrum can be probably linked with the fact that some of the pyrometallurgical operations such as roasting, heating of furnaces before re-melting etc. did not require a selected type of fuel.

6.7. Settlement complex

The magnetometric survey was the most effective tool for detecting construction relics of the mining settlement. Planar magnetograms provide sufficient information on the presence of subsurface construction features, and if the data are interpreted correctly, their mutual spatial relationships at the primary level can be assumed. In comparison with medieval rural settlements, the remains of sunken dwellings in mining settlements manifest themselves as significant and contrasting magnetic anomalies. The mining settlement at *Cvilínek* represents an exception, as the contrast between the magnetic manifestation of sunken dwellings and the surrounding environment was very weak (*Crkal et al. 2019*, 887–923).

Altogether, 88 magnetic anomalies were detected in areas **B**, **E** and **F**, which can be interpreted as the so-called pit houses based on their dimensions and shape similarities (*Figs. 9: F*; *51*). Moreover, vertical aerial photographs taken in 2018 corroborated the existence of at least seven such structures arranged in a regular row along the mining works in area **B** (*Figs. 9: B* and *49: 1–7*). In the southern part of area **F**, another line of these structures can also be seen; however, they are arranged transversely to the direction of the leading mining stretch (*Fig. 49: 12–13*). Elsewhere, anomalies considered to be relics of constructions appear in more disordered clusters. Individual anomalies that are arranged in continuous lines are situated close to each other, and their distances vary from 1 to 2, maximum 3 m. On the other hand, structures in clusters are more spread; their distance varies between 6 and 16 m. According to magnetic prospection, the presence of settlement construction relics is not so apparent in the area **G** located to the west of the mining area; however, in the northern and central part of the area, anomalies are corresponding in magnetic value, size and partly shape to the structures in areas **F** and **B** (*Fig. 50*).

The area **K** laying to the west of the main group of mining dumps, which has not been subjected to the magnetic survey, artefacts prospections or metal detector prospections, remains mostly unknown (*Fig. 9: K*). We can probably mention a reference citing a tavern located on the way to Utín (*ad viam precedentes penes hospicium sepius dicti Th. Versus villam Ottonis*) preserved in a deed dated October 25th, 1258 (*CDB V/1*, No. 167, p. 267).

The spatial arrangement of medieval mining settlements, as well as the appearance of dwellings, belong among the long-term research topics targeted by medieval mining archaeology (*Crkal et al. 2019; Derner – Hrubý 2018; Hrubý – Derner – Skořepová 2019*). The construction and infrastructure of mining settlements were to be governed by specifically established principles. According to the Jihlava Mining Law, a total of 16 plots (*Item quilibet mons mensuratus XVI areas de jure*

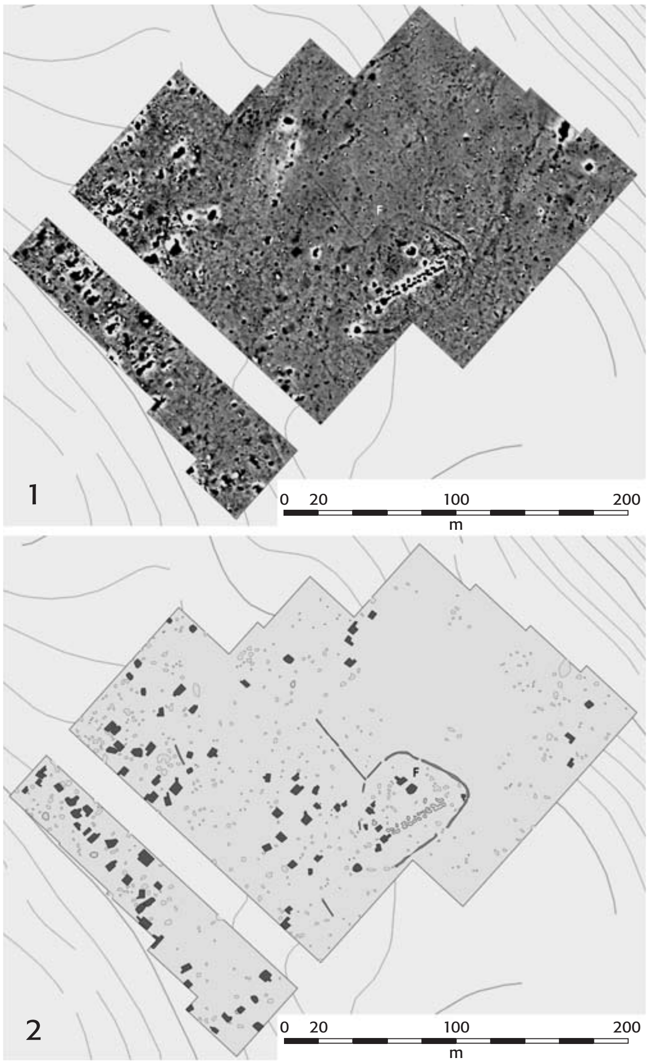


Fig. 50. *2013 and 2014 magnetic surveys in the areas B and F. Interpretation of the detected anomalies as probably settlement structures. —* ***Obr. 50.*** *Magnetické prospekce v letech 2013 a 2014 v plochách B a F. Větší z detekovaných anomálií lze s jistou pravděpodobností detekovat jako relikty staveb.*

obtinebit) were to be located for each mining rate measuring seven łans (in German *Lahn*, Latin *laneus*). The German legal text formulated in the second half of the 14th century in Jihlava clearly state that dwellings were to be established on these plots (in German: *Hofsteten*), which were to be adequately built (*die schollen ordenleich gepauet sein pei der zeche*). Meat and bread shops and spas were allowed to be established in one, two or more such buildings. Beer, mead and wine were also allowed to be tapped (*CIB I*, pp. 116 and 329; *Tomaschek 1897*, Nos. 84 and 86, pp. 46–47). The existence of such a tavern at *Buchberg* is mentioned in the Šlapanov deed from 1258.

6.8. Sacral building in the area of the Buchberg mining centre and its location

The presence of burial grounds in some mining centres can be directly linked to the existence of sacral constructions (*Bailly-Maître 2002*, 165–167; *Bailly-Maître – Dupraz 1994*, 145–151; *Alt – Lohrke 1998; Lohrke 2003*). Around the mid-13th century, mining churches and chapels were constructed only in the most populous mining centres in the Havlíčkův Brod region. There were several reasons for founding sacral buildings, but the most important was a large number of inhabitants of mining centres at the peak of mining activities. The capacity of the original churches located in the area was soon exceeded and, thus, the only solution was to build new churches or at least chapels directly in the mining settlements. Churches were established with the consent of the administrators and were affiliated to the most important religious centres; for *Buchberg*, such organisations were the parish churches in Brod, Přibyslav and Pohled.

None of the sacral buildings that were constructed in the mining settlements of the 13th century has been archaeologically examined in the Czech Republic; information about them is exclusively taken from documents. In the second half of the 13th century, several competence disputes occurred between the plebeians of the original parish churches on the one hand and the administrators of mining churches and chapels on the other. The first known dispute was recorded in 1256 and was judged by the Bishop of Olomouc under canonic law. The dispute concerned the churches in Dlouhá Ves and at the *Mons Medium* mine (*Mittelberg*; *Fig. 2: 7*), which were claimed by the Brod plebeian and the member of the Order of German Knights Benedict (*Benedictus*) against the mining administrator Henry (*Heinricus*); Benedict stated that the churches were located within the borders of his parish of Brod. In his defence, Henry cited that he had received both churches from the abbot of the monastery in Vilémov. However, his statement was not proved, and the churches were assigned to the Brod plebeian (*CDB V/1*, no. 90, p. 164).

The sacral building situated in the *Buchberg* mining centre was also affected by such a dispute, which was judged by the Archdeacon of Kouřim in 1265, and which broke out between the parish churches in Pohled and Přibyslav. The Pohled plebeian, Jacob, blamed Dietrich (*Dietricus*), a vicar from the church at the *mons Herliwini* (*Herliwinberg*) mine, for using income from the villages of Stříbrné Hory and Utín. However, according to Jacob, the income should have belonged to the church of Pohled. According to a complaint of the Pohled plebeian, the vicar of Herliwin caused damage to his church also by activities in a chapel at *Buchberg*, which according to him was also situated within the Pohled parish district (*CDB V/1*, No. 447, pp. 661–662). The Přibyslav plebeian did not intend to give up the chapel on *Buchberg*, and the dispute continued for many years, as is corroborated by a mandate deed dated August 27th, 1272, in which the Bishop of Prague, John III from Dražice, commissioned Helvik (the plebeian from Brod) to investigate the case. The Abbess Catherine of the local Cistercian monastery represented the Pohled side (*CDB V/2*, no. 673, pp. 307–308).

Surface surveys located the defunct mining centre Herliwinberg in the vicinity of the solitary church of St. Catherine surrounded with a cemetery (*Fig. 3: 3*; *4* and *5*). The site is located 900 m to the south-east of the village Stříbrné Hory (*Rous 1998a*, 108; *2001a*, 69, 71, 77;

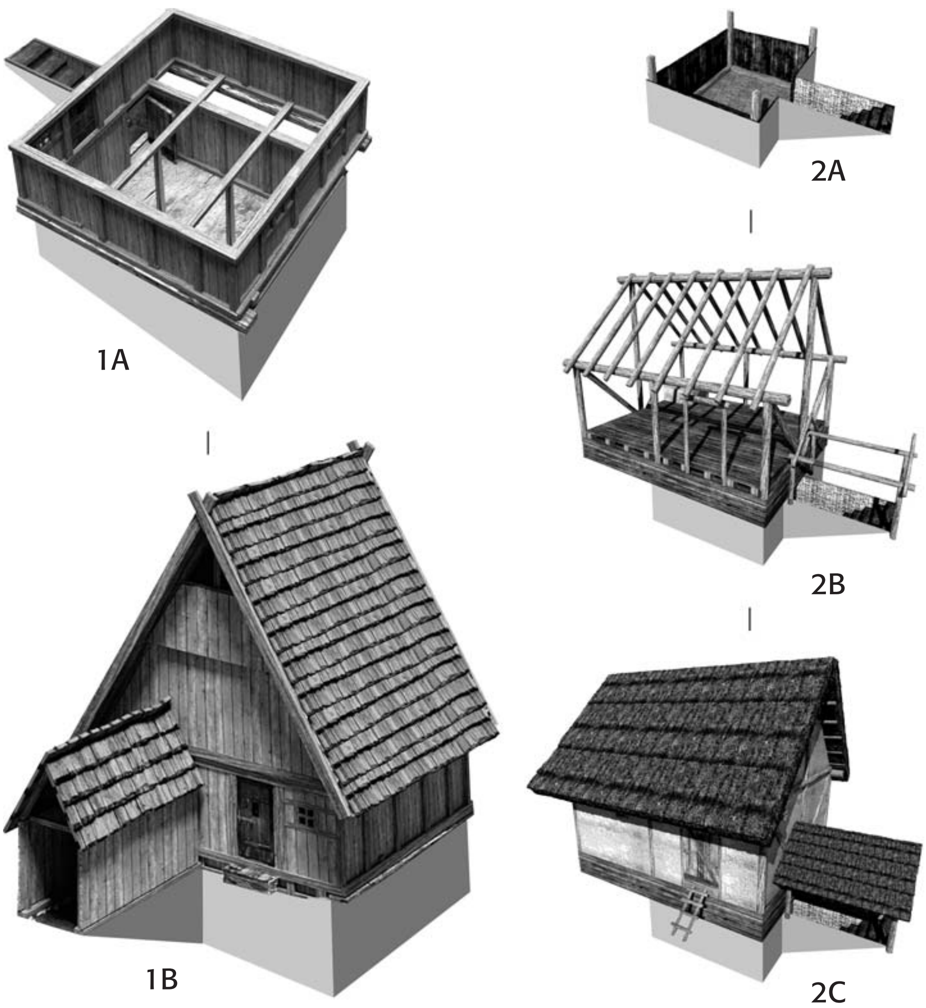


Fig. 51. *Hypothetical 3D reconstruction of the medieval mining settlement.* ***1A, 1B:*** *A model based on the excavations conducted on the Kremsiger site (Crkal et al. 2019, 906–908, 915, Fig. 3);* ***2A–2C:*** *Based on the excavated mining settlements in Jihlava and the Cvilínek site (Crkal et al. 2019, 896, Fig. 9). —* ***Obr. 51.*** *Hypotetické trojrozměrné rekonstrukce hornických obytných staveb.* ***1A, 1B:*** *model založený na výzkumu hornického areálu Kremsiger (Crkal et al. 2019, 906–908, 915, Fig. 3);* ***2A–2C:*** *model založený na výzkumu hornického areálu Jihlava a Cvilínek (Crkal et al. 2019, 896, Fig. 9).*

2004, 50). Although the medieval origin of the cemetery cannot be corroborated without proper excavations, mining communities from the *Herliwinberg* and *Buchberg* settlements could be buried here in the 13th century. At the same time, it is possible to assume that the *Buchberg* chapel probably did not fulfil this role. The chapel at *Buchberg*, unlike the *Herliwini* church, has disappeared and its location is the subject of prospecting. In this respect, the local toponymy *Hajba*, related to the northern part of the complex, is very interesting (*Fig. 9*). The Přibyslav chronicler František Půža noted in 1914 that it might be related to a distorted version of the German *Heilige Barbara*, indicating perhaps the chapel mentioned in the deeds (*Rous 1998a*, 107–108, 114; *Rous 2001a*, 80, Fig. 7). The dispute recorded in 1265 suggests a connection between the church at *Herliwinberg* and the chapel at *Buchberg*. It cannot be ruled out that the chapel was founded as a kind of branch of the *Herliwini* church. The effort of the Přibyslav plebeian to defend the chapel at *Buchberg* suggests that both sacral buildings were established at a time when both mines were under the administration of the parish of Přibyslav. However, with the establishment of the monastery in Pohled/ and the establishment of the local parish after 1265 (*Sviták 1996*, 8–11), both sites were incorporated in the newly allocated territory of the Pohled religious administration centre.

6.9. Conclusions

Systematic and long-term research and exploration of medieval mining areas in the last more than twenty years have provided a more comprehensive picture of mining activities at the end of the Přemyslid era, both in terms of spatial distribution and community infrastructure of the mining centres, as well as their social structure. Even though we are well aware that the evidence comes predominantly from non-destructive surveys and small-scale fieldwork, it can be assumed that our understanding the production of metals, and especially silver, as one of the phenomena of the later Bohemian Middle Ages has acquired more concrete contours thanks to the research of mining areas.

Buchberg can be described as a period large-scale operation. The extent of the mining area and the adjacent settlement in the 13th and 14th centuries ranks it among the largest sites of this type in the Přemyslid domain, together with sites such as *Mons medium* (*Mittelberg*) located to the south of Brod (*Fig. 2: 7*), Staré Hory near Jihlava, *Havírna* in the Svratka region and *Kremsiger* in the Ore Mountains (*Derner et al. 2019*, 932, Fig. 3; 934, Fig. 4). It can be easily compared to the most extensive European mining complexes, which briefly flourished in their time, but completely disappeared during the 14th or at the latest in the 15th century. To mention just a few of those that were archaeologically excavated: the historic *Bleiberg* at the *Treppenhauer* site in the Saxon part of the Podkrušnohoří (the foothills) region (*Schwabenicky 2009*), *Altenberg* in North Rhine-Westphalia (*Dahm – Lobbedey – Weisgerber 1998*), or *Brandes en Oisans* in the French Alps (*Bailly-Maître 2019*).

References mentioning the tavern in 1258 and the sacral building in 1265, 1272 and 1327 underline the notion of the exceptionally well-developed community infrastructure of the centre. However, the unique tenancy deed of 1258 citing a list of specific mines forming the so-called mountains (or the so-called Přibyslav mountains) also presents us with the unsolvable problem concerning the topographic identification of the named mines. The historic mining landscape around Utín undoubtedly contains other of the mines abovementioned in the text; however, they probably merged with the most dominant site as a result of later topographic and onomastic generalizations.

According to the written sources, the greatest prosperity of *Buchberg* can be traced back to the period between 1250–1278 (*Rous 2004*, 49–51). Even though the structures of the mining settlement have not been excavated (*Figs. 48–50*), it is admissible to assume that the majority of them belong to the period of the peak of local mining activities under Smil of Lichtenburg (died 1269), or in general during the reign of Ottokar II of Bohemia (1253–1278). The finds of coins of John of Luxembourg (*Fig. 45*) and the pottery belonging to the so-called second horizon (*Rous 2001a*, 80, Fig. 8: 22–49; 81, Fig. 9: 1–28) indicate that the centre continued to exist during the indignant reign of Smil's heirs and under Rajmund of Lichtenburg (died after 1329), Henry of Lipá (Jindřich z Lipé, died 1329) and possibly Hynek Žlebský of Lichtenburg (died 1351). The pottery sherds belonging to the latest horizon (*Rous 2001a*, 81, Fig. 9: 1–28) indicate that the mines survived well into the Late Middle Ages and the beginning of the Modern Era. This phase may have been related to attempts to resume metal mining under the noble family of Trčka of Lípa. However, comparing to the flourish of mining activities in the second half of the 13th century, the site underwent a period of decline. Even the rotary key (*Fig. 43*), which could be linked to the existence of mines and settlements at that time, may eventually represent a lost object.

In none of the deeds from 1258 to 1351, *Buchberg* is explicitly mentioned as a silver mine, although the reference of a urbarium (register of ownership) and the fact that Mint masters at the silver mines lent it may probably signify the production of silver. Quite the contrary, analyses of several samples of minerals from old mining waste have corroborated the presence of essentially only sulphides of non-ferrous metals (*Fig. 13*). Further possible mineralogical survey of the site would probably lead to the discovery of other ore minerals. For example, the nearby located *Ag-adit* at the Sázava River provided microscopic finds of tetrahedrite with a silver content of up to 20 wt. %, stanine and probably cassiterite (*Malý – Havlíček – Sobotka 2020*). Several ore minerals, such as boulangerite, bournonite, miargyrite, silver, berthierite, jamesonite, andorite, freibergite, chlorargyrite, or acanthite, have recently been attested and confirmed in other parts of the Havlíčkův Brod region (*Sejkora et al. 2015*). Moreover, the ore from the heaps around the shafts does not represent typical raw material to be processed, but unusable waste. Therefore, more reliable data on the quality and composition of ore concentrate can be obtained by systematic research in the areas of medieval gravity treatment facilities, where the valuable raw material was taken from the mines for further processing. Material from these facilities usually shows a larger proportion of silver-bearing lead ores, as well as a wide range of silver minerals that could be detected microscopically (*Hrubý et al. 2012*, 360, Tab. 5; *Hrubý et al. 2019*, 949–981), which contrasts with samples obtained from mining heaps. At the same time, we can probably repeat the statement that has been already mentioned in the literature, namely that the mining of polymetallic ores cannot end with the exclusive production of a single metal, however rare and expensive. The majority of mining and metallurgical centres produced a spectrum of metals according to the types of ores mined there and the sales on the market. The demand for utility metals was undoubtedly considerable at the time of emergence of towns with their rising suburbs, as well as in the construction of monasteries or new agricultural settlements. The viability of mining and metallurgical centres was, thus, proportional to their ability to meet this demand. In this respect, we can perceive the *Buchberg* mining complex as a wide-range producer of copper, lead and iron for the regional and long-distance market. Silver, which mainly utilised by the royal mint in Brod, may not have been the basis for a long-term economy and the existence of the centre as it represented a minority volume product.

English by Petra Maříková Vlčková

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Souhrn

Historické souvislosti nejstarší středověké těžby stříbronosných rud na Havlíčkobrodsku

Po polovině 13. století zažívaly přemyslovské země především zásluhou Českomoravské vrchoviny svůj první rozkvět produkce barevných kovů. Jedno z center těžby polymetalických rud se v té době nacházelo poblíž obce Utín (*obr. 1: 8*; *2: 10*). Neslo pojmenování *Buchberg* (*Mons Fagus*) a mělo rozvinutou komunitní infrastrukturu zahrnující sídliště, sakrální objekt a šenk (*hospicium*). Torzální obraz komplexu lze rekonstruovat na základě listin a nedestruktivní prospekce doplněné sondáží. Součástí studia komplexu jsou geochemické analýzy pestrého spektra archeometalurgického materiálu. Těžba stříbra u Utína vyplývá z listiny z 25. října 1258 (*CDB V/1*, č. 167, s. 267). Kromě jmen báňských královských úředníků známe i jména těžařů, kterým byly podniky propůjčeny. Listina obsahuje výčet dolů a štol, který dokládá mimořádný rozsah důlní činnosti. Poslední stopu o dole (*Puchberch*) lze zachytit k roku 1351 (*CIM II*, s. 575, č. 1362).

Topografie, geologické a ložiskově mineralogické poměry

Areál je situován na vyvýšenině mezi obcemi Hesov a Utín (*obr. 12*). *Buchberg* je vzdálen od Havlíčkova Brodu 9,3 km jihovýchodně.

Lokalita je součástí tzv. havlíčkobroského rudního revíru s výskyty polymetalických mineralizací. Typický je pyrit, pyrhotin, sfalerit a arsenopyrit; v žilovině převládá křemen. Žíly mají mocnost do desítek cm a směrnou délku nejvýše v prvních stovkách metrů. Dislokační zóny jsou podstatně mohutnější. Stopy historické důlní činnosti lze pozorovat na dvou rudonosných strukturách rozsáhlé dislokační zóny směru SSZ–JJV (*obr. 2, 9* a *10*).

Metodika prospekcí

Díky aktuálnímu odlesnění areálu bylo možné použít dálkového digitálního sběru dat metodou vícesnímkové fotogrammetrie *Structure from Motion* (SfM). Při magnetickém měření byla v sezónách 2013 a 2014 proměřena plocha **F** (5,0 ha; *Fig. 11: F*, parcel No. 209/1). V roce 2018 byla proměřena zatravněná plocha **G** (5,2 ha) západně od dobývek (*obr. 11: G*).

Při sběrech byla v ploše **B** a **F** vytyčena ortogonální síť odpovídající síti magnetického měření z let 2013 a 2014 (*obr. 11: F*). Po hranicích čtverců byly stanoveny sběrové trasy nejprve v podélném směru a pak i v příčném směru, což zvýšilo interpolační a interpretační potenciál při pozdější extrapolaci dat do plochy. V těchto trasách byly v pásech šířky 2 m prováděny sběry zaměřené zvlášť na keramiku a zvlášť na strusku. Data byla zpracována v prostředí ArcGIS interpolačními metodami *Nearest Neighbor* (*Burrough 1986*) a *Kriging* (*Ebdon 1985*). Sběrová prospekce byla doplněna prospekcí detektorem kovů. Při ní se ukázala problematická účinnost detektorů s pevným nastavením parametrů. Příčinou byl hojný výskyt strusky s přítomností kovových fází, jejichž odezvu se nepodařilo odladit.

Analytika archeometalurgického a antrakologického materiálu

Strusky (*obr. 26–29*; *tab. 1* a *2*): Na základě fyzikálních vlastností byla vybrána reprezentativní skupina vzorků představující 5–10 % souboru. U těchto vzorků bylo ručním XRF analyzátorem měřeno prvkové složení. Magnetická susceptibilta strusek byla měřena ručním kapametrem KP-5. Ze strusek byly zhotoveny výbrusy a nábrusy, které byly studovány v optickém mikroskopu Olympus BX40. Nábrusy byly studovány v elektronovém mikroskopu s EDX analyzátorem.

Sférule a okuje (*obr. 30* a *31*; *tab. 3*): Okuje byly z půdy separovány šlichováním. Takto získané těžké nerosty byly zkoumány v optickém mikroskopu. Dále byly vzorky zkoumány v elektronovém mikroskopu a po přípravě leštěných nábrusů i elektronovým rastrovacím mikroskopem s připojeným EDX analyzátorem.

Slitky barevných kovů (*obr. 32–36*; *tab. 4–8*): Slitky byly očištěny a analyzovány s pomocí ručního XRF spektrometru.

Dřevěné uhlíky (*tab. 10*; *graf 1*): Zlomky uhlíků byly analyzovány pomocí světelného mikroskopu. Na čerstvých lomných plochách byly uhlíky prohlíženy při zvětšení 50×, 100× a 200×.

Exkavace reliktů metalurgických zařízení sondou 2/2018

Magnetickým měřením byla v prospektovaném areálu **F** zachycena oblast maloplošných anomálií vysokých hodnot. Ty byly seřazeny v dvojité linii v ose JZ–SV a lze je interpretovat jako baterii asi dvaceti pecí (*obr. 11: F*).

Soustava výkopů 0501, 0506, 0508 a 0509 s komponenty metalurgické činnosti: Dominantním prvkem byl mělký, avšak rozsáhlý výkop 0501 s plochým dnem a s komponenty metalurgické činnosti (*obr. 20–25*).

Zahloubená struktura 0502 s komponenty metalurgické činnosti: Jedná se o výkop o rozměrech 190 × 190 cm. Ve svrchní části výplně se nalézala kovářská výheň s průměrem 55–58 cm stavěná z kamenů a především strusek (*obr. 22* a *26*).

Zahloubená struktura 0503 s komponenty metalurgické činnosti: jednalo se o výkop kruhového půdorysu s průměrem 120 cm a hloubkou 58 cm). Svrchní část výplně tvoří uloženina 0108 s výraznou příměsí strusek a uhlíků (*tab. 10*; *graf 1*).

Struktury vázané na výkopy 0501, 0502, 0503, 0506, 0508 a 0509 mají přes stratigrafickou posloupnost znaky přibližně současného vzniku i nedlouhé existence. Závěrečnou fázi datuje stříbrný *parvus* Jana Lucemburského (1310–1346), který byl nalezen ve výkopu 0501 a v uloženině 0106 (*obr. 49: 5*). V bezprostředním okolí nebyly nalezeny stopy žádných stavebních či dokonce obytných struktur. Uloženiny měly výlučně technogenní charakter.

Strusky s vyšším podílem železa

Vedle strusek, které nelze jednoznačně typizovat, a které tvoří většinu souboru, lze makroskopicky lze vyčlenit dva typy:

Typ 1 (*obr. 26, 27*; *28: 2, 3, 6, 12*; *tab. 1*): strusky mají na povrchu hnědou, hnědočernou či hnědošedou barvu. Povrchově jsou členité. Jsou silně porézní a obvykle s vysokým obsahem uhlíků. Nejčastěji mají plankonvexní tvar.

Typ 2 (*obr. 28: 4, 5, 7, 9–11, 13*; *29*; *tab. 2*): strusky jsou zpravidla šedé nebo černé, obsahují i zelené či modré sklovité partie. Drobné modrozelené sklovité úlomky byly nalézány i samostatně. Tyto strusky nemají miskovité (plankovexní) tvary. Na sklovitých partiích je někdy patrná fluidální struktura. Sklovité strusky jsou málo porézní a neobsahují uhlíky.

Okuje a sférule

Okuje jsou ploché (*obr. 30: 5*). Ve feromagnetickém podílu výrazně převažují nad sférulemi. Podle EDX analýz jsou okuje tvořeny hlavně wüstitem (FeO). Další podstatnou fází je sklo (*tab. 3*). Sférule jsou nejčastěji kulovité (*obr. 30: 2, 3, 4, 7*; *31*). Podle EDX analýz převládá wüstit. Méně je pak zastoupen magnetit, sklo a křemen (*tab. 3*).

Slitky olova, měďnatých kovů, cínu a stříbra

Z prospekcí pochází soubor více než 80 olověných slitků (*obr. 32–34*). U dalších slitků lze rozlišit čtyři materiálové skupiny. První jsou Cu-Sn slitiny (i. č. Bu 24, Bu 55, Bu 49, *obr. 36: 1–5, 7, 9*; *tab. 5*). Jde o bronzovinu se zastoupením olova v množství 1,51–2,05 %. Druhou jsou Cu-Pb slitiny (i. č. Bu 19, Bu 54; *obr. 36: 6*; *tab. 6*). U těchto předmětů byl zjištěn podíl stříbra do dvou procent. Poslední je Sn slitiny (i. č. Bu 43, *obr. 36: 8*; *tab. 7*). Jedná se o jediný předmět odlitý do záměrné formy. Z prospekcí v ploše **A** pochází slitek stříbra o hmotnosti 4,671 g (*obr. 36*; *tab. 8*; i. č. Bu 29).

Keramika

Celkově bylo prospekcemi v letech 1981 až 1998 získáno 2887 zlomků keramiky (*Rous 2001a*, 72, Obr. 7; 80–81, Obr. 8–9). Sondážemi v roce 2018 byl nalezen soubor asi jen tří desítek keramických zlomků (*obr. 43: 4*; *44*). Keramiku lze rozdělit do tří horizontů. Nejstarší představuje oxidačně vypalované zboží s podílem tuhové keramiky (*Rous 2001a*, 80, Obr. 8: 1–21). Druhý horizont je charakteristický protoredukčním výpalem (*Rous 2001a*, 80, Obr. 8: 22–49; 81, Obr. 9: 1–28). Část souboru tvoří zlomky pokročilé redukční keramiky z pokročilého 15. století a z 16. století (*Rous 2001a*, 81, Obr. 9: 1–28).

Železné předměty

Mezi železnými předměty, většinou neurčitelnými, nebo jiného, než středověkého stáří, vyniká esenciální druh artefaktů středověkých hornických lokalit, a sice hornická želízka (*obr. 45* a *46*). Součástí souboru železných předmětů je také otočný klíč s dutým dříkem a páskovým okem kruhového tvaru (*obr. 47*). Jde o rozšířený typ 15. až 17. století (*Kilian 2008*, 22, 27). Je otázka, zda nález souvisí s novověkými pokusy o obnovení těžby, nebo zda se jedná o náhodnou ztrátu.

Závaží v souvislostech produkce drahých kovů

Pravidelnou skupinou nálezů ze středověkých hornických center jsou závaží. Mohou souviset s činností zkoušečů (*examinatores*) a rudokupců (*emptores metalli*). Závaží na *Buchbergu* evidujeme šestnáct. Nejrozšířenější typ představují olověná závaží válcovitá až dvojkónická (*obr. 41: 1–9*). Druhým typem jsou bronzová nebo mosazná miskovitá závaží (*obr. 41: 10*; *42*). Specifickou skupinu představují olověná kolečka, popř. kužele s otvorem (*obr. 41: 11–15*).

Předměty z barevných kovů, skleněné perly a mince

V ploše **F** byly nalezeny dvě destičky s nýty, které byly nákončím opasků (*obr. 48: 7, 8*). Mezi součásti oděvu řadíme také dvě měděné ozdobné nášivky v podobě stylizovaného květu lilie a s kruhovým otvorem (*obr. 48: 1, 2*). Dále lze zmínit běžné středověké přezky (*obr. 48: 9–12*). Povrchovými prospekcemi byl nalezen také skleněný korálek a zlomek korálku (*obr. 50*). Detektorovým průzkumem byly nalezeny také čtyři pražské groše Jana Lucemburského (1310–1346). Parvus Jana Lucemburského představuje jediný exkavačně determinovaný mincovní nález (*obr. 49*).

Otázka těžebního areálu

Otázka doby vzniku a provozu štol na sázavském levobřeží je bez dendrochronologických dat z výdřev prakticky neřešitelná. To i přesto, že o dvou provozovaných a blíže nelokalizovaných štolách se výslovně zmiňuje již listina z 25. října 1258 (*CDB V/1*, č. 167, s. 267). Tzv. Freibergova štola se podle listiny z roku 1261 měla dokonce nacházet na *Buchbergu* (*CDB V/1*, č. 252, s. 385). Při zachování kritického přístupu je nejisté i datování pozůstatků šachet s odvaly. Zdá se, že pokusné a průzkumné práce v pozdním středověku a v raném novověku změnily starší montánní reliéf. Stopa hornictví ve 13. a 14. století tak zůstala zachována v rozměrech odvalových pásem.

Otázka hutnictví polymetalických rud a neželezné metalurgie

Vzhledem k absenci strusek po tavbě polymetalických rud předpokládáme, že hutnictví barevných kovů probíhalo na jiném místě. Nejbližším struskovištěm je asi 0,75 km vzdálený areál na jižním břehu Sázavy (*obr. 3: 2*). Zde byla potvrzena přítomnost drcené popř. mleté rudniny i vrstvy strusek (*Hrubý – Malý – Milo 2016*).

Interpretačně problematické jsou nálezy slitků mědi, dále slitin Cu-Sn a slitin Pb-Sn (*tab. 5–7*). Jedná se sice jen asi o desítku předmětů (*obr. 40*), avšak v rámci lokality zjevně nejde o náhodný výskyt bez souvislosti se středověkou metalurgií. V principu se může jednat i o doklady slévačství. Kromě toho může jít o stopu prubířství. Za indikátor hutnické, nebo pravděpodobněji prubířské praxe, lze rozhodně považovat četné slitky a úkapky olova (*obr. 36–38*; *tab. 4*). Souvislost s prubířstvím je velmi pravděpodobná u pecičkovitého slitku stříbra (*obr. 39*; *tab. 8*).

Otázka těžby železných rud, jejich hutnictví a prvotního kovářského zpracování

Sondáž zpřesnila naše představy o metalurgickém pracovišti na okraji hornického sídliště, které má znaky železářské huti a kováren. Některé ze strusek typu 2 mohly vzniknout přetavením vyzdívek a výmazů pecí a výhní. Další možností je, že jde o odpadní produkt z tavby nevytříděných železných rud s vyšším podílem hlušiny. Část strusek typu 2 je pravděpodobně odpadem po hutnictví železných rud. Část strusek (typ 1) vznikla při kovářském zpracování. Svědčí pro to miskovité celotvary, které nejspíš pochází z nístějí kovářských výhní (*obr. 30* and *31*). Dokládá to také extrémní obsah okují a sférulí.

Otázka metalurgických paliv

Zajímavou výpověď v otázkách kvality metalurgických paliv, popř. výběru vhodných druhů dřevin pro jejich výrobu poskytla anthrakologická analýza vzorku dřevěných uhlíků (*tab. 10*; *graf 1*). Dominantou souboru je bříza (67 % uhlíků), následovaná pravděpodobně osikou (*Populus* a taxon *Populus/Salix*) – celkem 23 % fragmentů uhlíků. „Klimaxové" dřeviny hlavního stromového patra lokálních lesů (buk, smrk, javor) tvoří pouhé 3 % uhlíků. Může to znamenat, že některé z pyrometalurgických úkonů (pražení, vyhřívání pecí před novou tavbou) nevyžadovaly selektovaný druh paliva.

Sídlištní areál

V ploše **B**, **E** a **F** bylo detekováno 88 magnetických anomálií, u nichž pozorujeme rozměrové shody s tzv. zemnicemi (*obr. 11: F*; *55*). V kombinaci s leteckým snímkováním z roku 2018 se na ploše **B** potvrdila přítomnost nejméně sedmi takových struktur v řadovém uspořádání (*obr. 11: B* a *53: 1–7*).

Sakrální objekt a otázka jeho lokalizace

Žádná z hornických sakrálních staveb 13. století nebyla v ČR zkoumána archeologicky, údaje o nich jsou výhradně z listin. V druhé polovině 13. století jde o kompetenční spory mezi plebány původních farních kostelů na straně jedné, a správci nebo vikáři hornických kostelů a kaplí na straně druhé. Sakrálního objektu v důlním středisku *Buchberg* se týká spor, který v roce 1265 soudil kouřimský arciděkan, vypukl mezi farními kostely v Pohledu a v Přibyslavi (*CDB V/1*, č. 447, s. 661–662). Snaha přibyslavského plebána uhájit kapli na *Buchbergu* naznačuje, že sakrální objekt byl založen ještě v době, kdy se důl nacházel ve správě přibyslavské farnosti. Se založením pohledského kláštera a vznikem tamní farnosti po roce 1265 (*Sviták 1996*, 8–11) se však tato střediska ocitla na nově vyčleněném území pohledské duchovní správy.

Závěrečné shrnutí

Největší rozkvět *Buchbergu* lze klást do období mezi léty 1250–1278. Nálezy ražeb Jana Lucemburského (*Fig. 49*) naznačují kontinuální existenci ve 14. století. Keramika nejmladšího horizontu naznačuje existenci dolů i na začátku novověku. V žádné z listin z let 1258 až 1351 není *Buchberg* výslovně jmenován jako stříbrný důl, ačkoliv skutečnost, že jej propůjčovali mincmistři na stříbrných dolech, produkci stříbra znamená. Lze však vyslovit myšlenku, že těžba polymetalických rud nemůže končit produkcí jediného kovu. Poptávka po kovech byla v době budování měst i s rodícími se předměstími, při výstavbě klášterů či nových zemědělských osad značná. Životaschopnost důlních středisek tak byla úměrná schopnosti této poptávce vyhovět. *Buchberg* si proto lze představit jako širokosortimentního producenta kovů pro regionální i dálkový trh. Stříbro tak nebylo jako objemově minoritní produkt základem dlouhodobé existence střediska.

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