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Metallurgical production sphere in the Bohemian-Moravian Highlands at the end of the Přemyslid era : summary

In: Hrubý, Petr. *Metalurgická produkční sféra na Českomoravské vrchovině v závěru přemyslovské éry.* Vydání první Brno: Filozofická fakulta, Masarykova univerzita, 2019, pp. 206-222

ISBN 978-80-210-9226-6; ISBN 978-80-210-9227-3 (online : pdf)

Stable URL (handle): https://hdl.handle.net/11222.digilib/141108
Access Date: 29. 11. 2024
Version: 20220831

SUMMARY

Metallurgical Production Sphere in the Bohemian-Moravian Highlands at the End of the Přemyslid Era

Content

1 Bohemian-Moravian Highlands in the context of medieval settlements

The discovery of argentiferous ores in the heart of the Bohemian-Moravian Highlands resulted after the mid-13th century in the emergence of a mining, urban and agrarian landscape. From written, archaeological and archaeo-environmental sources we know that the first traces of human presence in the 8th to 11th centuries were followed by real colonisation since the beginning of the 12th century.

The data on early medieval human activities were acquired from samples taken in alluvial plains (Tab. 1). An example is the floodplain of Puklický Stream (Fig. 5: 26). A calibrated AMS ^{14}C date AD 651–764 was acquired from a sample at the Quaternary base (*Cherkinsky 2015*). It is the most recent deposit still illustrating the situation before the arrival of colonists. The oldest human-based changes fall within the interval AD 760–882 after calibration (*Goslar 2015b*). Another dates resulted from the research into the floodplain of Bělá Stream (*Hrubý et al. 2014b*, 69–84). The sampling was focused on sediments with driftwood, which was dated with the help of ^{14}C to the interval AD 765–1023 after calibration (*Světlík 2013a*).

The region on the middle reaches of Jihlava River has been colonised since the beginning of the 12th century at the latest. An important role in this process was played by the Benedictine Abbey in Třebíč, founded in 1101 (*Kuthan 1994*, 407–422). Colonisation of the Jihlava region at the end of the first third of the 13th century is also mentioned in documents from the time span 1256–1257 (*CDB III/1*, No. 48, pp. 48–49; *CDB III/1*, No. 49, pp. 49–50). Settlements from before the mid-13th century are listed in the 1234 and 1238 charters (*CDB III/1*, No. 88, pp. 97–100 and No. 180, p. 224). Ceramic finds with elements of the late 12th and early 13th centuries were acquired from river sediments within sight of the Church of St. John the Baptist (Fig. 7 and 8; Fig. 9 and 30: 9). One part of a settlement area with ovens and ceramics from the first third of the 13th century (Fig. 10–12) was uncovered at the edge of the floodplain in Kostelec near Jihlava.

The existence of a settlement is supposed in the neighbourhood of St. Adalbert Church in Havlíčkův Brod (*Rous 1982*, 39, 44–45). Another indicator is a glass bead from Utín (Fig. 13: 1 and 2). This type is considered an import and is usually dated to the 10th to 12th centuries, but it also may have occurred around 1200 (*Krumphanzlová 1965*; *Schubert – Wegner 2015*, 233). From the same place we also know lead rings (Fig. 115: 10–12) which are difficult to date, but they correspond to 11th and 12th century finds (*Rozmus 2014*, 217, 219, 224; *Bláha et al. 2013*, 308). New information comes from the research in the floodplain of Březina Stream near Česká Bělá (Fig. 23: P1–3, Fig. 24 and Fig. 140) where a split wood plank was found. A sample taken from this piece of wood was dated AMS ^{14}C to the interval AD 1016–1155 after calibration (Tab. 1).

The monastery in Želiv was founded in 1144 as a Benedictine abbey, but it was reoccupied by the Premonstratensians in 1149. The small collection of finds from this locality encompasses assemblages of artefacts from older excavations of a burial ground (*Hejhal 2012*, 52–53; *Thomová 2014*, 64). The colonisation before the mid-12th century was initiated by the Bishopric of Prague (*Böhm 1926*, 47). In a 1203 charter we can find a list of settlements belonging to the Rynárec parish (*CDB II*, No. 33, p. 31). Most recently, a relic of a forest stand was uncovered near Ústrašín on the upper reaches of Želivka River (*Hrubý – Těsnohlídek 2016*). Traces of the slash-and-burn method were identified among the roots of felled trees in this area (Fig. 5: 27 and Fig. 14). The AMS ^{14}C dates from spruce branches yielded the intervals AD 1168–1266 and AD 1157–1264 after calibration (Tab. 1).

2 Deposits of gold and polymetallic ores

The primary auriferous mineralisation in the Želetava region is contained in quartz veins of gneisses and quartzites. Exogenous accumulations are mainly found in floodplains of watercourses (*Morávek 2015*, 74, 75, 76, 77; also Fig. 5: A). Quartz veins with gold can be characterised as stockworks of several decimetres to metres in thickness. They contain about one centimetre thick quartz veins. Gold is bound to the oldest quartz and is usually concentrated asymmetrically in contact of the quartz vein with gneiss (*Vokáč et al. 2007*; *Houzar et al. 2007*).

Gold in the Pacov region is predominantly of low purity and is bound to vein structures. In closer connection to primary deposits we can find eluvial and deluvial placers containing the so-called sharp-edged gold. Alluvial gold is found in sedimentary fills of floodplains and on terraces of watercourses. The size of gold flakes reaches a maximum of 1.5 mm (*Litochleb – Sejkora 2004*, 168–170; *Morávek 2015*, 64, 66, 67).

The primary gold deposit in the Humpolec region is situated in the area called *Trucbába* and is bound to migmatised paragneisses and quartziferous erlanes (Fig. 22). Weathering and erosion gave rise to exogenous accumulations. Gold flakes are little abraded (*Losertová et al. 2011*; *2012*, *Losertová 2013*). The *Orlík* and *Na štůlách* zones contain gold of 91.9–99.7% purity, with Ag content of up to 10% and with size of several decimal millimetres to millimetres (*Litochleb 1977*; *1981*; *Litochleb et al. 1982*; *Litochleb – Sztacho 1977*).

In the Havlíčkův Brod region, small primary deposits as well as numerous gold catchment areas are situated in the neighbourhood of Golčův Jeníkov and Vilémov (*Morávek 2015*, 35; see Fig. 5: E). Auriferous sediments are also registered south of Havlíčkův Brod (*Koutek 1960*; *Morávek et al. 1992*, No. 272). The occurrence of gold flakes in stream sediments near Česká Bělá was proved by schlich testing (Fig. 15: 1–6; Fig. 23: 2 and Fig. 25). Primary mineralisation zones, where gold is either interspersed in quartz or bound to polymetallic ore bodies, are eroded by water and the contained gold grains are washed out and drifted to the sedimentary fills of floodplains.

In the Havlíčkův Brod region and partly also in Jihlava and Pelhřimov regions we can find ores of the so-called sulphide polymetallic association (k-pol). Among typical ore minerals are black sphalerite, pyrite, galena, arsenopyrite and pyrrhotine; less frequent are chalcopyrite, stannine, pyrargyrite, cassiterite and silver sulphosalts, typical is the absence of barite. The second type is the Upper Variscan polymetallic mineralisation (pol) in one part of the Jihlava region and in the Svratka basin (*Malý 1998b*). Among typical ore minerals are sphalerite, galena, chalcopyrite and pyrite; rarely occurring minerals are pyrargyrite, tetrahedrite, freibergite and argentite (*Vosáhlo 1988*; *Litochleb 1996*; *Pluskal – Vosáhlo 1998*; *Malý 1998b*; *2001*).

Mineralised structures in the Jihlava region are distributed in the surroundings of dislocation zones. One of the most important structures is the Staré Hory dislocation zone (Fig. 30). The thickness in its northern part reaches up to 80–100 m (*Vosáhlo 1988*, 56–58). Ore minerals are represented by sphalerite, galena, less frequently chalcopyrite, arsenopyrite, pyrite and tetrahedrite (Fig. 17: 1, 2; *Pluskal – Vosáhlo 1998*).

The Havlíčkův Brod ore district is divided into several sub-regions (Fig. 5: E, G, H). Among described minerals are arsenopyrite, galena, chalcopyrite, pyrite, sphalerite, graphite; gangue is composed of quartz with chlorite and dolomitic carbonate (*Malý 2001*; *Malý – Rous 2001*; *Koutek 1960*).

The mineralised ore structures in the Pelhřimov region are found in the contact zone of the monotonous Moldanubicum group and the Central Moldanubian Pluton (Fig. 5: I). Typical is the occurrence of small veins copying the elements of geological structure. Mineralised segments in NE–SW direction are at most 500 m long. Ores are represented by pyrite, pyrrhotine, arsenopyrite, sphalerite, galena, tetrahedrite and chalcopyrite (Fig. 16, Fig. 17: 3–5, Fig. 61; *Litochleb 1996*).

3 Deposits of silver and non-ferrous metals in Europe until the 13th century

The latest studies map out the origins of lead and silver production on the British Isles in the Anglo-Saxon period (*Timberlake 2014*, 65, 66, 69). One of the oldest silver production centres in the western Frankish area is Melle. Mining was conducted here from the 6th century until the end of the 10th century (*Téreygeol 2002*; *2012*; *2014a, b*; *Bonnamour – Marconnet 2014*). The 10th and 11th century mining activities in the Vosges were carried out in the *Pfaffenloch* and *Haut Altenberg* complex (*Gauthier et al. 2015*). The first peak of ore mining activities after AD 950 was also recorded at Wiesloch near Heidelberg (*Hildebrandt 1993*, 255–265; *Kötz 2009*; *Ströbele et al. 2010*; *2014*). The earliest evidence of mining activity in the *Venetianer* adit in Sauerland dates back to the 10th century (*Straßburger 2014*, 210–214). The Harz Mountains represented a centre of copper ore mining and metallurgy since the Carolingian period already (*Bartels et al. 2007*, 114, Abb. 40, 131, Abb. 51, 136; *Alper 2003*).

An important centre in the all-European context was Samarkand in Central Asia, a famous city in the sphere of Khorasan. Several centres are located in Sentjab. The main centres of lead ore mining, however, are situated southeast of Tashkent. The most extensive relics of 7th to 10th century metallurgy are located in Lashkerek (*Merkel et al. 2013*). The research is also focused on silver in the Baltic region since the 9th century, which instigated the long-distance trade with Novgorod, Kiev and Central Asia. This also explains the occurrence of Islamic silver in North-Eastern Europe in the 9th and 10th centuries (*Merkel et al. 2012*; *2013*). The proportion of Central Asian metal among silver finds from the Nordic sphere has diminished after AD 1000 (*Merkel et al. 2015a*; *2015b*, 233; *2016*, 49–66, 91–120). Another well-known silver producers were the Imiter Mines in Central Morocco. They mainly flourished under Emir Abd ar-Rahman II around AD 800 (*Šrein et al. 2003*, 36).

Mining activity in Le Colombier, southern France, was conducted since the 11th century (*Minvielle Larousse – Bailly-Maître 2013*). The mining activities in the Vosges continued on the localities *Altenberg*, *Pfaffenloch* and *Patris* (*Gauthier et al. 2015*, 273–274). In Schwarzwald we can find evidence of 11th century ore mining on the *Riester* vein (*Goldenberg 1999*). The Wiesloch, Nußloch and Leimen complex experienced a boom of mining activities (*Kötz et al. 2009*; *Ströbele et al. 2010*; *2014*). The 11th century in the Harz Mountains is characterised by the upswing of Goslar and the local mint. The excavation of metallurgical facilities in *Huneberg* and *Riefenbach* revealed numerous innovations (*Asmus 2012*, 124–142). The discoveries from Tarnowskie Góry, Katowice and Dąbrowa Górnicza in southern

Poland represent a different spatial and chronological context (*Rozmus 2014*, 129–130, 192–200).

In the first half of the 12th century, plumbic ores began to be extracted in western England and Wales (*Rippon et al. 2009*, 13–35, 45–69; *Claughton 2007*; *2010*). In the highland region of the Massif Central in southern France, there was a centre near *La Rodde Bailly-Maître 2002*, 22). The *Largentière*, *Chassiers*, *Montréal* and *Tauries* complexes were situated in Ardèche (*Bailly-Maître – Girard 2002*; *Bailly-Maître – Gonon 2005*). Polymetallic ores were also extracted near *Gévaudan* in Mont-Lozère (*Bailly-Maître 2010a*). The centre in *Brandes* also was important (*Bailly-Maître 2002*).

In the Italian, Austrian and Bavarian alpine regions we must base ourselves mainly on written documents. These sources are related to monastic, episcopal and archiepiscopal demesnes and most of them come from the times of Frederick I Barbarossa (*Hägermann 1984*, p. 16, No. 12 and 13, p. 17, No. 28). Trentino represented an important silver ore mining region since the mid-12th century. Relics of mine workings were explored in the surroundings of the *Monte Calisio* massif (*Straßburger 2014*, 214–215). Research has also been conducted in the Montafon region in Vorarlberg. The origins of activities in metallurgical centres *Bartholomäberg* and *Kristberg* date back to the 11th and 12th centuries (*Krause et al. 2015*).

The mining activity in Schwarzwald continued on the *Riester* deposit near Sulzburg. The centres in Wiesloch and Plettenberg, or the complex near the Ramsbeck village in Central and Lower Rhineland still were in operation (*Straßburger 2014*, 210–214; *Hägermann 1984*, 15, No. 2). The precious metal production in the Harz Mountains culminated during the twelfth century. The old metallurgical centres on traditional deposits of cupriferous ores were superseded by the quickly developing processing facilities for sulphidic lead and silver ores. The ore mining and metallurgical production on the *Johanneser Kurhaus* site experienced the greatest upswing since the mid-12th century (*Bartels et al. 2007*, 115–117, 165–171, 171–188; *Alper 2003*; *Asmus 2012*, 124–142).

Mining activity in the Meissen region has developed since the 1160s (*Hoffmann – Richter 2012*). In the last quarter of the 12th century, silver ore mining has developed in Dippoldiswalde at the edge of the Ore Mountains in Saxony. Archaeological research revealed an extensive system of mine workings. An interesting find is represented by preserved mine timbering, dated by dendrochronology to the 1170s and later (*Hemker et al. 2012*; *Y. Hoffmann 2011*; *Hönig – Lentzsch 2014*; *Scholz 2012*; *2015*; *Westphal – Heußner 2012*).

12th century silver and lead production was conducted in Upper Silesia and Lesser Poland (*Rozmus 2013*, 128, Ryc. 2; *2014*, 17–28). A great deal of information was acquired from the area in Sosnowiec as well as from the excavated metallurgical facility in Dąbrowa Górnicza, where a hoard of silver ingots and coins from the second half of the 12th century was discovered (*Rozmus et al. 2014*).

The access of Western and South-Western Europe to silver was more or less secured, even though the influx of this metal was regionally and temporally imbalanced. An important epoch is represented by the 12th century when the prospecting activity was very intensive. Mining and metallurgical technologies were used for the first time in the eastern part of Central Europe as well. However, the mountainous regions in the Přemyslid domain were not influenced by this wave until the first half of the 13th century. The research tries to answer the question to what extent this hundred-year-long process was fluent and continuous, and to what extent it can be divided into partial waves determined by political, economic or demographic factors.

4 Metallurgy and distribution of non-ferrous metals in the Přemyslid domain until the 13th century

Evidence of precious metal processing was found in castle centres and suburbs (*Bartošková – Štefan 2006*, 739; *Boháčová 2006*, 714–715; *Klápště 2005*, 339). Unique late 11th century relics come from earlier excavations of the acropolis on Vyšehrad. They confirmed the purification of silver or gold, assay and smelting (*Varadzin – Zavřel 2015*). Evidence of metallurgy is known from the hill forts in Libice nad Cidlinou and Oldříš. The spectrum of finds comprises fragments of crucibles and shards with melt on the surface. Chemical composition of melts, including heterogeneous materials, indicates that they might represent the results of schlich testing (*Mařík – Zavřel 2012*).

The occurrence of lead artefacts can be observed with early medieval castle centres as well as with lowland settlements and market places (*Biermann – Macháček 2012*, 183, 184; *Macháček et al. 2013*; *Macháček – Měchura 2013*, 226–228; *Bláha et al. 2013*; *Blažková et al. 2017*, 124). Lead was used as a raw material in metallurgy, but this fact is not evidenced in the early medieval Přemyslid domain. Lead has also been used in building constructions, jewellery making and metal founding.

The relics of metallurgical facilities and metallurgical waste show that since the 12th century the influx of non-ferrous metals began to be stabilised, even in rural area. Workshops from the turn between the 12th and 13th centuries were excavated in the Prague's Klementinum (*Havrda – Zavřel 2008*). 12th century workshops were operated in the forefield of Vyšehrad, in the street Na Slupi. Analyses are applied to detect the

lead isotopes, which indicate the origin from southern Poland (*Ettler et al. 2015*). Metal founding at the end of the 12th century and at the dawn of the 13th century is evidenced in Brno (*Hložek et al. 2004*; *Procházka 2011*, *Gregerová et al. 2011*, 47–50; 215, 239–240). Another type of metallurgical areas in urban agglomerations is represented by bell-founding workshops, for example in the Náměstí Republiky square in Prague (*Vyšohlíd 2011*).

Small lead artefacts might be interpreted as low-value means of payment, which were widely used in the rural areas of Central and Eastern Europe, particularly since the 11th century when the accessibility of silver for these regions has diminished. An increased amount of non-ferrous metals in the Czech milieu since the end of the 12th century can be associated with the population growth in urban centres. High-developed market and crafts induced an increased demand for raw materials. The amount of raw materials imported from the newly established mining centres in the neighbourhood of the Czech lands surpassed the previous early medieval distribution.

5 Periodisation of precious metal mining until the end of the Přemyslid era

The earliest phase, beginning from the mid-12th century, can be associated with exploitation of exogenous gold deposits. This fact corresponds with trends in other parts of the Bohemian Massif (*CDB II*, No. 254, p. 244; *CDS XX*, No. 9 and 12, p. 3; *Večeřa et al. 2014*). Placer mining is indicated by the profile of Březina Stream near Česká Bělá. The local sediments contained a fir plank, which has been considered a remnant of ore washing facilities (Fig. 23: P3, Fig. 24). The calibrated AMS ^{14}C dates vary between AD 1016 and AD 1155. Placer mining is also evidenced by the situation on the stream north of the town. A fir trunk with cut marks (Fig. 23: 2 and 25) was documented at the base of a tailings pile. Dendrochronological dating revealed that the tree was felled in winter of 1228/1229 (Tab. 2). A similar situation was observed near the village of Hory, where a fir trunk, felled in 1209, was found at the base of a tailings pile (*Vokáč et al. 2007*, 33). The extraction of gold from placer deposits did not end with the beginning of silver-bearing polymetallic ore mining, even though the economic significance of these two metals was different.

A remarkable report on the mineral resources in Bohemia was provided by *Bartholomaeus Anglicus*. In the work *De proprietatibus rerum*, chapter *De Bohemia*, he mentioned that the land was rich in gold, silver, tin and other metals (*auro, argento, stanno et ceteris metallis ditissima*). The treatise is usually dated after 1235, to between the years 1242–1247 at the latest (*Keen 2007*). However, the chapter might have been written later and in that case it would reflect the situation at the end of the reign of Wenceslaus I, when ore mining has flourished. Numismatic research noticed that the volume of Bohemian bracteates produced until 1235 was smaller than the volume produced since the mid-1230s. At that time, the King of Bohemia must have owned much more silver than before (*Zaoral 1998*; *2000*).

The earliest activities in Staré Hory of Jihlava are evidenced by the finds of worked wood from ore washing facilities (Tab. 2, Fig. 30: 14 and Fig. 77). The wood was felled in winter of 1238/1239. Another indications come from the northern part of the Staré Hory dislocation, where a sunken-featured building was excavated (Fig. 30: 15, Fig. 127). In this building, carbonised fir round logs were preserved, whose felling date was determined by dendrochronology as 1247/1248 (Tab. 2; *Kyncl 2014a*). This find context is in accordance with an unstratified 1246–1247 pfennig of Vladislaus III, Margrave of Moravia (Fig. 13: 4).

An event which probably influenced the tempo of mining industry in the Přemyslid domain was the end of a domestic war between King Wenceslaus I and his son Přemysl. A unique information was found in the chronicle of the town of Kolmar in Rhineland. It describes remote events, when the number of Germans in Bohemia increased after defeat of the rebellious son. These people are said to have accumulated immense riches from gold and silver mines (*Post hac multiplicati sunt in Bohemia Theutonici; per hos rex ingentes divicias collexit ex auri et argenti fodinis* (*MGH SS XVII*, 245). The support granted to Wenceslaus by the Meissen region might have attracted mining entrepreneurs, who were ready to invest in new ore districts. In 1252, a mint master is mentioned in the town of Humpolec (*CDB IV/1*, No. 256, p. 436). The 1250s represent an era of mining prosperity in the Havlíčkův Brod region. In a 1257 document we can read about many silver mines (*CDB V/1*, No. 138, p. 223). In 1258, a tenancy deed was issued with names of individual mines and mining entrepreneurs. The name *Theodoricus dictus Vriberch* might indicate a connection to the Meissen region (*CDB V/1*, No. 167, p. 267, 268).

The earliest evidence of mining activities in the Pelhřimov region dates back to the 1260s. Dendrochronological dates from an ore preparation facility on the *Cvilínek* site fall within the years 1266/1267 to 1269/1270. The exploration of the area near Opatov and dendrochronological analysis of timbering in the mouth of one of the shafts yielded the dates 1266/1267 and 1267/1268 (Tab. 2). At the end of Přemysl's reign, the so-called Grand Privilege of Brod was issued on June 8, 1278 (*CDB V/2*, No. 873, pp. 601, 608). This document was inspired by the municipal and mining rights of the town of Jihlava.

The stagnant mines in the Bohemian-Moravian Highlands experienced a crisis in the form of the so-called "hard times" after 1278. One of the negative causes was the security situation in the country. Economic downfall has followed. At the end, a crop failure and famine came in 1281 and 1282 (*Žemlička 1986*, 159–160).

In the 1280s, mining and metallurgical industry in the Bohemian-Moravian Highlands were on the ropes. Besides the critical phenomena in 1278–1283 and 1287–1289, they also were negatively affected by the upswing of mining activity in the new mine enterprises at Kutná Hora. A 1303 document from the Havlíčkův Brod region mentioned that the mines near Bartoušov still were in operation (*RBM II*, No. 1948, p. 838). However, another reports and the silence of sources indicate that the deposits were exhausted. The diminished importance of Jihlava is documented by a 1297 privilege from Wenceslaus II for Brno. The king granted the burghers the rights to search for gold, silver, lead and other metals within a range of six miles from Brno (*CDM V*, No. 65, pp. 61–62). The turn between the 13th and 14th centuries is characterised by the decline of mining settlements.

6 Organisational structure of silver production and coinage in the 13th century Přemyslid domain

From the beginning of silver mining in the Přemyslid domain, a great deal of production was sold abroad. The Czech lands were opened to trade with developed regions of Europe, which underwent coinage reforms with similar characteristics since the beginning of the 13th century. The abolishment of the existing denier system in Europe represented a complicated process. The switchover to bracteates belonged to this reform, although its implementation in Moravia and Southwest Bohemia did not come into being until the reign of Ottokar II of Bohemia. This change created the base for the successful groschen reform of Wencelsaus II in 1300, which completed the transformation process that began on the Apennine Peninsula one hundred years earlier (*Janáček 1972*, 878–881, 904; *Zaoral 2007*; *2011*; *Hlubek – Zaoral 2015*).

The legal standards in the Přemyslid domain, such as mining and minting privileges, were determined by the overall situation in the empire (*Žemlička 2002*, 288–289, 707). The practice was not unified: coins were minted by the Duke of Bohemia, by Moravian appanage princes and later by the Margraves. On top of this, coins were also minted by several bishops in Prague and Olomouc. The sovereign applied royal privileges before the mid-13th century. Some specifics can be observed with the practice of the Lichtenburg family in the Havlíčkův Brod region (*Somer 2012a*, 129–137). Brod was the only liege town with a royal mint and with royal officials. In a 1257 charter, Smil of Lichtenburg granted a tithe from mines to monasteries (*CDB V/1*, No. 138, p. 223), which is an act normally performed by royal privilege holders.

The names of the first persons who were responsible for production of coins are sometimes identified in the inscriptions on 10th century deniers made from large planchets. The true reports on mint masters did not occur until the reign of Ottokar I of Bohemia and Wenceslaus I (*CDB II*, No. 74, p. 66; *CDB III/1*, No. 91, pp. 107–108; *CDB III/2*, No. 260, pp. 353–356; *CDB IV/1*, No. 127, p. 223). A mint master from beyond the old settlement territory is mentioned for the first time in a 1252 deed from Humpolec (*CDB IV/1*, No. 256, pp. 436–437). During the reign of Ottokar II of Bohemia, the mint master's office began to be leased to patricians – both individuals and consortia.

7 Gold and iron ores: a prelude to silver ore mining?

Relics of gold mining are found southwest of the town of Humpolec (Fig. 5: 1, Fig. 18: 3 and 4). Since we cannot date this complex more accurately, the connection with land holdings of the Želiv monastery gives us the only impulse to suppose that the mining activity on this site began in the mid-12th century. The complex *Na štůlách*, situated east of Humpolec, is the better known one (Fig. 5: 2, Fig. 20:, Fig. 22). The peak of mining activity is indicated by a 1252 written mention of the mint master from Humpolec.

Placer mining near Česká Bělá is evidenced by a wooden plank which was found in the alluvial plain of the Březina Stream (Fig. 5: E; Fig. 23: P 3 and Fig. 24). The acquired radiocarbon dates vary between AD 1016 and AD 1155 after calibration (Fig. 139, Tab. 1). Moreover, a felled fir trunk was found at the base of a tailings pile north of Česká Bělá (Fig. 23: 2, Fig. 15: 1–6; Fig. 25). Dendrochronological dating revealed that the tree was felled in winter of 1228/1229 (Tab. 2).

An example of a device for regulation of flowing water is a sluice or flume from round spruce logs in the floodplain of the Pstružný Stream above the Kejžlice village in the Humpolec region (Fig. 5: 4 and Fig. 26). A sample from one of these logs was conventionally dated to AD 1037–1286 after calibration (*Světlík 2013a*). Another sample from the same construction was dated to 690 ± 30 BP with the help of ^{14}C AMS method in the Poznań laboratory. This date is a little later, calibrated within the interval AD 1265–1314 (*Goslar 2014*).

Another area was found on the Perlový Stream near Květinov (Fig. 5: 5 and 24, Fig. 27). The research detected here a relic of a light construction, below which

three pit ovens were placed (Fig. 92: 13 and 19, Fig. 96: 3 and 4). In one of these ovens a millstone was found, which probably belonged to a hand-powered gold mill (Fig. 64: 1).

Another areas are situated on the Horský Stream in the Želetava region (Fig. 5: 7). A tailings pile was explored here with the help of test pits. Among charred and partly worked pieces of wood at the base of this pile, a felled fir trunk was found. The trunk was dated by dendrochronology to the summer of 1209 (Fig. 5: 6, Tab. 2; *Vokáč et al. 2007*, 33, 49). Another information was acquired by the research on the *Zlatomlýn* site near Opatov (*Vokáč et al. 2008*). The find context comprised fragments of millstones, waste from stamp-milling, grinding and washing, as well as gold flakes affected by grinding.

Summary of the technology level, work organisation and empirical knowledge on the eve of the "silver rush"

The early gold mining did not yet represent any breakthrough in production of coinage metal. The increased monetarisation until the 1230s might also be explained by the exchange of gold for the imported silver. The prospecting for gold deposits in the Bohemian-Moravian Highlands proceeded upstream the rivers, from the auriferous sedimentary fills of floodplains towards the exploitation of colluvial deposits. We can suppose that the switchover to silver mining was directly determined by the extraction of gold from placers with the help of simple technologies. Besides the placer mining and prospecting focused on gold, exploitation of iron ores also may have played an important role, following the same scheme. Some of the iron ore deposits in the Bohemian-Moravian Highlands are results of secondary metallogenesis in the uppermost weathered parts of the primary polymetallic mineralisation, where they represented a sought-after raw material in the form of a mixture of iron oxides and hydroxides (*Houzar 1996*).

Prospecting for gold or iron-ore deposits was traditionally carried out with the help of pits, trenches or schlich testing. New technologies comprised vertical shafts, galleries, multi-level stopes, extended stopes, etc. A new branch was ventilation and drainage. Novelties occurred in the spectrum of mining tools, for example the picks. Also new was the technique of vertical transport with the help of a winch. Hand picking and sorting had a special position among the methods of ore preparation. The method itself was technologically primitive, but the experience of sorters with various types of polymetallic ores was an imported article. A well-established branch of metallurgy in our country was the iron ore smelting. In the sphere of technical equipment we can suppose that the people living in our country were familiar with construction and operation of low shaft furnaces. As regards the non-ferrous metals, metallurgy of copper, bronze, lead and tin was well developed.

The isolation of East-Central Europe from the centres of technological progress was a limiting factor in the field of metallurgical technologies. Fast implementation of relevant technologies in production of silver from own primary resources was determined by the mastery of extraction and metallurgy of iron ores or placer mining of gold and tin. Novelties were represented by the organisation of work, intricate infrastructure of workplaces and legal standards of work. Structural prerequisites comprised the existence of towns and the implementation of cultural, trading-distributional and legal standards in the domestic urban milieu.

8 General characteristics of mining and metallurgical areas in the Přemyslid era

The explored contexts and finds illustrate the whole technological sequence from ore mining to metallurgy. These activities can be reflected in the category of terms such as workplace and area. This is a step towards creation of a theoretical model of infrastructure of mining areas, which has developed to various extent (Fig. 29). The most important source of information about infrastructure, technological processes and material culture in mining areas in the Jihlava region is represented by the excavation of a medieval agglomeration on the so-called Staré Hory dislocation zone on the western periphery of the town of Jihlava (Fig. 5: 8, Fig. 31–33).

The *Buchberg* mining centre, with advanced technical and settlement infrastructure (Fig. 34–35), developed on the *Poperek* site near Utín since the 1250s at the latest. It is one of the few centres mentioned in written sources; the oldest document dates back to 1258 (Fig. 34, 35, 117).

The *Cvilínek* site in the Pelhřimov region represented a small-scale mining enterprise (Fig. 5: 13, Fig. 37, 79–83, Fig. 90). It was founded in the 1260s, the works were well-organised and were completed within a short period of time.

Another mining area is situated south of Vyskytná (Fig. 5: 15, Fig. 38–39). The area is dated by the local finds to the advanced 13th or the early 14th century (Fig. 122). Geomagnetic survey detected here an extensive settlement area (Fig. 39 and 119) which exhibited several anomalies interpreted as smithies (Fig. 39: A, C–E, Fig. 108: 4–6). One of these anomalies included a concentration of slags from metallurgy of non-ferrous metals (Fig. 39: B, Fig. 107).

A mining area is also situated northeast of the town of Česká Bělá in the Havlíčkův Brod region (Fig. 5: E, 23, Fig. 23: 3, Fig. 40 and 41, Fig. 57 and 58). Archaeological excavations in this area yielded only sparse ceramic finds (Fig. 41).

9 Relics of hard rock mining and placer mining

Evidence of prospecting activities is mostly found in the form of small pits or spoil heaps which usually accompanied these places of work (Fig. 63 and 74). To this day, prospecting pits are only evidenced by archaeological excavations in Jihlava (e.g. Fig. 39, 47 and 62). Prospecting pits on this site were dug into a zone of Lower Quaternary and Tertiary layers of 3 – 5 m in thickness. Some of these pits were irregularly quadratic in plan, and their side length only sporadically exceeded 1.0 – 1.3 m (Fig. 45). By the extensive excavations in Staré Hory of Jihlava have been detected systems of prospecting pits in linear arrangement. Most of these pits were arranged in groups of three, less frequently two, and sporadically in a row of, for example, five pits. Mining claims were evidently laid out with regard to the already known or estimated course of mineralisation (Fig. 31–33).

The information on spatial distribution and distances between mining pits was acquired from excavations in Staré Hory of Jihlava (*Hrubý 2011*, Fig. 31–33, 38–42). The deepest explored shaft was the pit No. 3515. The cross-section of the shaft is variable, mostly four-cornered, and the side length is approximately 2.2 to 2.5 m. The shaft is inclined (80°). Important information about the dimensions and shape of the 13th century mining shafts resulted from the exploration of a shaft situated northwest of Opatov village (Fig. 5: 16, Fig. 42, 43 and 47). The shaft had a square plan with side length of about 2 – 2.1 m. It was equipped with timbering composed of corner posts, which held an external casing from split wood planks. Four samples of this wood yielded the felling dates 1266/1267 and 1267/1268 (Tab. 2; *Kyncl 2015a*).

10 Evidence of preliminary ore preparation

The preferred type of ores extracted in the Bohemian-Moravian Highlands were sulphidic ores (Fig. 16, 17, 60 and 61). The main type of silver-bearer was the galena. The fundamental part of metallurgical processing of ores was their sorting into galena concentrate and mixed concentrate with low lead content. Interesting information was acquired from the excavations near Česká Bělá, where a soil contamination with elements like Zn, Cd and Pb was observed west of the mining pits. The analysis of the area in the neighbourhood of the mining pits gives an example of a workplace where ores were sorted and roasted (Fig. 57–58). Two hearths were situated in the vicinity of a gangue dump. The dump exhibited local increase in Pb and Ag contents. The highest concentration of heavy metals in soil was detected with As and Cd in the working area around the hearths. Evidence of preliminary sorting of ores was also found on the *Cvilínek* site (Fig. 37). Spoil heaps near the local watercourse contained both gangue and sorted ore, and small tips of sorted ore were also found in workplaces near the stream (Fig. 59).

Different is the case with ore grinding and with evidence of ore grinding mills. The so far best example of an ore grinding mill is known from *Brandes* (*Minvielle Larousse 2017*). In our country we know an example from the 13th to 14th centuries, which was found during archaeological excavations near Kašperské Hory (*Waldhauser et al. 1993*). Some information was provided by excavations on the shore of the Nohavický Stream near Koječín. Test trenches, which were laid out in a spoil heap, detected layers of crushed and ground ore. At the base of the spoil heap some pieces of wood were found, which indicate the existence of a building construction. The find context is supplemented with two fragments of millstones from the riverbed within a distance of 20 m (Fig. 67: 18 and 21).

The construction of the ore grinding mill is probably the same as we know from the 16th century illustrations, however, it might have been more subtle (Fig. 70 and 71). Ore grinding mills are mostly evidenced by millstones made from granite. The millimetre fraction of the ground sediment in basins of the ore washing facilities (Fig. 72–75) indicates that multi-phase ore grinding has been applied. In Staré Hory of Jihlava, as well as in *Cvilínek,* millstones with depressions were found (Fig. 65: 7, Fig. 66: 11, 12, 14, Fig. 67: 21). They give a proof that millstones were secondarily used as stone pads for manual crushing of ores.

The main function of ore washing facilities was to produce concentrate through multi-phase gravity separation (Fig. 76). Galena probably was sorted out manually from mixed concentrates. Information about this procedure was acquired from the excavation of three areas with relics of basins, channels, gutters and flumes which are dated back to the 13th century or to the turn between the 13th and 14th centuries. The first two areas are situated in Staré Hory of Jihlava and the third one is the *Cvilínek* site (Fig. 37, 74, 75, 79–83). The only contemporaneous analogy is represented by the ore preparation plant on the *Brandes* site (Fig. 73), even though its constructional concept is different with regard to the accessible material – local stone (*Bailly-Maître 2002,* 126–132).

In Staré Hory of Jihlava, excavation area 2002, systems of dug-out basins, flumes and gutters were found, whose axis is a large channel leading from one of the

mining pits (Fig. 32: 1 and Fig. 78: 1). The systems were fed with water from the nearby stream or with water pumped out from the shafts. Ore washing facilities in Staré Hory of Jihlava, excavation area 2006, were associated with mining pits (Fig. 33 and Fig. 78: 2). Ore washing facilities on the *Cvilínek* site are connected with local stream (Fig. 33 and Fig. 74–75, Fig. 79–83). They comprised wooden tanks, wattlework flumes, chiselled gutters and sluices made from wooden planks (Fig. 81, 82, 83).

11 Evidence of metallurgical treatment and metallurgy of argentiferous polymetallic ores

Relics of European metallurgical facilities from between the 11th and the turn of the 17th/18th centuries, producing precious and non-ferrous metals, were explored in Schwarzwald and in the Vosges. From these localities we know slag types which are analogous to metallurgical waste from the Bohemian-Moravian Highlands (*Goldenberg 1996*, 50–105, 194; *Gauthier et al. 2015*, 274–276). From Siegerland we also know slag dumps which are associated with the well-developed 13th century mining centre at *Altenberg* (*Dahm et al. 1998*, 199–210; *Zeiler et al. 2016*, 193–195). The most extensive concentrations of metallurgical facilities from between the 8th and 17th centuries are known from the Harz Mountains (*Bartels et al. 2007*, 439–488). In the German part of the Ore Mountains we know smelteries in the neighbourhood of the *Bleiberg* mining centre (*Schwabenicky 2009*, 87–90).

The smeltery area near Čejkov has been classed among metallurgical facilities in the valleys of watercourses (Fig. 5: 14, Fig. 87–88). Geomagnetic survey revealed anomalies in the southern part of the area, where a large amount of slags and the fragments of furnace lining were found (Fig. 103: 11, Fig. 104). An example of a variegated infrastructure is the area on the lower reaches of the Bělokamenský Stream (Fig. 5: 9, Fig. 30: 4 and Fig. 89). On its western bank we can find a motte-and-bailey castle and a slag dump in its neighbourhood. Recent finds are represented by fragments of millstones (Fig. 67: 19) which indicate the existence of an ore grinding mill and extend therewith the technological spectrum on this site.

An interesting picture can be observed on a site in the valley of Sázava River near Utín (Fig. 5: 11, Fig. 34: 2). The local stratigraphies were sampled for ore, slag, lead ingots and litharge (*Rous – Malý 2004*, 124–126, 136–141, 137–139, Tab. 6). Geomagnetic and metallometric survey were conducted in 2013–2015. The results indicate a practical infrastructure (Fig. 84–86). In the northern part we can observe Zn, Cd and As anomalies in accordance with a geomagnetic anomaly. The presence of metallurgical slag attests to large-capacity smelting. A second geochemical anomaly is situated more to the south. From among the analysed elements it mainly contained Cu, Pb and Ag. This composition might refer to a smelting facility where concentrates with high lead content have been processed.

An example of a smeltery located at the edge of a mining zone, with no relation to any riverbed, is Vyskytná (Fig. 5: 15, Fig. 39: B). On this site, a geomagnetic anomaly was detected. Surface survey in this area identified a concentration of slags from metallurgy of polymetallic ores (Fig. 107).

Real archaeological evidence of metallurgical facilities

The attempt of a critical interpretation of the relics of furnaces is problematic. Numerous relics of pyrotechnological devices were found in centres like *Johanneser Kurhaus* and Pandelbach in the Harz Mountains (*Bartels et al. 2007*, 173, 184–186, 479; *Alper 2003*). Many relics of furnaces of various types and purposes were found on the *Treppenhauer* site and most recently in Dippoldiswalde (*Schwabenicky 2009*, 62–63, Abb. 122 and 124, 83–86; *Schubert – Wegner 2014*; *2015*). 12th century devices can be exemplified by furnaces from localities in Southern Poland (*Rozmus 2014*, 159–170). Also interesting is the metallurgical facility from the turn between the 13th and 14th centuries in the courtyard of Český Krumlov Castle (*Ernée et al. 1999*). It generally seems that the construction of furnaces was determined by immediate needs of metallurgists and local conditions rather than by technological standards. The typology of metallurgical devices is therefore purely based on dimensions and morphological features of the excavated relics of these devices: 1) flat hearths without any construction elements (Fig. 93), 2) concave hearths without any construction elements (Fig. 93), c) pit ovens without any construction elements (Fig. 94), d) concave pear-shaped or oval-shaped furnaces with construction elements (Fig. 95), e) aboveground oval furnaces with stone base (Fig. 96), f) stone bases of quadratic shape (Fig. 97), g) quadratic ovens with stone walls and flat bottom (Fig. 97), h) large stone-built furnaces (Fig. 98).

In the 13th century smelteries producing precious metals we could expect the presence of shaft furnaces (Fig. 91). Relics of such furnaces might be hidden in many find contexts. We can also detect the absence of metallurgical waste in the surrounding area. This makes us suppose that these devices were intended for small-capacity processing of galena concentrate. Waste from these smelting procedures was not accumulated at this place but in a central slag dump, where it was crushed, ground and prepared as a part of the charges during large-capacity smelting of mixed concentrate

with low lead (and silver) content. Small-capacity smelting of thoroughly sorted galena concentrates probably involved small wood-fired ovens (*Holub – Malý 2012*, 5–6; *Timberlake 2014*, 70–72; *Holub 2015*, 664–665).

Briefly on metallurgical waste

The analyses of slags from metallurgy of polymetallic ores were carried out with a considerable amount of samples. However, it might seem that the number of analyses is not yet representative (*Malý et al. 2007*, 130–131; *Kapusta et al. 2012*; *2013*; *2014*; *2015* and *2017*; *Malý – Rous 2001*; *Rous – Malý 2004*, 137–140; *Janíčková et al. 2012*; *Hrubý et al. 2012*, 372–376). In Staré Hory of Jihlava no concentrated slag dump was identified. Earlier analyses revealed high lead and zinc contents. These results, in the context of analyses conducted later on other samples, indicate that the metallurgical technologies have changed and ores also were of many different types. Nevertheless, different results might also indicate the necessity to revise the analytic methods used. The conceptually, methodically and procedurally more advanced analyses distinguish two types of slags, which differ from each other macroscopically, in the phase composition and in chemistry (*Kapusta et al. 2017*). One of them exhibits unusually high barium contents and only minimal lead content. Barium prevents lead from entering the slag and, at the same time, facilitates its passage through the smelting process. An increased barium content was also identified with slags from Čejkov. The addition of barite to individual furnace charges supposedly represented a stabilised technology, which initiated the export of barite from its primary deposits to smelteries in mining districts where barite does not occur. The origin of barium must be sought in the barite ore from the Jihlava region, mainly from the Staré Hory dislocation zone.

Geomagnetic survey and surface collecting in the surroundings of Vyskytná identified three anomalies with concentrations of forging slags (Fig. 39). These slags are also known from Staré Hory of Jihlava or from *Buchberg*, and from the sites of *Cvilínek* and Opatov in the eastern part of the Pelhřimov region (Fig. 108). On the *Cvilínek* site, two find contexts with increased occurrence of forging slags were explored. These places can be interpreted as relics of forges (Fig. 96: 1; Fig. 96: 2). The presence of a smithy might be indicated by a hoard of worn horseshoes (Fig. 109: 1–10).

12 Evidence of leading, cupellation and assay

Metallurgical and assay processes can be indicated by lead ingots and drop-offs found on all sites (Fig. 110 and 111). They also might have belonged to the equipment of an assayer who used desilvered lead in many tests (*Vitouš 1974*, 34–35, 41, 45). Finds of this type are known from many centres in Europe (*Rozmus et al. 2005*, 24–25; *Bailly-Maître 2002*, 134–136; *Bourgarit 2008*; *Schwabenicky 2009*, 138–140, 149–150; *Alper 2003*, 310–317). The detected lead contents of 1 – 23 ppm refer to desilvered lead. Separation of crude silver is indicated by fragments of impure litharge, i.e. lead oxide. Nevertheless, litharge was also used as an assay tool. A litharge fragment was found during the 2014 excavations on Staré Hory site. Its shape is given by a bowl or a crucible (Fig. 112: 1). A small piece of litharge from the second half of the 13th century comes from the *Cvilínek* site (Fig. 112: 2).

A special group of finds is represented by ceramic fragments coated with melt residues. Among them mostly are kitchen pottery or tableware fragments which have been used as a tool in assay tests or in silver leading, cupellation or purification (Fig. 113 and 114).

From the 13th and 14th century mining centres we know finds of scales and weights which might be related to the presence of assayers (*examinatores*) and ore emptors (*emptores metalli*; Fig. 115). The so far isolated example of a touchstone discovered within a mining area is known from the *Cvilínek* site (*Hrubý et al. 2012a*). The object exhibited abrasion marks of non-ferrous and precious metals. Analogous finds of touchstones are known from the *Treppenhauer* or *Fürstenberg* sites in the Ore Mountains (*Schwabenicky 2009*, 159, 199–200). A touchstone perforated by a drilled hole comes from metallurgical workshops in the Corvey Abbey (*Krabath 2001/2*, pp. 579, 668, Taf. 15: 4).

13 The problems of silver production and distribution

A serious deficiency in the knowledge of precious metal production is the absence of metallurgical production outputs. Attention must be paid to components of material culture, such as silver ingots, discs and hack-silver. Silver in these forms is mainly found in hoards, less frequently in trading centres or settlements and, surprisingly enough, on mining sites. These silver items occurred continuously since the 11th till 12th centuries (*Bogucki et al. 2016*; *Der Schatzfund 2004*; *Chabrzyk 2010*; *Chabrzyk – Młodecka 2012*; *Rozmus et al. 2014*). The traditional interpretation of the 13th and 14th century bullion silver accentuates its role of currency which replaced the bracteate coins in the Přemyslid milieu (*Petrtyl 1976*; *Janáček 1972*, 882). This idea does not categorically reject the concept of 13th century payments in non-coin silver, but it draws attention to the fact that a term from written sources has automatically been associated with a group of real artefacts.

The circulation of non-coin silver is a characteristic phenomenon of economy and trade in early medieval Northern and North-Eastern Europe, for which a German term *Gewichtsgeldwirtschaft* (non-monetary economy) has been used. The opposite term is *Münzgeldwirtschaft* (monetary economy), that is an economy based on monetary means of payment with guaranteed coin nominals of exact value. The boundary between these two spheres was fuzzy and varied in time (*Görmer 2006*; *Kilger 2004*; *Steuer 1987*; *1997*; 11–18, 342–356). The testimony of chronicles and deeds is ambiguous as regards the distinction of non-monetary and monetary payments. Earlier it was suggested that the term *marca argenti*, which can be encountered, for example, in the texts by Cosmas, refers to a bullion silver bar (*Pánek – Hladík 1968*, 84; *FRB II*, pp. 106, 137, 143, 229). Cosmas, on the contrary, describes a currency bar as *Marcam nostrae monetae CC nummos dicimus* (*FRB II*, p. 80), which might indicate that a silver bar corresponds to a particular number of denier coins minted from silver in the weight of a bullion bar, i.e. not to the total weight of coins and much less to the weight of non-minted silver.

In the late 12th century Czech written sources, two new terms occurred for the first time. One of them is assayed silver (*examinatum argentum*) and the other is purified silver (*purum argentum*). These terms originally referred to technological categories of metal, but in the context of written documents they were used to express the form of payments. Purification represented the final stage of refinement of the silver product from smelteries, which contained adulterant admixtures, predominantly lead. These undesirable admixtures had to be removed by purification. A unique term might be the *conbustum argentum*, i.e. burnt silver (*RBM II*, No. 1525, p. 656). In the second half of the 13th century, both the *examinatum argentum* and the *purum argentum* occur in connection with the activity of mint masters, mining officials, assayers and mint leaseholders (*Jan 2006*, 82, 93). When coins were minted from an alloy based on purified silver, then the lead content should meet the standards of purified silver. According to analyses, lead content in several coins ranged between 0.090 % and 0.431 %. In other bracteates lead was represented by 0.386 % and 0.863 % (*Hrubý et al. 2005*, tab. 1 and 2). Lead contents within an interval of 2.6 – 3.8 % were detected with pfennigs of Ottokar II of Bohemia from the hoard Třebíč – Borovinka. The XRF analysis of their surface showed that the lead content amounts to 0.0 – 2.2 % (*Richtera et al. 2011*). These numbers are important for the following discussion on silver ingots.

The term *marca denariorum* represents a particular number of silver coins, which were minted from silver in the weight of one bullion bar. The term *marcas/marcis argenti*, or just *marca*, is less clear, but it might represent the bullions of minted coins. This interpretation, however, is contradicted by equally formulated payments in gold, from which no coeval domestic coins were minted. The terms *examinatum argentum*, *purum argentum*, or *conbustum argentum* probably are synonyms.

The usual interpretation of silver ingots in the Přemyslid domain reflected their occurrence on the domestic territory and their synchronism with implementation of the bracteate currency (*Janáček 1972*, 882; *Petrtyl 1976*). Earlier discussions on this topic did not pay attention to elemental composition. The silver content is varied, sometimes decreasing to below 70 %, and the lead content, reaching up to the first tens of percent, is significant. These characteristics refer to unrefined and little-malleable silver, corresponding to crude silver from smelteries. An increased occurrence of ingots from the end of the 12th until the beginning of the 14th century is related to silver production boom in Central Europe. This process was reflected in an increased amount of silver in long-distance trade and, consequently, among archaeological finds as well. The involvement of these items in exchange is possible, but it did not represent the reason and purpose of their production.

14 Relics of mining settlements

Unlike agrarian villages and unlike towns as well, mining settlements were inhabited by specific groups of medieval population, whose legal and social status were defined by their profession. The founding of mining settlements culminated after the mid-13th century. Mining settlements, in contrast to agrarian villages, are not reflected in the historical landscape as an integral, or even generating, element of the ploughland. In the wide spectrum of arrangements of the 13th and 14th century mining settlements we do not find any uniform pattern.

Mining settlements fulfilled multiple functions, which can be identified on the basis of written sources and archaeological finds. Their infrastructure consisted of houses; many buildings may have also served as baths, tap rooms, meat and bread shops (*Tomaschek 1897*, No. 84 and 86, pp. 46–47). From archaeological excavations follows that these settlements also included smithies and assay workshops (Fig. 39, 108, 109–115). The communal space encompassed pasture land and agricultural background (in more detail *CIB I*, p. 329). On the basis of legal texts from the 13th century and from around 1300, we can attempt to create a simple spatial model of a mining settlement. From the Jihlava mining rights, from *Ius regale montanorum*, as well as from later legal texts related to Jihlava we know that sixteen plots were laid out at every mining claim. On

these plots then houses were built. Pasture land was established within bow shot range (approximately 250 m) from the mine (*CIB I*, pp. 116 and 329; *Tomaschek 1897*, No. 84 and 86, pp. 46–47). This universal and ideal model, however, is sharply confronted with reality. In the wide spectrum of 13th and 14th century settlements we do not find any uniform pattern.

The population in mining settlements was predominantly composed of mineworkers. In the metal production, however, also their family members were involved. Among the inhabitants of these settlements probably also were mining smiths, secondary miners who were not burghers, the lowest ranked mining officials, or their helpers. Lower clergy may have lived in settlements where a church or a chapel were founded during the second half of the 13th century. Population in mining settlements also included individuals who operated shops and tap rooms, or people connected with market and trade in general. The patrician mine holders, high-ranked mining officials and burghers, on the other hand, did not belong among the inhabitants of mining settlements. However, they supposedly owned special buildings in the settlement which were used by their helpers whenever necessary. The same is probably true of assayers who also were burghers.

The oldest domestic written document that indicates the legal and social distinction of miners is a 1234 charter, in which Přemysl, Margrave of Moravia, confirmed urban rights for the town of Uničov. The text stipulates that the people working in gold mines shall not be allowed to overnight in villages and to seek shelter in their surroundings (*CDBIII/1*, No. 76, p. 82). According to *Ius regale montanorum*, issued in 1300, landlords were not entitled to infringe the mining freedoms. Miners were not obliged to pay taxes to their landlord: neither for their mining activity nor for wood felling. Moreover, they were allowed to establish pasture land for their livestock within bow shot range from the allotted claim (*CIB I*, pp. 116 and 329).

From the above-mentioned information we can infer that in the eyes of townspeople, villagers but also manorial lords, the communities of mineworkers represented a potential problem. The mineworker population was exempted from allegiance and removed from the authority of other than mining courts. The stipulation in the 1234 charter indicates that the coexistence of mineworker communities with the other people was considered undesirable. In the Přemyslid milieu, the above-mentioned text might represent the very first indication of a phenomenon which subsequently resulted in standard founding of mining settlements.

A mining enterprise with adjacent settlement, whose existence is documented by a 1256 deed (*CDB V/1*, No. 90, p. 164), is *Mittelberg* (Fig. 36: 1). There was a chapel of St. Margaret, still standing in 1346. *Mittelberg* is mentioned for the last time in 1351. South of the Bartoušov village we can find mine workings mentioned in 1281 (*Partuzchdorf Minari, Muhlgraben, montem Gebhardi, montem Hennigi, montem Sutmani*; *CDB VI/1*, No. 143, pp. 191–192). Finally, near the Church of St. Catherine in the neighbourhood of Stříbrné Hory, there is a settlement which can be associated with the *Herliwinberg* mine (Fig. 34: 3). Another settlement is *Buchberg* east of the Utín village. It has been mentioned since 1258 (*CDB V/1*, No. 167, p. 267), since 1265 with a chapel (*CDB V/1*, No. 447, pp. 661–662).

Surprisingly extensive also was the mining settlement situated south of Vyskytná. Geomagnetic survey detected here more than 160 anomalies which can be interpreted as the underground parts of buildings. Most of the house plans are arranged in lines parallel to the main exploitation area. A specific grouping of three large anomalies seems to be the remnant of a building complex, probably a homestead with courtyard arrangement (Fig. 39: G). Similar interpretation is possible with a system of anomalies in the eastern part of the surveyed area (Fig. 39: E). The main dating tool for the settlement is a collection of buckles (Fig. 122: 1–7, 9).

Typical phenomenon connected with the most advanced mining centres is the emergence of mining churches and chapels. The main reason for the construction of sacred buildings was the high number of inhabitants in mining centres who were taking part in religious ceremonies and feasts. None of the sacred buildings in mining settlements were excavated; all data were acquired from written documents. These written mentions are related to questions of jurisdiction between the priests from parish churches and the administrators of miners' churches and chapels. The first recorded dispute has taken place in 1256 and regarded the churches in Dlouhá Ves and at the *Mons Medium* mine (*CDB V/1*, No. 90, p. 164). The description most probably corresponds to the present-day Church of the Finding of the True Cross in Svatý Kříž village (*David – Rous 2006*, 123). The building is situated 100 m to the north of an extensive mining relics (Fig. 36).

Another dispute flared up in 1265 between the parish churches in Pohled and Přibyslav because of the revenues from the church in the mining centre *Mons Herliwini* (*Herliwinberg*) and the chapel in the mining centre *Buchberg* (*CDB V/1*, No. 447, pp. 661 – 662). Near the Church of St. Catherine on *Herliwinberg*, there is a still functioning cemetery where the communities from the above-mentioned two centres may have buried their dead in the 13th century (Fig. 34: 3; *Rous 1998*, 108; *2001*, 69, 71; *2004*, 50). The defunct chapel on *Buchberg* mines was not yet exactly localised. Interesting in this regard is the local toponym *Hejba*, related to the northern part of the area (Fig. 35: D). The name might be a relic of former German name

Heilige Barbara (Saint Barbara), which probably refers to the above-mentioned chapel (*Rous 1998*, 107–108, 114; *Rous 2001*, 80, obr. 7).

The founding of sacred buildings in mining areas was not necessarily the consequence of overpopulation in mining regions. It might have been connected with the accessibility of parish churches. Churches and chapels did not emerge in mining settlements which are situated within a distance of 3.5 km from older spiritual centres. Such church foundings can only be documented in mining centres *Herliwinberg*, *Buchberg* and *Mittelberg*. The emergence of sacred buildings in these cases distinctly correlates not only with an immense extent of these settlements and the high number of their inhabitants, but also with the increasing distance from the original parish churches, which exceeds 3.5 km.

The most frequent building relics in mining settlements are underground structures (Fig. 117, 119, 124–128). They might have been used for processing of raw materials and for metallurgical activities, but their main purpose was residential. In mining settlements, apart from some uncertain exceptions, we do not find relics of multi-room houses, accessory buildings or the evidence of homesteads with courtyard arrangement (Fig. 120 and 128). The knowledge of wooden architecture in mining settlements is mainly enhanced by excavations on the Staré Hory site (Fig. 124–126). The attempts to reconstruct the original appearance of buildings oscillate between two extremes, but the most frequent types are simple houses with gabled roof (Fig. 129 and 130).

15 Subsistence, supply, economy and market in mining communities

Some information about the supply of mining communities can be acquired from the constitution and regulation standards of mining settlements, which are included in legal documents from the advanced 13th and the early 14th century. From among the sixteen houses belonging to a mine, one or two can operate a butchery, bakery and baths, and the inhabitants also can tap beer, mead and wine there (*CIB I*, pp. 116 and 329). An example of such tap room was found in the mining centre *Buchberg* in the Havlíčkův Brod region (*CDB V/1*, No. 447, pp. 661–662). Clear evidence of storage and processing of foodstuffs is not easy to find in the archaeological material from mining settlements. Leaving completely aside the discussion about the storage function of sunken-featured buildings, we should pay attention to storage pits which are found very seldom. Interpretation problems arise with ovens in the interiors of buildings, because these devices might be also related to metallurgy. The problem of stock-keeping is connected with very low or even zero occurrence of storage jars (Fig. 131).

The macroremains from the *Cvilínek* settlement contained unpretending species like oat, common barley and marginally also rye and millet. From among the other crops, flax was detected (*Hrubý et al. 2012*, 403–405). A different botanical spectrum is known from Staré Hory of Jihlava. Cereals represent 43.5 %, the other useful plants 8.5 %. Among the macroremains are grains of barley, rye and club wheat. Waste from wheat and barley winnowing also was found. Legumes were represented by lentil seeds. The find of this thermophilous plant species supports the idea that some foodstuffs probably were imported from regions with more favourable climate, as it was already indicated by the find of millet grains. Unfavourable natural conditions per se did not diminish the potential of grain production (Fig. 132). The main reason for the non-existence of grain production was a legal boundary between the land use for mining and the land ownership: people from mining settlements had no right to cultivate this land. On Staré Hory site, the proportion of wheat, which is considered an extrazonal plant, reaches up to 30.9 % and the proportion of lentil is 1.8 %. This might be either an evidence of high population density in the Jihlava region, which exceeded the possibilities of self-supply, or a proof of economic power which allowed to purchase wheat. Not all the macroremains must necessarily refer to food production. Straw, for example, represented a building material which has been added to clay daub as a temper.

Mining settlements are characterised by a low representation of osteological finds, even though animal breeding is mentioned in legal texts of that time. In the *Brandes* settlement, sheep and goat predominated over bovines (*Bailly-Maître – Dupraz 1994*, 122–123). Sheep are also present on *Kristberg* in Tyrol (*Stopp 2003*, 82). *Altenberg* in Siegerland is different: cattle butchered on this site was older than that in towns and the bones exhibited stress marks (*Doll 1998*, 173). The collection from Staré Hory of Jihlava contained 1 % of horse bones. Also interesting are 862 bone fragments from large ungulates, indicating a wider spectrum of these animals which also comprised hinnies, mules, etc. The highest representation was detected with domestic cattle (57 %). One phalanx exhibited pathological changes induced by excessive traction. The second most frequent animal was pig (32 %), followed by sheep/goat (6 %); one fragment of domestic goat also was found. The predominance of adult individuals is evident with domestic cattle. In pigs, on the contrary, juvenile individuals are predominant (cf. *Sůvová 2012*). On the *Kremsiger* and *Starý Zámek* sites in the heart of the Ore Mountains, the bones and teeth of bovines and large mammals

represent more than one half of the whole osteological collection (*Kyselý 2015*).

Animal husbandry is indicated by written sources. In mining settlements we should take into consideration the breeding of animals both for meat and for work; the reports on establishing pasture land may contain mentions of both types of animal breeding. With regard to meat consumption we must distinguish between meat production as such and meat supply. Adult horses, undetermined ungulates and partly also bovines were most probably primarily used as draught animals. When they served out or died, both working and dairy animals were utilized for meat, hide, bones, horns and hoofs. Also important may have been the production of tallow for lamps (*Doležalová 2012*).

The grain, bread, meat and beer supply were in the hands of burghers. These individuals probably were the holders of mining offices and mines. Agricultural land in the neighbourhood of mining enterprises, which has been in the hands of mine holders and mining officials, can be identified in the Brod privilege issued in 1278. Hereditary land holding by mint masters and mining entrepreneurs is reflected in the 1328 urbarium from Pohled (*Somer 2016*, 26–27). In the initial phases of mining in regions where agriculture and market were just coming into existence, the mining entrepreneurs and officials faced the task of starting and boosting the mining activity. This process was connected with the arrival of many people, whose subsistence and supply had to be secured for a long period of time. A good solution thereof was the colonisation activity itself, which increased the agricultural production in the mining areas.

16 The impact of ore mining on landscape and natural environment

Mining activity is accompanied by an intensified deforestation of the landscape (Fig. 63 and 144, Tab. 2, Fig. 145, also Fig. 81: 4). The turn between the 13th and 14th centuries, even in the overstrained and overpopulated mining regions of the Bohemian-Moravian Highlands, represented a period of founding and refounding of settlements. In the Jihlava region, this process is documented by a deed issued in 1303. At that time, a man named Eberhard made a commitment to establish the village of *Symonsdorf* within the Želiv monastic domain (*CDM V*, No. 145, p. 149). However, problems arise with localisation of this settlement within the distance of 10 km northwest from Jihlava. Its founder might have been the Prague burgher Eberlin od Kamene (*de Lapide*), who in the years 1310 and 1312 held the office named *urburéř* (royal mining official of highest rank) and in around 1290 also the mint master's office (*Jan 2006*, 94–95, 108–109).

17 Conclusion

The state of research on underground relics of medieval mining in our country is unsatisfactory when compared with the situation abroad. The reasons thereof stem from legislation. Nevertheless, the examples of Dippoldiswalde and Niederpöbel complexes in the Ore Mountains show that the recovery of underground mines can be carried out in connection with archaeological research.

More advanced is the knowledge of ore preparation areas and technologies. Less is known about the appearance of metallurgical facilities and the smelting technologies themselves. The study of metallurgical tools and waste proved very instrumental in this regard. The chapters on bullion silver must be regarded as a search for the right way. Cast silver may have played many roles, but from a critical point of view it is the only candidate for the product of smelteries.

Archaeology is also focused on settlement architecture, construction elements, dimensions of individual buildings, etc. The level of knowledge in this area seems to be good. We do not know whether the production in winter was completely stopped or just reduced. In other words, we do not know whether or not one part of the people from mining communities left the mines to spend the winter in the surrounding farmsteads or towns and came back again in the spring. Operating a mine in winter to the full extent would namely require stockpiling of foodstuffs for people and fodder for working animals. Reduced winter operation, on the other hand, must have demanded butchering of redundant animals or their placement in surrounding farmsteads. The problem of subsistence and supply of mining communities goes hand in hand with their integration into the medieval majority society.