Przegląd Archeologiczny
Vol. 70, 2022, pp. 151-174
PL ISSN 0079-7138
DOI: 10.23858/PA70.2022.3000

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OVRUCH SLATE SPINDLE WHORLS IN THE CZECH LANDS

The article discusses the state of knowledge and the significance of a special group of early medieval material culture artefacts – namely, spindle whorls made of Ovruch pyrophyllite slate originating from the territory of present-day Ukraine. Thousands of these artefacts, interesting not only for their specific, usually reddish color, but also for their professional standardized design, were made between the 10th and 13th c. Their occurrence in the Czech lands is very limited, however: only 13 specimens are presently known. In Bohemia, they have been discovered only in Prague, which was their target destination. In Moravia and Czech Silesia, they are known from five sites: with a single exception (a cemetery), they are important supra-regional and local fortified centers. Non-destructive analyses carried out have shown that all detected spindle whorls can be considered originals. An analysis of the archaeological contexts showed that the earliest occurrence of these imports can be dated as far back as the second half of the 10th century. However, most of them probably belong to the 11th century, and some, exceptionally, even to the 12th century. Given their low number, we assume that this most probably was not a regular item in long-distance trade.

KEY WORDS: Czech lands, Kievan Rus', Early Middle Ages, spindle whorls, Ovruch slate

1. INTRODUCTION

Spindle whorls made of Ovruch slate, whose origin is associated with Eastern European regions, have attracted continuing attention among early medieval finds in the Czech lands as well as the Baltic countries, Scandinavia, Poland, the Jutland Peninsula, and north-east Germany, as we follow the direction of their circulation to the west or north-west[1]. Except for the Polish lands (and especially their eastern border regions), where their number is estimated at 800-1,000 specimens (Michalik *et al*. 2003, 57; Wołoszyn 2007, 186), they represent rather rare artefacts; altogether 13 of them have been collected from the territory of today's Czech Republic (Fig. 1; and none is yet known from Slovakia). In 1990, J. Sláma, who was the first to deal with them more comprehensively in our country, published four specimens known at that time from Bohemia and Moravia. They are interesting not only for their specific coloration, related to the material used (one that covers a wide range of hues from light pink to pink orange, red, ochre brown and dark violet), but also for the precise technique of a professional, standardized design. The color and properties (low hardness above all) of the rock from which they were produced, of which thousands of

[1] Of course, a considerable quantity of them are known from the wider areas of northern and eastern Rus', and in smaller numbers they have also reached the Balkans, for example (Yotov 2018, 469-470).

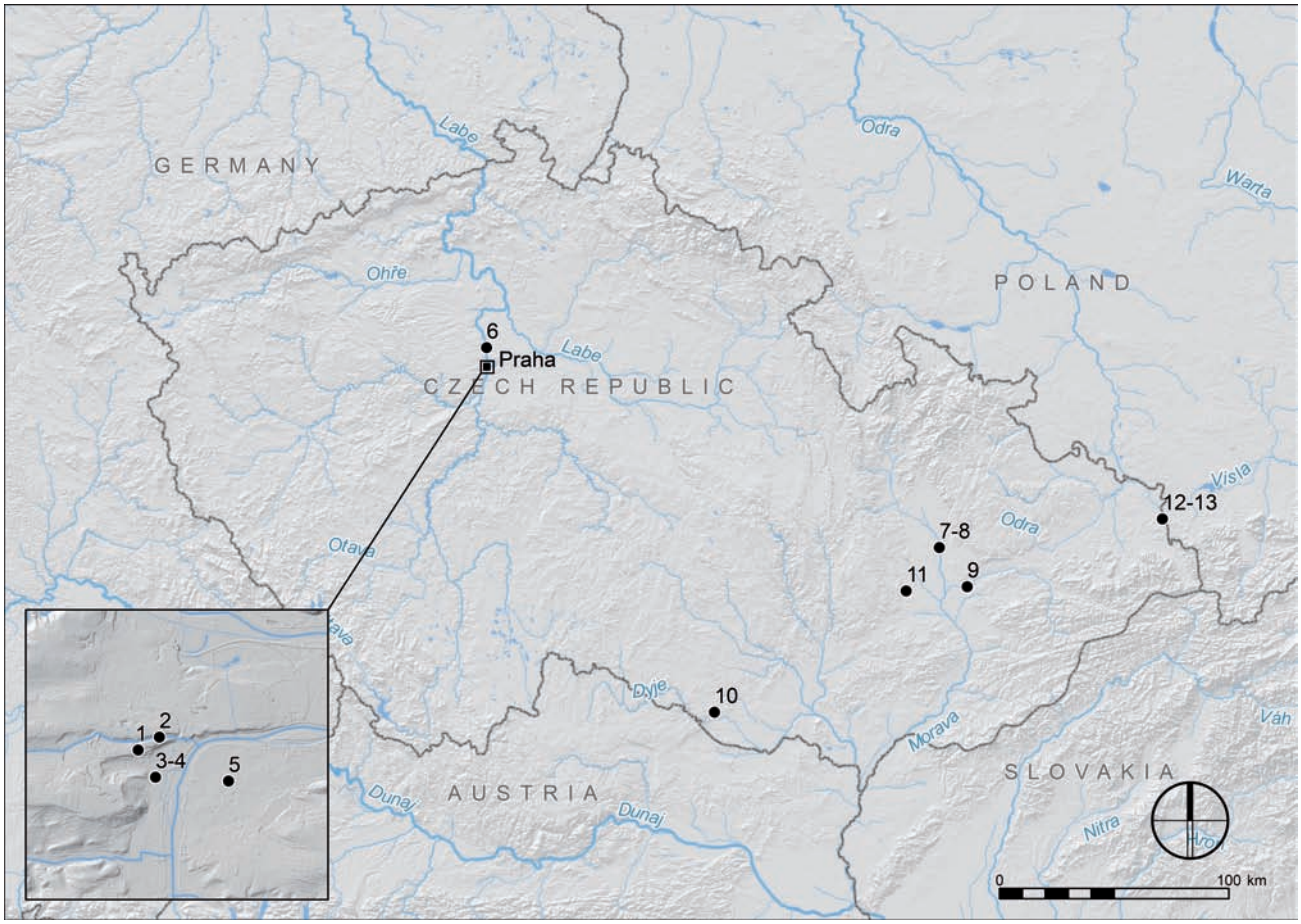

Fig. 1. Localization of the individual spindle whorls in the Czech lands (1: Prague Castle, 2: Prague – Castle District, 3-4: Prague – Lesser Town, 5: Prague – Old Town, 6: Levý Hradec, 7-8: Olomouc, 9: Přerov, 10: Znojmo, 11: Dětkovice, 12-13: Chotěbuz-Podobora); graphics: M. Vlach

tons were mined (Tomashevsky *et al*. 2003, 131), are determined by the numerous mineral components, especially pyrophyllite, hematite, and quartz.

The production of spindle whorls from stone materials was an innovation in the Early Middle Ages; ceramic whorls, fired from the material used in vessel production, had mostly predominated throughout prehistory. Like pottery, some were made of very fine, high-quality clay body; others contained quartz or rock fragments up to several millimeters large as the material of temper. A gradual change can be observed only in the Middle Ages, when stone forms increasingly asserted themselves in Central and partially also Northern Europe; they were more labor intensive, however, and required more inventiveness. Soft and easily workable rocks were used to produce them, including talc, talc schist, serpentinite, siltstone, silty schist shale, marlstone, and limestone. Along with spindles, they represent clear evidence of thread spinning within home textile production (Březinová 2007, 68, 77-79). Especially in recent decades, numerous collections of spindle whorls from important (not only) Central European sites have been paid increased attention with an emphasis on their typological classification and material analysis (e.g., Marek, Kostelníková 1998, 171-326; Dominiczak-Głowacka 2008, 243-273; Březinová, Přichystalová 2014, 170-180; Schietzel 2014, 357-359; Janowski 2019, 291-309 with further relevant literature).

The origin of the material of the specimens we study needs to be sought in the east, however, on the present-day territory of Ukraine. There, a rock designated as Ovruch (pyrophyllite) slate was known to Ukrainian, Russian, and Polish scholars already before World War II. It was recognized as the matter from which the products in question were made as early as 1878 by geologist G. O. Ossovski (and verified by many others after him), who also identified its natural outcrops close to the small town of Norynsk and processing workshops near the municipalities of

Nahoryani and Kamenschina (cf. e.g. Pavlenko 2005, 195-196). The slate itself is of Proterozoic (pre-Palaeozoic) age and comes from the northern part of the country, from Volhynia, the original territory of the East Slavic tribal union of the Drevlians; from the 10th century, their administrative center was Ovruch (Tomashevsky 1998, 151; 2008, 56-58). This part of Ukraine's territory consists of the monotonous surface of the extensive Polesian Lowland, which stretches into Belarus and, beyond the Bug river, also into eastern Poland, where it is called Podlasie; in some maps, the territory is marked as the Pinsk Marshes. The old Proterozoic bedrock of the Ovruch Ridge[2] rises up from the Polesian Lowland near the border with Belarus, c. 50 km long in the east-west direction, with a width ranging from 5 km in the east to 15-20 km in the west. The highest point of the Ovruch Ridge is close to the municipality of Horodets', 316 m above sea level.

Despite its age (1.2 to 1.7 billion years), the projecting geological bedrock consists of only weakly regionally metamorphosed sediments – slates, locally with an admixture of volcanic (pyroclastic) material. Detailed petrographic classification of Ovruch slate was carried out by a team of Polish and Ukrainian researchers (Michalik *et al*. 2003), who singled out sericite-pyrophyllite-quartz phyllites, quartz-muscovite-pyrophyllite meta-siltstones, and meta-tuffite with a pellet-like structure within the material. A characteristic identification attribute is a substantial presence of the remove mineral pyrophyllite – $Al_2Si_4O_{10}(OH)_2$, formed by thermal metamorphism from kaolinite and quartz. The hardness of pyrophyllite is very low (1-1.5 on the Mohs scale); the streak is white; it has a higher density (2.66-2.9 g/cm^3; for comparison, quartz has a density of 2.65 g/cm^3, feldspars 2.54-2.76 g/cm^3). The Ovruch pyrophyllite slate is a unique material in all of Europe. To understand the exceptionality of its occurrence, let us say that in Czech Silesia, it is registered in a single boulder from glaciofluvial sediments in Vidnava (Kruťa 1973, 308). No pyrophyllite slates are described from Poland (Kozlowski 1986); mineralogical occurrences of pyrophyllite are reported only from the vicinity of Strzelin (quartz veins in granites) and Kowary (Żaba 2006, 345). In Moravia, a small mineralogical occurrence is registered in pegmatite from Dolní Bory (Bernard *et al*. 1981). It is not common in Bohemian deposits, either; in Slovakia, it projects as part of some neovolcanic rocks metasomatically transformed all into secondary quartzites (Kalinka, Víglašská Huta, Banská Belá; Bernard *et al*. 1981; Herčko 1984).

Truly mass production of products from Ovruch slate in Old Rus' (Kievan Rus') took place between the second half of the 10th and the middle of the 13th centuries (until the Mongol-Tartar invasion) with remnants continuing in the late 13th and early 14th centuries, although earlier finds are also mentioned (Rosenfeldt 1964, 221; Pavlenko 2010, 163). It did not consist solely of spindle whorls, even though these were clearly the most numerous and most widely spread artefacts coming from the local workshops; thousands of them were produced there, mostly in a biconical version (e.g., Rybakov 1948, 189; 1959, 102). Other products made in parallel with them include beads (pearls), crosses, icons, small cult items, and ornaments (bijouterie), quern stones, specially adapted and ornamented plates/parts used in the decoration and furnishing of churches including architectural elements, tiles, sarcophagi, crucibles, various casting molds, whetstones, etc. (Tomashevsky *et al*. 2003, 131-132; Ivakin *et al*. 2013, 56-70). It is believed that the individual production facilities with specific technical equipment were more or less specialized in certain types of items (e.g., spindle whorls, crosses, beads) and had their distinctive styles (Pavlenko 2008, 242). It is not ruled out that Byzantine master craftsmen were present at the beginning of the organization of mining, the processing of the material, and the production itself (Tomashevsky *et al.* 2003, 134). Even though most workshops were concentrated in the immediate vicinity of the mining areas (e.g., Pavlenko 2008)[3], there is evidence of spindle whorl production in other, rather distant parts of the land (for instance, in Kiev, which was connected with Ovruch via a waterway – this was still denied by Rybakov 1948, 190, in Suzdal and other places). The material, perhaps partially worked, must have been transported there[4].

[2] The Ukrainian name, Ovrutskyi kriazh, is derived from the town of Ovruch, situated about 160 km north-west of Kiev (Gabriel 1991, 258); its English name is the Ovruch Ridge.

[3] It is said that in parallel with them, there were also metallurgical complexes producing iron and iron products, including the tools necessary for the production and working of stone/slate (Pavlenko 2005, 197; 2010, 161).

[4] It is also assumed that, e.g., in an important craft and trade center in Daugmale, Latvia, near the river mouth of the Daugava flowing into the Baltic Sea, about one-third of the beads and spindle whorls from Ovruch slate found there were made from imported raw material (Radiņš 2007, 264; 2013, 77).

2. INVENTORY OF FINDS FROM THE CZECH LANDS

As we have said, 13 spindle whorls[5] that can be classified as eastern imports with absolute certainty are available from the Czech lands at present. Six are known from Bohemia (or, more specifically, Prague, Fig. 2), five from Moravia and two from Czech Silesia (Fig. 3). It was the relatively recently acquired Silesian finds from the long-examined stronghold in Chotěbuz-Podobora near Český Těšín that gave the impulse for their overall processing (Kouřil 1994; Kouřil, Gryc 2011; 2014); the reason was that we were not certain that these artefacts had not been made of a local source of material from the Polish part of the Sudetenland, as they resemble some local specimens of reddish color (especially from the Gilów stronghold in Lower Silesia). We have had an opportunity to examine all the whorls in detail, document them, and carry out non-destructive X-ray analysis using a specially adapted diffractometer (see below). Let us present them in more detail here.

Bohemia

1. Prague Castle (Old Provostry 48/IV, section 6, layer 48, excavation: 1986, Fig. 2: 1); slightly asymmetrical subtle flat disc shape with a hint of a small central rib; the surface and the two opposite flat areas are smooth; diameter: 2.1 cm; height: 0.6 cm; diameter of the very slightly conical central aperture: 0.9 cm; weight: 5.0 g; closest color according to the Munsell Rock-Color Chart: "very dark red" 5R 2/6; dating: second half of the 11th century; reference in the literature (Boháčová, Frolík, Petříčková, Žegklitz 1990, 178; Frolík 2000, 108).

2. Prague – Hradčany (Castle District, Loretánské Square, in an ash and charcoal layer, excavation: 1935, Fig. 2: 2); slightly asymmetrical biconical shape, slightly chipped off on one of the peak sides; irregularly lathed (the central rib does not run at the same height); the surface and the two opposite flat areas are smooth; diameter: 2.4 cm; height: 1.3 cm; diameter of the cylindrical central aperture: 0.7 cm (the aperture is somewhat worn out in the place where the spindle entered); weight: 11.8 g; irregularly permeated by pink-brown stripes; color according to the Munsell Rock-Color Chart: non-homogeneous, with "moderate red" 5R 5/4 most represented; without specific dating (perhaps the 12th century); reference in the literature (Sláma 1990; Boháčová, Blažková 2011, 65).

3. Prague – Lesser Town (192 Thunovská Street, excavation: 2012, Fig. 2: 3); biconical shape with a slight hint of a central rib; the surface and the two opposite flat areas are smooth; diameter: 2.4 cm; height: 1.1 cm; diameter of the conical central aperture: 0.9/0.7 cm; weight: 9.8 g; closest color according to the Munsell Rock-Color Chart: "dusky red" 5R 3/4; dating: 10th-century context; reference in the literature (Čiháková 2018, 300).

4. Prague – Lesser Town (192 Thunovská Street, excavation: 2012, Fig. 2: 4); flat disc shape with a rounded central rib; the surface and the two opposite flat areas are smooth; diameter: 2.3 cm; height: 0.85 cm; diameter of the conical central aperture: 0.7/0.6 cm; weight: 8.2 g; color according to the Munsell Rock-Color Chart: close to "grayish red" 5R 4/2; dating: 10th-century context; reference in the literature (Čiháková 2018, 300).

5. Prague – Old Town (1064 Týnská Street, excavation: 2006, Fig. 2: 5); higher but subtle biconical shape with a regularly lathed central rib; the surface and the two opposite flat areas are smooth; diameter: 1.8 cm; height: 1.3 cm; diameter of the cylindrical central aperture: 0.7 cm; weight: 5.5 g; color according to the Munsell Rock-Color Chart: closest to "dusky red" 5R 3/4; dating: 12th century; reference in the literature (Podliska 2009, 8).

6. Levý Hradec (outer bailey, excavation: 1888-1890, Fig. 2: 6); slightly biconical, more massive shape with a rounded central rib; the surface and the two opposite flat areas are smooth; diameter: 2.7 cm; height: 1.5 cm; diameter of the cylindrical central aperture: 1.1 cm; weight: 17.9 g; color according to the Munsell Rock-Color Chart approaching "dark reddish-brown" 10R 3/4; without specific dating; reference in the literature (Tomková 2001, 124, 128, 147).

Moravia

1. Olomouc (Rajský dvůr /Paradise Courtyard/ near the Cathedral, excavation: 1981?, Fig. 3: 1); smaller subtle biconical shape with a regularly

[5] However, spindle whorls from Mikulčice, which are considered to be probably products made of Ovruch slate (Mrázek 2000, 13), cannot be interpreted in this way.

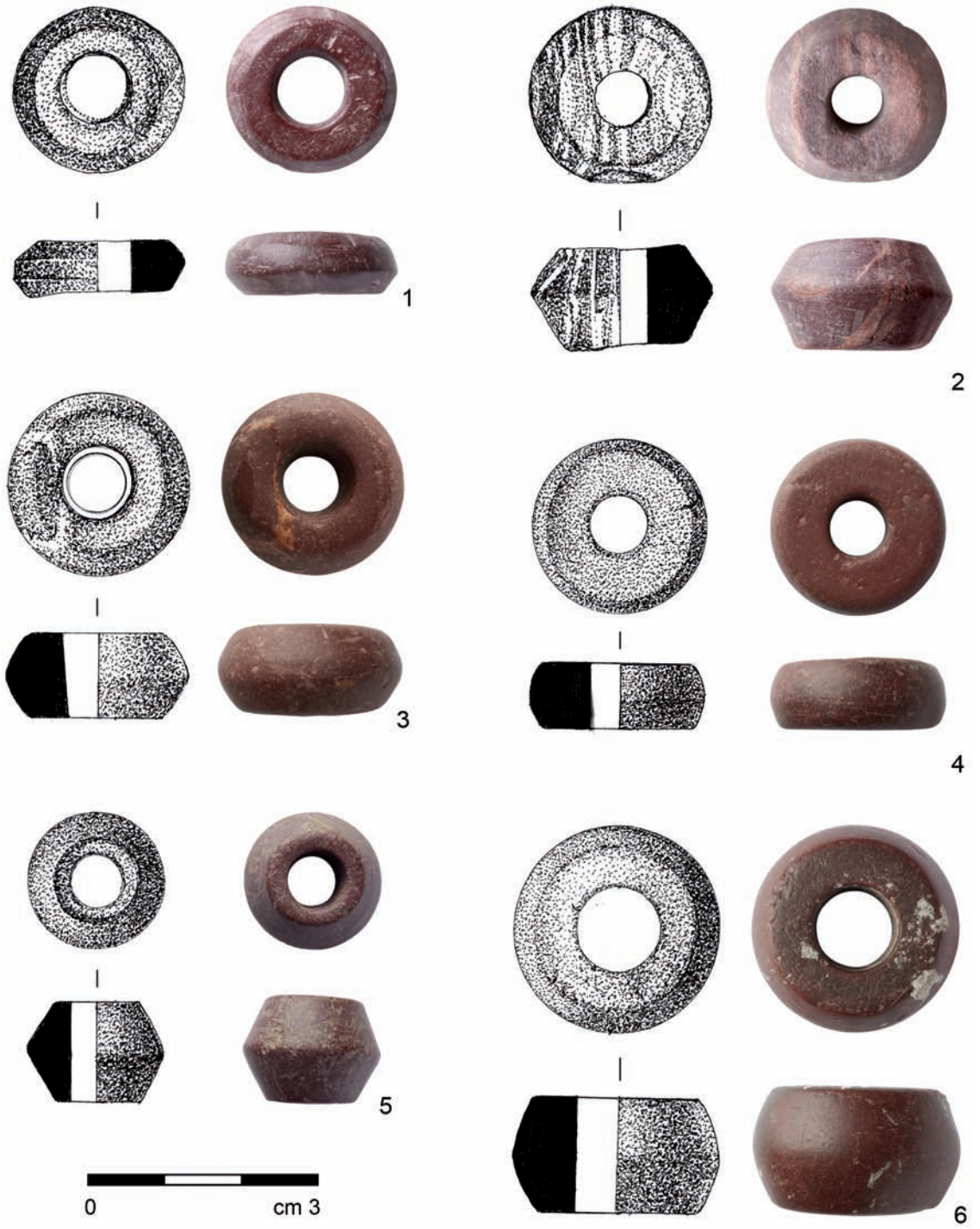

Fig. 2. Ovruch spindle whorls from Bohemia (1: Prague Castle, 2: Prague – Castle District, 3-4: Prague – Lesser Town, 5: Prague – Old Town, 6: Levý Hradec); drawing: J. Grieblerová, photo: J. Foltýn

lathed central rib; the surface and the two opposite flat areas are smooth; diameter: 1.8 cm; height: 0.85 cm; diameter of the cylindrical central aperture: 0.8 cm; weight: 4.2 g; color according to the Munsell Rock Color Chart: "very dark red" 5R 2/6; dating: probably second half of the 11th century; reference in the literature (Dohnal 1981, 264; 1985, 104; 1997, 31; 2001, 292; 2005, 93; Šlézar 2018, 129).

2. Olomouc (Křížkovského Street, excavation: 2017, Fig. 3: 2); flat disc shape with a considerably rounded central rib; the surface and the two opposite flat areas are smooth; diameter: 2.4 cm; height: 0.9 cm; diameter of the cylindrical central

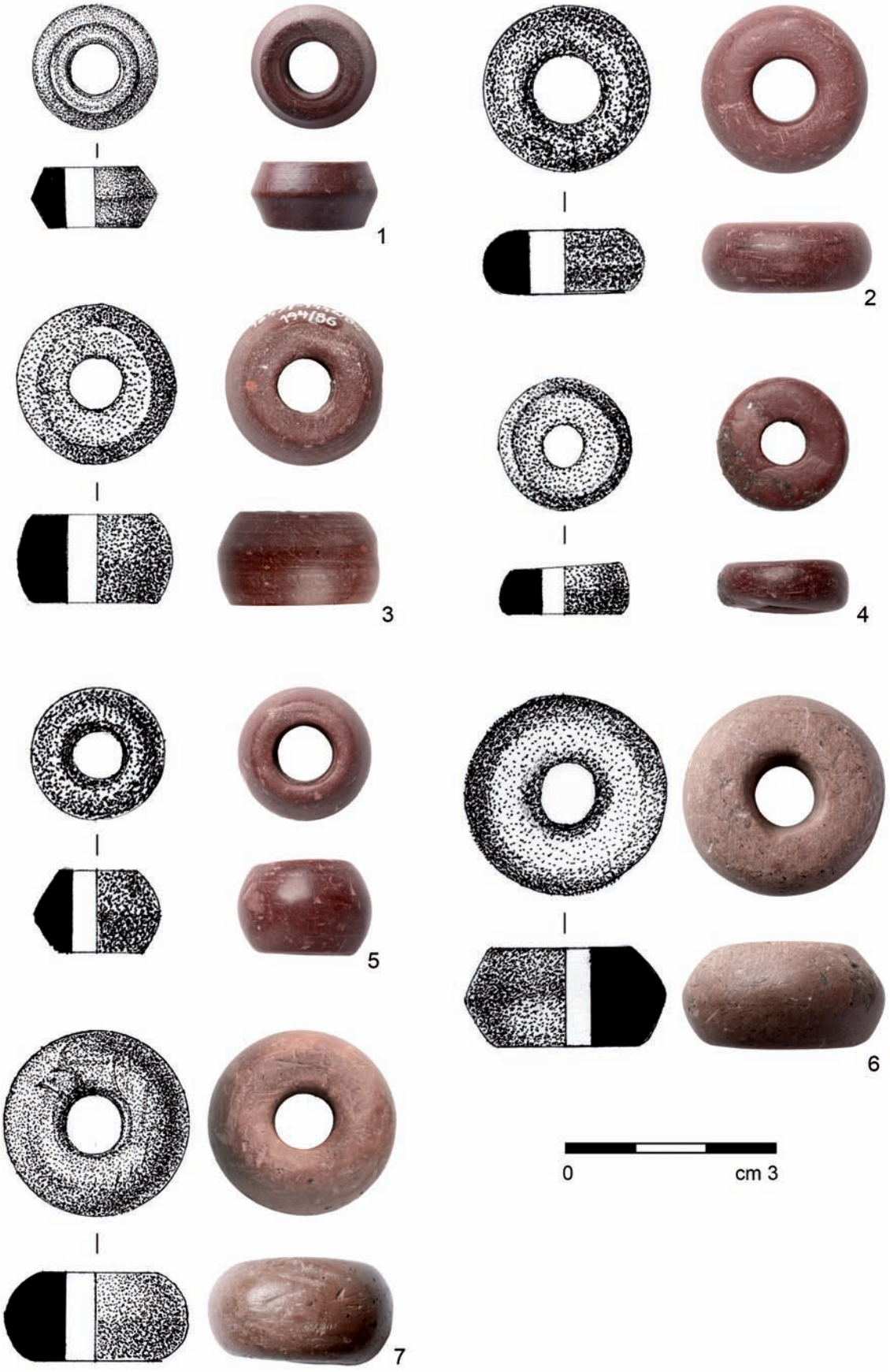

Fig. 3. Ovruch spindle whorls from Moravia and Czech Silesia (1: Olomouc – Rajský dvůr near the Cathedral, 2: Olomouc – Křížkovského Street, 3: Přerov, 4: Znojmo, 5: Dětkovice, 6-7: Chotěbuz-Podobora); drawing: J. Grieblerová, photo: J. Foltýn

aperture: 1.0 cm; weight: 9.4 g; color according to the Munsell Rock-Color Chart: "grayish red" 5R 4/2; dating: late 10th – mid-11th centuries; reference in the literature (Šlézar 2018, 129).

3. Přerov (8 Horní Square, excavation: 1986, Fig. 3: 3); barrel-shaped with a considerably rounded central rib; the surface and the two opposite flat areas are smooth; diameter: 2.3 cm; height: 1.25 cm; diameter of the cylindrical central aperture: 0.6 cm (the aperture is somewhat worn out in the place where the spindle entered); weight: 11.2 g; color according to the Munsell Rock-Color Chart: "grayish red" 5R 4/2; dating: second half of the 11th century or the 12th century; reference in the literature (Mrázek 2000, 13; Procházka 2018, 159); traces of an earlier thin section on the lower surface (cf. Wołoszyn *et al.* 2016, 601).

4. Znojmo – Castle (excavation: 1882-1894, Fig. 3: 4); smaller, subtle, slightly asymmetrical shape; the surface and the two opposite flat areas are smooth; diameter: 1.9 cm; height: 0.5/0.7 cm; diameter of the cylindrical central aperture: 0.6 cm; weight: 4.3 g; color according to the Munsell Rock-Color Chart: "dusky red" 5R 3/4; dating: 11th or 12th century; reference in the literature (Šikulová 1956, 98; Marešová 1977, 29; Kostelníková 1980, 78).

5. Dětkovice, Prostějov District (Late Hillfort Period cemetery – grave No. 37, excavation: 2010, Fig. 3: 5); barrel-shaped with a rounded central rib; the surface and the two opposite flat areas are smooth; diameter: 1.9 cm; height: 1.4 cm; diameter of the cylindrical central aperture: 0.8 cm (the aperture is somewhat worn out in the place where the spindle entered); weight: 6.8 g; color according to the Munsell Rock-Color Chart: "dusky red" 5R 3/4; dating: 11th century; reference in the literature (Fojtík 2012, 97).

Czech Silesia

1. Chotěbuz-Podobora (stronghold acropolis, excavation: 2005, Fig. 3: 6); slightly biconical shape with a strongly rounded central rib; the surface and the two opposite flat areas are smooth; diameter: 2.9 cm; height: 1.45 cm; diameter of the cylindrical central aperture: 0.9 cm; weight: 17.3 g; color according to the Munsell Rock-Color Chart: "moderate orange pink" 10R 7/4; dating: late 10th – mid-11th centuries; reference in the literature (Kouřil, Gryc 2014, 142; Kouřil, Procházka 2018, 69).

2. Chotěbuz-Podobora (stronghold acropolis, excavation: 2014, Fig. 3: 7); barrel-shaped with a considerably rounded central rib; the surface and the two opposite flat areas are smooth; diameter: 2.7 cm; height: 1.3 cm; diameter of the cylindrical central aperture: 0.9 cm; weight: 15.2 g; color according to the Munsell Rock-Color Chart: moderate reddish orange 10R 6/6; dating: late 10th – mid-11th centuries; reference in the literature (Kouřil, Procházka 2018, 69).

The following information can be derived from the description above and a summarizing table (Tab. 1). As for the shape of the spindle whorls, the biconical form prevails, represented by six specimens, followed by a disc (circular) form with four finds and three barrel-shaped artefacts. This is above all due to the considerable roundness of the central rib[6]; the upper and lower areas are both flat in all cases[7]. The maximum diameter of the body ranges from 1.8 to 2.9 cm; really small spindle whorls have been registered in four cases, including both the biconical and disc forms. The size category of 2.1-2.4 cm prevails (6 specimens); more massive artefacts (2.7-2.9 cm)[8]

[6] S.V. Pavlenko (2001, 39; 2008, 248) believes that a rounded shape testifies to long use, primarily of biconical forms.

[7] Biconically shaped spindle whorls clearly predominate, for example, also in the material from important Great Moravian sites such as Mikulčice or Pohansko, where stone spindle whorls represent c. 80% and over 60% of all finds of this kind, respectively; soft rocks were used most often for their production (Marek, Kostelníková 1998, 186; Březinová, Přichystalová 2014, 184-185). In contrast to that, an absolute majority of spindle whorls from the important Nordic centre of Hedeby/Haithabu, with conical shapes predominating but biconical, disc and spherical shapes also present, was made of clay (or, rather rarely, antler, bone, glass, amber or lead) and only sporadically of sandstone or talc (Schietzel 2014, 356-358).

[8] It is interesting that the more massive artefacts completely predominate in the small collection of Ovruch slate spindle whorls from north-east Germany (altogether 13 specimens, 10 measured ones) – the diameter of five of them is 2.8 cm (Biermann, Pust, Ansorge 2007, 6-8); two newly published whorls of the same material published from above-mentioned Haithabu, Schleswig correlate with these relatively high values (Schietzel 2014, 358). Earlier Russian and Ukrainian works list diameters between 1.0 and 2.5 cm (e.g., Rybakov 1948, 189; 1959, 101). Others state a maximum diameter of up to 3.0 cm; larger and heavier specimens with corresponding other parameters (greater height, larger central aperture diameter) are considered ear-

are represented only three times, with a corresponding height, weight, and central aperture diameter; it is cylindrical in almost the whole set, only sporadically slightly conical (0.6-1.1 cm, measured at both the upper and lower bases); sporadically, the spindle entry aperture is somewhat worn out. The weight varies between 4.1 and 18.0 g, with a direct proportion visible between the maximum diameter and the size of the central aperture. The color of the used material respects the above-mentioned color scale. The spindle whorls are made in rather good quality, except for the artefacts from Znojmo and Prague – Hradčany (Castle District).

3. ANALYSES

Only non-destructive methods were used in the analyses. After viewing under a stereo-microscope, the color was determined using the Munsell color system and magnetic susceptibility measured using KT-6 hand-held kappameter. For some specimens, the density was determined using the method of double weighing in air and in water[9]; non-destructive X-ray diffraction records were made for all of them, with an estimate of the percentage representation of the individual minerals[10] using a specially adapted Bruker D8 Advance diffractometer with a Cu-anode ($\lambda_{K\alpha}$ = 0.15418 nm). Only the last X-ray record for the spindle whorls from Olomouc was carried out using Panalytical X'Pert diffractometer with a Co-anode ($\lambda_{K\alpha}$ = 0.178901 nm). The measurement was done using conventional Bragg-Brentano parafocusing Θ-Θ reflection geometry. The black line represents the specimen's record; the lines of the corresponding materials are assigned to the individual reflections in color (red: pyrophyllite; blue: quartz; green: potassium feldspar or albite). Table 2 shows the data ascertained for the individual spindle whorls.

Non-destructive X-ray diffraction analyses make it clear that the color shades of the individual spindle whorls depend on the content of the hematite component, ranging from less conspicuous medium orange-pink (Munsell 10R 7/4) to dark red or ochre (Munsell 5R 3/4). The two spindle whorls from Chotěbuz-Podobora differ from most of the collection in having greater weight as well as a lighter color. They are both of orange shades (10R 7/4 and 10R 6/8), whereas the color of the other whorls ranges from deep dark to purplish red. The colors of the spindle whorls from Dětkovice and Znojmo are very similar.

The density was not measured for all the artefacts, but the gathered values imply that it is relatively high – 2.66 to 2.94 g/cm^3. This is undoubtedly linked to the presence of pyrophyllite. Regrettably, no data for comparison have been found in the published literature. In any case, it is considerably higher than for silty schist shale, marlstone, or limestone spindle whorls; this can be used to distinguish imitations or when an X-ray diffraction record cannot be made. The densities are quite volatile, which is connected with the changing contents of pyrophyllite and hematite. Once again, the two spindle whorls from Chotěbuz-Podobora have very similar densities (2.66 and 2.71 g/cm^3).

The magnetic susceptibility measurement was only approximate, because the spindle whorls did not cover the entire measuring head and are not thick enough, either. On the other hand, they are relatively similar in size, which means that a certain comparison can be made. Almost all provided very low data between 0.01 and 0.04 x 10^{-3} SI; higher values were shown by the spindle whorl from Thunovská Street in Prague (No. 3; 1012; 0.21 x 10^{-3} SI) and especially from Levý Hradec (No. 6; 2.33 x 10^{-3} SI).

The stereo-microscope survey showed that some of the spindle whorls are not made up of a homogeneous rock in terms of granularity but rather are characterized by an alternation of strips differing in granularity. Such marked strip structure was registered for instance with the spindle whorl from Prague – Hradčany (Castle District), Loretánské Square (No. 2), where up to 2 mm thick lighter and darker strips could be distinguished; a similar structure with strips up to 1 mm thick (wider, lighter strips alternating with thinner, darker red ones) was registered also for a spindle whorl from Chotěbuz-Podobora (No. 12). The most significant change in granularity was observed for

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lier (Rosenfeldt 1964, 222-223; Goncharova 1996, 105). Other researchers, however, find no link between the central aperture diameter and other metric data; there seems to be a direct proportion between the height, the maximum diameter and the diameter of both bases (Pavlenko 2005, 202; 2008, 248).

[9] The measurement was carried out by P. Kadlec from the Department of Geological Sciences, Faculty of Science, Masaryk University in Brno.

[10] The measurement was carried out by D. Všianský from the Department of Geological Sciences, Faculty of Science, Masaryk University in Brno.

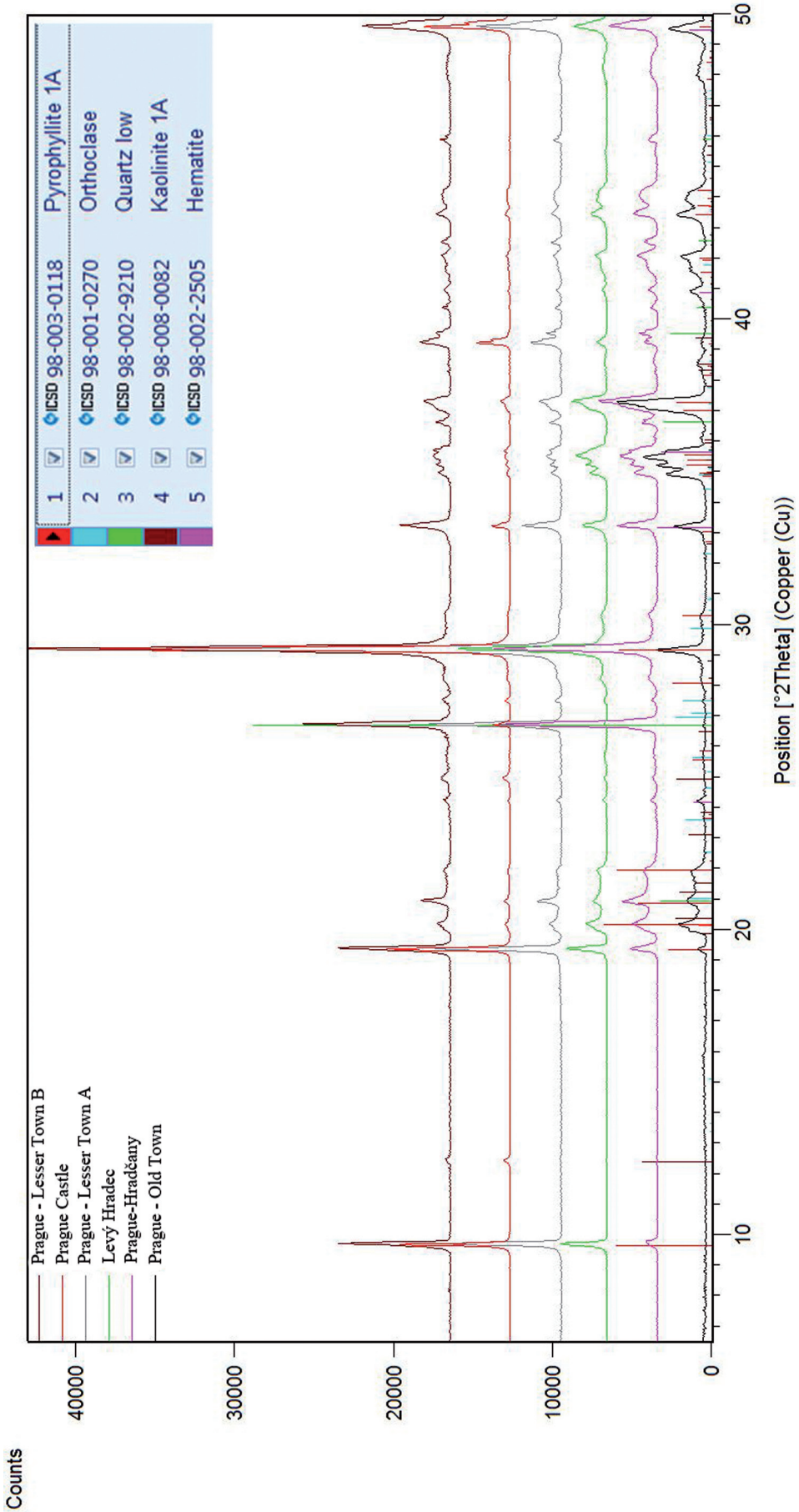

Fig. 4. Round-up of X-ray diffraction records for spindle whorls from Bohemia. Processed by D. Všianský from Department of Geological Sciences, Masaryk University, Brno

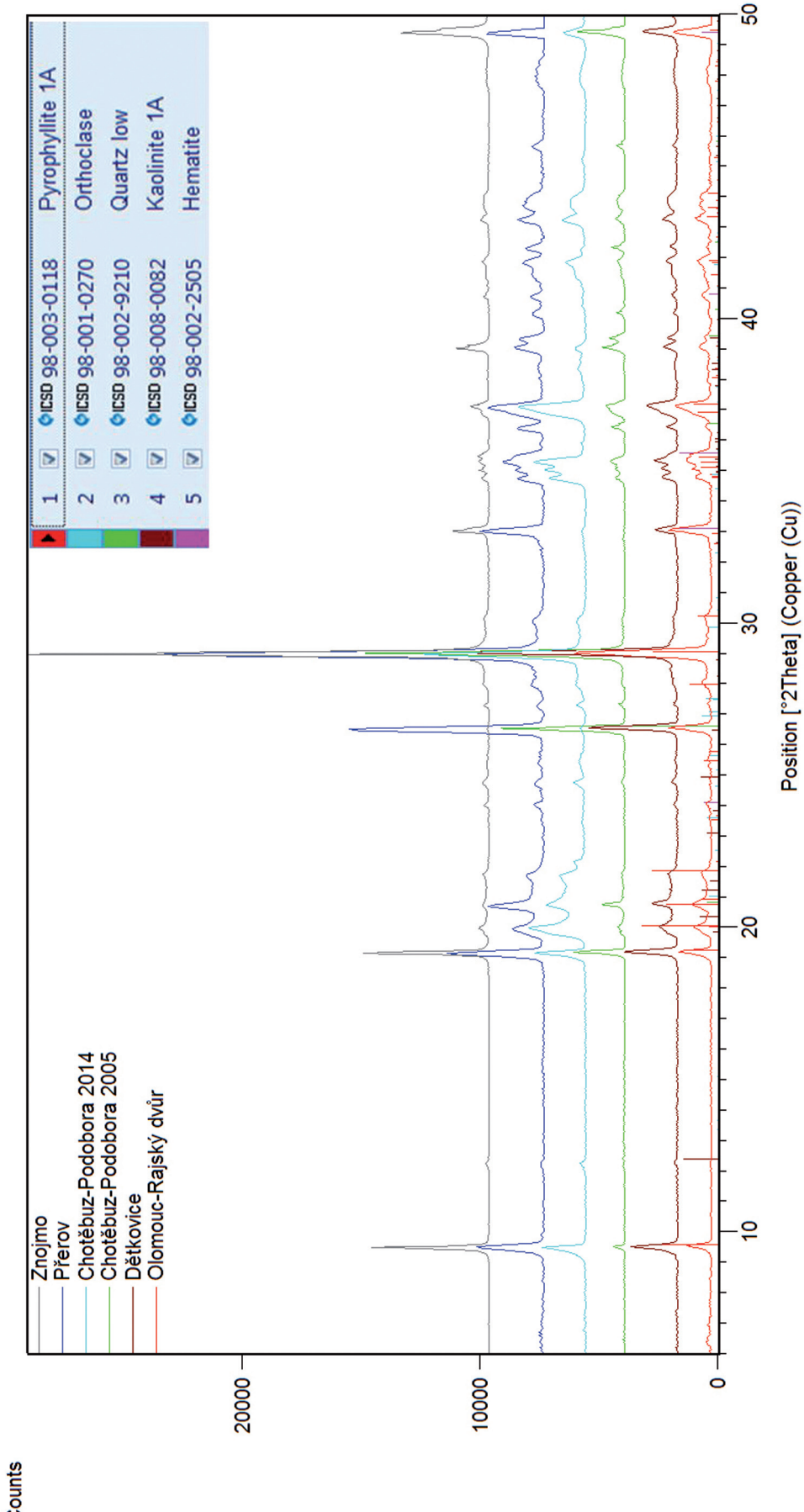

Fig. 5. Round-up of X-ray diffraction records for spindle whorls from Moravia and Silesia (excluding the spindle whorl from Olomouc – Křížkovského Street, see Fig. 6). Processed by D. Všiansky from Department of Geological Sciences, Masaryk University, Brno

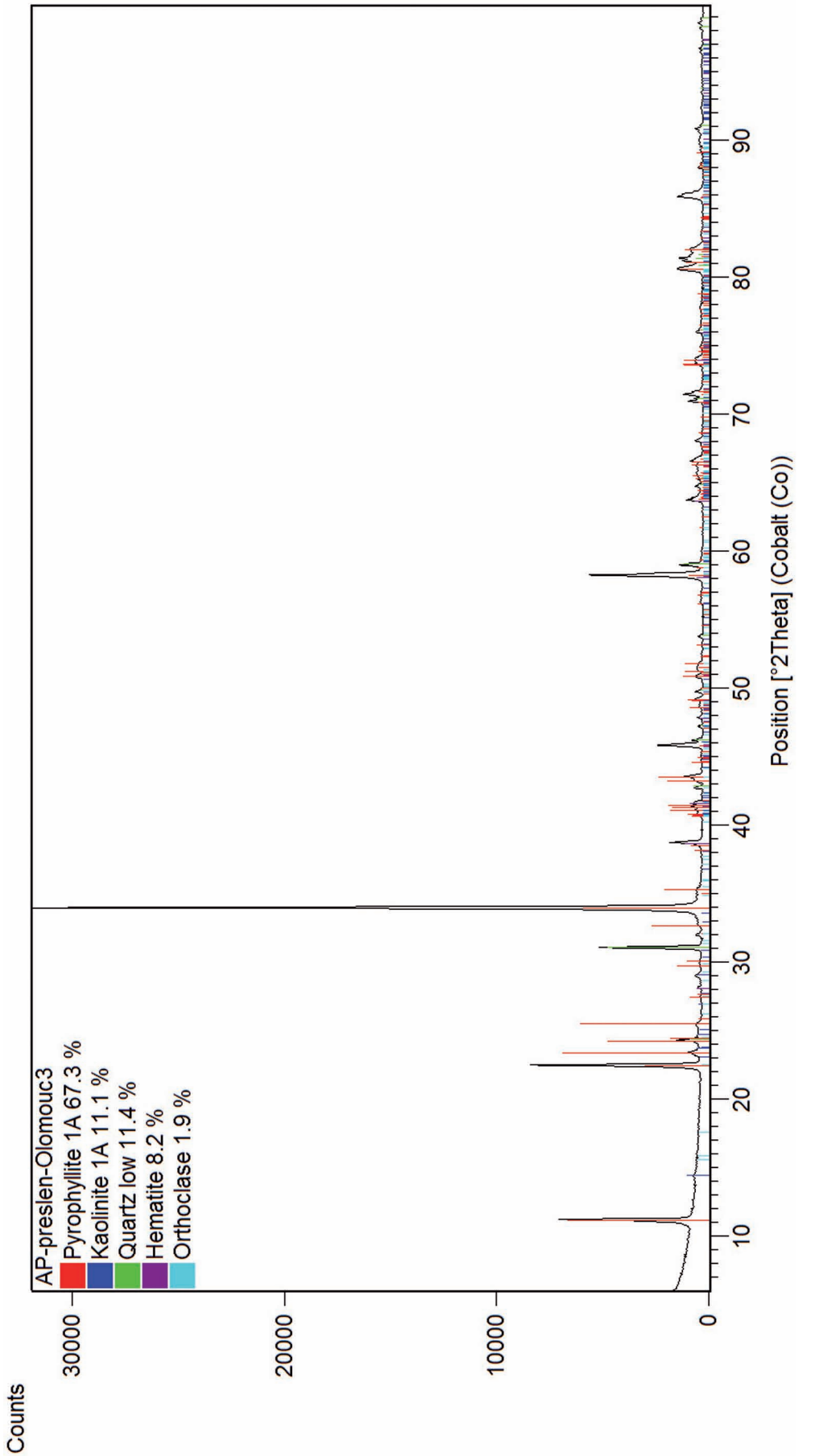

Fig. 6. Individual X-ray diffraction record for spindle whorl from Olomouc – Křížkovského Street. Analyzed by D. Všiansky from Department of Geological Sciences, Masaryk University, Brno

a spindle whorl from Olomouc (No. 7); its larger part is made up of red slate, a smaller part of distinctly granular sediment on the boundary between siltstone and a very fine-grained sandstone.

The X-ray diffraction survey registered a considerable occurrence of pyrophyllite in all 13 analyzed spindle whorls, its content exceeding 60% and sometimes even 70%. Hematite (up to 7%) and quartz were also recognized in all the artefacts. Kaolinite and feldspars – orthoclase, albite (Figs. 4, 5, 6) comprise considerable components in some spindle whorls. For comparison, we can state the X-ray diffraction record of powder preparation from a spindle whorl from Czermno, Poland (Wołoszyn *et al.* 2016, 606), whose composition was estimated at 57.8% of pyrophyllite, 13.8% of kaolinite, 22.3% of mica mineral, and 6.1% of quartz; moreover, this structure was confirmed by the study of a petrographical thin section under a polarizing microscope. A spindle whorl from Radzyń was subjected to a detailed analysis, observing besides pyrophyllite also hematite, quartz, and albite; these minerals were detected also by the X-ray diffraction record (Michalak, Sadowski 2012). Earlier petrographical analyses of two spindle whorls from Wolin proved a considerable share of pyrophyllite (60% and 54%) and a very distinct representation of hematite, indicating Ovruch as the source (28% and 35.5%; Jochemczyk, Skoczylas 1984, 62-63). Of the Polish finds, the X-ray fluorescence method was also used to examine a spindle whorl from Pełnatycz, for which Volhynia slate was also named as the very likely original material (Paszkowski *et al*. 2001, 61-64). A possible local source in the Polish part of Sudetenland was considered in connection with pink-colored spindle whorls from the Lower Silesian stronghold in Gilów (Jaworski, Wójcik 1997; also Jaworski 2005, 280-283); according to Wojcik's later conclusions, this material is clearly different from Ovruch slate; moreover, it was not very widely used even in Silesia (Michalik et al. 2003)[11].

4. SPINDLE WHORLS – TERRITORIAL DISLOCATION AND ARCHAEOLOGICAL CONTEXT

Let us first discuss the situation in the Bohemian Basin. The list above makes it quite clear that Prague with its immediate hinterland (Levý Hradec) was the westernmost destination in the Czech lands reached by spindle whorls made of Ovruch slate; it is symptomatic in a way that we do not know of them (yet) from any other place in early medieval Bohemia. The finds from Prague undoubtedly show that such goods along with other trade products were available, albeit not on a mass scale, in the nascent town, which was perhaps already from the 920s gradually profiling itself as an important center and international trade cross-road (Žemlička 1997, 38-39; Třeštík 2000, 59; 2001, 119). Nevertheless, the spindle whorls themselves could not have arrived there before the second half of the 10th century. It was only at that time, most likely in the late 950s, that men of the Duke of Prague, Boleslav I (935-967/973), probably gained control of and opened a section of the west-east transcontinental trade route connecting Prague with Kraków and continuing on towards Kiev (Jankowiak 2013, 142; 2021, 174); at the same time, mass production of slate items, including the spindle whorls under study, began in Volhynia.

Both spindle whorls from the Lesser Town can be quite easily dated to this period based on stratigraphic observations and other accompanying, albeit not numerous imported and exceptional material culture artefacts (glass fragments from the Mediterranean, the Levant and Egypt, small glazed vessels from the Far East, inlaid stirrups of Western provenance, etc.). Tenth-century Lesser Town was very probably the market center mentioned as "the city of Prague" in

[11] Some admit that the material comes from the immediate neighbourhood of Gilów or from more distant Wałbrzych; moreover, the existence of the stronghold is dated to the late 9th or early 10th centuries (Wołoszyn 2004, 250; Lisowska 2013, 141). As for the Czech lands, rocks suitable for the production of early medieval spindle whorls naturally existed there as well. They can be reliably distinguished from Ovruch slate, however; this is true of Uherské Hradiště – Sady, a source that supplied the local region and its neighborhood, as well as of another south Moravian source, not yet localized, which was used in Mikulčice and Pohansko. These are both non-metamorphosed fine-grained sediments with the character of silty schists, shales, or marlstones. The material used in Uherské Hradiště – Sady was exploited in the Rača unit of the Magura group of the Carpathian flysch belt (Zacherle 1971; Marešová 1977, 35); the source for Mikulčice and Pohansko very probably also lies in the flysch belt, but in a different place (Přichystal 2009, 247); one possibility sometimes considered is that the material for the production of stone spindle whorls from these sites very probably comes also from outcrops of Tertiary Menilite Formation in the cadastral areas of the nearby municipalities of Zaječí, Popice, and Kobylí (Březinová, Přichystalová 2014, 185).

Ibrahim ibn Jakub's relation; after all, this is confirmed by the latest archaeological and geological observations (Čiháková, Dragoun, Podliska 2000, 127-129; Čiháková 2018, 300-301; Čiháková, Müller 2020, 310-311)[12].

The dating of the spindle whorl from Prague Castle is also quite clear, which was excavated from horizon A2 during the survey of the Old Provostry – the earliest residence of the bishops of Prague; the horizon is dated to the second half of the 11th century, possibly before the 1060-1092 time range (Boháčová, Frolík, Chotěbor, Žegklitz 1986, 117-126; Boháčová *et al.* 1990, 177-178).

The spindle whorl from Loretánské Square in Hradčany (Castle District), found in the area of cremation grounds, lack a clear archaeological context. The cremation grounds themselves belong to the latest phase of early medieval occupation or the beginning of the High Middle Ages; from the stratigraphic perspective, it apparently represents the boundary between the earlier and the later phase of burial there. The beginnings of the burial site are linked to the second half of the 11th century and the final stages of the earlier phase most probably to the late 12th century, the early 13th century or its first half (Boháčová, Blažková 2011, 74-89). Very tentatively, therefore, we can date the whorl somewhere to the 12th century, although it cannot be ruled out *a priori* that it might belong to a disrupted grave of the earlier horizon of burials.

Good dating evidence, on the other hand, is available for the spindle whorl from Prague's Old Town, Týnská Street, found within the framework of an early medieval horizon in a pit dated to the 12th century. Besides ordinary pottery production or evidence of metal-casting activities, another imported artefact was also detected – a glass fragment from a hollow vessel, probably made in a Mediterranean workshop (Podliska 2009, 7-8).

The least relevant information is available about the spindle whorl from Levý Hradec. The only known fact is that it comes from surveys carried out in the late 19th century in the fortified outer bailey of an important Přemyslid stronghold where a concentration of trade and craft activities including textile production is presumed. The hillfort played an important role especially in the 10th and 11th centuries; then, transformed into a secondary center, it survived until the 12th or 13th century (Sommer 1997, 586-595; Tomková 2001, 7, 146-147, 178-186; 2013, 43-55). Taking into account the fact that the site reached its peak in the 10th and 11th centuries and that the spindle whorl is one of the larger specimens, which tend to be ascribed higher age (although not all researchers share this opinion – see footnote 7), we might date it, with a certain leeway, in this period (?).

In contrast to Bohemia, the Moravian Ovruch spindle whorls are more widely spread territorially. Logically, they were discovered above all at fortified sites, i.e., strongholds that played a key part in the construction and consolidation of the land. One whorl comes from the burial context – the only such case documented from the Czech lands. Two specimens are known from Moravia's most important center at that time – Olomouc. The first one is from the area of Rajský dvůr (Paradise Courtyard) near the Cathedral, where the Přemyslid royal stronghold was also situated (cf. Bláha 2000, 182-183). The spindle whorl lay in the lower part of the backfill, resting on a compacted 10th-century layer, together with a denarius of Spytihněv II (1055-1061) and situla-shaped fully wrapped pot (Dohnal 1981, 264), certainly an import from the northern regions[13] datable to the middle or the second half of the 11th century (cf., e.g., Kurnatowska, Kara 1994, 121-14; Bojarski 2012, 268-276 with many analogies and relevant literature); it means that the backfill was probably piled up in the second half of the 11th century, most likely after 1061 (Dohnal 1981, 264), but the spindle whorl itself may theoretically be older.

The other specimen from Olomouc was found in the outer bailey of the stronghold (Křížkovského Street) in layers from the late 10th to mid-11th centuries (as yet unpublished excavation). The dating is based mainly on an analysis of pottery fragments, but also on an antler bridle bit cheek-piece(?) decorated in the Wolin Borre style (Wolin/Jómsborg). Many other minor items imported from the north and east are known from the suburbium including, for instance, amber and amber products, glazed ceramic eggs, called *pisanky*, crosses, carnelian pearls, unprocessed carnelian, glass laundry and textile smoothers,

[12] On the identification of places connected with trade and exchange in the Early Middle Ages, see most recent Pankiewicz 2019, 145-160.

[13] J. Bláha (2000, 196) points out, however, that in contrast to nearby Přerov, the amount of pottery with very probable northern links occurring in 10th–11th-century contexts in Olomouc is negligible.

etc. (e.g., Bláha 1998, esp. 144-149; 2000, 191-192; Šlézar 2014, 214-221; 2018, 127-129).

Another important stronghold, Přerov, came into existence thanks to Piast ambitions, which culminated with the occupation of Moravia by Bolesław the Brave apparently in the very late 10th or early 11th century and which continued until the end of the 1020s; after that, it was incorporated in the Přemyslid administrative system (Procházka 2017, 290-293; 2018, 137-170; Kouřil, Procházka 2018, 62). The spindle whorl was excavated from layer No. 113, stage 5 in 8 Horní Square, situated above an earlier deposit containing a denarius of Břetislav I (1034-1055)[14]. The layer is dated to the second half of the 11th century, with an overlap into the following century. In Přerov, we also encounter artefacts imported from eastern (Oriental) regions (such as pearls of carnelian, crystal and other semi-precious stones; Procházka 2014, 226-227), including belt fitting dated more widely to the 11th century with an undoubted link to Old Rus' regions (Parma 2001, 185-187; Kouřil, Gryc 2018, 204-205).

An archaeological excavation carried out in the area of the residence of the appanage princes of Znojmo in the 1880s and 1890s yielded many valuable finds (Červinka 1928, 127), including a low-quality Ovruch slate spindle whorl[15]. Together with pottery (thrown and graphite), temple rings, a spur with a pinnacle-shaped prick, denarii of Prince Conrad I (1061-1092), etc., it was situated in the lowest early medieval layer (IV) dated by the leader of excavation generally in the 11th or 12th century. No other exceptional item with relations to the northern or eastern territories was detected there, however.

As we have mentioned above, the single spindle whorl in Bohemia and Moravia of Kievan Rus' origin coming from a burial context was acquired from the probably female grave No. 37[16] in the rural row cemetery in Dětkovice not far from Prostějov. The necropolis containing over 130 graves from the late 10th and 11th centuries was relatively rich in burials with above-standard grave goods (e.g., grave 126 with 10 S-shaped temple rings, a necklace of basket beads and 20 cut semi-precious stones – carnelians and crystals, clearly of eastern origin; imported amber and amethyst were found in other graves). Many graves also contained Hungarian, Bohemian, and Moravian coinage (Fojtík 2011, 142-143; 2012, 97; 2014, 206-207; Fojtík, Šmíd 2008, 65-68). The spindle whorl from grave 37 lay in the space between the right hand of the skeleton damaged by mechanical stripping and the edge of the grave pit; it is therefore possible that the deceased carried it either in a pouch at her (if she was indeed a girl) waist or at a strap attached to the waist in the form of a pendant, as an inseparable part of female garment (?). As the spindle whorl represented the only find in the grave (no other accompanying material was recorded), however, we cannot fully eliminate the possibility that it might have been simply put into the deceased's palm (or close to her) as a solitary object. Spindle whorls are quite commonly found in female (exceptionally children's) graves in Rus', and less frequently also in Polish or Baltic regions, in the area of the hands and the waist, sporadically also as parts of necklaces (Twarowska 1982, 247-248; Sláma 1990, 394). In this context, the possibility can be considered that some of the Ovruch slate spindle whorls might have come to Central Europe together with their users, who most probably married into their new homes or were brought there for another purpose (Wołoszyn 2004, 251). This is how the person buried in the Dětkovice necropolis might have hypothetically resettled to the Olomouc region, whose administrators – the appanage princes – maintained rather lively contacts (both marriage and economic) with the Rurikids in Rus' (but also with the Árpáds; Havlík 1975, 189-191; Krzemieńska 1987, 259-268).

Spindle whorls generally (it is not certain whether deposited with or without the spindle) as an intentional part of the grave goods of female (exceptionally also male) burials are nothing unusual in the early medieval period (for a selective summary from Bohemia,

[14] Archaeological report Ref. No. 291/05, Archive of the Institute of Archaeology of the Czech Academy of Sciences, Brno, author: R. Procházka.

[15] This was highlighted by V. Šikulová in her Master's thesis Slovanské osídlení Moravy v mladší době hradištní (Slavic occupation in Moravia in the Late Hillfort Period), Brno 1956, 98 (the thesis is deposited under sign. D 2966-100/56 at the Department of Archaeology and Museology of Masaryk University in Brno). She assumed rather correctly that along with another spindle whorl of identical color, it was an import from Kievan Rus'; this has been confirmed for the first one, but the second is definitely a very hard baked pottery product.

[16] An anthropological analysis speaks about a juvenile individual (cf. archaeological report by P. Fojtík Dětkovice 2010, Event No. 59/10, deposited in the Archive of the Institute of Archaeology of the Czech Academy of Sciences in Brno; also Jungerová *et al.* 2016, 253-264).

Moravia and Slovakia with some Nordic analogies, cf. Březinová, Přichystalová 2014, 190). They represent a rather unambiguous indicator of the deceased, an attribute of womanhood and a symbol of her status and role in life and society[17], undoubtedly also with an eschatological meaning; the burial turned them from functional items/tools into items of a magical nature (e.g., Biermann, Pust, Ansorge 2007, 11-12; Biermann 2009, 76; Mierzwiński 2019, 83-84 with references to further literature).

Finally, the last two spindle whorls, which gave rise to the writing of this study, come from the territory of Czech Silesia (the Těšín region), from a site situated in the immediate vicinity of present-day Czech-Polish state border, the bi-cultural three-part stronghold of Chotěbuz-Podobora, whose early medieval period divided into two phases can be dated to the 8th through 11th centuries. Both spindle whorls are linked to the second, later phase (late 10th to mid-11th centuries). They were gathered from layers on the stronghold's acropolis together with some other (non-ceramic) artefacts of eastern or north-eastern provenance (e.g., a black bead of glass-like paste with fused decoration, an iron spatulate key, a bronze coral, etc.), but also a silver half-denarius – i.e., an obolus of King of Hungary Stephen (997-1038). The presence of these artefacts is not coincidental, as the later Těšín region was probably an integral part of the Piast monarchy at that time and the fortification, situated on an important road passing through the northern foreland of the Moravian Gate further towards the south, played a rather fundamental role there (for more information, see Kouřil, Gryc 2014, 133-146)[18].

5. CONCLUSION

It is quite clear that all spindle whorls discussed in the present study can be considered originals imported from Kievan Rus' territory; none is a local imitation[19]. Their small number is only seemingly surprising, taking into account that Princes Boleslav I and Boleslav II of Bohemia controlled "their" section of the trans-European route along which spindle whorls could probably reach our territory for three or four decades at the most. The loss of control and occupation of this area by the Piasts led to a significant negation of the importance of trade routes leading through Prague (cf. e.g. Adamczyk 2018, 248-249). Material culture artefacts of Rus' provenance in Bohemia, however scarce (Nechvátal 1979, 213-251; Lutovský 1986, 1-12; Sláma 2018, 13), suggest that the connection with the East probably did not stop completely in the 11th century (and probably not even later).

Ovruch spindle whorl finds from Prague suggest that the city was their target destination. According to the current state of research, they were not distributed further from there. The well-stratified spindle whorls from Thunovská Street can be connected with the second half of the 10th century without major problems. So may be the spindle whorl from Levý Hradec (?), taking its parameters into account, but this is not at all certain; let us recall that their production and distribution were only beginning at that time. Relatively reliable dating is available also for the spindle whorls from Prague Castle (second half of the 11th century) and Týnská Street (12th century); the remaining specimen from Loretánské Square (possibly 12th century) lacks a conclusive archaeological context. Let us emphasize, however, that as these high-quality and popular products were used for a relatively long time, especially in regions remote from the center of their production, they might be even earlier. If they indeed reached the Prague agglomeration in the 11th or 12th centuries, they were quite certainly (like the older specimens) rare and valuable artefacts; almost certainly, it was not a regular article in long-distance trade. This situ-

[17] Russian literature speaks about the customary donation of a spindle or a spinning wheel by the bridegroom to the bride during the wedding ceremony (Medyntseva 2008, 231).

[18] In this context, we can draw attention to a very recent discovery of an Ovruch spindle whorl on neighboring Castle Hill (Góra Zamkowa) in Cieszyn, Poland, which was excavated from an 11th-century layer preceding the foundation of the rotunda of SS Nicholas and Wenceslas (Gryc 2020, 154). Regrettably, a similar artefact that was published from this area earlier is unaccounted for today (cf. Wołoszyn 2007, 188, Fig. 6; Gryc 2020, 154).

[19] Such imitation is known, for instance, from Starigard/Oldenburg (Biermann, Pust, Ansorge 2007, 7); we can also point out a so far unpublished spindle whorl of marl limestone of the Cretaceous Age from the Opava-Kylešovice stronghold (10th or 11th century) with red paint on the surface; it was possibly applied in an effort to imitate items from Volhynia (?).

ation is in harmony, for instance, with the conditions stated for the regions west of the Odra river (Polabian Slavs), where these unusual goods are also present only sparsely (Gabriel 1991, 261; Biermann, Pust, Ansorge 2007, 11). Dozens of these spindle whorls are known, in contrast, from neighboring Lower Silesia; c. 86 of them were found in its center, Wrocław, alone (situation as of 1989). This undoubtedly testifies to extensive contacts between Poland and Rus' in the course of the 10th to 13th centuries; after all, this is true of the whole territory of Poland (Wołoszyn 2007, 186-187; 2010, 307, 319; Lisowska 2013, 137-141). Inscribed spindle whorls are sporadically found there as well. They are more common in Rus' (where they also bear various signs and drawings), but they are late, mostly from the 12th and 13th centuries, testifying to certain literacy of the local population (Rybakov 1948, 196-202; Rozenfeldt 1964, 223; Gončarova 1996, 102-105; Medynceva 2008, 228-232; Wołoszyn *et al.* 2016, 597-612).

From the delineated situation and the relatively distinctive absence of evidence of long-distance trade and exchange including the coin component, it seems evident that the relations between Bohemia and Rus' were not very intensive, as J. Sláma (1990) has already stated. This is true despite the fact that the presence of eastern merchants (Russians and Slavs but also Jews and Turks, i.e. Hungarians) is documented at the Prague marketplace[20] and we are also informed about likely dynastic unions; the first wife of the future Prince of Kiev Vladimir I (958/960-1015) was allegedly from Bohemia (certainly from a ducal family, most likely a Přemyslid); it cannot be ruled out that one of his other wives was also born in Bohemia (Havlík 1975, 186; Téra 2019, 218-222). Nevertheless, after the collapse of the Přemyslid state at the end of the 10th century and the related deep political and economic crisis, the already not very substantial contacts with Kievan Rus' were further restricted, although the Přemyslid princes in Olomouc maintained their contacts with the Rurikids for a relatively long time, as we have suggested above.

Let us now return to Těšín and Opava in Silesia and to Moravia proper. As for the first territory, the Těšín region, evidently tending to the Polish milieu, we assume that both spindle whorls, which are very similar, reached the Chotěbuz stronghold most probably in the same period (late 10th to mid-11th centuries), and they apparently also come from the same deposits and the same production center. Brand new excavations in the Opava region (especially the Kylešovice stronghold) have brought surprising but clear evidence of the presence of eastern elites (Varangians from Rus'; e.g., belt fittings, pendant crosses, etc.) and their share in the construction of the land in the second half of the 10th and the 11th centuries, at the beginning most probably in the services of Piast rulers. The relations between this territory and the eastern regions must, therefore, have been rather intensive during these two centuries (Kouřil, Gryc 2018, 185-213; Kouřil 2021, 258-267).

In Moravia, it was above all Olomouc and its wider hinterland (including the Přerov and Prostějov regions), where northern and eastern imports (including Oriental goods) are represented perhaps the most intensively in material culture artefacts of the late 10th to 11th/12th centuries within the Czech lands (e.g., Šlézar 2014, 214-221; Procházka 2014, 226-227; Procházka *et al.* 2020, 15-17). All spindle whorls from this area (Olomouc, Přerov, Dětkovice) and probably also the more distant specimen from south-western Moravia (Znojmo – Castle) can be dated to this time horizon, mainly the 11th century. We have suggested why this was so: the key role was played by the Polish occupation of the land in the late 10th century and the fact that it remained in Poland's sphere of influence basically until the end of the 1020s, and later also by the marriage policy of the appanage princes of Olomouc towards Rurikid princes (due to economic reasons, among others). These factors enabled the supply of unusual and, in a way, rare and attractive commodities into the area, evidencing that the trade route along which merchant caravans travelled from Kiev and Kraków was still operable and in use in the 11th and even 12th centuries[21].

Acknowledgements

The authors thank the following colleagues for loans of material for treatment and publication: J. Čiháková, H. Dehnerová, A. Humpolová, V. Brych, P. Fojtík, J. Frolík, J. Podliska and P. Šlézar.

[20] Compare the relation of the Jewish merchant and diplomat Ibrahim ibn Jakub, probably from the mid-960s (MMFH III, 413).

[21] As late as 1129, Russian merchants travelling from Moravia were robbed in Poland, with considerable Polish-Russian political consequences (Bláha 1998, 147; Havlík 1975, 189; Krzemieńska 1987, 263-264); also e. g. Wołoszyn 2007, 184-185.

Tab. I. Table summarizing the basic data on Ovruch slate spindle whorls from the Czech lands

No.	Locality	Shape	Max. diameter (cm)	Height (cm)	Aperture diameter (cm)	Weight (g)	Colour (Munsell Rock Color Chart)	Dating
1	Prague Castle	disc	2.1	0.6	0.9 slightly conical	5.0	very dark red 5R 2/6	2nd half of the 11th c.
2	Prague - Hradčany	biconical	2.3	1.3	0.7 cylindrical	11.8	moderate red 5 R 5/4	12th c. (?)
3	Prague - Lesser Town A	biconical	2.4	1.1	0.9/0.7 conical	9.8	dusky red 5R 3/4	10th c.
4	Prague - Lesser Town B	disc	2.3	0.85	0.7/0.6 conical	8.2	grayish red 5R 4/2	10th c.
5	Prague - Old Town	biconical	1.8	1.3	0.7 cylindrical	5.5	dusky red 5R 3/4	12th c.
6	Levý Hradec	biconical	2.7	1.5	1.1 cylindrical	17.9	dark reddish-brown 10R 3/4	without specific dating
7	Olomouc - Rajský dvůr	biconical	1.8	0.85	0.8 cylindrical	4.2	very dark red 5R 2/6	2nd half of the 11th c.
8	Olomouc - Křížkovského Street	disc	2.4	0.9	1.0 cylindrical	9.4	grayish red 5R 4/2	late 10th-mid-11th c.
9	Přerov - Horní Square	barrel-shaped	2.3	1.25	0.6 cylindrical	11.2	grayish red 5R 4/2	2nd half of the 11th c. or the 12th c.
10	Znojmo - Castle	disc	1.9	0.5/0.7	0.6 cylindrical	4.3	dusky red 5R 3/4	11th-12th c.
11	Dětkovice, Prostějov District	barrel-shaped	1.9	1.4	0.8 cylindrical	6.8	dusky red 5R 3/4	11th c.
12	Chotěbuz - Podobora 2005	biconical	2.9	1.45	0.9 cylindrical	17.3	moderate orange pink 10R 7/4	late 10th-mid-11th c.
13	Chotěbuz - Podobora 2014	barrel-shaped	2.7	1.3	0.9 cylindrical	15.2	moderate reddish orange 10R 6/6	late 10th-mid-11th c.

Tab. II. Petrophysical properties and mineralogical composition of studied spindle whorls from Bohemia (1 – 6), Moravia (7 – 11) and Silesia (12 – 13). Occurrence of individual minerals is rounded to whole and half of per cent. Explanations: n.d. – non determined, MS – magnetic susceptibility

No.	Locality	Density (g/cm^{-3})	MS (x 10^{-3} SI)	Appearance	Mineral composition
1	Prague Castle	n.d.	0.02	homogeneous rock	72.8 % pyrophyllite; 6.4 % hematite; 14.7 % kaolinite; 6 % quartz; < 0.1 % orthoclase
2	Prague - Hradčany	n.d.	0.02	bands up to 2 mm	69 % pyrophyllite; 5 % hematite; 7 % kaolinite; 16 % quartz; 3 % orthoclase
3	Prague - Lesser Town A	n.d.	0.02	homogeneous rock	61 % pyrophyllite; 10.2 % hematite; 4 % kaolinite; 24.5 % quartz; 0.3 % orthoclase
4	Prague - Lesser Town B	n.d.	0.21	homogeneous rock	51.5 % pyrophyllite; 11 % hematite; 8.5 % kaolinite; 23 % quartz; 6 % orthoclase
5	Prague - Old Town	n.d.	0.01	homogeneous rock	77.5 % pyrophyllite; 22 % hematite; 0.5 % quartz
6	Levý Hradec	n.d.	2.33	homogeneous rock	80.5 % pyrophyllite; 10.5 % hematite; 8.5 % kaolinite; 0.5 % quartz
7	Olomouc - Rajský dvůr	n.d.	0.02	shale, partly siltstone	77.5 % pyrophyllite; 14.5 % hematite; 8 % quartz
8	Olomouc - Křížkovského Street	2.92	0.02	homogeneous rock	67. 5 % pyrophyllite; 8 % hematite; 11.5 % kaolinite; 11 % quartz; 2 % orthoclase
9	Přerov - Horní Square	2.79	0.03	homogeneous rock	64 % pyrophyllite; 9.5 % hematite; 25 % quartz; 1.5 % orthoclase
10	Znojmo - Castle	2.86	0.01	homogeneous rock	82.5 % pyrophyllite; 9 % hematite; 7.8 % kaolinite; 0.5 % quartz; 0.2 % orthoclase
11	Dětkovice, Prostějov District	2.94	0.01	homogeneous rock	62 % pyrophyllite; 7 % hematite; 12 % kaolinite; 17 % quartz; 2 % orthoclase
12	Chotěbuz - Podobora 2005	2.66	0.02	bands up to 1 mm	63.5 pyrophyllite; 1 % hematite; 2 % kaolinite; 33 % quartz; 0.5 % orthoclase
13	Chotěbuz - Podobora 2014	2.71	0.04	homogeneous rock	76.5 % pyrophyllite; 1 % hematite; 19 % kaolinite; 0.5 % quartz; 3 % orthoclase

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Otrzymano (Received): 22.01.2022; zrecenzowano (Revised): 22.02.2022; zaakceptowano (Accepted): 28.02.2022

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