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19

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VI. SANITATION AND STREET SURFACE CONSTRUCTION

Successful urban development, something that the three towns analysed here evidently enjoyed, was a cause of serious disturbance to the natural ecosystem. The density of the urban population, their life needs, increased water usage and intensification of production meant that there was an accumulation of all kinds of waste. The growing demand for timber, for construction and for fuel, and the intensification of agriculture resulted in deforestation and the destruction of the area surrounding the town. The level of sanitary hazard, problems with water supply, tightly packed buildings, transport and communication depended on numerous factors, which in each centre evolved over successive stages of their development. On the one hand, these were natural conditions such as the town's topography, hydrographical pattern, soils, on the other hand, manmade factors – the town's size, its economic potential and the nature of its trades, industries and commerce. With the townspeople of individual towns of Central Europe keeping in touch and exchanging information methods of combating pollution were similar everywhere, although every town retained its own character in this regard. While fascination with nature was not unknown to the people of the Middle Ages, actions taken by them were not dictated by their awareness of the need to protect the environment (Barros 1998, 287–300). Rather, their purpose was to control the side effects of civilization's development.

The sanitary status of a town depended largely on natural factors. The groundwater level, soil conditions and the relief had a significant impact on cleanliness levels in town squares, streets and burgage plots. On light soils over a dry substrate, on land with good permeability or lying on a slope, the processes of decomposition of organic waste left on the ground surface were relatively rapid.

These were the natural conditions of medieval Prague, especially its left bank area – the Lesser Town below Prague Castle. The slope of the ground towards the river with groundwater at a low level and flowing over a rocky substrate, prevented organic waste from remaining permanently on the site. On the right bank of the Vltava, the situation was similar despite much smaller differences in elevation. The natural substrate of the Old Town terrace is formed by thick deposits of gravel, washed in by water flowing downwards from a higher level. The deep groundwater table did not block the access of oxygen. This found reflection in the structure of deposits accumulated in the town prior to the laying of stable pavements and the organising of the regular cleaning of street surfaces (Hrdlička 2000; Zavřel 2001). The thickness of the cultural deposit that has accumulated in Prague since the early medieval period until the present varies, ranging between 3.5 and 4.5 m but as much as 6 m in the area bordering the river (Havrda and Tryml 2011, 197). Organic waste deposited in the streets and yards mostly decomposed. Studying the stratigraphy of the main marketplace of Prague's Old Town, Ladislav Hrdlička (2000, 200) distinguished a lower complex of deposits formed in a spontaneous manner without the control of the inhabitants. Slightly over 1 m thick, this sequence was found to contain some organic matter but the frequency of waste is relatively small. There was no evidence for organic content in the upper part of the stratigraphical sequence.

Similarly situated on a large river, Wrocław had natural conditions different from those in Prague. The differences in elevation in the town and its surrounding area were small. Much of the town's area, especially in its northern zone, was marshy and subject to flooding. We have to assume that the earth-and-timber ramparts on Ostrów Tumski served a double function, defensive, but also one of flood control. The shallow groundwater table, generally unfavourable for health conditions, inhibited the

decomposition of organic waste. Action to improve this situation was taken during the 13th century, after the town's incorporation. Much of the town's surface was spread with layers of sand, which raised its level by about 50 cm. One side effect of human occupation that soon made an impact was the unrestrained build-up of layers of waste, which raised the ground level by as much as 4 m but at the same time, was detrimental for the sanitation level in the town and for communication. Regulation of the river and the construction of structures for damming up water for economic use had the less welcome effect of raising the groundwater table (Badura 2010, 40–44; Konczewski and Piekalski 2010, 91–151; Sowina 2009, 52–65).

In this regard, the inhabitants of medieval Krakow were a little better off. The distinctly shaped high terrace of the Vistula – the Prądnik Cone – offered an elevated tract of ground with a steep slope, raised several metres above the floodplain. Sloping gently southwards it had a sunny aspect. A sandy substrate offered good conditions for building construction. The groundwater level was at a comfortable depth of 5–6 m. On the evidence from geological analyses it would appear that contrary to earlier surmises, there were no wetlands or natural watercourses on the southern part of the Prądnik Cone. Neither was there any more substantial variation in elevation. Rather, the terrace was a level, sandy upland separated from the floodplain. The cultural deposit accumulated during the Middle Ages does not contain as much organic material as the one in Wrocław. It is composed of various dumped layers of sand from levelling and from construction, but also, muck and slippery humus, showing that the streets and squares were in need of regular maintenance by the townspeople (Kmietowicz-Drahtowa 1971, 1974; Wierzbicki 2010, 177; Zaitz 2010, 216–226; Niemiec 2007, 2011). The thickness of the stratigraphical layers was in the range of 3.5–4.5 m as in Prague and Wrocław.

The problems with maintaining the proper sanitary levels of the town were compounded by the density of urban development. In earlier relevant publications especially, the accepted view was that medieval towns were largely overcrowded (Gruber 1942; Beresford 1967). Today we know that this view was the result of a retrospective analysis of late medieval and post-medieval source. Archaeological research of earlier phases of development is in need of a separate analysis in this regard and the actual density of urban development tended to be lower than previously thought. In most towns, at least from the late Middle Ages onwards, there was a reserve of land for construction. In the western region of Central Europe, the 14th-century economic crisis and epidemics resulted in a major reduction of the population. In Prague, Wrocław and in Krakow, the opposite was the case; this was a century of intensive growth. At the same, there is no evidence to conclude that there was overpopulation. The development of all plots laid out earlier and the exhaustion of the reserves of land, thus, obtaining profit from them in the form of rent, usually caused the territorial lord to allot the commune additional land or to organize a new town (Maschke and Sydow 1969; Słoń 2010). In Prague, this presumably prompted the incorporation in 1348 of the spacious New Town, not fully built over by the end of the Middle Ages. Thus, presumably in the Old Town, at least according to the view of its inhabitants, there was no drastic overpopulation. In Wrocław the area of the original Old Town was surrounded from the south and west by a zone granted to the townspeople additionally during the 1260s. Until the modern period, plots laid out in this zone continued to have an area of green space not occupied by development. In addition, the poorly developed New Town continued to have timber buildings (Młynarska and Eysymontt 2001, Plates 4, 13). The burgage plots in Krakow were developed with some delay, and apparently, by the end of the 13th century there was still a shortage in population. Despite this, three new towns were incorporated during the 14th century giving rise to the large late medieval agglomeration composed of several segments. Apart from the Old Town, it included the reorganized former suburbium of Okół and the new towns of Kazimierz and Florencja – the latter now known as Kleparz. Thus, it is hard to accept that the consequences of the sanitary levels due to the increased density of urban development in the towns of interest, at least during the developmental phase under investigation, were higher than the norm adopted by the owners of the towns and by the townspeople themselves. They are no different in this regard from many other towns across Central Europe (Piekalski 2001, 207–216).

The quality of air, water and soil were definitely affected by the economic activity carried on in the town. The most affected in this regard were mining towns and settlements (Schwabenicky 1993; Stolarczyk 2010; Hrubý 2011). The extraction and pre-treatment of ores – cleaning, washing, roasting and smelting – caused changes in the environment both in the town and in its neighbourhood. Other towns were not immune to this nuisance. In Prague, there is evidence from earlier occupation phases

that confirms the intensive metallurgical activity – extraction of iron ore and smelting on the Old Town terrace (Podliska 2008). Bog ores were also present in the Odra valley in Wrocław, e.g. by the northern stretch of the Szewska and along Więzienna streets (Konczewski et al. 2010, 311–313). The smelting of iron in the area between Więzienna and Odrzańska streets is confirmed for the 13th century (evidence from the research of Aleksander Limisiewicz 1996–1997). Several tons of iron slag from the 14th century was discovered by the outer section of św. Mikołaja Street and smaller amounts in the regularly laid out area of the town at Malarska Street (Buśko and Piekalski 1994; Jastrzębski, Piekalski and Wysocka 2001, 339–340). In Krakow too, intensive and varied metallurgical activity was pursued. During the investigation of the Main Market Square, it was confirmed for the pre-incorporation phase, prior to the laying out of the square and for the later Middle Ages as well. During the proto-urban phase, bloomery iron was treated as a preparatory product to forging, and there is evidence for the casting of copper and silver (Radwański 1975, 157–158; Buśko and Głowa 2010, 147–148). During the 14th century, mass and retail trade in lead, copper and iron assumed a major scale, confirmed by both the written and the archaeological sources. The excavation of the area next to the Great Scales, (the weighing and measuring area known as 'Wielka Waga'), dating from the early 14th century at the latest, identified a significant series of metal finds ranging from dust through assorted fragments, to a fully moulded and marked lump of lead weighing 693 kg within the medieval deposit (Wyrozumski 1992, 391; Szejbal-Dereń and Garbacz-Klempka 2010, 34–38). The metals were hacked into pieces but also melted down close to the Great Scales. Long-term contamination of the soil by heavy metals was also confirmed next to not only the Great Scales but also elsewhere in the Market Square, in the Cloth Hall and near the rows of stalls. If the soil was affected, then the groundwater must have been too (Pawlikowski et al. 2010; Wardas-Lasoń and Głowa 2010; Wardas-Lasoń, Zaitz and Such 2010).

Air and water pollution was caused also by other trades that were present in each of the discussed towns. Of these, the most widespread was tanning with its smell of decomposing hides and its use of a significant quantity of water. To reduce the nuisance caused by tanneries an effort was made to group them on the outskirts of the town. At the same time, tanners needed to have good access to water, in practice, to a river or a moat. Districts settled by tanners, also due to the low social status of this group of tradespeople, were often regarded as inferior (Cramer 1981; Ruckstuhl 1993; Buśko 1999b). The technological necessity for water was sufficiently strong to dictate the location of this production to the extent that in Wrocław, the tanners' district was next to the castle, where they drew the water from the nearby Odra River. In Krakow during the 14th century, tanners occupied plots by the north-western stretch of the city moat, fed by the waters of the Rudawa, a left tributary of the Vistula. While discussing the significance and uses of water in the town, Urszula Sowina noted briefly that the economic importance of tannery production was sufficiently high for its inconvenience to be disregarded in the decision regarding its location (Sowina 2009, 81–82). In any case, unlike the permanent environmental pollution caused by metallurgy, tanneries only caused temporary inconvenience. Less of a threat to the sanitary levels were slaughterhouses and dyers' workshops, found in a small concentration or relegated to outside the town's limits.

The main elements of public space in medieval towns were its squares and streets. The technical quality of their surface had a significant impact on the conditions of everyday communication, and less directly, on economic life too. It is hard to ignore their significance for the general atmosphere in the town, including the relationship of the commune members, municipal government and the town's territorial lord. Presumably, in large towns on a river with climatic conditions typical for Central Europe, where the autumn-winter season lasted six months, maintaining the streets in a proper condition was a real challenge. The rapid build-up of layers of organic waste and the muddy condition of the streets and squares, especially during the wet season of the year, made it necessary to develop methods of metalling and managing street surfaces. Systems developed in each of the discussed towns differed in some ways.

From proto-urban Prague, the suburbium below the castle, there is evidence that street surfaces were lined with timber. This was so both on the streets and in the area inside the walls and on at least some stretches of access roads. As noted earlier, the survival of organic substances, including timber, was poor in the Prague suburbium. There is evidence nevertheless, that the road leading from its centre to the Vltava crossing was lined with timber. Traces of similar street surfaces were confirmed in other locations within the suburbium, indicating that the method of lining the surface with timber was generally accepted in early medieval, left bank Prague (Čiháková 1997; Čiháková and Dobry 1999, 339;

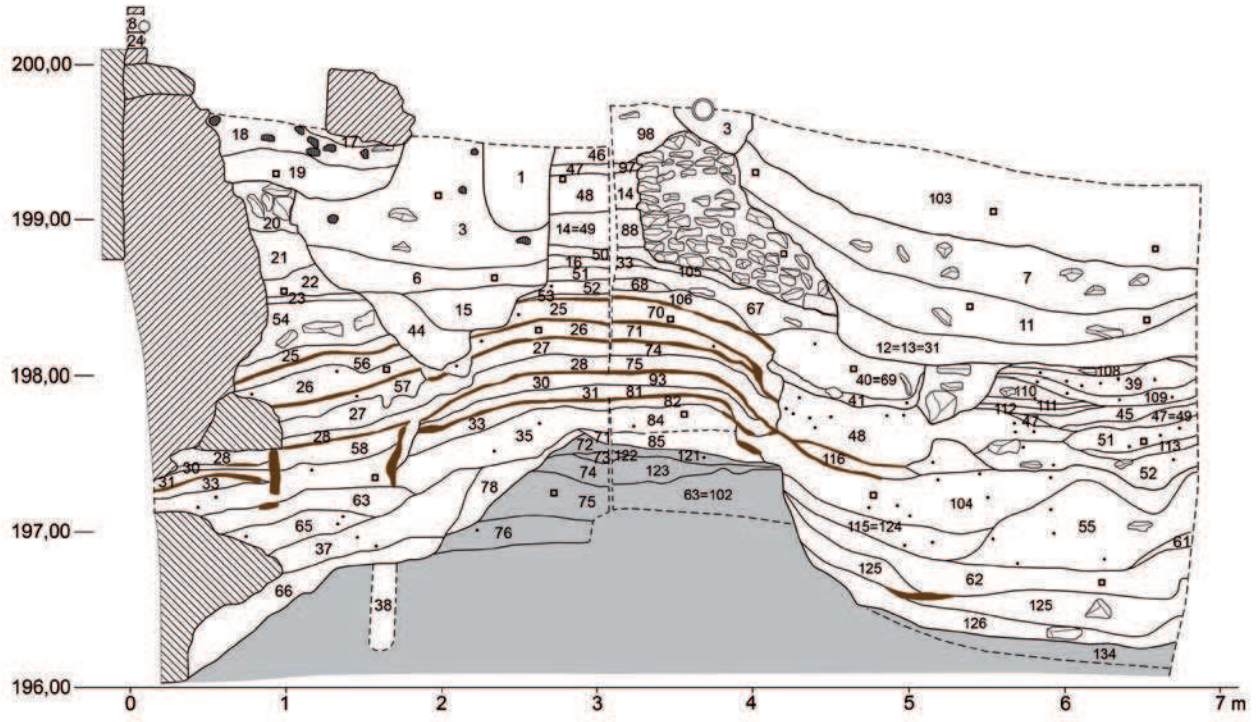

Fig. 90. Prague, Lesser Town Square. Street level stratigraphy. Cymbalak and Podliska 2011

Čiháková and Müller 2008; Čiháková and Zavřel 1998). The details of construction were furnished by fieldwork carried out in the area off the south-western corner of the town's principal square (Lesser Town Square). Here a junction of streets was discovered with five levels of street surfaces of oak wood (Figs. 90, 91). Their preservation level varied, especially the timber from the younger layers was heavily decomposed. It is evident, nevertheless that this system of road construction was used repeatedly (Cymbalak and Podliska 2011, 303–305). It consisted of solid sleepers and rough planks laid over them transversely to the direction of the traffic. Some of the sleepers rested on stakes driven into the ground. The whole structure thus formed a sort of a causeway over marshy ground. The lowest street phase rested over a layer of trampled natural subsoil and was overlaid by a succession of later street levels. The earliest of them, running east-west, had a width of 2.4 m. Its successors were wider; up to 3.2–3.4 m. A timber-lined ditch was recorded by the edge of the youngest street surface level. The whole structure was dated by small finds to the 10th–11th century.

Different methods of surfacing streets were used on the opposite bank of the Vltava, in the crafts-and-market settlement that subsequently evolved into the communal town. Apparently, there many of the access roads and streets in the built-up area were not surfaced at all, especially during the earlier phases of settlement (Havrda and Tryml 2011, 195). This did not apply to the main thoroughfares. In their case, the metalling of their surface is confirmed by source evidence sufficiently rich to describe the techniques and their evolution. The use of dirt roads by wheeled traffic resulted in the destruction of the natural humus layer and even their cutting into the sandy substrate. Discovered in 1975 during construction work on the Prague Metro, the road between the marketplace and the Vltava crossing had a width of 4.20 m and had the form of a sunken road with a depth of about 40 cm and observable ruts (Širová 1977). Sometime later, the y was filled in with a layer of river pebbles over a foundation of clay. The stone was spread in a random fashion and compacted, forming a metalled surface (Fig. 92). During subsequent use, the road surface was repaired repeatedly by spreading it with more pebbles (Havrda and Tryml 2011, 195–197). It is broadly dated to the 12th century with the possibility of moving this dating to an earlier as well as a later time.

A similar system was recorded in two spots on Platnerská Street. There also the earliest phase of the road was unsurfaced. After the dirt surface was churned up and compacted by traffic to the form of a sunken road it was banked up with a layer of pebbles with an average diameter of 10 cm, sup-

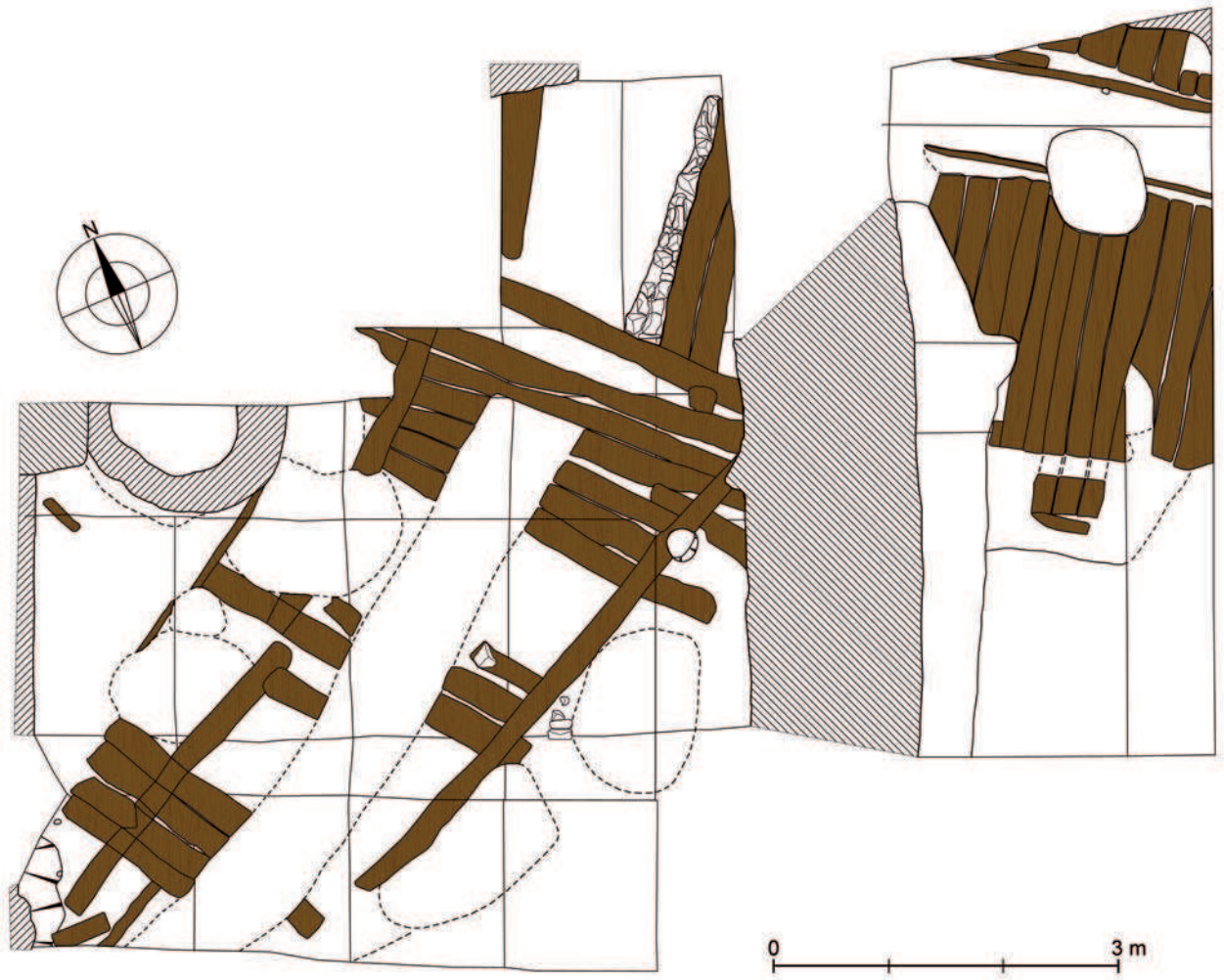

Fig. 91. Prague, Lesser Town Square. Road surface construction. Cymbalak and Podliska 2011

plemented with marl. This road phase was dated by pottery finds to the 12th–13th century, therefore, to the pre-incorporation period. The remains of later pavements, attributed to the communal town were recorded over it. The stones used in them were larger with a diameter of as much as 40, even 60 cm. These

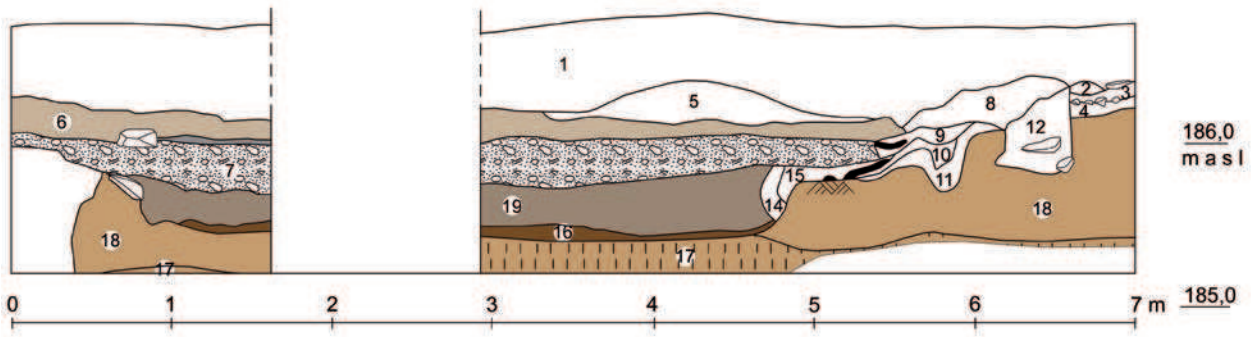

Fig. 92. Prague, Kaprova Street. A section through the road: yellow – subsoil, grey – phases of road construction. Havrda and Tryml 2011

were river pebbles set in a grey-black cultural deposit, which also accumulated after the road surface was put in place. The width of this street was around 5.5 m, thus, significantly wider than the road from the pre-incorporation period (Podliska 2004, 372–273; Havrda and Tryml 2011, 197–198).

More constructions of this sort were identified in Prague Old Town, most notably, under the Jesuit college, the Clementinum (Fig. 93), on Benediktská, Masná, Královodvorská, Dušni, and Rytířská streets, and in the eastern area of the Old Town marketplace (Hrdlička 1984a, 151; Havrda and Tryml 2011). Our aim is not their detailed description but they may be useful for formulating more general conclusions on the methods of metalling road surfaces in Prague during the High Middle Ages. Apparently, the material used in road construction was sourced in the town and around – mostly being pebbles, gravel and sand from the Vltava. Limestone in the form of lumps and rubble was sourced in large quantities at Petřin and Strahov on the left bank part of the agglomeration. Also used was limestone from shallow lying deposits on the river terrace in the right bank town; it was dug up during the construction of fortifications and cellars. This material was used throughout the Middle Ages, both prior to and after incorporation. During the High and Late Middle Ages, coarse quartzite gravel was also used. Less frequently used was slate, which was also available in the Prague Basin (Rybařík 1999, 15; Zavřel 2007, 247). Observing the evolution of road surface construction on the right bank of the Vltava it may be said that different to the Lesser Town, timber causeways were not used a great deal. From the beginning roads metalled with stone prevailed but their technical quality was varied. During the pre-incorporation phase pebbles or limestone rubble were spread on the road without any subbase. This material was unsorted and ranged in diameter usually from 5 to 13 cm. Street surfaces of this type easily became damaged and mixed with the soil. In such cases, they required repair, carried out in a makeshift manner by spreading a new layer of pebbles or limestone rubble. The thickness of these repeatedly applied layers reached a few dozen centimetres. They did not prevent the accumulation of the layer while the street continued in use and were

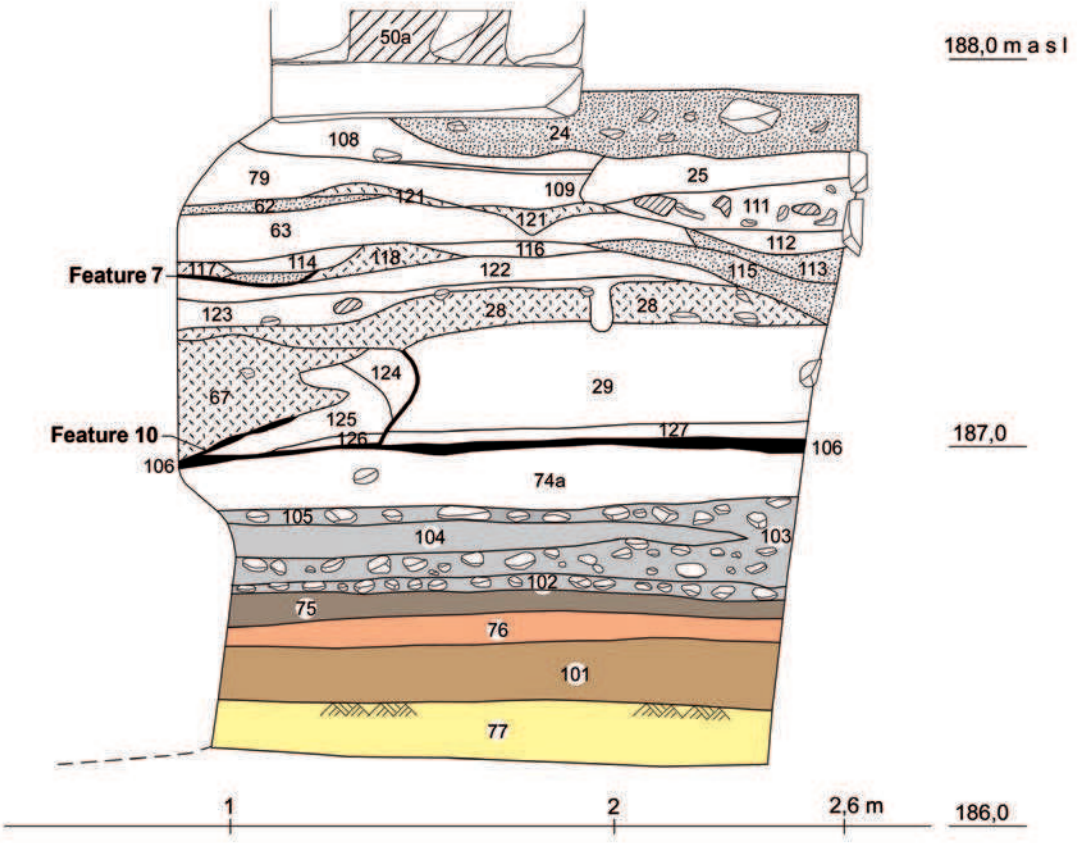

Fig. 93. Prague, Clementinum. A section through the medieval portion of the stratigraphy (pavements highlighted): the road, dated to the 10th–11th centuries (grey; nos. 102–105); rests on a marked settlement horizon (orange; layers nos. 101, 75, 76). The road becomes completely silted and loses its function at the latest in the 12th century (layer no. 74a). Cymbalak and Podliska 2011

difficult to clean. After incorporation, the technique of using loose pebble-gravel banks continued on streets of minor importance. Introduced at this time, and used extensively during the 14th century, were stable cobbled surfaces built by laying the stone close together on a subbase of sand. An example of such a pavement was recorded during archaeological fieldwork in Bilková Street (Havrda 2003, 324). Similar trends are observed in other towns in Bohemia, e.g. in Brno and Opava, which have been well investigated using archaeological methods. Surfaces composed of small, loosely spread stones used there during the 13th century were gradually replaced during the late Middle Ages with carefully laid higher quality pavements. Their durability was enhanced by providing them with street gutters to drain the street surface and these were installed along the edge of the street or down its central axis (Procházka 2011; Kolář and Zezula 2011).

The street constructions of Wrocław are relatively well understood, both those of the proto-urban and the communal town. In the early medieval castle on Ostrów Tumski and the left bank settlement *ad sanctum Adalbertum* at least some thoroughfares were surfaced with timber. Their construction usually consisted of sleepers laid down the length of the street with rough planks placed over them transversely, similar to the suburbium below Prague Castle (Fig. 17). The material used in road construction was oak from dismantled and rebuilt ramparts (Bykowski et al. 2004). In addition to durable structures of heavy oak logs, there is evidence also of lighter and more perishable surfaces lined with brushwood. In the proto-urban settlement on the left bank, timber was used in surfacing the streets, but also footpaths, less than a metre wide (Fig. 94).

Changes in urban space during the 13th century significantly increased the number of streets and added to their length. They were now surfaced in various ways depending on the phase of the development of the town, the moisture content of the ground and the socio-topographical status of the street. Archaeological investigation of several kilometres of streets of the Old Town lead to the conclusion that the area, covered by the incorporation and laid out in a regular manner during the 13th century, had mostly unpaved dirt roads (Konczewski and Piekalski 2010, 2011, 158; Piekalski and Wachowski 2010). While they were in use they developed a layer of churned up and mixed original humus and sand with the addition of at least some of the rubbish removed from plots and animal manure. Locally, in front of the houses, surfaces were improved using simple techniques – lining them with rough planks, spreading sand,

Fig. 94. Wrocław, Szewska Street/bishop Nanker Square. Timber-lined surface of a pedestrian walkway. Konczewski and Piekalski 211

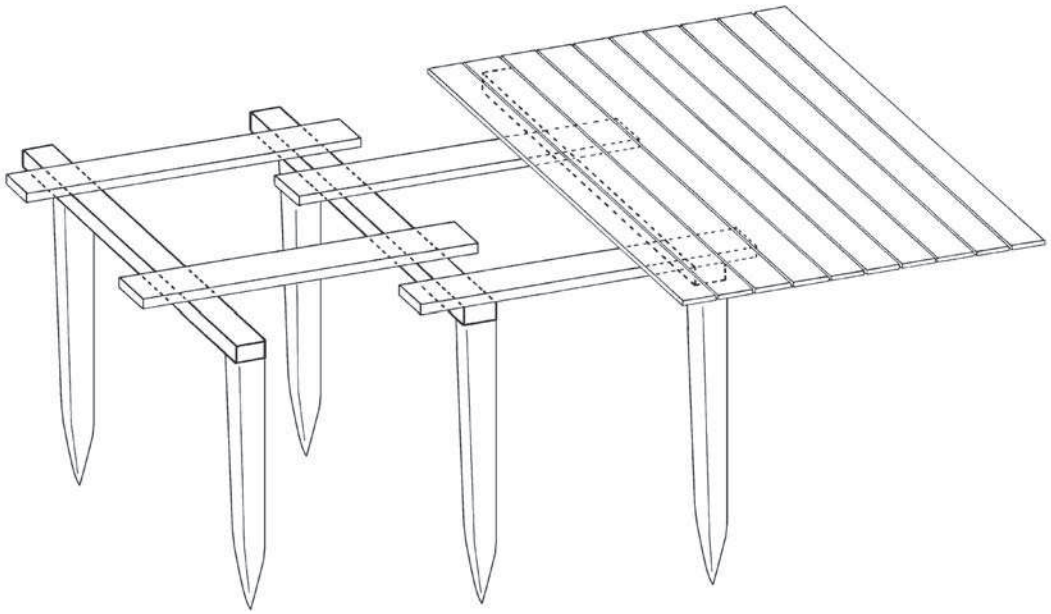

Fig. 95. Wrocław. Graphic reconstruction of a street walkway. Drawing Nicole Lenkow

wood shavings, ashes and wattle-and-daub debris from burnt timber-framed houses.

There is no evidence to confirm the earlier view, one also shared by the author of this study, on the early construction of permanent timber street surfaces in the town directly after its incorporation (Kaźmierczyk 1966–1970, part 2, 60–67; Buśko 1997, 126; Piekalski 2004, 355). It used to be accepted that based on dendrochronological dates that they were introduced already during the 1240s. However, analysis of a larger quantity of better preserved timber from street levels carried out more recently proved that the oak used in the street surfaces was recycled, mostly from dismantled timber-framed houses. While in the written sources the sale of old timber is mentioned only infrequently (Goliński 2011, 152) archaeological evidence is fairly unambiguous on this subject.

On the other hand, stable timber street surfaces are documented during the first half of the 13th century in the area in Wrocław not covered by incorporation in the earlier left bank settlement. Several series of such timber-lined streets were confirmed during archaeological fieldwork in New Market Square in 2010–2011. In the newly laid out streets of the incorporated town timber surfaces were very likely only introduced starting from the early 14th century.

Timber surfaced streets in the form of a causeway were the most technologically advanced (Fig. 95). Their construction started with the driving of vertical uprights into the unstable substrate. Onto them posts, transversely to the line of the street, supporting beams were laid spaced every 3–4 m. Next sleepers were placed onto them down the length of the street. Over this stable base, the rough planks of the street surface were laid transversely (Kaźmierczyk 1966–1970, part 1, 63–64, Fig. 14; Mruczek 2000, 263–271). These were installed in the principal streets in the richer districts of Wrocław (Pańska [now Kiełbaśnicza], Junkierska [now Ofiar Oświęcimskich], Oławska, Kurzy Targ and Kotlarska), and in the northern, lower-lying area of the town and in streets inhabited by less affluent tradespeople (Szewska, Łaciarska, Malarska and Drewniana streets). The causeways covered a 2–2.5 m wide strip down the centre of a street. It was also so in marketplaces where only the thoroughfares set aside for traffic were secured – around the square and between the stalls (Fig. 96). The presence of timber causeways, especially in the northern part of the town, is recalled by street names known from the 14th century that are characteristic for Wrocław – *Schmiedebrücke*, *Schuebrücke* and *Oderbrücke* (Markgraf 1896, 143–144, 184–190; Stein 1995, 20, 66).

The high standard of raised rough plank street surfaces offered the best conditions for foot traffic and transport. At the same time, findings from field research confirm the use of less sophisticated systems as described by Józef Kaźmierczyk (1966–1970, part 2, 60–63) separated into three groups. These were documented in particular on the street margin bordering the plots but also on repaired or provisionally improved surfaces of thoroughfares. Some elements of the causeway were dispensed with (Fig. 97). If

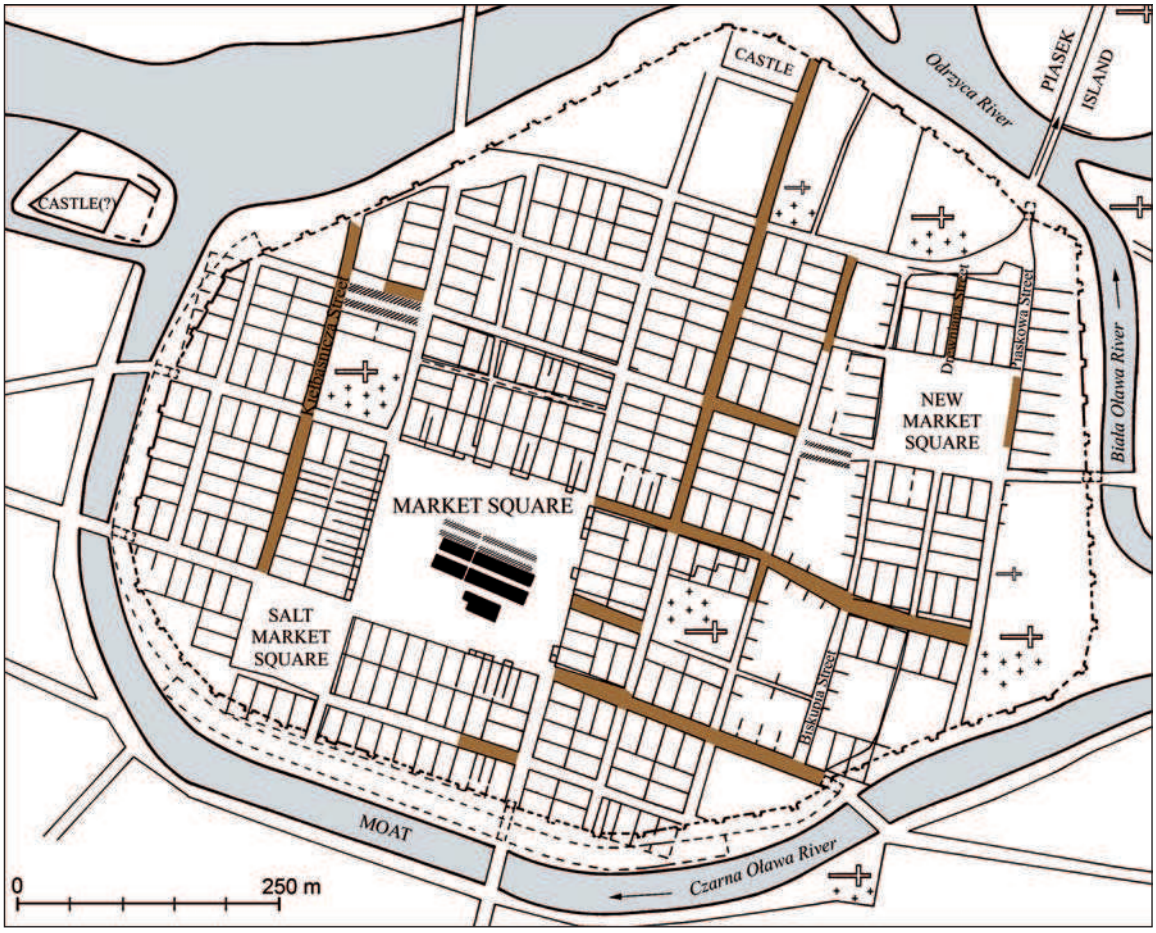

Fig. 96. Wrocław. Timber-lined streets confirmed by archaeological research. Description N. Lenkow and J. Piekalski

the ground was not susceptible to compression, no stabilizing uprights were used; in which case the construction was of transverse supporting beams, sleepers laid lengthwise and rough planks laid transversely over them. A further step in simplifying the construction was to dispense with the supporting beams and to lay the sleepers immediately over the organic layer or on a subbase of sand. An example of a simplified method of street surface maintenance is a succession of alternating layers of humus mixed with animal manure and layers of sand. Spreading the streets with sand was a regular method of draining, cleaning and making them level. The layer of sand was secured by covering it with loosely placed rough planks. Evidence of similar practices was identified on a number of occasions (Buśko 1997).

The most advanced method of street surfacing was to lay a layer of cobbles over a subbase of sand. In Wrocław the typical material were postglacial pebbles that were typical for the European Lowland and were easily available in the fields around the town. The surfaces with the best cobbled layer were laid over a subbase of clean sand spread to level and drain the underlying ground, forming a stable subbase for the stone pavement. This resulted in the raising of the ground level by 20–40 cm, at times, up to 80 cm. The diameter of the cobblestones was on average 15 cm, at the most, about 20 cm. They were laid close together forming surfaces bordered by sequences of larger stones or vertically placed rough planks. The earliest cobbled surfaces in Wrocław in its main marketplace date to the end of the 13th century (Buśko 1997, 118; Płonka and Wiśniewski 2000, 248; Bresch et al. 2002, 14). Their distribution in the square was local. They covered the transit ways through the square and access to some stalls. In the streets cobbled surfaces were introduced during the 14th and 15th century they became the most common method of surfacing a street. In most streets, they replaced timber causeways. Damaged cobbled surfaces were dismantled and built anew, reusing the cobbles. As a result of this practice, archaeological investigations in Wrocław did not discover well-preserved cobbled street surfaces.

Krakow, similar to Prague, and in contrast to Wrocław, lies in an area with good access to lime-

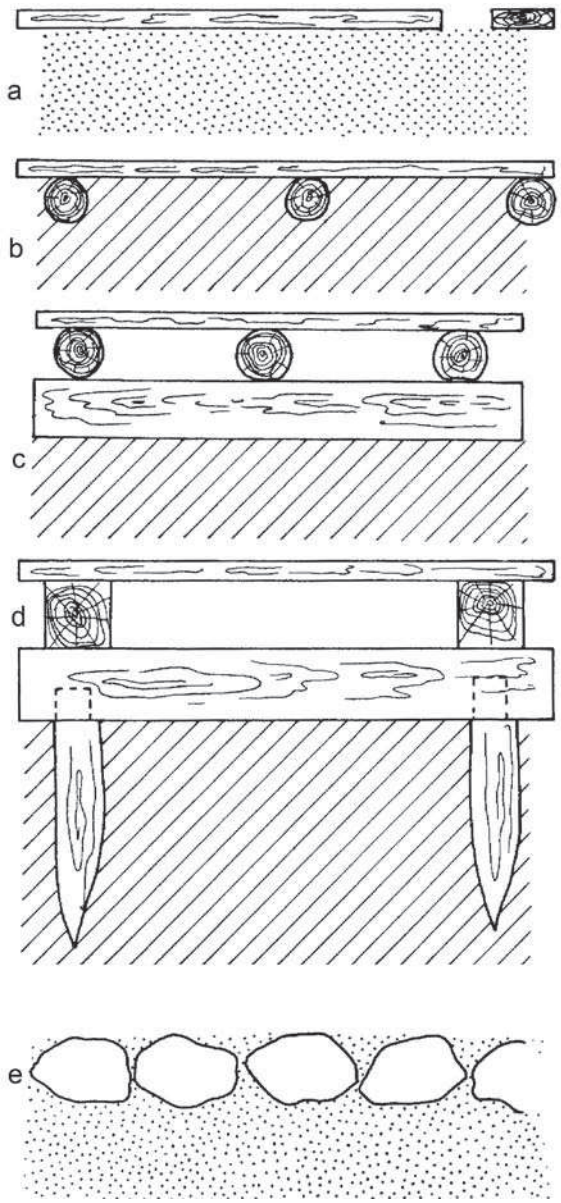

Fig. 97. Wrocław. Medieval street construction methods. Kaźmierczyk 1966–1970, part 1 with author's additions

stone. This was the material that during the 12th–14th century was the mainstay of Krakow's stone-based construction, including the construction of street surfaces. Jurassic limestone in the form of fine-grained crushed stone was used in metalling the earliest street surface known to us from Krakow, in the marketplace of the pre-incorporation suburbium of Okół, to the north-west of the church of St Andrew and on the site of the later church of St Mary Magdalene (Lenkiewicz 1959; Radwański 1975, 105). The technique used there was not too sophisticated, broken stone was spread and rammed into the ground without any prior preparation of the subsurface. This street surface dated to the 12th– mid–13th century and was not the last of those installed on this site, which was resurfaced several times using the same method during the 14th century and later. It has been suggested that this was the paving of the surface of the marketplace of *Nova civitas in Okol* constituted during the 1330s (Niewalda and Krasnowolski 1981, 76; Krasnowolski 2008, 55; Niemiec 2011, 276–277).

The discovery of an early cobbled surface in Okół does not contradict the fact that at least some of the streets of incorporated Krakow were surfaced with timber. Data on this subject collected by Dariusz Niemiec (2011, 275–276, with reference literature), is from past research and does not have the advantage of up-to-date archaeological documentation. Nevertheless, its shows clearly that some of the construction methods used were similar to those of Wrocław, and others are peculiar to Krakow. In the late 19th century, at the time of the installation of the sewage system in św. Jana Street, a timber causeway was discovered, described as built of pinewood. The rough planks of this surface rested on sleepers stabilized with stakes driven vertically into the ground. Similar constructions were recorded in Szpitalna and św. Józefa streets (Łuszczkiewicz 1899, 19). We do not know their dating, only that they rested under a layer of cobbles. Medieval dating of similar structures is confirmed by Gabriel Leńczyk who is familiar with similar causeways from other stretches of św. Jana Street identified within an organic layer at a depth of 2.95 m below a 20th century surface. By the north-western corner of Cloth Hall, the same researcher recorded a causeway resting on oaken piles that were driven into the natural subsoil. At the same time from the area in the north-eastern corner of the Main Market Square comes the find of structures of a different character. They were described as three levels of paving of 2–3 logs laid side by side and stabilized with pegs (Leńczyk 1959, 31–46). They rested within a homogeneous organic layer dated by the coins of King Wenceslaus II (1300–1305), but also of Louis I of Hungary (1370–1382). On the opposite, southern side of the Main Market Square, timber structures of a street surface were confirmed in 1962 by Kazimierz Radwański (1964, 232; cf. Zaitz 2010, 203–209).

References to timber surfaces are accompanied by similar, rather general information about cobbled surfaces discovered in the streets and in the Main Market Square. Of greater value for our purpose are results of research of more recent decades supported by stratigraphical analysis and more accurate dating. On their basis, we are able to confirm the use in Krakow of two principal methods of paving the street surfaces with stone.

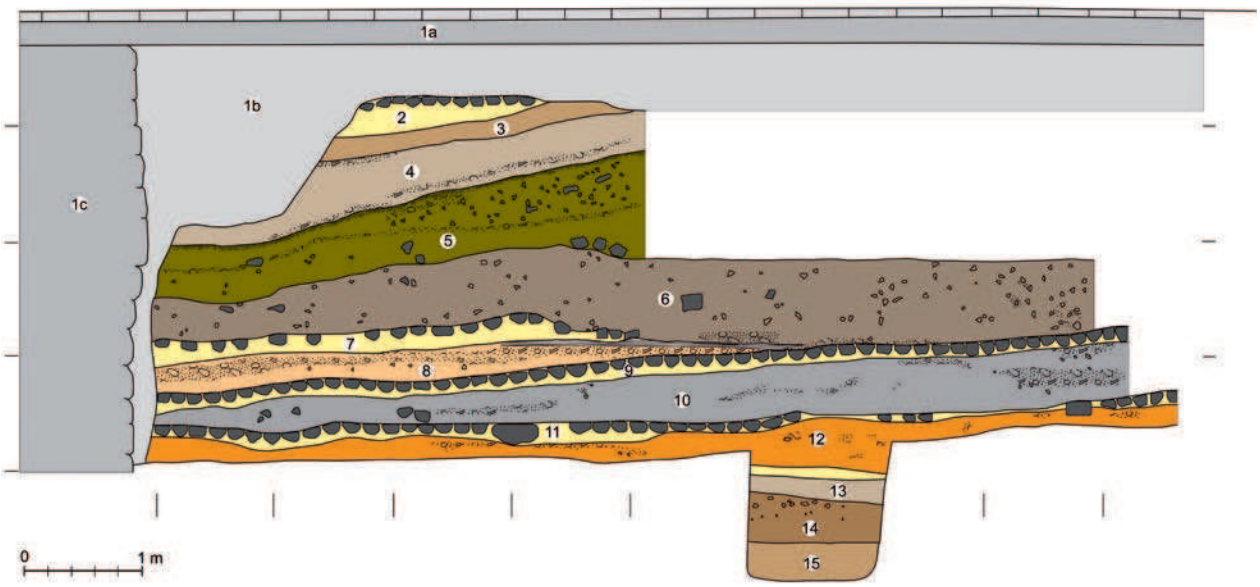

Fig. 98. Krakow, Cloth Hall, trench 31. Stratigraphy. Zaitz 2010

The first involved spreading the road surface with finely broken limestone rubble and then compacting it. Individual stones were not laid in any planned way only pressed into the ground by the wheels while the road was in use. This technique, used during the pre-incorporation period in Okół, continued in use at least into the early phases of the incorporated town (Niemiec 2011, 275; cf. Rosset 1974, 33). It was confirmed in the northern area of the town by the defensive wall that was erected in the early 14th century. The difference in relation to the street surfaces of the pre-incorporation period was that the broken stone

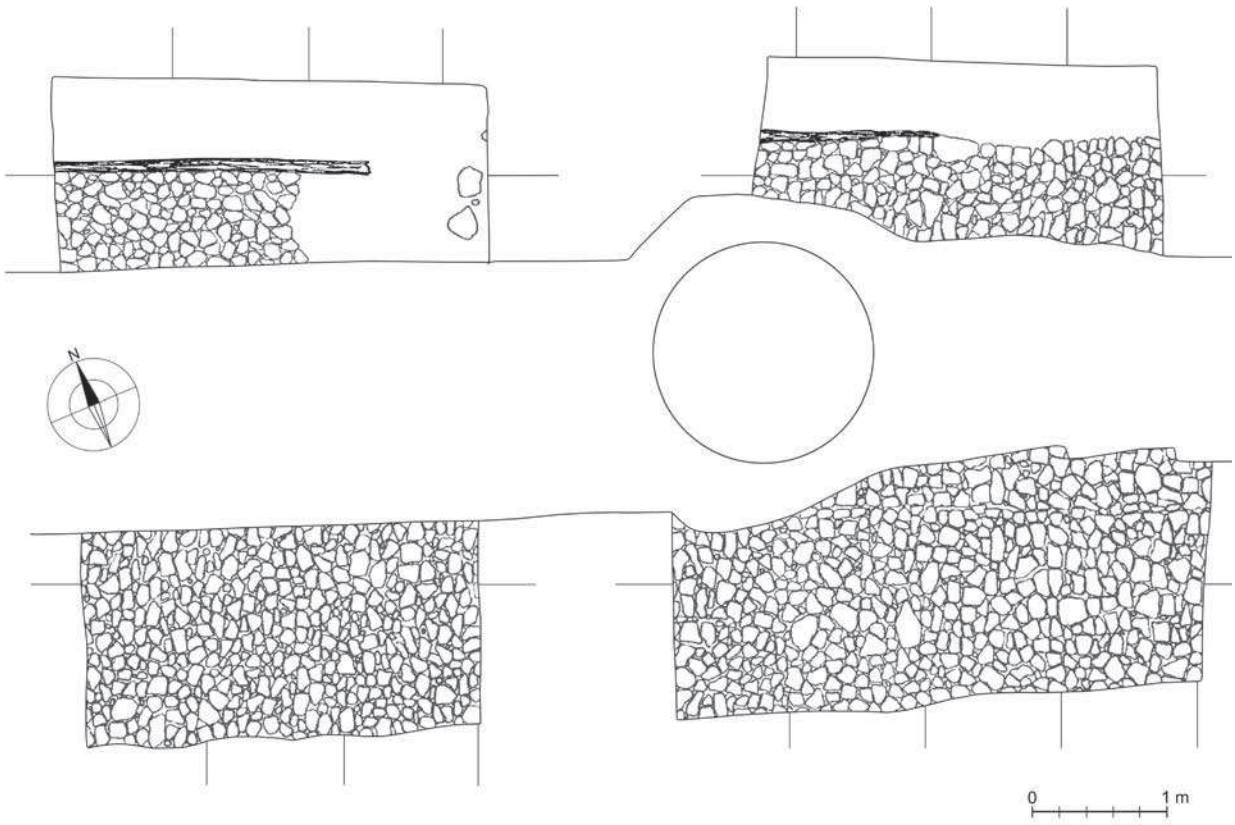

Fig. 99. Krakow, Town Hall, trench 31. Cobbled surface, early 14th century. Zaitz 2010

Fig. 100. Krakow, Main Market Square, cobbled surface to the north of the Cloth Hall. Dryja et al. 2010. Photo. Wojciech Głowa

Fig. 101. Krakow, Main Market Square, cobbled surface between stalls. Dryja et al. 2010. Photo. T. Kalarus

was spread over a subbase of sand. The surfacing of the street has the same dating as the wall (Radwański 1986, 21). A similar stone paved structure from that period was unearthed by the south-western section of the city wall at No. 9 Kanonicza Street (Radwański 1986, 67).

The other technique of cobblestone paving was in use during the 14th century. In it, selected lumps of limestone were dressed to a roughly triangular form. They were set in a subbase of sand to form a compact, stable surface. A cobbled surface of this description was confirmed in the Main Market Square, next to the church of St Adalbert (Wojciech), for the period when the cemetery passed out of use (Radwański 1975, 189). At a similar time – the first half of the 14th century – the western area of the Main Market Square was paved with cobbles between the wooden stalls (presumably selling bread) and the block of buildings fronting the square. Next to the stalls, gutters were installed in the cobbled surface draining water southwards, towards Bracka or Wiślna streets (Zaitz 2006a, 85, 89; Niemiec 2008, 89, 2011, 279). From the early 14th century similar pavements were laid in the central area of the marketplace, between Cloth Hall and rows of stalls (Buśko 2007, 227; Niemiec 2008, 85, 2011, 279; Dryja et al. 2010, 104–197; Zaitz 2010, 213–239; Bojęś-Białasik and Zaitz 2011, 106). It is notable that in contrast to Wrocław, cobbled surfaces of this sort were not dismantled and their preservation in many locations is very good (Figs. 98–101) and they were installed not only in the town centre, but other parts as well. Around 1300 an area by Floriańska Gate on the northern boundary of the incorporated town was paved with limestone cobbles set in a thick subbase of sand (Fig. 102). Nonetheless, during the first quarter of the 14th century the passageway under the gate was repaved, this time with larger stones, worked to a wedge-like form or set in sand (Radwański 1986, 10, 15; Niemiec 2011, 227–228). High quality cobble pavements of limestone set in sand became widespread in Krakow during the 14th century. They were installed at least on the main thoroughfares and provided with stone. This is best illustrated by findings from Sławkowska and św. Marka streets (Myszka 1997, 119–120; Niemiec 2011, 283–284). The older cobblestone levels

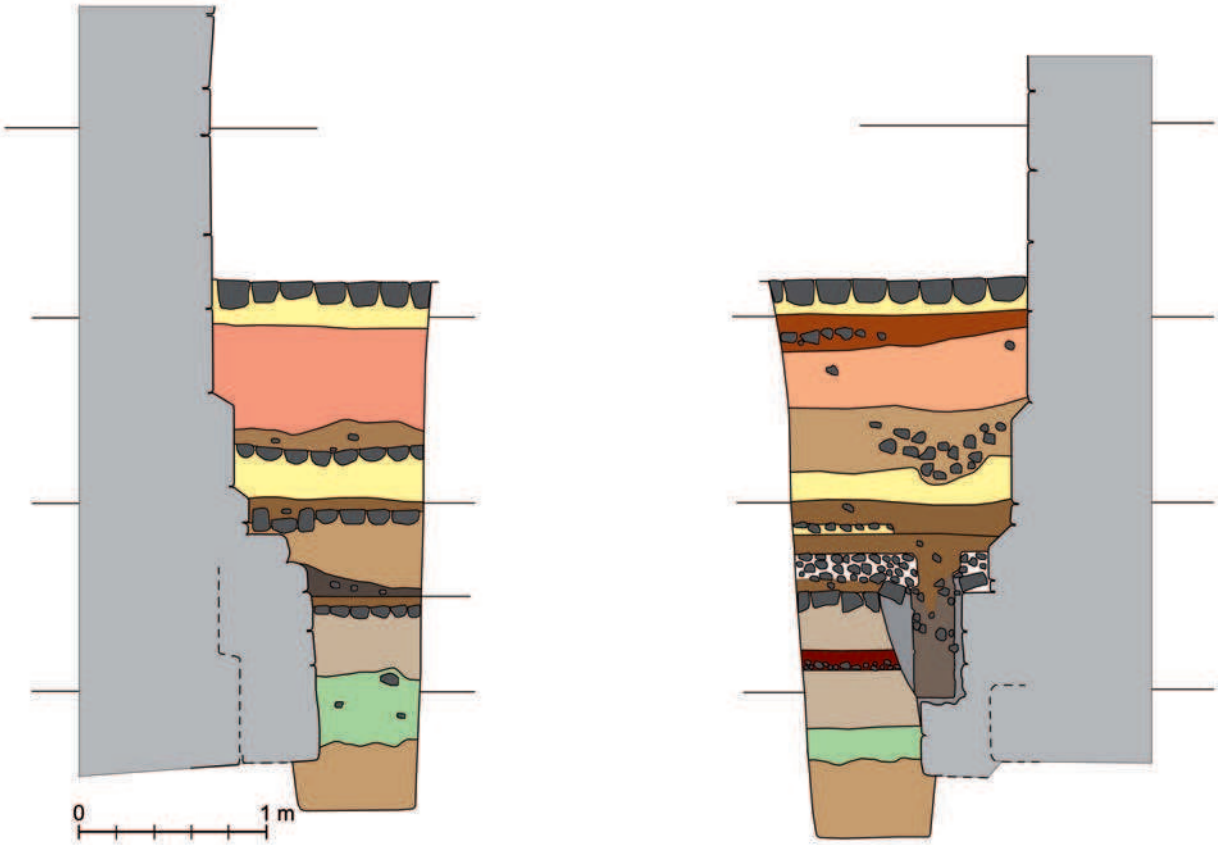

Fig. 102. Krakow, Floriańska Gate. Yellow colour – sandy subbase of the earliest cobbled surfaces, blue colour – earliest cobbled surface levels. Niewalda et al. 2001 and Niemiec 2011

were overlaid by a layer accumulated when the street in use, subsequently spread with sand and surfaced with a new layer of cobblestones. More widescale paving projects were made possible by the involvement in their financing by the town council and the ready supply of limestone from the municipal quarry at the nearby Krzemionki Hills.

During the first centuries in the development of incorporated towns, there was a marked rise in the ground level. In each town under discussion, it exceeded 3 m, in places even reaching 5–6 m. Waste was not removed outside the town. Refuse from activities within the plots was dumped into the street and included sand from the excavation of cellars, foundation trenches and cess pits, clay left after the construction of wattle-and-daub buildings, ashes from stoves and hearths. In addition, the destruction of houses – by fire or by deliberate demolition – is at times evident in the stratigraphy of the street surfaces. The content of the layers in individual sections, at least to some extent, was the result of the activity of the owners and residents of individual houses, who treated the area in front of their property in an individual manner. A quantitatively significant proportion of the cultural deposit was animal faeces. In conditions favouring the survival of organic material, manure mixed with wood shavings, straw, animal bone and sand was the main component of the cultural deposit investigated archaeologically. The animal species easiest to rear and feed in the town was the pig. Advantages from having a stock of meat, important in times when crop failure, natural disasters and wars were common, were too soon, in the 14th century, offset by the side effects, mostly filth accumulating in the streets and erosion of their surfaces and the reaction of the town government was to restrict the number of livestock in the town. From written sources, we know the nature of these regulations: the privilege of keeping livestock was given only to some groups of tradespeople, mainly bakers and maltsters; there was a law against setting animals loose in the street, or this was allowed only at night. Livestock breeding was permitted only in some districts of the town and there were regulations as to where and in what manner the disposal and transport of manure could take place (Dirlmeier 1981, 146; Gechter 1987, 255; Wyrozumski 2010).

During the first centuries after incorporation, the established method of reducing the nuisance associated with the build-up of layers was to successively spread and drain them with sand, ashes or rubble, which with time, was trampled into the ground. The construction of street and yard surfaces did not slow down the accumulation of the cultural deposit. This was so with both timber causeways and early cobbled surfaces. As noted earlier, after a century at the latest, the ground floors of buildings had to turn into cellars and access to them required installing new construction solutions. There was need to delay this process already by the 14th century and appropriate steps were taken by the municipal government. One of the main actions was to regulate for the disposal of waste outside the town, householders were required to keep the street in front of their plot tidy and lay them with cobblestones. Regulations on sanitation introduced around the mid–14th century were clear-cut and non-compliance was punished by fines (Wyrozumski 1992, 462; Goliński 2011). It transpired to be especially beneficial to combine investment into good quality cobblestone pavements with the requirement of keeping the street surfaces clean. In Prague and in Wrocław these actions, relatively successfully, curbed the build-up of the cultural deposit. In Prague this occurred already at the end of the 13th century (Hrdlička 2000). In Wrocław, the ground level stabilized during the second half of the 14th century. Later layers occur only locally and did not achieve any greater thickness (Bresch et al. 2001, 15–108; Bresch et al. 2002, 11–69; Konczewski and Piekalski 2010, 91–151). They consist mostly of sand that remained from the replacement and repairs of the cobblestone paving.

In Krakow on the other hand, there is evidence that the ground level continued to build up until the 16th century, proving that sanitation efforts made in the town were less successful. Relatively well constructed cobbled surfaces datable to the 14th–15th century recorded during archaeological investigation rested under a layer of waste and dirt, which was interpreted as humus or muck. Poor conditions for communication in the town during the Late Middle Ages and the early modern period are documented by written records assembled by Dariusz Niemiec (2011, 287).

While sanitation level in the streets and squares, understood as public spaces, was the object of concern and of variously successful activity by the municipal government, the interference of town authorities into the situation inside private yards was limited (Goliński 2011a). This is where all manner of waste was removed to, including the most offensive. Cesspits in the backyard were the receptacle for, next to night soil, wastewater and a wide assortment of discarded or damaged objects –portable items of urban culture. This makes them an important resource for medieval urban archaeology. So much so that

Fig. 103. Most, cesspit. Klápště et al. 2002.

some researchers from related disciplines have begun to describe our branch of study jokingly as *Kloaken-archäologie* (Fig. 103). In inventories recovered during the investigation of these structures we find: ceramic, glass and wooden vessels, well-preserved leather and textile objects, small finds made of bone and antler, an occasional wax tablet, merchant's seals, toys and a number of other finds, sometimes quite unexpected, such as eyeglasses. Cesspits helped improve the level of sanitation in the medieval town because they could be used over a long period, new pits could be installed next to those already full or they could be emptied periodically and had the form of a lined cesspit. They allowed liquid waste to drain away and the more offensive solids to decay to some extent. The cleaning out of cesspits is confirmed for the western area of Central Europe by written sources, the earliest from the 14th century (Gechter 1987, 246–248). In Wrocław, the first references date from after 1350 (Goliński 2011a). Findings from archaeological fieldwork suggest that at least a part of their contents may have been removed. Some medieval cesspits had a much later fill next to them. Analysis suggests that some of these structures continued in use for several decades. With so many different methods of disposing of cesspit contents, neither written or archaeological sources can supply the whole truth about the disposal of faeces in the town. The contents of a cesspit, collected by nightmen, could be buried at some other location in the town – as documented by finds of so-called unlined cesspits observed by archaeologists (Piekalski, Płonka and Wiśniewski 1991; Buśko 1996; Niemiec 2007); or they could be removed from the town for a special charge. An established method of disposal of the troublesome load was, until the 19th century, dumping it in the river (Dirlmeier 1981, 140–143; Gechter 1987, 247–248).

To summarize the evidence on the level of sanitation in Prague, Wrocław and Krakow during the Middle Ages we may assume that it was an object of steady concern of the townspeople. Measures taken to deal with it were subject to change and their results may be described as variable. Archaeological sources prove that adverse effects produced by having a large group of people occupy the enclosed town space met with a response aimed at reducing these drawbacks. Filth and stench were not part of the norm accepted in the town and traces of daily activities prove that impurities were treated as a highly negative occurrence. Not all problems could be solved forever. Insufficient understanding of bacteriology resulted in many hazards going undetected, e.g. the level of pollution of groundwater. We do not know the impact of urban sewage and excrement on river pollution. However, presumably the Vltava, Odra and Vistula had the capacity to receive urban waste without suffering more long-term damage. Problems increased with population growth. The towns as they were in the 12th–13th century and during a later age differed significantly in this regard. Demographic urban growth during the late Middle Ages and during the modern period within the early boundaries stabilized during the 13th–14th century brought significant deterioration of their sanitary levels (Piekalski 2013, 383–387). In the 18th–19th centuries, it became the reason for demolishing the town fortifications, and opened a new stage in the spatial growth of towns.