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The Piast castle on Ostrów Tumski island in Wrocław

Abstract. The article briefly presents the author's hypothesis of architectural changes in the ducal castle on Ostrów Tumski in Wrocław, which was developed based on the results of architectural studies of the relics of the castle walls uncovered in excavations in 2011–2012 and 2014, in combination with the results of laboratory tests such as petrographic and mineralogical analysis of mortars, ^{14}C analysis of charcoal contained in mortars and extensive analysis of brick dimensions using statistical methods. As a result, a chronological stratification into eight phases from the 12th to 15th centuries is proposed. Absolute dating was addressed through radiocarbon analyses and historical context.

Keywords: castle, palace, tower, architectural analyses, mortar, brick, petrography, ^{14}C.

Introduction

The range of medieval construction techniques has long been analysed in terms of distinctions between the material properties of mortars and bricks as an architectural and archaeological research method. It is helpful in chronologically classifying buildings lacking details and legible stylistic features. However, observing the characteristics of building material with the naked eye, a building can be assigned to phases of each spanning two or three centuries. In the current case, this is insufficient. Moreover, macroscopic observations are not entirely objective, as mortar properties such as hardness and colour vary and change with changing external conditions. The methods presented below as complementary to the range of standard architectural analyses are laboratory tests and yield repeatable results. In Wrocław, we have been using them since 2012 to study objects that are poorly preserved but of importance to national heritage, such as the ducal castle in Wrocław (being the second oldest and most important stronghold in the Polish kingdom) and the castle in Wleń (Chorowska, Bartz 2019).

The castle in Wrocław was built on a river island on the Oder, where a dual stronghold was in operation as of the 10th century. In 1166, the castle became the seat of dukes of the Piast dynasty, who ruled Silesia (Śląsk) as their hereditary duchy during the time of Polan's division into duchies (1138–1314). The first was Bolesław the Tall (1163–1201)[1], followed by Henryk I the Bearded (1201–1238), Henryk II the Pious (1238–1241), Bolesław the Horned (1241–1248), Henryk III the White (1248–1266), Władysław of Salzburg (1266–1270) and Henryk IV Probus (1270–1290)[2]. After the death of the final successor, the castle and all ducal property on the island began gradually to pass into the hands of the bishop, and was then divided into the curies of the canons of the Collegiate Church of the Holy Cross. As a result of construction changes made by the canons in the 14th–18th centuries and activities following the secularisation of church property in 1810, the castle walls disappeared entirely from the ground surface. Until the first excavations in the 1960s, it passed entirely out of human knowledge. In 1985–1988, spectacular discoveries of the remains of brick sacral-residential buildings were made by Edmund Małachowicz and Czesław Lasota.

The discovered walls were preserved in a rudimentary state, however, and the excavations of that time, despite having covered a relatively large area, were necessarily localised point excavations (Fig. 1). In an extensive publication summarising

[1] In Wrocław after the end of the 'war of the stronghold', i.e. from 1166 (at latest) onwards (Mika 2013, pp. 92–95).

[2] In fact, the last of the Piasts, Henryk IV died only in 1335, but he did not reside on Ostrów Tumski, but in a new castle on the left bank of the Oder.

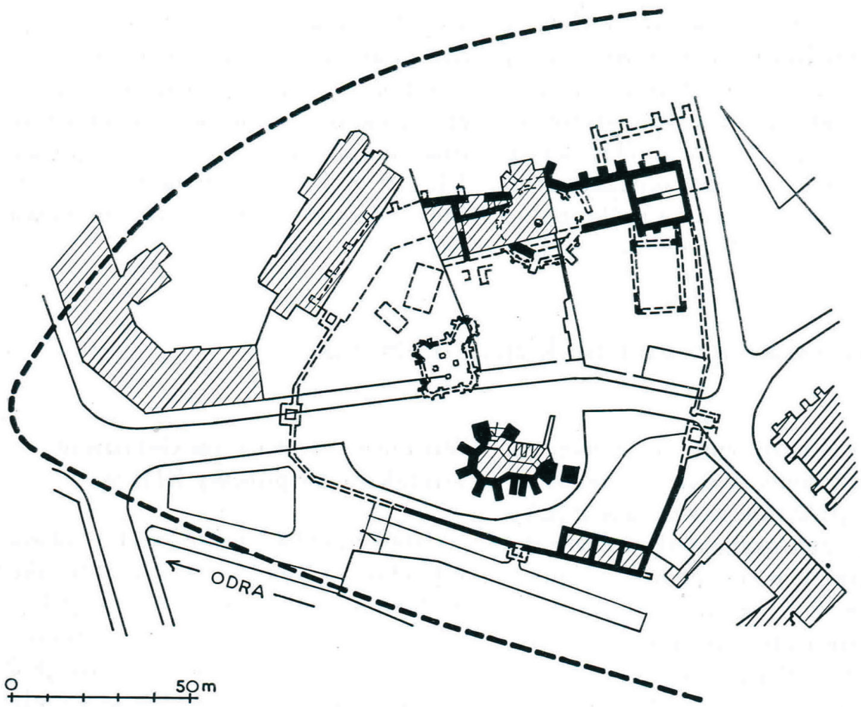

Fig. 1. Wrocław, Piast castle on Ostrów Tumski, Situation of exposed walls against background of modern buildings of western Ostrów (after Chorowska 2003)

the research results, Małachowicz presented reconstructions of the shapes of individual castle buildings, perceiving them mainly to be religious (Małachowicz 1993). Among the oldest parts of the castle buildings, which are dated to the 4th quarter of the 12th century and the first third of the 13th, he included: the central octadecagonal building, a fragment of the nearby wall on the west side, a fragment of the curving wall around the eastern side of the octadecagon, the octagonal side chapel with apses, and a two-part building with the remains of the hypocaust ovens. The octadecagonal building has been interpreted as a Romanesque manor chapel, the wall adjacent to it to the west as a rectangular residential tower from the same time[3] and the arched section of wall as a sacristy. The house with stoves was thought to be the monastery of the abbey of St Martin. The younger finds include: fragments of a northern part of the defensive wall, substantial remains of the buttressed octagon and the octadecagon erected in its place, and a square wall resembling the outline of a building in the castle's north-east corner. The latter is thought to have come from an expansion of the abbey of St Martin. The octagon

3 The chapel with the tower is thought to have formed a small palace of Bolesław the Tall.

and adjoining walls are thought to have constituted a two-storey gothic manor chapel with an elongated presbytery. The residential part of the castle is thought to have been limited to a tower measuring 14.5×9 m, adjacent to the gothic chapel. Despite criticism, especially of the interpretation of the octadecagonal building being a chapel and the similarly created octagon at the same location, as well as the interpretation of the house with ovens and adjacent walls as a monastery, these hypotheses have become established in the literature (Żurek 1996, pp. 26, 35–36; Kutzner 1995, p. 146; Rozpędowski 1999, pp. 265–268; Świechowski 2000, pp. 295–297; Kajzer et al. 2001, p. 546; Chorowska 2003, pp. 46–49, 59–62).

A second series of tests could only be conducted about 25 later, upon the renovation of the house of the Sisters de Notre-Dame that had been built in the early 20th century on the remains of the main castle (Wodejko et al. 2012; Ciara et al. 2014; Chorowska 2017a). Archaeological excavations were carried out along the outer walls of this building and in its cellars, and the largest excavation, located outside the building and extending almost to the eastern section of the defensive wall, ultimately covered 435 m^2. This was an opportunity to verify previous findings and to take samples of mortars for petrographic and radiocarbon tests, and to study the dimensions of bricks.

The research in 2011–2012 failed to confirm the presence of a 12th-century rectangular keep. The relic of a foundation, which was indicated by Małachowicz to be a fragment of its northern wall, turned out to be made of brick with dimensions analogous to material found in the walls of younger phases. Later in the article, it is assigned to the relics categorised under the working title 'palace 1' The remains of the apse of the alleged octadecagonal chapel were not found. The 2014 research also concluded that the foundation wall of the supposed sacristy that was built onto the east side of the octadecagon was surrounded by an earth-and-timber rampart that followed a curved route that was similar to that of the wall[4]. This rampart indicates the defensive nature of the surrounding building, and furthermore, its presence cut the interior of the octadecagon off from daylight, which further puts its function as a castle chapel in doubt.

There have also been doubts as to interpretations of the functions of younger parts of the castle. Within the presbytery of the alleged gothic manor chapel, which was thought to have been built on the site of the octadecagon, relics of two more heating devices were uncovered – hypocaust oven 2 and a heating duct or oven 3 (Wodejko 2018). The objects date back to the period when the alleged presbytery was being built and in operation. Furthermore, in one of the octagon's buttresses of the alleged nave of the gothic castle chapel, the remains of an internal corridor

[4] On the foundation of the alleged sacristy's wall, there was a layer of sanded clay (no. 9a) of up to 10 cm thick, followed by an approximately 40-cm-thick layer of sand with fascine. These layers ran into the remains of the rampart with traces of a sandwich structure in the form of streaks of decayed wooden logs. Further to the north-east, at 117.35 m a.s.l. there was a layer of dark, greasy clay.

probably leading to toilet facilities were discovered. In light of these discoveries, the alleged Gothic manor chapel appears to us to be a residential building, most likely a palace. Later in the article it is referred to as ‘palace 2’.

In light of these doubts, the main goal of the architectural research carried out in the excavations of 2011–2012, 2014 and 2018 was to re-read the stratigraphy of the castle walls, to establish the relative chronology of the creation of its individual parts and to try to approximate their functions and absolute chronology. This task was made difficult by the poor state of preservation of some of the relics, their dispersion over a relatively large research area, and the lack of stratigraphic continuity. We should add that almost all the exposed walls were faced with brickwork in a wendish bond[5], and were built using a lime mortar of relatively consistent characteristics. In this situation the need for material research is of special importance here. A study of the petrographic composition of mortars and analysis of brick dimensions helped answer whether stratigraphically unrelated walls belonged to the same or different construction phases.

The first step involved a wide range of physicochemical analyses to determine the specifics of the mortars in the castle’s successive construction phases, e.g. aggregate grain size, content of accessory elements, proportion of binder to aggregate, etc. The second step was to assign unidentified relics to specific phases, i.e. to determine their relative chronology. The third step was to approximately date the phase based on ^{14}C analysis and analysis and brick dimensions.

Petrographic and physicochemical tests

Tests were performed on 48 mortar samples. The samples were taken after the initial stratification of the exposed castle foundations into eight phases (excluding the modern phase); sampling points are indicated on the plan of the remains (Fig. 2: b), and their phases are marked with colours. Different shades of the same colour indicate the walls’ state of preservation (the darker, the better):

– phase 1 (dark and light grey) – foundation pillars of a building on a circular plan (in the ground floor of the 18-sided building), hereinafter referred to as the ‘octadecagon’ or ‘keep’;

– phase 2 (dark brown) – fragment of the footing of a mantle wall that ran tightly around the older building to the north and east; preserved only in the eastern section; hereinafter referred to as the mantle wall;

– phase 3 (light brown) – pillar-arch foundations of a bipartite building, most probably a tower, hereinafter referred to as tower 1;

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[5] Of the analysed castle walls, only the foundations of the canonical houses and a hypocaust furnace were made using a stretcher bond.

– phase 4a (dark and light green) – extension of tower 1 southwards on a continuous foundation, hereinafter referred to as tower 2;

– phase 4b (dark and light green) – continuous footings of a single-nave building measuring 15×50 m, most probably a palace, hereinafter referred to as the palace 1; its southern wall cut into the keep and rested its central pillar;

– phase 5 (purple) – continuous foundation wall of the northern section of the defensive wall with buttresses;

– phase 6 (dark and light blue) – continuous footings of a building with an octagonal central part reinforced with powerful buttresses, hereinafter referred to as palace 2; the octagon was built after the octadecagon had been completely demolished;

– phase 7 (red) – remains of hypocaust furnaces1, 2 i 3, other heating devices, and latrines;

– phase 8 (orange and yellow) – pillar-arch foundations and strip footings of canonical houses erected after the demolition of a significant part of the castle walls.

Mineralogical and petrographic research on the mortars were carried out at: the Microscopy Laboratory of Department of Experimental Petrology at University of Wrocław's Institute of Geological Sciences; the Laboratory for Technological and Conservation Research at Wrocław University of Science and Technology's Faculty of Architecture; and the Geological Materials Research Laboratory (Crystallography Laboratory) at Wrocław Research Centre EIT+. Thin sections (microscopic preparations for analysis in polarised transmitted light) were made (one each) from the mortar samples in the Grinding Shop of the University of Wrocław Institute of Geological Sciences. The scope of the tests and methods used are described in 'Wstęp do badań petrograficznych próbek zapraw. Zamek na Ostrowie Tumskim we Wrocławiu. Zaprawy' (Gąsior *et al*. 2014; Bartz 2018).

The mortar samples from the castle in Ostrów Tumski differed slightly in the grain-size distribution and composition of the aggregate (the filler). Its main ingredient was detrital quartz, followed by small amounts of feldspar and rock (lithic) grains. These were mainly fragments of felsic (intrusive, silica-rich) rocks of granite-like composition, and grains of siliceous rocks (cherts, flints, etc.). Clastic rocks i.e. mudstone, sandstone, were much less frequent, as well as limestone and volcanic rocks of basalt-like composition. The grain morphology of the aggregate was relatively consistent. The grains exhibit a good degree of roundness; this was coarse sand, less often medium-grained sand, and moderately sorted to (less often) poorly sorted. These features, together with the high degree of sediment maturity, suggested that river sand was most likely used in the mortars as a filler. The castle's location near the Odra channel suggested that the clastic material was exploited directly from the river sediments. The deposit's fluvial origin presumably accounts for the low diversity of the aggregate. In addition to the aforementioned main components of the aggregate, the mortars contained a wide range of accessory

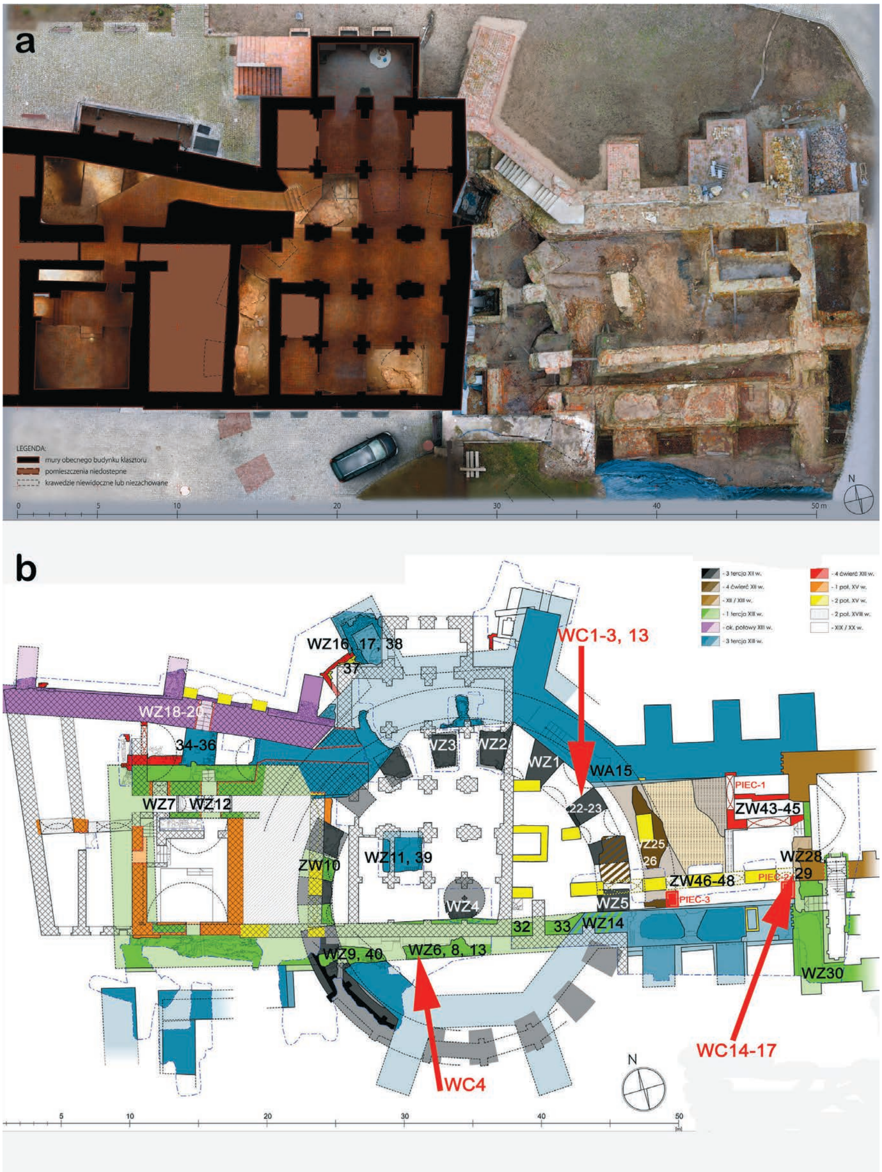

Fig. 2. Wrocław. Remains of castle on Ostrów Tumski discovered in 1985–1988 and 2010–2014: a – on orthophotomap (edited by P. Rajski); b – in chronological stratification of walls into construction phases; numbers of mortars for petrographic and mineralogical tests (WZ 1, 2, ...) shown in black or white; and mortar samples with charcoal for ^{14}C tests (WC 1, 2, ...) shown in red (prepared by M. Chorowska)

constituents. These were both minerals such as amphibole, zircon, garnet, glauconite and others, being a component of sand used as a filler to make the mortars, as well as constituents of anthropogenic origin and associated with lime firing, such as brick fragments, silicate sinters, and particles of charcoal.

The binder in all the mortars was calcitic. This was a fairly homogeneous, microcrystalline mass, and though lime lumps were present, they were relatively rare. It can be assumed that the lime had been carefully calcined at optimal temperature, almost completely converting carbonates to quicklime (calcium oxide).

The silicate sinters that were present in some mortars indicated that the lime had been fired using a carbonate raw material that contained small amounts of silicate constituents (e.g. clay minerals). As a result of the firing temperature in the lime kiln locally exceeding the optimum, these reacted with the formed quicklime to eventually form the calcium silicate sinters, such as wollastonite ($Ca_3Si_3O_9$) and rankinite ($Ca_3Si_2O_7$). A characteristic feature of some of the mortars was the presence of orange-brown intergrowths dispersed throughout the mass of the binder, representing iron minerals (iron oxide-hydroxide). Their presence should also be associated with the raw material used in lime firing, which contained iron phases, e.g. iron sulphides found in carbonate rocks (pyrite, marcasite), and which formed the iron hydroxides (getite, lepidocrocite) as a result of the calcination and binding of the mortar. Another characteristic feature of the binder of most samples was a recrystallisation of its carbonates. In most of the mortars, micrite (microcrystalline form of a calcium carbonate) partly recrystallised, creating small crystals of sparite (relatively coarse- to medium grained calcite) growing within cracks and voids.

However, an interesting diversity of mortar samples could be seen in:

1) the composition of the group of accessory elements;

2) the modal composition (volumetric proportion of binder to filler);

3) the grain-size distribution of the filler;

4) the ratios of major components, i.e. quartz to rock fragments.

Analysing the petrographic nature of the mortars revealed their features. The greatest variability was found in the mortars from the octadecagon, depleted in mineral accessory constituents, and anthropogenic ones such as fragments of ceramics and silicate sinters, which were quite often found in mortars from the other phases. Moreover, the octadecagon mortars had a filler clearly enriched with a gravel fraction, alongside a small amount of silt-fraction grains.

The highest proportions of accessory constituents were found in samples from palace 1, palace 2 and the defensive wall, which resulted from the presence of brick particles in them. A significant proportion of the mortars also contained the silicate sinters described above. The complete absence of such structures in mortars of the octadecagon phase is notable, as are the single occurrences in palace 1 mortars – in contrast to the very frequent occurrences in mortars of palace 2, the defensive wall, the canon phase and all samples from the remains of the hypocaust furnace 1.

As previously mentioned, some of the mortars contained intergrowths of iron oxide-hydroxides in the binder. This was especially typical of palace 1 and tower 2 mortars. The presence of these thermally active components was reflected in the results of thermal analysis. The samples included in the palace 1 phase had a much higher ratio of loss-of-mass in the >600°C range (decomposition of carbonates in the binder) to loss-of-mass in the 200–600°C range (decomposition of iron oxide-hydroxides from the binder), averaging 8.08. The same ratio for all other samples averaged 6.12. This led us to conclude that the mortars from palace 1 and tower 2 contained more iron oxide-hydroxides relative to calcium carbonates, which probably resulted from the use of a different raw material for the lime calcination.

The mortar samples from the footings of the walls of the canonical houses did not differ in characteristics from the basic characteristics of other mortars from the Wrocław castle. The main components were quartz grains and carbonate binder. Numerous brick fragments and silicate sinters appeared as accessories. But most importantly – apart from the typical fragments with an orange-brown metallic binder, there were also grains with a dark, black-brown binder attesting to strong firing under reducing conditions. At the same time, the same type of ceramic grain was observed in three samples of mortars from the hypocaustic furnace 1, which were probably associated with the construction phase of the canonical houses. Since no such similar grains occurred in any other tested samples from the castle area, it can be assumed that the addition of powdered ceramics fired under reducing conditions was a distinguishing feature of the set of construction techniques used in the canonical houses.

Summarising the above results, it can be confirmed that the mortars from individual phases showed sufficient differentiation to be distinguishable. Although the easiest to identify was the mortar used in the octadecagon, those from the palace 1 and the canonical houses also had their distinguishing features. The following questions were therefore asked:

– could the construction of the mantle wall have been synchronous with the construction of the octadecagon wall?;

– which mortar should be linked to the mortar adhering to the shaped piece of ceramic reused in the foundation of the mantle wall?;

– was tower 2 built synchronously to tower 1 or palace 1?;

– should the construction of the hypocaust furnace 1 be combined with the construction phase of the canonical houses, or instead with palace 2?

Ad. 1. The composition of mortars from the mantle wall included such accessory elements as opaque minerals, brick fragments and bog iron ore. They also exhibited thermally transformed quartz, fractured, with optically isotropic edges. Grains of brick, and above all of the aforementioned quartz and iron structures, were never observed in the octadecagon samples. It is therefore possible to exclude samples from the mantle wall belonging to the octadecagon phase, and confirm that they exhibit features typical of mortars from younger phases.

Ad. 2. The sample of mortar adhered to the reused brick had features typical of the octadecagon mortar, which was similarly poor in accessory elements. This is interesting because the mortar stuck to a shaped piece from a cornice, and perhaps even a cornice from the octadecagon. This piece eventually found its way to the foundation of the mantle wall, so it is likely that the wall was built in connection with the partial destruction of the 18-sided keep and in order to protect it against a subsequent attack.

Ad. 3. The main difference in the mortars from towers 1 and 2 was the grain-size distribution of the aggregate. In the case of tower 1 it was fine, with a significant share of 0.2–0.3-mm grains, while in tower 2 it was typical of the samples of other mortars.The composition of the aggregate was also typical – mainly consisting of quartz grains with minor feldspars and rock grains. On the other hand, the set of accessory elements was characteristic, being more varied in quality than other samples. This seems to be related to the presence of relatively numerous particles of charcoal and brick fragments. These two elements, but primarily the brick grains, were most often found in samples from palace 1. Elements not found in the mortars from either tower, such as silicate sinters or thermally transformed quartz, were most often found in samples from the defensive wall and palace 2. This absence means that the samples from the two towers are closer to the mortars from palace 1 than to the phases in which the defensive wall or palace 2 were built.

Ad. 4. The mortars taken from the hypocaust furnace 1 were petrographically typical. Also, the set of accessory constituents was similar, consisting of grains of opaque minerals, glauconite aggregates, individual prisms of amphibole and fine plates of mica (mainly dark variety i.e. biotite, and, rarely, white mica i.e. muscovite). One sample also contained zircon. In addition to the aforementioned, the composition included characteristic ceramic-like grains of up to a few millimetres across. Importantly, however, they differed from the ceramic grains found in almost all other mortar samples. They had a red-orange microcrystalline clay mass, while the ceramic grains present in the furnace samples had a cryptocrystalline grey-black meta-clay mass that was much more heavily sintered. The colour of the grains from the furnace indicate firing under reducing conditions. In addition, the samples contained characteristic silicate sinters, consisting of fine quartz grains embedded in a colourless glass-like mass, and a few particles that appeared to be charcoal. Comparison of the analysed samples against the other mortars reveals a range of features typical of the samples correlated with the younger construction phases of the castle on Ostrów Tumski. Because atypical, grey ceramic grains were found in samples from both the hypocaust furnace 1 and the canonical house phase, they appear to have been created using the same technology.

Radiocarbon analysis results

The following were taken for analysis: 4 samples from one octadecagon foundation pillar (Wrocław Castle 1–3, 13; Fig. 3), 4 samples from the south-west pillar of tower 1 (Wrocław Castle 14–17), and 1 from the walls of palace 1 (Wrocław Castle 4). The number of tests was determined by the number of charcoals found in the mortar. In one case (WC16), the only particles of charcoal in the sample were embedded in carbonate mortar. The analysis was performed by Doctor Natalia Piotrowska of the Gliwice Radiocarbon Laboratory, at the Institute of Physics Centre for Science and Education of Silesian University of Technology (Piotrowska 2015). Radiocarbon dates were calibrated with OxCal 4.2.4 (Bronk Ramsey 2013) using the IntCal13 calibration curve.

Three tests from the octadecagon yielded dating results that were very likely (Fig. 4), though not very precise. The result for one sample (WroclawCastle 3) had to be rejected as completely unreliable[6]. Ultimately, the erecting of the building was approximately dated as the year common to the different intervals, identifying the years 1166–86 with 68% probability. For 95% probability, the range was 1117–1112 (Piotrowska 2015).

Tower 1 was approximately dated based on radiocarbon analysis of charcoal from samples WC 14, 15 and 17 to the years 1169–1212 with 68.2% probability, and to 1155–1257 with 95.4% probability (Fig. 5). Radiocarbon analysis of WC16 carbonate mortar indicated the years 1316–1355, 1389–1403 with 68.2% probability and 1301–1413 with 95.4% probability, which should be rejected.Charcoals from palace 1 mortar were dated to 1224–1261 with 68% probability, or to 1212–1274 with 95% probability (Piotrowska 2015).

Brick dimension analysis results

Analysis was performed by Mariusz Caban in 2012–2014,[7] and the results have been published in part (Chorowska *et al.* 2015, pp. 143–148). We will only cite here those that can somewhat narrow down the dating of the octadecagon, tower 2 and palace1.

From the octadecagonal structure, four series of measurements were taken from external pillars and one series from the central pillar. Analysis of the brick measurements showed that the building was erected using homogeneous bricks

[6] It indicated around 300 BCE (Piotrowska 2015).

[7] As part of work on a doctoral dissertation at the Wrocław University of Science and Technology's Faculty of Architecture supervised by Professor Jacek Kościuk.

Fig. 3. Wrocław. Remains of oldest part of castle exposed on Ostrów Tumski. Arrow marks remains of pillar of octadecagon from which charcoal samples were taken for ^{14}C tests (photo by M. Chorowska)

of median value 76×116×252 mm. Scattergrams of the dimensions were tightly packed, indicating the homogeneity of the items and that construction was completed in a single phase. Two partial measurement series were collected from the mantle wall. The brick dimensions averaged from the incomplete data was similar to those of the octadecagon, at 82×117×257 mm.

The brick dimensions for tower 2 were sampled in one complete measurement series on an inner wall face in the south-west corner. These were decidedly larger than the previous bricks from this building, at 87×116×258 mm.

Palace 1 was analysed with five measurement series. The analysis of brick dimensions showed that it was constructed using two slightly differing brick formats. The first, median 84×116×254 mm, was located on the inner face of the southern wall. The second brick format, with larger median value of 92×122×259 mm, was recorded in western parts of the northern wall, on both inner and outer faces. The shared history of palace 1 and tower 2 was indicated not only by its similarly sized bricks, but also by the presence of broken-off bricks protruding from a wall of tower 2 towards the southern wall of palace 1. At this point, it is worth showing a graphical comparative analysis of bricks from these two buildings against bricks that were uncovered in an annex at Legnica (Caban 2015) and originate from the remains of the Chapel of St Benedict and St Laurence at Legnica castle (Fig. 6) founded by Henryk the Bearded (Rozpędowski 1961). The similarity in brick dimensions between these three buildings gives reason to suppose that the construction of both palace 1 and tower 2 was funded by Duke Henryk I the Bearded.

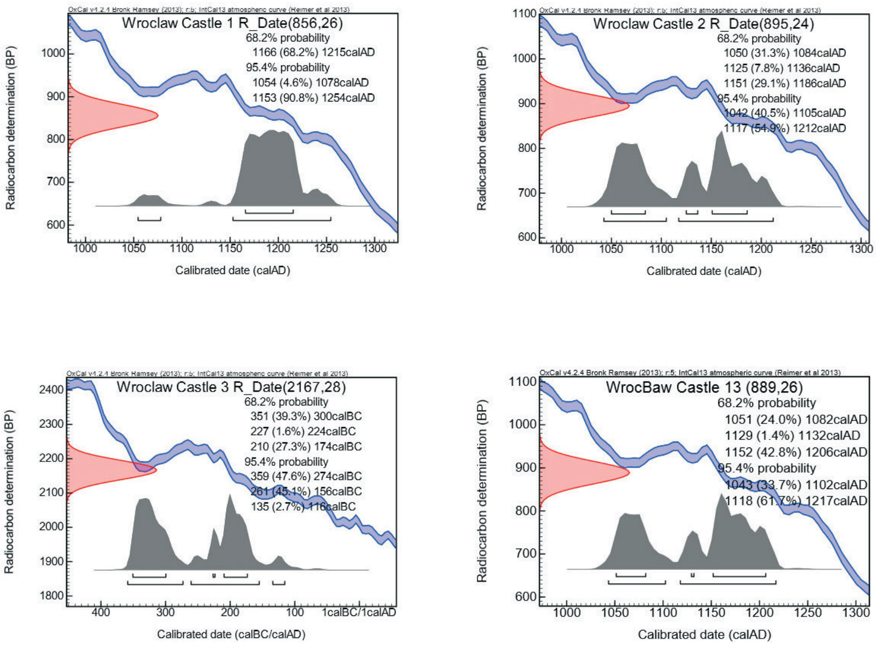

Fig. 4. Dating calibration charts for charcoal from pillar on perimeter of octadecagon (after Piotrowska 2015)

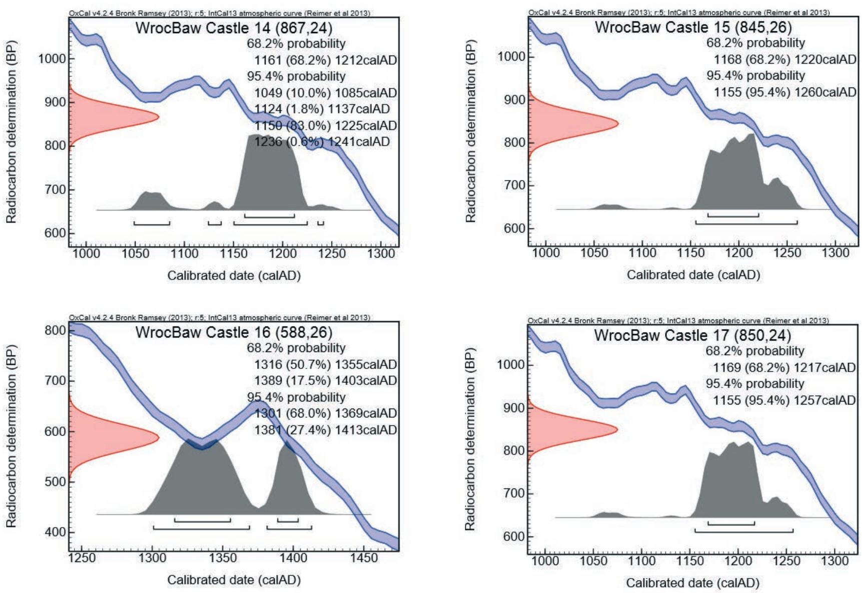

Fig. 5. Calibration charts of charcoal and mortar dating from south-east pillar of tower 1 (after Piotrowska 2015)

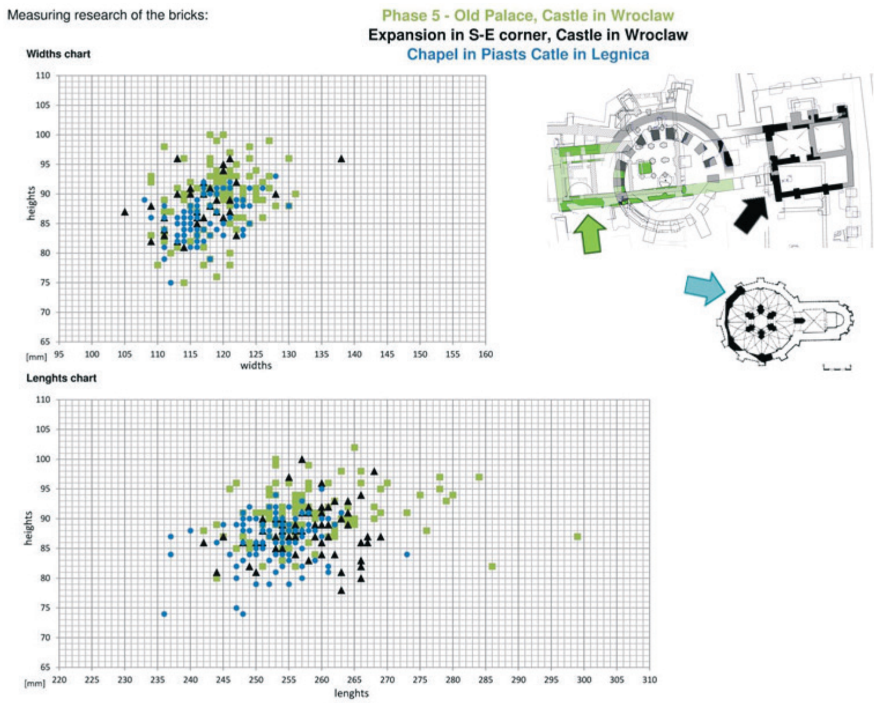

Fig. 6. Comparative analysis of dimensions of bricks from palace 1 and tower 2 at the castle in Wrocław against bricks from the chapel of St Benedykt and Wawrzyniec at the castle in Legnica. Bricks from palace 1 are marked in green, from the corner of tower 2 in black, and from chapel in Legnica in blue (edited by M. Caban)

Relative and absolute dating of the phases of transformations of the castle on Ostrów Tumski in Wrocław in light of the foregoing analyse

The oldest brick phase of the castle was a large octadecagonal building (a keep) that with a probability of 68% was built in the years 1166–1186, and thus after the return to Wrocław of the Piast duke from the senior line of Bolesław the Tall. This building was made of bricks of identical dimensions to the ceramic material used in the undercroft of the Cistercian monastery in Lubiąż (Fig. 7) founded by Bolesław the Tall in 1175 (Małachowicz 1993, p. 69; Łużyniecka 1995, p. 20; Chorowska *et al.* 2015, pp. 143–148). Moreover, in microscopic tests carried out in 2016, the mortar used in the undercroft showed exactly the same properties and petrographic composition as that of the octadecagon, i.e. a total absence of ceramic

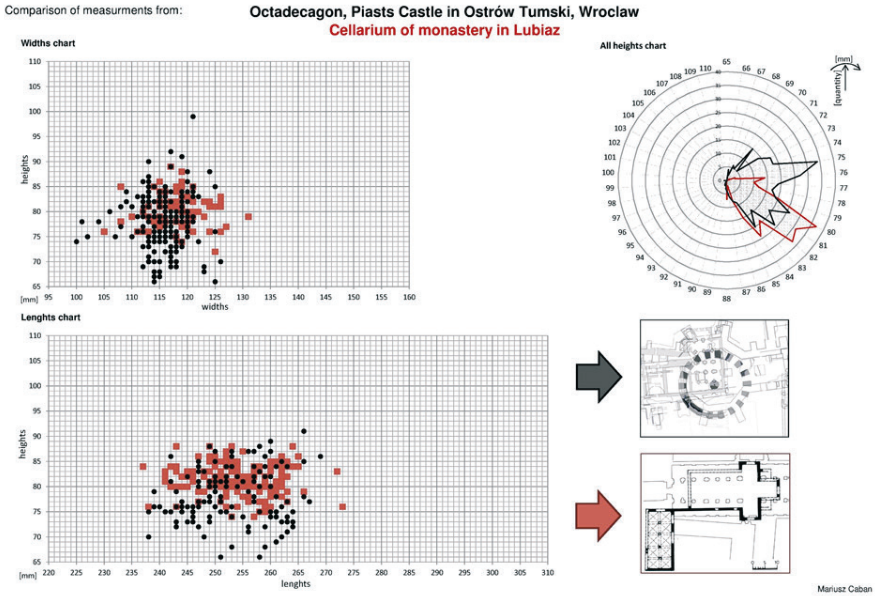

Fig. 7. Comparative analysis of the dimensions of bricks from the octadecagon at the Wrocław castle and from the cellar of the Cistercian monastery in Lubiąż. Bricks of the octadecagon marked in black, and the cellarium in red (edited by M. Caban)

admixtures and quartzite agglomerates, and a small proportion of accessory elements and micrite clusters (Bartz 2016). This also indicates that very well calcined and well aged lime was used. The limestone must have been burnt under optimal temperature conditions, preventing the formation of larger lumps of unburnt material. Mortar of a similar class was used to build the lower storeys of St Peter's tower in Legnica castle (Bartz 2015), which are also characterised by different from the others brick dimensions. The analyses carried out attest to the activity, in the last third of the 12th century, of a high-class construction workshop in Silesia implementing the construction plans of Duke Bolesław the Tall in brick.

The skirting of the octadecagon to the north and east with a mantle wall was a separate construction phase, despite using bricks of similar dimensions. Moreover, the octadecagon cornice piece was added to the foundation of the mantle wall, as evidenced by the mortar adhering to it exhibiting features typical of octadecagon mortars, which, similarly to the ones analysed above, were relatively poor in accessory elements. This latter circumstance arouses extensive speculation. The mantle wall and its surrounding embankment may have been constructed after damage to the octadecagon in the events of 1177–1179 (Mika 2013, pp. 127–131), when Duke Bolesław the Tall was forced by his brother, the duke of Racibórz, Mieszko Plątonogi to leave Wrocław and Silesia and flee again Germany. The construction of a long house on a rectangular plan to the south-east of the octadecagon was not analysed because its remains lay beyond the range of the 2012–2016 research. One thing that can be said is that it presumably lay outside the mantle wall and outside the rampart, surrounding this wall from the east. (Fig. 8). This hypothesis results from analysing the course of the later castle walls and excluding places where archaeological research (Pankiewicz, Jaworski 2011; Pankiewicz 2015, pp. 21–29; Wodejko, Chorowska 2020) failed to come across any rampart remains under the walls.

The construction of tower 1 should be associated with the early reign of Henryk the Bearded in Silesia with 68.2% probability. It was a long and politically effective reign, so is almost certain to have abounded in construction projects at the Wrocław castle.

Although the attribution of the building erected at that time was not unequivocally settled by the radiocarbon dating of palace 1, it can be attempted based on analysis of mortar compositions and brick dimensions from tower 2, palace 1 and the Chapel of St Benedict and St Lawrence at Legnica castle. As mentioned above, we associate them with the construction activity of Duke Henryk I the Bearded. Taking into account the time period determined by radiocarbon analysis, they probably date to the 1230s.

The mortar in the defensive wall did not differ in hardness, colour or mineralogical and petrographic composition from the mortar in the walls of palace 2, which indicates the two buildings having been built at a similar time, while the analysis of brick dimensions shows that they were manufactured for two different construction campaigns. In the north-eastern area of the castle, a defensive wall was first built, upon which walls associated with the palace were then layered up. It is not possible to date these activities from the laboratory analyses presented herein. However, a document was issued by Henryk III in 1257 granting the Church an area *usque ad plancas inferius, ubi olim ecclesia sancti Petri fuerat locata* and from then on the bishop and the chapter could have this area *ad castrum vero lapideum* (SUB, 1977, no. 257; see also Żurek 1996, pp. 26–27) as compensation for areas appropriated during the expansion of the castle fortifications in response to the Tartar threat; it indicates that it was only then that the defensive walls of the castle's eastern and south-eastern sections were built. Both the Grodzka Gate itself and the aforementioned sections were built outside the rampart, in an area that in the first half of the 13th century was still part of the settlement adjacent to the stronghold (Pankiewicz, Jaworski 2011; Wodejko, Chorowska 2020).

Palace 2 was the youngest building in the castle to have walls faced in block bond brickwork. Admittedly, the dimensions of its bricks of similar dimensions to the bricks from the chapel of St Martin (Chorowska 2017b, pp. 217–219) and the basement of the presbytery of the church of the Saint Cross founded by Henryk IV Probus from 1288, though both of these buildings employed a more modern, stretcher bond

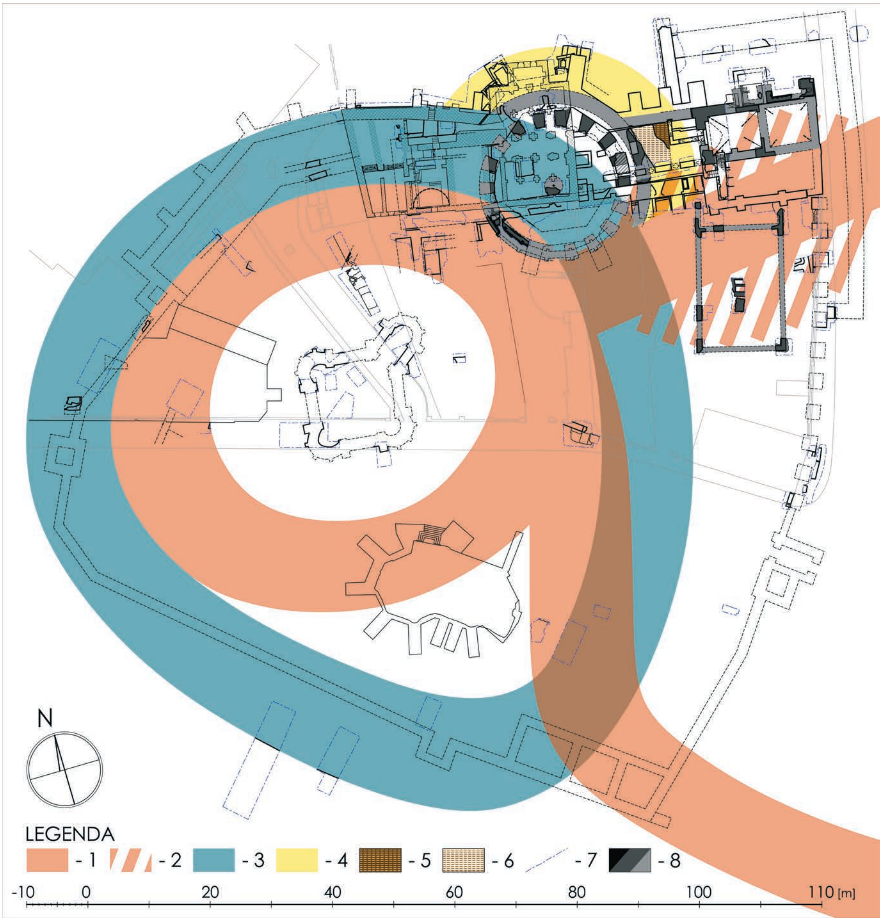

Fig. 8. Hypothetical plan of the castle on Ostrów Tumsk in Wrocław, circa 1200, on the background of earth-and-timber reinforment (after Chorowska et al. in print): 1 – rampart (10th century); 2 – rubble from rampart (10th century); 3 – rampart (11th century); 4 – rampart (Q4 of 12th century); 5 – rampart curtain (Q4 of 12th century); 6 – thickness of rampart (Q4 of 12th century); 7 – limits of archaeological excavation; 8 – wall remains (Q4 of 12th century to early 13th century) (after M. Chorowska and A. Pankiewicz, edited by M. Caban)

brickwork. It is therefore possible that the construction of the palace was initiated by Duke Władysław of Salzburg, and its continuation fell to Henryk IV Probus.

The most important of the results presented above is the confirmation of the dating of the octadecagonal building to the 4th quarter of the 12th century and the confirmation of the workshop connections between it and the cellarium of the monastery in Lubiąż founded by Bolesław the Tall in 1175. The existence of these connections and the early dating of both buildings have previously been indicated (Małachowicz 1993, p. 69), and now these assumptions have been confirmed by the results of the dimensional analysis of bricks, tests on the oldest mortars and radiocarbon analysis of three mortar samples. However, the interpretation of the octadecagon's function as a Romanesque castle chapel was not confirmed (Małachowicz 1993, pp. 57–69). The reconstruction of the body of this building as a cylindrical residential tower is supported by its strategic location on the 11th-century rampart (Chorowska *et al.* in print) and its being surrounded by a curtain wall and another rampart at the turn of the 13th century.

The attribution of the reconstruction of the octadecagon into the elongated palace 1 (4a and 4b) to Henryk the Bearded (1201–1238) has much weaker chronological foundations, as it results mainly from the analysis of brick dimensions. On the other hand, the question of the religious function of palace 2 was answered in the negative (Małachowicz 1993, pp. 92–106), because in the light of the discovery of the remains of the two ovens 2 and 3 associated with the walls of its alleged presbytery, this hypothesis is unsustainable. Both palace 1 and palace 2 were residential buildings.

The mortars in the walls of phases 4, 5 and 6 had a similar mineralogical and petrographic composition, which did not allow them to be differentiated. The usefulness of the laboratory tests used turned out to be significant in distinguishing phases 7 and 8, because their mortars contained ceramics from firing in a reducing atmosphere that were not present anywhere else. When assessing the usefulness of the applied research methods, it should be confirmed that they constitute a significant supplement to standard architectural analyses and that they should be used, especially in cases of such complex, repeatedly rebuilt objects of importance to national heritage as the oldest ducal castle in Wrocław.

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