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HISTORY | RESEARCH ARTICLE

A methodology to identify a fragment of painted glass from excavations at John Paul II Square in Wrocław

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Abstract: The aim of the paper is to discuss and analyze the discovery made during an archaeological and architectural rescue research conducted by a team led by Dr Ing. Arch. Piotr Kmiecik and Dr Robert Szwed in the years 2015–2019 on the premises of the former Babiński Hospital at John Paul II Square in Wrocław/Poland. During the research, a piece of glass with a very interesting painting decoration was discovered. The carried out architectural and archaeological research made it possible to unequivocally state that the discovery came from the times when Wrocław was within the borders of the Kingdom of Bohemia within the Holy Roman Empire. The research used the method of historical, architectural and heraldic analysis, as well as physico-chemical research on glass together with its historical comparative analysis. This allowed to determine with great accuracy the time of creation and the origin of decoration. The graphical representation on the analyzed piece was also specified. It is the coat of arms of Stefan Batory as Polish king, reconstructed on the basis of conducted analyses. Due to the high quality of elaboration of the detail and the subject matter of the presentation, this discovery was connected with court

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PUBLIC INTEREST STATEMENT

During large archaeological and architectural research carried out in 2015–2019 in Wrocław (Poland), a seemingly insignificant fragment of painted glass was found, which after initial cleaning turned out to be much more interesting than it was originally thought. The analysis of the preserved graphics indicated its creation at the end of the 16th century and connection with the Kingdom of Poland (Wrocław was at that time part of the Kingdom of Bohemia). At the beginning, it was thought to be a part of a larger stained glass window. This discovery was so unusual that it was considered very important to confirm the dating, as well as identification of the presented graphic and an attempt to confirm the original function of the complete artifact. Confirming these hypotheses is a step towards better understanding of political and trade relations in central Europe at the end of the 16th century.

circles. Therefore, the discovery complements the knowledge about relations between Wrocław and Poland at the end of the 16th century. The research itself allows to analyze the methodology of conducting interdisciplinary research in the field of history of art and architecture based on the cultural context of the place.

Subjects: Architecture; Architectural Conservation and Building Conservation; Architectural History; Heritage Management & Conservation; Design History; History of Art; Regional Art; History of Art & Design; Archaeology

Keywords: applied arts; historical glasswork; artistic glass; Wrocław; Silesia; Stefan Batory; architectural excavations; architectural analysis; monument conservation; medieval architecture

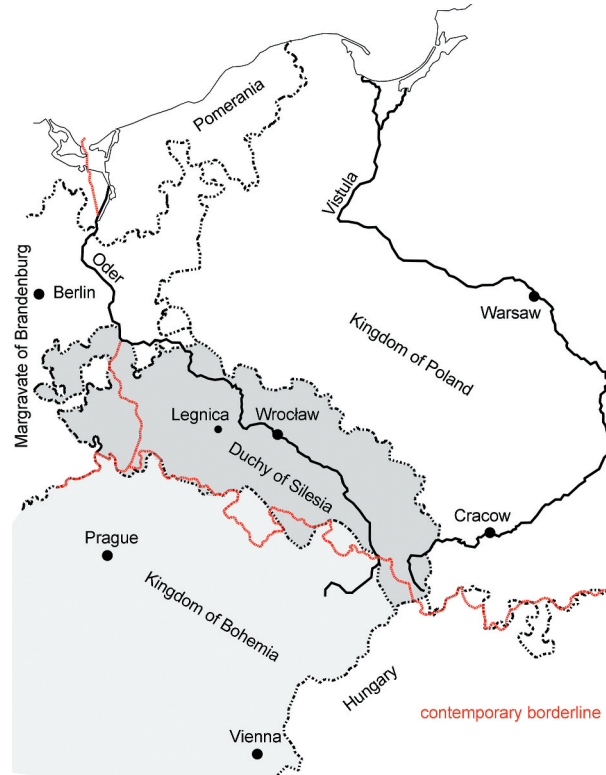
1. Introduction

The reason for this paper was a discovery made during a piece of archaeological and architectural rescue research conducted by a team led by Dr Ing. arch. Piotr Kmiecik and Dr Robert Szwed, with the participation of Dr Czesław Lasota, which started in spring 2015 on the premises of the former Babiński Hospital at John Paul II Square (plac Jana Pawła II) in Wrocław (Poland).

Wrocław, which is the historical capital of Silesia and its largest city, together with the entire geographical region is characterized by an extremely complex history. From the 9th century to around the mid-12th century it passed several times from Czech to Polish administration and back. For the next two centuries it was an independent political entity with changing names and borders (the Duchy of Silesia, of Lower Silesia, of Wrocław), and later it came under Czech rule. In the 15th century, it belonged to the Kingdom of Hungary for 21 years, then it returned to Czech rule. Subsequently, it was ruled by the Habsburgs (1620–1742), and then became part of the Kingdom of Prussia (until 1871) and Germany (until 1945). After World War II, it was incorporated into Poland. The period covered by the following text falls shortly before the outbreak of the Thirty Years' War, when the city was part of the Czech Kingdom, ruled by Maximilian II and then Rudolph II of the Habsburg dynasty. This was one of the periods of particularly intense development for the town. At that time Silesia bordered the Kingdom of Poland from the north-east, the German states of Brandenburg and Saxony from the north-west, and the remaining regions of the Czech Kingdom from the south (Figure 1).

The area covered by the above-mentioned archaeological and architectural research is located at the northwestern end of the area adjacent to the second line of city walls, erected in the mid-14th century. From the south, it was bordered by St. Nicholas' Gate, leading west towards Legnica, while at the opposite (north-western) end there was one of the first municipal hospitals (All Saints' Hospital) and the building of St. Nicholas' Arsenal. In the 15th century, another line of roundel fortifications was built in front of the previously mentioned line of city walls, and then around 1544 one of the first bastions in Europe, originally called the Neu Grossebastei and later the Tenaille (die Scheere), nowadays Tenaille Bastion, defending the city's moat estuary, leading to the River Oder. The vast majority of these military facilities were destroyed after the capture of Wrocław by Napoleon's army in 1807. At the time, All Saints' Hospital was gradually expanding in this area. The last buildings of this complex were erected in the 1930s (Wójtowicz, 2008, pp. 21–22). After 1945 and the incorporation of the city into Poland, the complex was renamed the Józef Babiński Provincial Hospital and functioned under this name until its liquidation in 2007. Today, the area of the former hospital occupies an area with a shape similar to an elongated triangle, bound to the north by the bank of the Oder river, and to the west by the city moat, to the east by Wszystkich Świętych and Antoniego Cieszyńskiego streets and the building of St. Nicholas' Arsenal (the City Museum of Wrocław). Its total area exceeds 2.5 ha. Due to the number of cultural layers, it is also one of the most valuable areas in terms of archaeology and architecture in Wrocław.

Figure 1. The geographical situation of Silesia in the second half of the 16th century with the presentation of contemporary boundaries: (a) historical borders of the Duchy of Silesia in the second half of the 16th century, (b) contemporary borders (developed by authors).



In 2008, the area was intended for sale, and in 2014 it was sold. The new owner decided to adapt and expand the hospital facilities for residential and commercial purposes. Therefore, rescue archaeological and architectural research had to be conducted. The main purpose was to identify the preserved relics of the city fortifications, especially Tenaille Bastion. During the works carried out in the years 2015–2020, many extremely interesting archaeological artifacts were also found, including the glass fragment discussed in this paper. A question may be asked why one piece of glass measuring 55 × 45 mm has become so important for the history of the city and the region, and why it is worth paying more attention to it than just an ordinary inventory item in the catalog of finds. Its first identification as a fragment of stained glass with the representation of the coat of arms of the Kingdom of Poland becomes particularly surprising, as one takes into account the turbulent history of Wrocław and the part of the city where the works were carried out. In these circumstances, both the confirmation of the function and the verification of the design, as well as the attempt to determine the origin of the item seemed to be extremely important.

The circumstances of the discovery of the discussed find require a broader analysis of both the area of research and its specific function, as well as the place in which it was found, which is described more precisely in the next paragraphs. However, it is worth mentioning at the outset that none of the sources in this context provided any answers as to the possible origin of the analyzed artifact. No construction or excavation works had been carried out at the site of the discovery since the construction and subsequent renovations of the fortifications within which the artifact was found. Building B9 was erected in the immediate vicinity (the so-called “building with a clock”, Johann Friedrich Knorr, 1821–23) (Wójtowicz, 2008, pp. 45–46), but nothing is known about any archaeological discoveries made on this occasion. Analyzing the entire area of the former hospital, reference is made to just a few previous bibliographic sources and emergency research conducted throughout the area.

A team led by Jerzy Romanow (1979), whose research hypothesis was later quoted by Edmund Małachowicz (1994), investigated the area adjacent to the site of the finding of the artifact from the east, including the building of the Municipal Arsenal and a fragment of the moat running along today's Cieszyński Street. It refers to the existence of an unfinished left-bank castle, the construction of which began during the reign of Henryk IV Probus, Duke of Silesia (1266–1290), and was abandoned after his death. The walls and foundations of this investment were then to be used to build the later St. Nicolas Arsenal (Romanow et al., 1979). The arsenal building itself has received a small study by Marcin Bukowski (Bukowski, 1974) and a much more extensive monograph by Marek Burak (Burak, 2012).

Attempts to reconstruct the medieval and modern fortifications of this part of the city undertaken by Bimler (1940, pp. 13–20), Ludwig von Petry (1983) as well as in later publications (Młynarska—Kaletynowa & Eysmontt, 2001) were also important for this study. In the period from the eighties of the 15th century to the end of the thirties of the 16th century, an additional line of bastion fortifications was erected, surrounding the earlier, 14th-century, walls, described by Małachowicz (1985). Work on the wall behind All Saints' Hospital (this was the first municipal hospital in Wrocław and the first building of the subsequent Babiński Hospital) lasted from 1530 (Bimler, 1940, pp. 24–26). So far, none of the city's fortification lines has been researched in this part. However, an archival query may be extremely helpful in determining their location. When analyzing Weiner's plan (Młynarska—Kaletynowa & Eysmontt, 2001) it can be assumed that the western wall of the hospital almost adjoined the curtain running behind it. An element that can help in its location with great accuracy is the unfinished project to expand the hospital, located in the collection of the Construction Archive of Wrocław (Wójtowicz, 2008, p. 8). It assumed the founding of one of the walls of the building on the curtain, at the same time allowing for its very precise location. However, this applies only to the northern part of the plot. Some important information determining the form of the curtain is also provided by the plan by Frederik Hendriks Vroom and Friedrich Gross from 1587 (Vroom & Gross, 1588). Its course can be described as parallel to the line of the previous fortifications, with the zwingler belt.

In the second half of the 13th century, the cemetery of St. Barbara's church, bordering the south-eastern end of the site, was probably also established. Burak and Okólska (2007) have discussed it in a cross-sectional study.

The former All Saints Hospital as a building complex is also an extremely important facility for the undertaken research. It was founded in 1526 and was consistently expanded until the mid-twentieth century. It has been fully elaborated by Małgorzata Wójtowicz (2008).

The Tenaille Bastion, in the southern shoulder of which the find was made, was erected around 1544, situated at the fork of the Odra River and the city moat (Małachowicz, 1981). It is visible both on the Weiner plan from 1562 (Młynarska—Kaletynowa & Eysmontt, 2001), as well as on Gross's measurement plan from 1581 (Małachowicz, 1985) and many later cartographic studies.

The only contemporary information enabling the exact location of this element are the results of archaeological and architectural rescue research carried out by a team of: Robert Szwed, Czesław Lasota and Jerzy Burnita (Szwed et al. n.d.) at the construction site of the water supply line w600, limiting the trench from the north and west. During their research, fragments of brick spurs identified as the southern shoulder of the bastion were found. The bastion was probably erected according to the plans of the town builder, Lorenz Gunther (Klawitter, 1941). According to Grzegorz Podruczny, the retracted south shoulder was equipped with an artillery casemate (Podruczny, 2009). Stanisław Kolouszek (2014) confirms this information but none of the authors gives its source. The information about the construction system possible to be used in such an element was to be found by analogy. An almost identical construction plan of the bastion (a single one) shows Viollet-le-Duc as an element of Troyes fortifications from the period after 1530 (Viollet-le-Duc, 1854–68).

The literature within the scope of the study area itself shows, as presented above, many gaps, regarding both the form, scope and time of creation of individual elements of the fortification system from the period covered by the study. These gaps were filled thanks to field work research. In the case of the artifact itself that contributed to the creation of this text, there is virtually no literature discussing both the scale of political and commercial contacts that could have resulted in the creation of relations strong enough to justify the presence of this type of representation in Wrocław. No literary references or any heraldic representations related to the reign of King Stefan Batory in Wrocław were found during the first stage of research. In general, the reign of Batory in Poland was described by, among others, Jerzy Besala (1992) and Karol Olejnik (1988), while information about heraldic elements referring to the Kingdom of Poland (but not necessarily from the period in question) appearing in the iconographic program of Wrocław objects is mentioned in several studies (Kaczmarek, 2008, p. 32). It is known that a very extensive iconographic program containing heraldic elements, including the coats of arms of cities and countries with which Wrocław had contacts, was located in the town hall (Bukowski & Zlat, 1958) (Zlat, 1958, pp. 220–225), (Kaczmarek, 2014, pp. 182–183). However, all this information is fragmentary and does not give a chance for a comprehensive look at the phenomenon. Therefore, the conducted research fills a very important gap in the literature on these issues.

There are few or limited studies on early-modern historical glassware. The anonymity of the existing works and the lack of sources about individual manufacturers make research in these areas very difficult (Letkiewicz, 1993). The works of Wańtuch-Jarkiewicz and Moszak (2019) are very important in this context, giving a general view of the technology, dating and identification of historical glass producers from Silesia. General studies on the technology of historical glass are also valuable (Smedley & Jackson, 2002) (Michałek, 2018).

2. Methodology

Due to the considerable complexity of the historical context and the specificity of the discovered artifact, the methodology used for the research is complex and multi-threaded.

The first stage of the study comprised archaeological and architectural research. They were preceded by a preliminary analysis of written sources, which were supplemented after the discovery. Their main purpose with regard to the discussed artifact was to determine the historical context as accurately as possible, which could provide valuable guidance for later attempts to determine the dating and origin of the element. In addition to architectural in situ research, a comparative analysis of historical layers with similar architectural objects of the area were used.

The work was followed by laboratory research, carried out in two threads: further analysis of the archaeological context, and research on the glass itself. The research used the method of dendrochronology (context research), dating of glass used in the conservation of works of art, the comparative method and UV-light research, glass and stained-glass technology, and many others, the most important of which was the comparative analysis with lead, forest and sodium glasses from different periods (from the 15th to the 19th century) from the archives of the Glass Conservation and Restoration Workshop at the Academy of Fine Arts in Wrocław, made in 2019 and 2020.

It is also worth paying attention to UV-fluorescence testing. This test involves the excitation of secondary radiation in the visible-light range by illuminating the sample with ultraviolet rays (Slansky, 1965), (Letkiewicz, 1993, p. 60), (Kowalczyk, 2018). Under specific conditions, this allows the identification of certain substances contained in the illuminated object (Gancarczyk & Gancarczyk, 2010). For example, the unmistakable identification of a material based on copper oxides (including *schwarzlot*) is possible, because in such a test it is the only material characterized by the total absorption of illuminating rays (Kunicki-Goldfinger, 2020) (Figure 13).

Dendrochronology is based on the study of annual growth rates of trees and allows extremely precise determination of the age and date of cutting the tree from which the sample was taken

(Kaennel & Schweingruber, 1995). In this case, it was assumed that the discovered fragment had to get to the trench during the construction of the wooden icehouse, hence its dating was very important. In this section, only the research methods used are discussed. A precise description of the discovered artifacts will be given later in the text. An additional advantage here is the high precision of dendrochronological tests, in which, under certain conditions, the exact calendar year each tree ring was formed can be determined (Krzpiec & Ważny, 1994).

The analysis of bibliographic and iconographic sources, referring not only to architectural but also historical research, has also become an important element. Also in this respect, the auxiliary sciences of history, especially heraldry, were used widely. They were used to perform a stylistic analysis of the sign, followed by its recognition and verification. This was very important because the coat of arms was originally recognized as a sign of the king of Poland, Stefan Batory—which, given the location of the discovery, seemed highly unlikely to the researchers. Therefore, all other possibilities had to be analyzed, especially the coats of arms of the Silesian nobility as well as Silesian cities. At the same time, a search was carried out in Polish armorials which were contemporary to Batory.

The heraldic analysis was carried out on the basis of available bibliographic materials, including Polish armorials (Paprocki, 1858), (Paprocki, 1578) and German ones (Siebmacher, 1605), (Von Prey, 1740), as well as a comparative analysis of graphic representations contained in preserved works of art, including applied art (Stężyński Bandtke, 1839) (Treter, 1840) (Kober, 1586). This required an archival query in museum resources, including those with the largest collections in this field: the National Museum in Wrocław and in the branch of the National Museum in Krakow—the Princes Czartoryski Museum, dealing with the documentation of the activities of the Polish kings at the time when Krakow was the seat of the kingdom (these are also the times of the reign of Stefan Batory).

Due to the specific method of obtaining the examined element and the interdisciplinary nature of its analysis, the structure of the paper reflects the chronology of work on the find, partly as fieldwork in the area of archaeological and architectural research, and partly including further research already carried out in laboratory and archival conditions. The initial part of the paper discusses the circumstances of finding the studied glass fragment, along with the location of the find in the broader context of the history of architecture in Wrocław. In the adopted research methodology, four basic groups of issues were distinguished, the mutual arrangement of which partly reflects the chronology of the research, and partly is only a record in the form of a logical explanation of the system of gradually flowing data. Archaeological and architectural research conducted in situ, preceded by an appropriate archival query, were the first to be conducted.

The next stage was physical and chemical research of the finding itself based on knowledge of history and conservation of works of art. During that time, the results of dendrochronological research of the elements surrounding the find were also obtained. The last stage of the research was an iconographic and heraldic analysis connected with an attempt to place the find in a cultural and social context and to reconstruct the complete item. The results of the research were presented together with conclusions and discussion.

3. Results

3.1. The excavation site

In the former hospital area, there were 13 buildings marked with symbols from B1 to B13. One of them (marked B9) was intended by the investor to be demolished. The others were only to be rebuilt or restored to the extent agreed with the Municipal and Provincial Conservator of Monuments. Both the open area and the area underneath the buildings were designated for the research. The current ground level in this area is between 116.8 and 117.8 m AMSL. The water level

in the moat is about 113.1 m AMSL. The stable groundwater level is slightly lower and is about 112.5 m AMSL.

Figures 2, 3 and 4 show the general view of the construction site, and at the same time the area of research, which consequently led to the discovery of a fragment of the analyzed glass. The discoveries made in this area can be divided into several groups: architectural, urban, archaeological and anthropological. The most important ones include: the discovery of the medieval and modern city fortifications of Wrocław, the third, never-finished castle dating back to the first half of the 13th century, a large number of Romanesque sculptures of great historical importance, a medieval and modern cemetery and many smaller artifacts found during the works. The discoveries made were generally related to the entire period of operation of the aforementioned area, first as a part of city fortifications, then a cult area, the first municipal hospital, until its liquidation at the end of the 20th century. Due to the very wide range of discoveries made in the course of the work, they have been described in more detail in other publications, already published or under development (Kleszcz & Kmiecik, 2018), (Kleszcz & Kmiecik, 2020), (Kmiecik & Szwed, 2018).

Due to the size of the site and the results of the archive search, several research tasks were designated. As already mentioned, one of the main tasks was to find the relics of the Tenaille Bastion. Due to the size and the number of networks running through the area, as well as the vegetation growing over it, it was decided not to excavate the entirety of the area. Instead, 41 trenches of different sizes were dug at key points. They were marked with Roman numerals from I to XLI. In addition, several trenches were dug inside the buildings. Their markings were

Figure 2. The front part of the southern shoulder of the Tenaille bastion.

Photograph from April 2017.
Photo by Piotr Kmiecik



Figure 3. General view of the trench No. XXXII. The view from the south.

Photograph from April 2017.
Photo by Piotr Kmiecik.



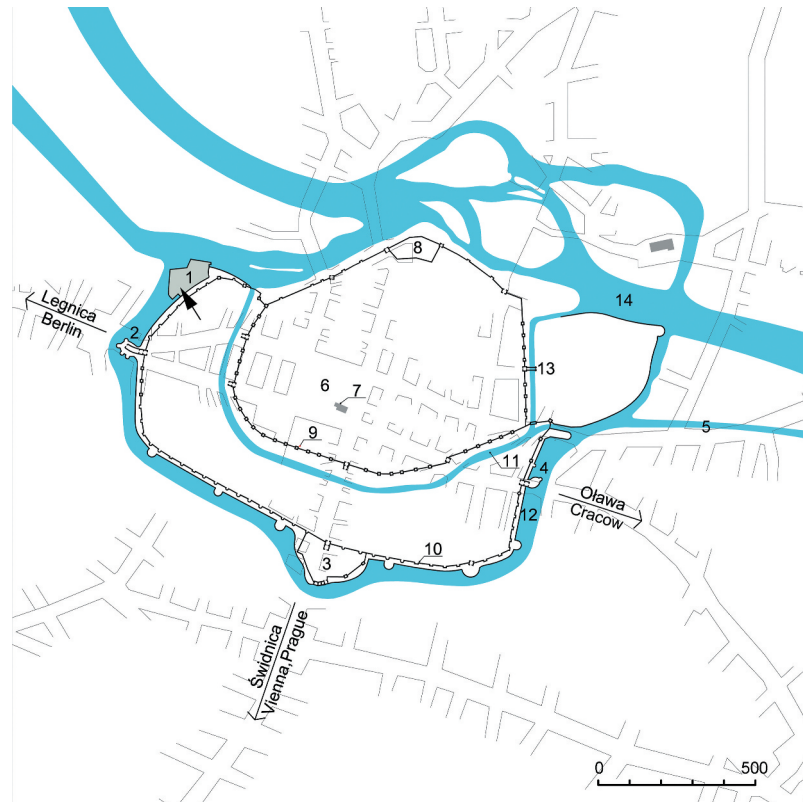
Figure 4. General view of the trench No. XXXII. In the foreground there is perfectly preserved receding southern shoulder of the bastion. An arrow marks the place where the alleged icehouse was discovered. Photograph from April 2017. Photo by Piotr Kmiecik.



constructed in two parts and consisted of an Arabic building number and a Roman trench number (For example, Trench No. 7.IV meant the 4th trench in building No. 7.). The largest of them were trenches Nos. 13.I, III, IV, XXXII and XXXIII. In the first of them, fragments of the curtain of the roundel fortifications were discovered. This strip was erected between the 1480s and the late 1530s (Małachowicz, 1973, 1985). The trenches No. III and IV revealed fragments of the curtain of the southern face of the bastion, together with an element difficult to identify, referred to as the foundation of the gate tower. In trench No. XXXIII, further relics of the curtain of the roundel fortifications and a corner of the bastion were found. The historical water level in the moat was also established between 112 and 113.5 m AMSL. (Figure 5).

In trench No. XXXII, a perfectly preserved receding southern shoulder of the bastion was discovered, together with a lowered artillery terrace. The established level of its crown is about

Figure 5. Historical plan of Wrocław with the presentation of the contemporary development plan and historical watercourses within the city moat. List of the most important objects: (1) the Tenaille Bastion from around 1544; (2) the St. Nicholas Gate; (3) Świdnicka Gate; (4) Oławska Gate; (5) Oława river; (6) marketplace; (7) town hall; (8) left-bank castle; (9) first line of city walls; (10) second line of city walls; (11) inner moat; (12) outer moat; (13) Bridge “At the Krupnicza Tower”; (14) Odra river; (developed by authors on the basis of (Małachowicz, 1973)).

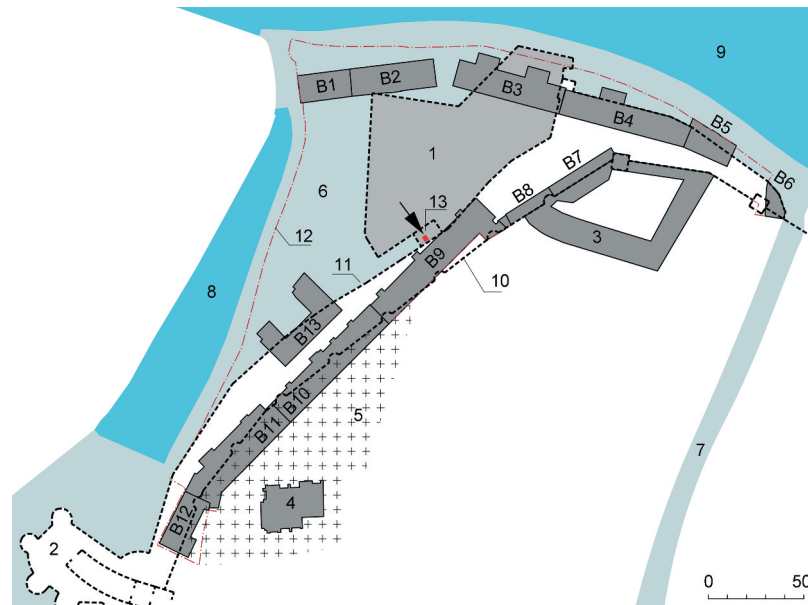


+114.2 m AMSL, and is the original height (without the breastwork), thanks to the negative preserved on the bastion's curtain, and could certainly be determined at about +115 m AMSL. In the south-east corner of the terrace, remains of a wooden structure interpreted as an icehouse were discovered (Figure 4). Both quite large dimensions (much larger than in the case of wells or latrines known from Wrocław) support this interpretation, as well as archaeological artifacts found inside. The largest structures of this type discovered so far had a longer side dimension not exceeding 2 m (Limisiewicz, 1998). An extremely similar (though not identical) construction found also in Wrocław at Bernardyńska Street, and also within the medieval city limits, was described by Jerzy Piekalski (2004). Other similar constructions of both icehouses and wells have also been described by Konczewski (2007). (Figure 6)

The construction system of the facility is analogous to similar devices already known from other excavations in Wrocław. The whole terrace space was filled with a uniform sand backfill in which the construction of the icehouse was recessed. Its lower level was determined at about +111.70 m AMSL, i.e. about 1 m below the bastion foundation level, 0.6 m below the current water level and 3.3 m below the original terrace level.

The structure with external dimensions of 2.6×2.1 m consisted of two parts. The upper boarding was made of horizontally laid staves. It was based on a structure made of posts and beams of square cross-section, joined by pivots, and placed outside the contour of the lower part. The main construction was made with vertical staves, sharpened at the bottom and driven into the ground. In the corners, elements with a square section and side length of about 8 cm were used. Staves about 6 cm thick were cut, ciseled and joined with a tongue-and-groove joint to a rectangular section. In front of them, there was another layer of construction made of posts and beams. In contrast to the structure described by

Figure 6. Site plan of the research area. List of the most important objects: B1 to B13—former hospital buildings; the numbering adopted in accordance with the numbering of the design documentation; (1) the Tenaille Bastion from around 1544; (2) the St. Nicholas Gate; (3) the St. Nicholas Arsenal (4) St Barbara’s Church; (5) parish cemetery at St Barbara’s Church; (6) outer moat around 1544; (7) inner moat; (8) remains of the external moat—current state of preservation; (9) Odra river; (10) the line of the second circuit of the city walls; (11) curtain wall of the bastille fortifications from the 15th century; (12) research work area; (13) the place of discovery of the artifact; The modern course of watercourses is marked in blue, while the course of watercourses in 1544 is marked in light blue.



Piekalski, the horizontal elements of the structure (beams) in this case were at one height and were not connected in any way with the boarding. No remains of the floor were found.

Oak was used for the construction. Dendrochronological analyses gave two dates of wood samples from the walls: after 1570 and after 1527 (both analyzed samples lacked a subcortical ring) (Krzepiec, 2017).

In the sand at the edge of one of the staves, in the south-west corner of the construction (i.e. about 0.5 m below the lower level), the artifact described below was discovered, an enamel-painted glass with a fragment of the coat of arms (Figure 7). The object was found directly under the sharpened lower end of the lath, in the layer of original soil, so there is realistically no possibility of it getting there other than during the construction of the icehouse. It was also the only piece of glass found in this area—and most of the area of trench No. XXXII was explored to the level of the original soil, just above the groundwater level. Initially, it was assumed that the find was a fragment of stained glass coming from a window of one of the buildings in Wrocław.

3.2. The examined artifact

The discovered artifact is a piece of flat glass with an irregular, polygonal contour and maximum dimensions of about 55 × 45 mm, with a thickness of between 1.8 and 2.5 mm, covered with enamel engraving in the grisaille technique (monochromatic painting made on, among other things, glass, with possible highlighting of details with argent yellow) (Gajewska-Prorok, 2014). It shows a fragment of an eagle’s body with a part of the neck, left wing and leg. There is a heraldic shield with an elaborate shape on it. The field of the shield is black, with three elements resembling horizontally placed silver teeth, pointing the blades to the left (Figure 8).

Figure 7. View of trench No. XXXII with the remains of the wooden structure interpreted as an icehouse. An arrow marks the place where the glass artifact was discovered. In the foreground there are visible ceramic elements also found in the trench. Photograph from April 2017. Photo by Piotr Kmiecik.



Figure 8. A photograph showing the analyzed glass find (a) left side, (b) right side. Photo by Piotr Kmiecik and Katarzyna Gemborys.



Both the placement of the pattern on a visible, probably white underpainting made on the upper side of the painting, a thick layer of paint, as well as a low translucency suggest a product designed to be viewed in diffused light, in contrast to a stained-glass window, which was to be viewed against the light. The original theory concerning the purpose of the object was therefore overturned already at the initial stage of research.

The visible fragments of the eagle were made in the grisaille technique, popular especially at the end of the 16th century (The Editors of *Encyclopaedia Britannica*, n.d.). The probable order of application of the enamel was as follows: on the glass surface, there was a layer of white underpainting, then a thinned black and brown patina, resulting in a gray color, currently, as a result of chemical processes, locally metallic (by precipitation of iron oxides). The last layer was schwarzlot—a black opaque glaze—an alloy of high-lead glass with iron and copper oxide. It is an enamel

paint used already in the Middle Ages to paint lines and shadows on stained glass windows (Cenutti & Dorigato, 1998), (Kurmann-Schwarz & Carson Pastan, 2019). In this case, it was used to emphasize the contours of remiges and heraldic elements linearly, and to fill the shield, as well as to attempt to build a linear chiaroscuro visible especially on the underside of the feathers and the left side of the eagle's neck. The interior of the coat of arms was made by applying a layer of schwarzlöt, with the exception of heraldic elements (teeth).

The discovered fragment, due to the very destructive environmental conditions in which it was located (the bottom of the moat), was very strongly corroded. It is particularly visible on the wing and neck of the eagle in the form of a metallic layer (probably hematite), as well as iridescence between the feathers, shoulder and neck. Both surfaces of the glass have been heavily etched, which makes it impossible to determine the original shape of the underpainting (Figure 8). In the case of a better-preserved surface, this would be at least partially possible—for example, in the case of round glass, the concentric traces resulting from the forming process remain visible (Butts & Hendrix, 2000). The longest visible feather of the wing is with a large flake at the end, formed earlier or during the driving in of the icehouse's fortifications, which is indicated by even edge corrosion, consistent with the corrosion of the whole section. On the underside of the glass there are several scratches and a few small flakes, probably made during archaeological works. In the glass breakthrough, two parallel grooves are visible, indicating stresses occurring in the glass (Figure 9(d)).

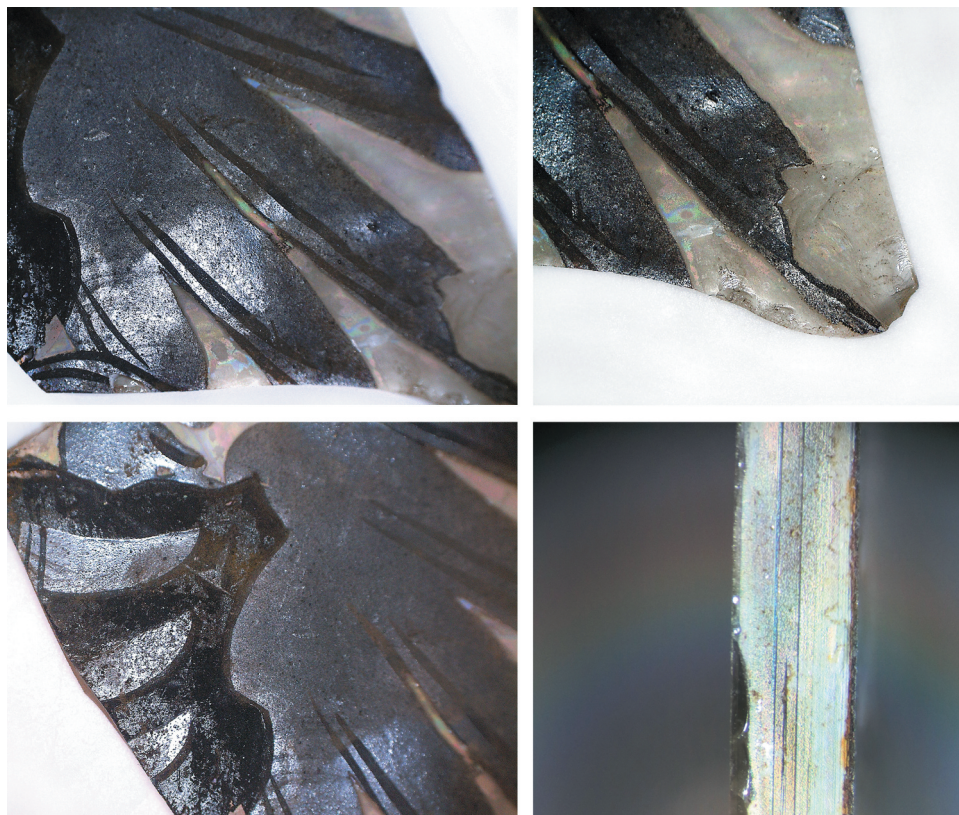
3.3. The process of dating the artifact

Archaeological data, especially the results of dendrochronological studies of the icehouse construction, were used for preliminary dating. Two obtained dates: after 1570 and after 1527 (both analyzed samples lacked a subcortical ring) (Krąpiec, 2017) made it possible to establish the lower caesura after 1570. This is confirmed by physico-chemical analysis of the glass and enamel, as well as formal analysis of the presented image. The shape of the presented coat of arms shield, with its quite extensive shape characteristic of the 16th century, referring to the tournament shields, turned out to be particularly important (Szymański, 2001). Heraldic analysis can be the final stage of the research. Both the form of the coat of arms placed in the inescutcheon as well as its representation, show a strong similarity to the Polish-Hungarian Zęby coat of arms. It was used by, among others, King Stefan Batory (The portrait of King Stefan Batory n.d.) (gules, three argent teeth fesswise in pale) and placed on the chest of the eagle, which is the coat of arms of the Polish Kingdom. Such a representation was reserved for rulers, so it is the coat of arms of the Polish Kingdom under Stefan Batory, which limits the dating exactly to the years 1575–1586 (Paprocki, 1858). It should be added that the direction of teeth in Batory's coat of arms is not the same in all representations. For example, on his tombstone in St. Mary's Chapel in the Wawel Cathedral, the teeth are depicted with blades to the right (Mikocka-Rachubowa, 1984) (according to heraldic nomenclature). Sometimes, there was also a change of the field color into blue.

In order to confirm this hypothesis, formal analysis and research on the Silesian, German, Polish and Czech heraldry of that period was carried out to indicate other possibilities or to exclude them. The eagle was the first element of the analysis. Due to the lack of the silver sickle-shaped band on the preserved wing and breast, the Silesian eagle can be excluded. The way of representation suggests the same—in the coat of arms of Silesia it was usually presented more vigorously, in contrast to gentle, dignified Polish images. The light color of the eagle on the analyzed fragment also allows the excluding of black Silesian and Prussian emblems. It also excludes those coats of arms of Silesian cities, where this image is a variation on the Silesian emblem. Siebmacher's armorial also presents a depiction of the eagle with an inescutcheon as several coats of arms of cities, but no corresponding find was found (Siebmacher, 1605).

Research on the coat of arms in the inescutcheon itself was the second stage of the analysis. There are not many representations in German and Silesian heraldry characterized by a one-field shield with three identical elements placed horizontally. Siebmacher (1605) presents only three of

Figure 9. Analysis of a glass fragment—details: (a) ailerons and schwartzlot with metallic irritation; (b) aileron end detail; (c) heart shield with visible fragment of teeth; (d) two parallel grooves visible glass in the breakthrough. Photo by Piotr Kmiecik and Katarzyna Gemborys.



them, but in most of them there are no closer similarities to the described item. These are coats of arms of v. Scharnstete, v. Krösig and die Auer v. Tobel (Figure 10). The latter, with three black teeth placed horizontally in a red field, with blades to the right, seems to be the closest. However, while the graphical representation of the tooth itself is almost identical to the one on the described artifact, the reverse colors (dark teeth in a lighter field) excludes this coat of arms. At the same time, the representation on the glass fragment is slightly different from the Zęby coat of arms painted by artists associated with the Polish court, but when analyzing the blazoning it can be concluded that it is the same sign (Figure 11).

After the analysis of studies and archival sources, it can be assumed with great probability that this is a fragment of the coat of arms of the Kingdom of Poland with the Zęby coat of arms belonging to the Batory family placed on the inescutcheon. It can also be assumed that the painter never saw this coat of arms and painted using only blazoning, which would explain the formal differences between it and Polish representations (Figure 10). The finding was very unusual and difficult to connect with Wrocław and Silesia. Stefan Batory's foreign policy was rather focused on the East (Besala, 1992). The connections between Wrocław and Poland were not above average at that time. All this makes it very difficult to make any working research hypotheses.

The formal premises indicate the origin of this piece of glass from the times of the reign of Stefan Batory in Poland, i.e. the years 1576–1586. It is suggested by a pattern of painting that clearly indicates the connection between Batory's coat of arms and the coat of arms of the Kingdom of Poland, i.e. the period when he was already on the Polish throne. The manufacturing precision and the techniques used, both metallurgical and painting, enabled researchers to analyze that the fragment was initially assumed to be made in a Western European workshop.

Figure 10. Representations of teeth heraldic element: (a) Die Auer von Tobel (Von Prey, 1740); (b) Die Auer von Tobel (Siebmacher, 1605, p. 80); (c) von Krosig (Siebmacher, 1605, p. 169); (d) von Scharnstete (Siebmacher, 1605, p. 119).



Initially, it was not possible to determine how this fragment arrived in the Czech Kingdom due to the fact that, just until 1742, Wrocław belonged to the Czech Kingdom, and since 1526 it has been under the rule of the Habsburg monarchy.

Recognition of the last layer of painting, as well as comparative studies of glass, were carried out using UV-light analyses carried out under the supervision of Dr Katarzyna Wantuch-Jarkiewicz from the E. Geppert Academy of Fine Arts and Design in Wrocław.

The glass is surprisingly bright, which was the source of the original hypothesis about the origin from Western European rather than Polish or Silesian glassworks. In the 16th century, local glassworks (Silesian, Polish) were usually characterized by the so-called forest glass, of much lower quality, greenish color, and with much contamination, inclusions, air bubbles and traces of ash (Chrzanowska, 1965).

On the basis of comparative analyses with lead, forest and sodium glasses from different periods (from the 15th to the 19th century; using the archives of the Glass Conservation and Restoration Workshop at the Academy of Fine Arts in Wrocław), made with the use of the UV lamp, it can be concluded that the discovered fragment was made on a support of potassium glass with sodium addition and with the use of a decolorizing agent (most probably arsenic or manganese; it requires further research). During the test, the fracture of the sample shone yellow-olive color, more delicate than in the case of high-lead glass (a strong yellow color). Soda glass gave a blue, and forest glass, a dark olive glow. Contrary to the original hypothesis, the result of this study suggests rather Czech glassworks, which used a similar technology in that period (Letkiewicz, 1995, p. 60).

Figure 11. Selected, closest to the analyzed representation of the teeth—Stefan Batory's coat of arms as king of Poland: (a) from 1584 (Paprocki, 1858, p. 12); (b) from the chronicle by Marcin Kromer from 1589 (Treter, 1840); (c) from 1578 (Paprocki, 1578); (d) from 1582 (Skarga, 1582); (e) crown thaler by Stefan Batory from 1580, reverse (Stężyński Bandtke, 1839); (f) from 1582 (Nobili, 1582).



Both hypotheses are likely because the import of glassware from various glassworks in Europe was very popular due to the dynamic development of glass-making in the 16th century. It mainly resulted from the increased demand for window glass, which in turn was connected with the wholesale glazing of windows in residential rooms at that time (Letkiewicz, 1993, pp. 354–355), but of course it also concerned other applications. It is also important to note that at that time the enamel painting process itself was connected with glassworks and was mostly carried out there (Letkiewicz, 1995, pp. 27, 37). It can therefore be assumed that the painting on the discussed fragment is also the work of an artist associated with a glassworks from Bohemia or Western Europe.

4. Discussion

The discovery and its multidisciplinary analysis made it possible to confirm clearly the existence of broader socio-economic relations between Poland and the Kingdom of Bohemia, although with the

current state of research it is difficult to assess the wider impact of the find on the state of knowledge about these relations.

The piece of painted glass found during excavations in the southern shoulder of the Tenaille bastion was a puzzle in several fields. The basic one was dating, determining the purpose and origin of the element, but also the reason why it was located in such a specific place, below the wooden structure of the icehouse of the 16th-century bastion. The problem of dating was solved unequivocally by dendrochronological research and analysis of the representation. This also made it possible to confirm the dating of the icehouse itself as slightly later than the entire defensive system. This is important, as it seems to confirm the hypothesis regarding the reconstruction of the bastion shortly after its erection. So far, it has mainly resulted from the comparative analysis of two plans: by Weiner from 1562, showing the bastion in its original state and by Vroom and Gross from 1587, with changes concerning, among other items, the southern shoulder. Thanks to the heraldic analysis of the graphical representation, it was possible to clarify the dating of this reconstruction, resulting from dendrochronological research and the dating of the second of the plans for the date range after 1570 to 1587 to the range between 1576 and 1586. The most surprising fact is that the discovery of such a small piece of glass made it possible to clarify the dates important for the history of the city of Wrocław and its defense lines.

However, it was a surprise to refute the hypothesis that it was a fragment of stained glass. In this situation, it can be assumed that we are dealing with an interior-design element. This makes any more precise identification difficult and, without finding additional sources, makes it almost impossible to link it precisely with specific people or objects. However, taking into account that the analysis of the glass indicates a Czech origin of the element and the heraldic analysis effectively excluded the Kingdom of Poland as the source of the decoration, because the way of presenting the teeth of the coat of arms is significantly different from that used in Poland, but similar to the coats of arms found in Germany, it can be assumed that we are dealing with a local product. Thus a new hypothesis can be made that a locally made object with an iconographic program referring to one of the neighboring countries had to be associated with a person or institution maintaining such contacts. So what is at stake is politics or trade. It is all the more likely as it is known that the coat of arms of the Kingdom of Poland was at that time in the iconographic program presented in the interior of Wrocław town hall.

Therefore, in order to obtain a complete picture of the analyzed subject matter, it has become essential to reconstruct the image fully, the preserved fragment of which was analyzed.

Based on the discovered fragment, the complete image was reconstructed. For this purpose, the authors assumed symmetry of the representation (except for the head) and unknown fragments were supplemented in accordance with the principles of heraldry and analysis of similar representations from the period.

The overlapping of the claw on the lower part of the remex feather is a certain incompatibility with the rules. Despite the lack of evidence for such a solution, the use of yellow in the representation was also assumed due to the known and very frequent use of argent yellow as the only known color to break the monochrome of the representation in the grisaille technique (Gajewska-Prorok, 2014). At the same time, it is one of the colors found in the coat of arms of the Polish Kingdom. The claws, beak and crown of the eagle could be depicted in this color. The most uncertain fragments of the reconstruction, supported only by a comparative analysis, are the tail and head of the eagle, with particular emphasis on the crown. While the presence of the crown is almost certain, its form in the reconstruction is rather symbolic. According to heraldic rules, it is known that it should be a closed crown (*corona clausa*) (Figure 12). A crown with three intersecting bows, crowned with a sphere with a cross appeared in Polish royal iconography at the end of the 15th century. This form was also proposed in the reconstruction (Figure 14).

Figure 12. Reconstructive analysis of the heraldic representation. A thick continuous line, together with a color subtrack, marks the preserved fragment of glass, while the thick line itself—elements of the composition resulting from its symmetry in relation to the preserved element. The axis of symmetry is marked on the drawing. A thin continuous line marks the fragments of the composition resulting from the continuation of the preserved lines, while a thin dashed line marks the elements whose shape results only from a comparison with the preserved representations of the royal coat of arms of Stefan Batory. (Developed by authors).

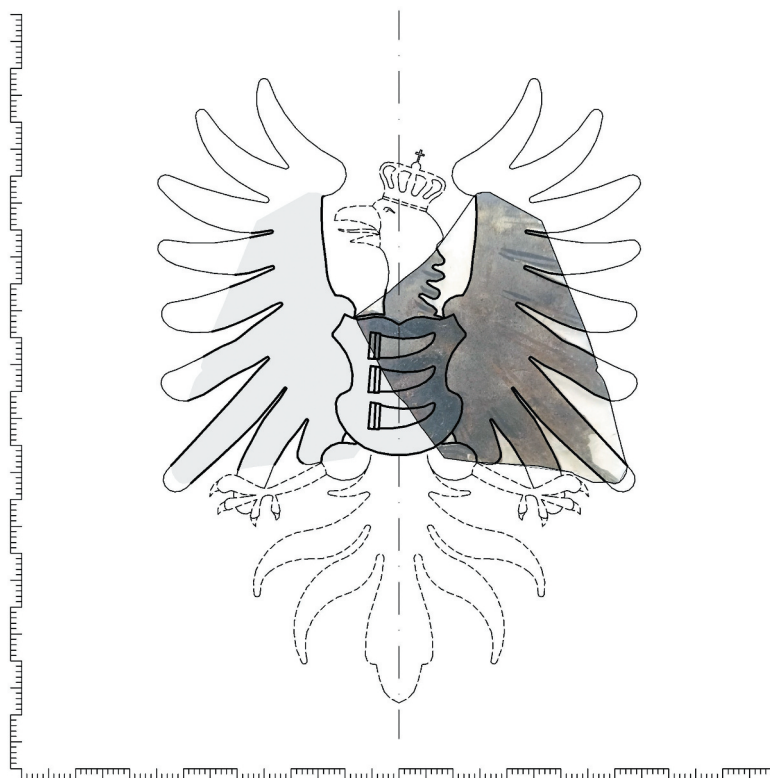


Figure 13. Analysis of a glass fragment in a UV light test. From above: cross-section, top view. Visible: breakthrough colour suggesting potassium glass with soda added using a de-inking agent, matt black of the schwartzlot and metallic irritation on ailerons. Photo by Piotr Kmiecik and Katarzyna Gemborys.

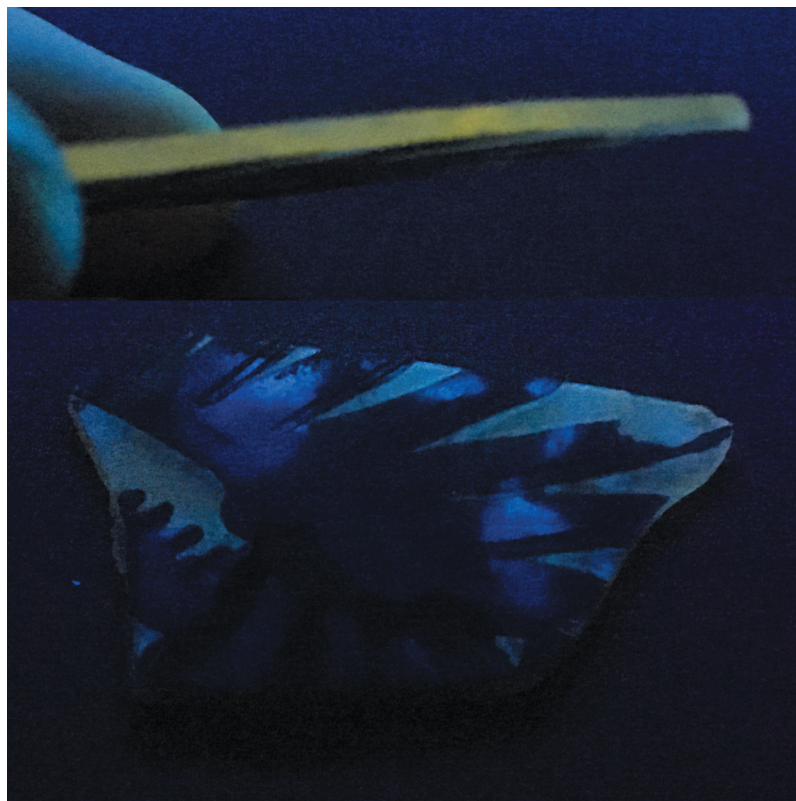


Figure 14. An attempt at color reconstruction of an ornamental element based on a preserved piece of painted glass. (Developed by authors).



The last element of the analysis is an attempt to determine the purpose of the object. Analyzing the size of the discovery, it can be assumed that the entire representation was about 15x15cm. A stained glass window was excluded due to the way it was made. However, utility glassware (including guild vessels) cannot be ruled out, except that it had to be a flat form—for example, a plate or a platter. It is also possible it was used in furniture or as a standalone form.

5. Conclusions

The way in which the piece of glass was found, in the place where it was found should be considered as accidental. It is not related to the use of the icehouse, nor to its creation—it could only be there when the wooden elements were hammered into the ground. This is all the more puzzling as no other glass fragments had been found in the vicinity.

It seems logical to assume that the artifact should be combined with the circles of court art and city buildings or private houses of wealthy burghers of Wrocław. The list of the former is very limited: representative rooms where this type of decoration could be present could only be found in the Town Hall or the ducal castle. Unfortunately, the list describing the second group seems to be much broader and effectively impossible to close.

Further analysis will be possible only in case of finding further parts of the glass, which, however, seems unlikely due to the completion of archaeological and architectural research in this area, as well as not finding any elements matching the already discovered one. Another significant obstacle is the completion of the investment in the Bulwar Starego Miejskiego residential and service complex in Wrocław by i2 Development S.A., the implementation of which contributed to the conduct of the above-mentioned research. The implementation of all architectural elements and land development is to reduce significantly, if not prevent access to the site for

many years. Currently, material for further comparative analysis can only be provided by a museum query conducted outside the already examined network of Polish National Museums. Currently, the Czech, Hungarian, and especially German museum collections related to the person of Stefan Batory should be analyzed more broadly, taking into account the already obtained results. The comparative analysis in this case should focus on the depictions of the images of Stefan Batory's coat of arms as the king of Poland, preserved in museum collections, mainly on elements of applied art, especially glass ones. This is problematic because they are the most impermanent, often treated only for practical purposes, which has resulted in a poor state of preservation and a small number of representations of this type of artifacts in museum collections.

At the current stage of research, it seems also impossible to explain how the discussed fragment got into the construction of the icehouse in the southern shoulder of the Tenaille Bastion—all the more so as no other elements were found in this place.

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Authors contributions

Conceptualization, methodology, formal analysis, investigation, K.G., J.K., P.K. and R.S.; resources, data curation, P. K. and R.S.; Writing—original draft preparation, K.G., J.K., P. K. and R.S.; writing—review and editing, K.G., J.K., P.K.; supervision, J.K.; project administration, J.K.

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