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Contents

ARTICLES

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Polychrome from the southern crypt of the church of the Holy Trinity in Byszewo in light of archaeological and conservation studies

Abstract

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Polychrome on the vaults or walls of grave crypts are a rare category of finds and they are often accompanied by problems for specialist analyses or restoration. A composition of five images of religious and symbolic character was registered on a completely plastered barrel vault with lunettes in a crypt situated under the chapel of The Passion in postcistercian church of The Holy Trinity in Byszewo.

Archaeological exploration of the crypt resulted in the excavation of 92 coffins of lay representatives – both adults and children. Burial and grave goods analyses confirmed that the crypt could have been erected in the middle of 18th century and used until the beginning of 19th century.

Physicochemical tests and conservation analysis of the painting suggest that walls and the vault completing works could be continued in the time of intense use of the room as a burial place, and the present polychrome is probably the fourth layer of painting. The elements preserved until the present day might have been created between the 18th and 19th century.

Key words: Byszewo, archaeology, crypts, conservation, paintings, conservation studies

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The church of The Holy Trinity in Byszewo

Byszewo is a small village situated at the eastern border of Pojezierze Krajeńskie (Krajeńskie Lakeland), in a glacial trough of the Byszewskie lakes (Wyrwa 1999, 83; Grupa and Nowak 2019, 4), North-West from Bydgoszcz. Its documented history is related to the Cistercian Order, although as a result of the monastery relocation (Okoń *et al.* 2016, 9), sources and other written material do not give univocal information.

The beginnings of Byszewo Abbey foundation take us back to middle of 13th century, when in 1250, when the Treasurer of Kujawy-Łęczyca, Duke Mikołaj, donated eight villages situated in the location of the future monastery (Wyrwa 1999, 83). It can be assumed that the generous donation might have been part of the noble's last will, written just before his death. Duke Kazimierz Konradowic was a guarantor and the foundation chancellor (Karczewski 2000, 301–303).

The first monks arrived only six years later, possibly delayed by the war activities on the borderline of Kujawy–Wielkopolska–Pomorze (Kujavia–Great Poland–Pomerania) between 1255–1256, but their origin is not evident. The *Annales Cistercienses* only provides the information that monks arrived from the monastery in Lubiąż in 1256, although there is also a note on Cistercians from the abbey in Sulejowo or a convent in Szpetal, the abbey founded about 20 years earlier on the right bank of the Vistula River, opposite Włocławek (Wyrwa 1999, 83–84; Karczewski 2000, 304–306). The monks probably started by erecting a wooden church, or redecorating a temple which had functioned there earlier (Adrich 2016, 13). We can suppose that it was more likely to have been a new wooden temple when we consider other Cistercian monastery structures. For the first years or even decades following the founding of a monastery, the monks typically used temporary buildings and, after achieving some economic prosperity, they started more serious investments (Świechowski and Zachwatowicz 1964, 168).

In 1285, as a result of reforms in monasteries of Sulejowo, Byszewo and Szpetal, the Byszewo properties were expanded to include the lands of the Szpetal monastery and Dobrowolski estate. Silesian Lubiąż was probably the primaeval seat for the Byszewo monastery, supplying its future abbots (Wyrwa 1999, 48; Karczewski 2000, 307). The significant regional development and plans for investment can be confirmed by the attempt to found a town in Byszewo, a matter that was taken up by the monks in 1286. The duke of Inowrocław, Ziemomysł, granted founding privileges based on Środa Śląska rights, also giving his consent to establish a fair, an inn, a slaughterhouse and other facilities necessary for a town to function. However, undefined reasons meant that the idea failed and the monks turned their attention towards a hamlet located about 10 km away called *Smeysche* (Śmiewce), situated in an evidently more economically attractive location, on the bank of the Brda River (Kabaciński 1968, 22–23; Okoń *et al.* 2016, 10).

Based on the goods and tithes exchanged with the Włocławek bishop, Wisław, the Byszewo Cistercians became the owners of Śmiewce in 1288. Some months later they decided to relocate their seat to a new place, establishing the settlement of Nowe Byszewo, later called Byszewo (Kabaciński 1968, 23; Wyrwa 1999, 84; Okoń *et al.* 2016, 10). The relocation of the monastery is not an isolated case as sometimes there were economic or health reasons to do so (e.g. Samboria – Pelplin or Kacice – Mogiła), or safety precautions (e.g. Wieleń – Przemęt or Łekno – Wągrowiec) (Świechowski, Zachwatowicz 1964, 168). In turn, the fact that the same name was used for both settlements leads to some mistakes in the source information. Koronowo, as a seat of the relocated convent, is commonly used as late as the middle of the 15th century (Okoń *et al.* 2016, 10).

In 1368, Casimir the Great granted a privilege for the Abbot of Byszewo to locate a town based on Magdeburg rights in the place of the *Smaysche.* village. It can be estimated that by the year 1370 Byszewo Cistercian properties included forty seven villages and two hamlets (Okoń *et al.* 2016, 10).

Having moved the convent to a new location, the Cistercians handed care of the temple and believers to a diocesan priest from Włocławek. The church returned to the monastery, according to sources, in 1460. From that time until the secularization of the monastery in 1828, Byszewo parish priests came from Koronowo convent (Adrich 2016, 15).

The 15th century brought the church's modernization. Instead of a wooden temple, a brick, one nave church was erected, which unfortunately burned to the ground at the beginning of the 17th century. The next structure, was built in the mannerist style between 1651–1663. In the 18th century, thanks to the Byszewo provost Mikołaj Liszkiewicz and the care and financial support of the founders, the Elzanowski and Chrząstowski families, the church was redecorated and extended, adding a narthex and two side chapels to the main body and thus making a transept. The chapels had crypts underneath, probably designed as family burial places for the donors (Adrich 2016, 15). The church has preserved in nearly unchanged form to the present day. Modern historical sources have not yet been properly elaborated. It negatively affects the possibilities of interpretation and identification of burials discovered during archaeological research.

The need to explore the Byszewo crypts appeared together with a grant for the restoration of both burial places. Archaeological rescue operations revealed the need for both crypts to be disinfected, although conservation works in the southern crypt were disturbed by the irregular burials deposited all around the room. After consulting the problem with the Voivodeship Monument Conservation Office and the owner of the site, the decision to undertake complete archaeological research was made (Grupa and Nowak 2019, 5–7).

The southern crypt in archaeological terms

Research supervised by NCU prof. Małgorzata Grupa and Sebastian Nowak, M.A., from the Institute of Archaeology of NCU in Toruń was performed in the winter season of 2017/2018. Preliminary recognition estimated that the relatively small space of southern crypt might contain approximately 100 coffins belonging to both adults and children (Fig. 1). The large number of remains within one enclosed space excludes the notion that the room served as the burial place of only one noble family.

The lack of space required a special work method – particular burials were transported to the nave, where they were carefully examined. A series of documentation charts (Fig. 2) for selecting obtained information concerning each burial was prepared (Grupa, Nowak 2019, 6). A burial chart (Fig. 2.1) contained basic

Fig. 1. The state of the southern crypt after removing the protective wall which had closed the entrance. Irregular burial layers seen throughout the whole space. Photo by M. Majorek.

information on the human remains, their composition in a coffin, the coffins planigraphy within the crypt and their contents. A coffin chart (Fig. 2.2) collected data concerning a coffin chest, its cover, decoration, if any, and metrical data. The sample inventory (Fig. 2.3.) enabled the collection of the planigraphy of the material monuments and botanical and entomological samples to be taken for laboratory analysis from every burial. To summarize all the material, a simple graph with symbols and numbers was used.

The researchers were able to establish that there were 92 wooden coffins, including 25 coffins belonging to adult representatives and 67 child coffins, in the examined crypt (Grupa and Nowak 2019, 15). Some of them contained skeletons of more than one individual, which might suggest that other burials from the church area were intentionally collected only in the southern crypt, placing the remains from damaged coffins in those which were better preserved. Coffins are generally simple in construction, most being made of rough planks with visible signs of polishing or processing (Grupa and Nowak 2019, 16). Despite the predominant simple form, 40 coffins had signs of decorating in form of painting layers (26 coffins) or upholstery (16 coffins). 34 coffin lids were decorated with painted or nailed crosses and other religious symbols (Grupa and Nowak 2019, 15–16).

Grave goods were preserved in a relatively good condition. Most of these dead bodies were dressed in linen garments in the form of a long shirt-robe, sometimes folded under the body's legs, with some accessories made of bands, or silk textiles pinned to the clothes or tied around wrists, necks, forming decorative bows. This type of grave attire is known from numerous sites in the Polish Republic such as: Szczecin, Kostrzyn on Odra, Lublin, Toruń or Bytom Odrzański (Grupa *et al.* 2013, 104), although the flax clothes preserved in good condition are rare finds. This is a consequence of flax fibres' poor physicochemical resistance as a textile production material (Drążkowska and Grupa 1998, 121–123).

The entire collection includes only four garment elements made completely of silk. A long żupan made

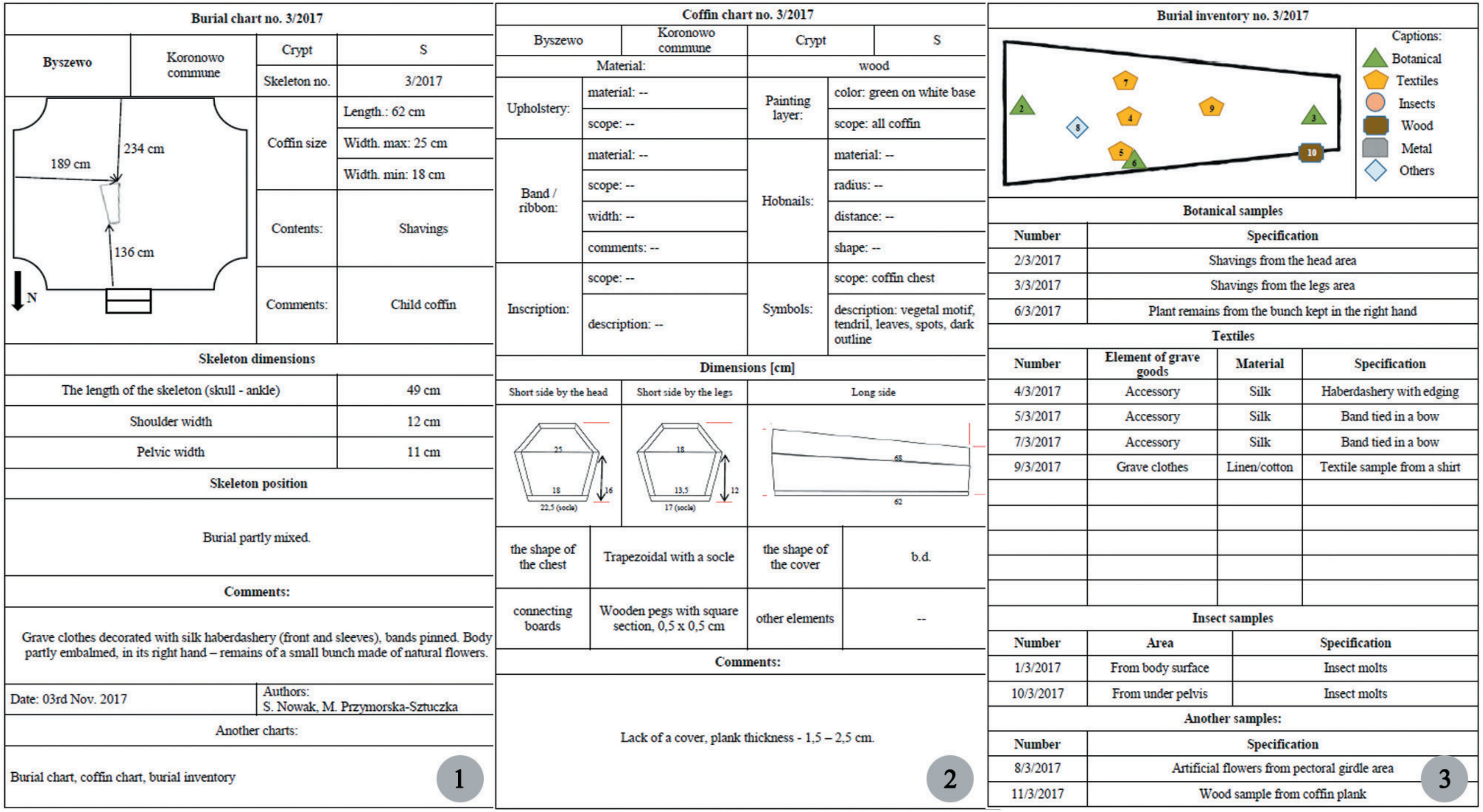


Fig. 2. Documentation chart system designed for the archaeological explorations of the crypt of the Holy Trinity church in Byszewo. Author: S. Nowak.

of silk satin from a male burial (nr 61/2018) is the only element of Polish national costume, characteristic as grave equipment of noble burials from the territory of the Polish Republic (Nowak 2016, 88–90). Similar żupans made of the same textile were also found in sites of Lubiń, Toruń, Gniew (Grupa 1998, 287; 2005, 46; Grupa *et al.* 2015, 97–98; Nowak 2016, 91). The other three elements of silk garments consist of child bonnets of sheared velvet, richly decorated with galloons. This type of a headwear is rather a frequent archeological find excavated in burial grounds, characterized by a variety of forms (Grupa *et al.* 2015, 104).

A female burial (no 81/2018) revealed a large fragment of silk gauze (Grupa and Nowak 2019, 17), which appears very rarely in archaeological finds. The textile name comes from the name of the city of Gaza in the Middle East, which was famous for its production. Thanks to its transparency and delicate construction, obtained by using special weaving techniques, it was an attractive element of a multi-layered dress, although the same properties are responsible for its limited mechanical resistance and it is easily destroyed in grave conditions (Grupa 2012, 182–184; Grupa *et al.* 2014, 65–66).

Coffin interiors were richly filled with plants and wooden shavings, sometimes covered with a piece of linen and making a kind of a mattress. Plant concentrations at the head sides suggests that they were also used as pillows covered with textiles which could have been made of vegetal fibers. Vegetal fibers deposited in soil in poor conditions can decompose within 5–10 years (Nowosad *et al.* 2018, 76). The researchers registered only two pillows whose cases were made of silk patterned damask (Grupa and Nowak 2019, 17–18).

The characteristics of the grave goods confirms the chronology of burials assumed for the second half of 18th century to the beginning of 19th century. It corresponds with chronology of the crypt itself, which is dated from the middle of the 18th century (Adrich 2016, 15). Despite this fact, we cannot exclude the possibility that the crypt also contains burials which are chronologically older, as suggested by the date of 1712 identified on a short coffin side of an adult person (Grupa and Nowak 2019, 15). We are not able to identify the buried persons univocally. Marks in the form of initial letters, party unreadable due to the dye oxidation of the paint layers, were registered on only six coffins (Grupa and Nowak 2019, 15). Further analysis of grave goods may help us to specify the interpretation of the burials in terms of the social groups registered in the collection.

Architectonic analysis of the crypt

The southern crypt was erected on a rectangular plan with sizes 430 * 460 cm, with a shift of south-eastern corner. Its walls are compatible with the foundations of the Passion chapel above. Wooden joists (Fig.3) were identified under the burial layers, which originally served to place the coffins on to protect them from direct contact with the pugging of the floor. The floor had places with identified layers of lime mortar, being signs of the plastering of the crypt vaults and walls (Grupa and Nowak 2019, 6, 12).

The northern wall has an entrance with a narrow neck equipped with 6 bricked stairs, made of gothic brick in a rolled composition. The opening was secondarily expanded with three irregular cuts in a brick frame, which might have been caused by the relocation of the coffins or the deposition of a coffin which was wider than the door.

The eastern (Fig. 3), southern and western walls were equipped with one light ventilation hole each, protected with grates. This probably contributed to the good state of preservation of the grave goods and human remains, which naturally mummified. The situation changed after the bricking up the holes, which caused a lack of air circulation and growing humidity, which finally led to gradual degradation of burials, walls (Fig. 3) and painted decorations in the crypt.

The crypt foundations were erected of stone, while the circumferential walls and the vault were all made of brick. The room was covered with a barrel vault with lunettes, covered with plaster. Lunettes concentrate in the middle on East-West axis, with a slight shift towards each other of about 45 cm (Grupa and Nowak 2019, 6).

Painting decoration – iconographical program

The southern crypt vault is decorated with painting, an interesting factor which is rarely encountered in the Polish context. Until now, only three crypts with painted decoration coming from 18th century have been identified: in the church of the Piarists of the Transfiguration of Jesus in Krakow, the church of the Holy Trinity in Radzyń Podlaski and the church of the Immaculate Conception of the Holy Virgin Mary in Wigry. In Radzyn Podlaski and Wigry there are images of the danse macabre, while in Krakow there is the Passion (https://dzieje.pl/dziedzictwo-kulturowe/xviii-w-polichromie-w-krypcie-kosciola-oo-pijarow-w-krakowie-mozliwe-do [online 05.06.2019];

Fig. 3. The crypt's eastern wall: with a ventilation-light opening, the wall's destruction and original wooden joists visible in the crypt pugging. Photo by S. Nowak.

https://wane.wigry.pro/krypty.html [online 05.06.2019]; authors' own study).

The walls and the vault were plastered using lime-sand mortar and next whitewashed, forming the base for painting (Fig. 3–4). On the northern side of the barrel (from the entrance side) there is a disc with a solar glory, inside which there is a cipher *Maria* (Fig. 5), on the southern side – there is similar disc with a cipher *IHS* with three nails below and a cross above it (Fig. 6). The lunettes from the East and West are equipped with the heads of winged angels – putti, looking to the south (Fig. 7–8). The central vault part is decorated with a simple four-petal flower (Fig. 9) with edgings (leaves) at their joints, being a closed composition and optical keystone.

To paint these simple and schematic images, only a few colors were used: curcuma yellow, red and green-blue. Sun discs with monograms are designed likewise – the central disc is painted red with a yellow monogram. The disc is surrounded by a broad, yellow border with a red outline. Sun rays appear in turn as closed triangles and with flaming tongues with two round edgings. Each ray is outlined in red and in some places matched additionally with a glazed line, giving a delicate spatial character. Some rays also have extra lines running along the entire form and enriching the drawing.

The monogram *Maria* (Fig. 5) consists of entangled decorated letters with serifs. The base of the composition is a capital letter "M" with decorative weaving edgings at the sides, and "A" and "I" composed in the middle, with the side arms marked by the letters "R" and "A" directed inside. The Christogram *IHS* is visible practically only in the picture made using UV light and after computer processing. This made a considerable contrast between the background and the drawing (Fig. 6). Letters with serifs were also used in this case. The horizontal line of the "H", breaks upward in the middle, making a triangle finished with a cross with serifs. Below the line, there are three crossed nails. The UV light photo shows two diagonal lines between the letters "I" and "H" (Fig. 4), which can be interpreted as the author having changed the composition of the letters while painting.

The putti are painted similarly, but the western one is preserved in a much poorer condition than the eastern one (Fig. 7–8). The figure composition was made here first of all using a red line. Their yellow faces are round and chubby. Only the large almond eyes and straight noses are schematically marked with red, and the lips were probably made in the same way (the least readable). The putti's yellow hair is short, with red painted weaves and locks. Under their heads there are single fragments of feathers and, at the sides, yellow-or-

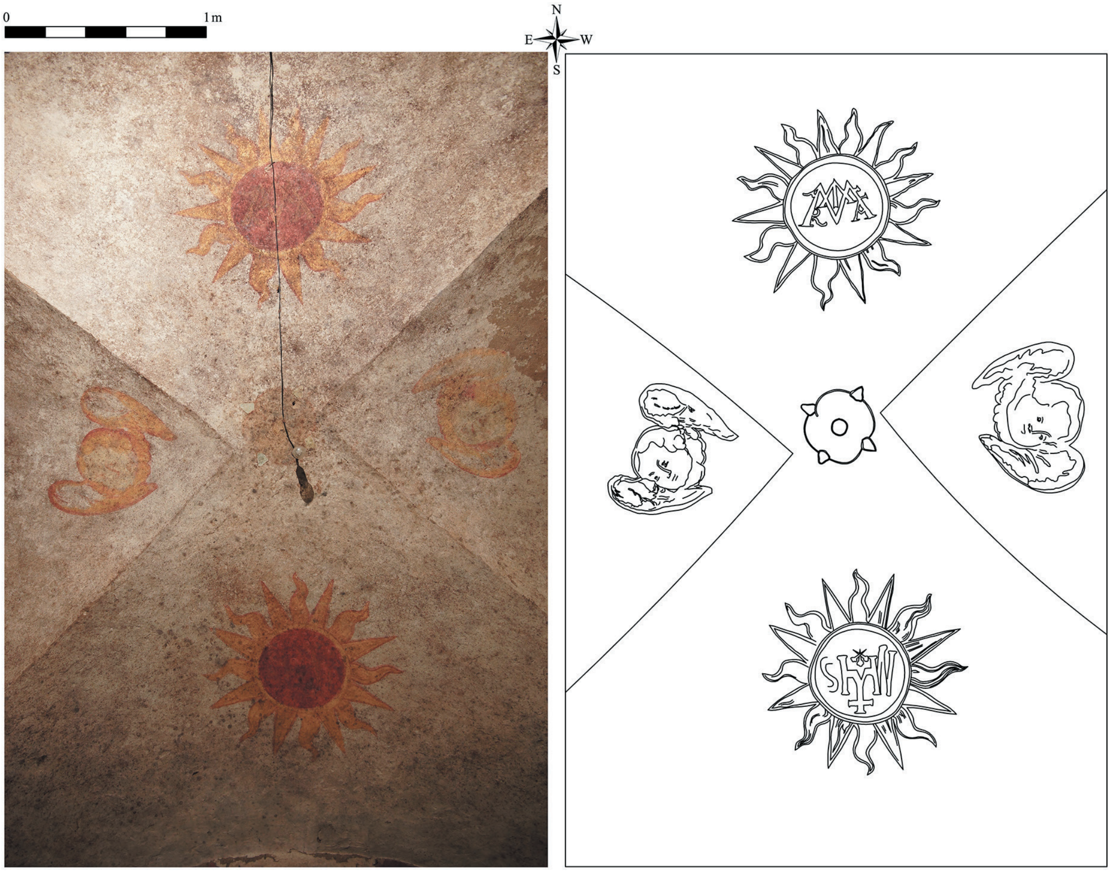


Fig. 4. Polychrome photo and graphic outline of the composition. Photo S. Nowak, graphic design A. Kaźmierczak.

Fig. 5. Solar disc with the cipher *Maria* in solar glory on the barrel vault from the northern side. Photo by A. Kaźmierczak.

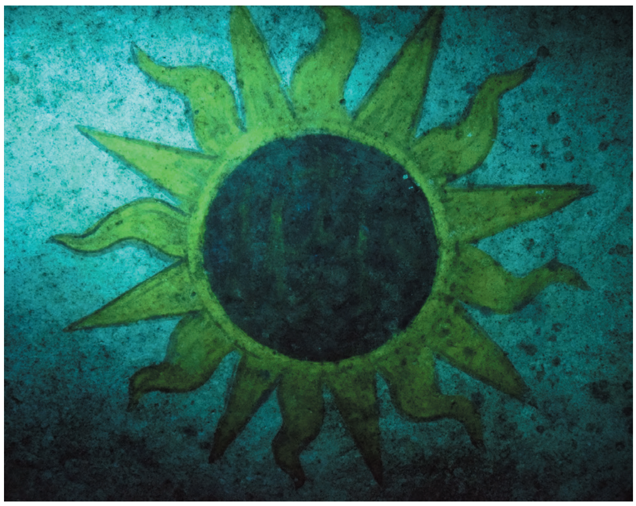


Fig. 6. Solar with the cipher *IHS*, a cross and nails in solar glory on the barrel vault from the southern side using UV light. When the iron red fluorescence is blanked, the monogram outline is better seen. Photo by A. Kaźmierczak.

Fig. 7. Putto in the eastern lunette. Photo by A. Kaźmierczak.

Fig. 8. Putto in the western lunette. Photo by A. Kaźmierczak.

Fig. 9. A flower in the central crypt vault section. Photo by A. Kaźmierczak.

ange wings lined around with red (barely discernible at present). Whitewash was used for lightening the faces and for the parts of the upper wings.

A primitive flower in the middle of a vault (Fig. 9) has four rounded bright orange petals with a small round yellow center lined in red. Straight malachite leaves are small and close triangles. All elements are lined in red.

The entire iconographical program of the ceiling's decoration is simplified and refers to traditional signs and images of the Catholic Church. Christological, Marian and angelical motifs often appeared on scapulars, coffins, funeral banners, epitaphs and tombs. The sun disc symbolizes Christ, Church and Paradise (Moisan and Szafraniec 1987, fig. 32, 61, 114, 136–137, 152, 164; Rządek *et al.* 1991, 50; Majorek and Grupa 2014, 76–79; Nowak and Przymorska-Sztuczka 2013, 59–65). The monogram *IHS* traditionally refers to an appeal: *Iesus Hominum Salvator* – Jesus Savior of Men, or *In Hoc Signo [Vinces]* – in this sign thou shalt [conquer] (Rządek *et al.* 1991, 22). The crucifix is the fundamental sign of faith and victory of life over death. Nails – the Instruments of the Passion – *arma Christi*, are to remind of the Crucifixion of Jesus Christ (Gibson 2010, 181). The monogram *Maria* refers to God's Mother, whose intercession is to help the soul of a dead man to be accepted by God in eternal paradise.

Winged angels as bright, good and beautiful spiritual creatures symbolize heavenly nature and function as emissaries of God (Gibson 2010, 195). The angel image was particularly popular in the context of death and Eschata from the end of 18th century and often became a motif of funeral art in the Romantic period (Pieniążek-Samek 2013, 61). Angels were also guards protecting the Gates of Paradise from sinners (Grzesik *et al.* 2016, 9). A flower in the vault center can symbolize hope, innocence, virtue, compassion, but also mourning and sadness (Grzesik *et al.* 2016, 167).

Physicochemical tests

To estimate the technical parameters and methods of the finishing of the crypt walls and vault, several samples of plaster, whitewash and polychrome were taken. The tests served for the examination of the physical and mechanical properties of the mortar, its structure, water absorption by weight, color, binder kind, but also the chemical analysis of insoluble elements was made to identify the binder and granulation analysis of the separated aggregate. Conservation analysis of mineral plaster mortar was made by Dr Aleksandra Gralińska-Grubecka.

The water absorption weight of mortar sample was calculated in reference to mass of dry material. To make the chemical analyses of the insoluble parts, first a small sample of mineral mortar with irregular shape was dried solid. A strictly defined quantity was then treated with a hydrochloric acid solution. The sample dissolved quickly and intensely, extracting gas ↑CO_2. After the proper time, the solution was filtered through a tissue. Rinsing was continued until a pH indifferent of the filtrate was obtained. The mineral filler was dried, weighed and adhesive to a filler weight ratio was calculated. The filler was sifted in a set of sieves with meshes: 1,1 mm; 0,5 mm; 0,315 mm; 0,2 mm; 0,071 mm to establish masses of particular fractions of aggregate and pelite fraction – below 0,071 mm. Next, the weight ratio of both the adhesive and the filler was calculated. The extracted filler was observed with a microscope to estimate the approximate qualitative composition. The weight proportions of particular aggregate fractions to the total sample mass was presented in the diagram (Fig. 10).

Mortar is grey-yellow and contains lime-silt binder and quartz aggregate in the main. It contains about 17% of binder and about 83% aggregate, i.e., 1 part by weight of binder and about 5 parts of aggregate. Participation of a silt fraction is high and amounts about 18,21% of tested sample.

Plaster is characterized by low mechanical resistance and high water absorption by weight – 11,97%, which is typical for plasters with a lime-silt binder. The aggregate demonstrates predomination of fraction with granulation 0,2–0,071 mm, which is as much as 33,43% of the sample mass. Fraction with granulation over 1,1 mm is 1,28%, 1,1–0,5 mm – 7,54%; 0,5–3,15 mm – 7,25%; 0,315–0,2 mm – 15,50%, and the finest fraction below 0,071 mm is 18,21% of the sample mass (Fig. 10).

The general filler component is a metrically varied granulation of colorless quartz – fine and medium grained, but also milky and yellow (medium and fine grained). There were also pink, white-pink and grey felspars, fragments of igneous rock and numerous black minerals.

Thermogravimetric analysis of mortar was also performed. Thermogravimetric tests were made by Dr Marta Chylińska in the Laboratory of Conservation of Architectonic Details and Elements of the Institute for the Study and Conservation of Cultural Monuments (IZiK), Fine Arts Department (WSP), NCU Toruń, using a Perkin Elmer TG/DSC – STA 6000 thermal analyzer with an autosampler. Analysis evidenced the existence of two crystalline forms of calcium carbonate: micrite and sparite. On the energy curve, polymorphic transformation of quartz was observed at a temperature of about 573°C.

In the range of temperature 200–600°C, a bias in the thermogravimetric curve was observed, perhaps evidence of the dehydroxylation processes of the clay minerals or the degradation of FeOOH.

Particular paint layers composing the polychrome were identified, recognizing pigments and binders by making basic microchemical tests. Pigment and binder micro chemical tests were made by the PKZLAB SC lab in Toruń: Dorota Sobkowiak and Elżbieta Orłowska. The authors would like to express their gratitude to Barbara Mrożkiewicz for releasing the test results.

Basic microchemical tests were performed, with reactions characteristic for pigment and adhesive identification present in the examined material. Ocher $Fe_2O_3 \times nH_2O$ was identified as follows: a test by dissolving a sample in hydrochloric acid HCl and nitric

Sample mass [g]	7,03					
Mass of insoluble parts in 2n HCl [g]	5,85					
Aggregate fraction [mm]	over 1,1	1,1 – 0,5	0,5 – 0,315	0,315 – 0,2	0,2 – 0,071	pelite below 0,071
Particular fraction aggregate mass [g]	0,09	0,53	0,51	1,09	2,35	1,28
Particular fraction aggregate mass [%] compared to sample mass	1,28	7,54	7,25	15,50	33,43	18,21

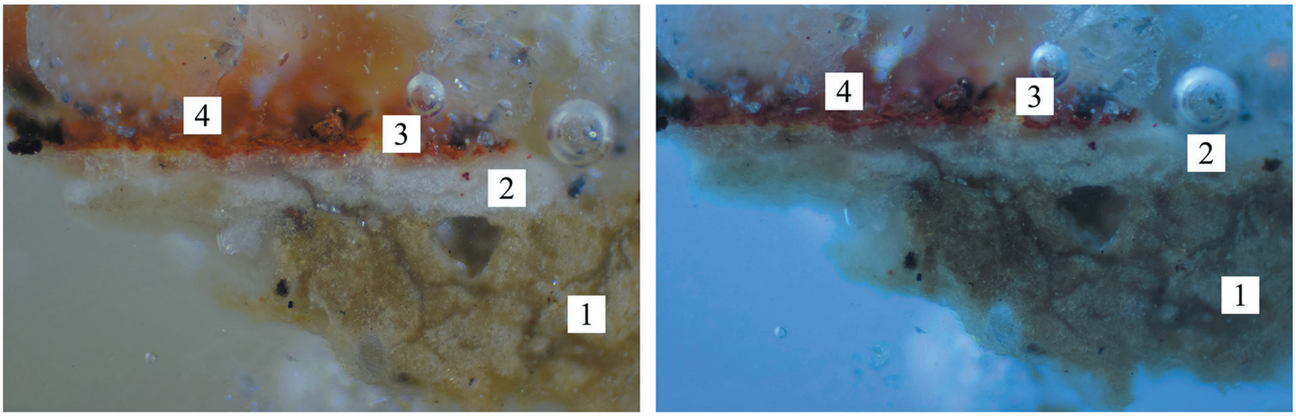
Fig. 10. Weight proportions of particular aggregate fractions from the lime-sand mortar compared to total sample mass. Compilation: A. Gralińska-Grubecka, A. Kaźmierczak.

acid HNO_3, which gave partial dissolving. In sodium hydroxide (base) the sample was untouched. In reaction with acetic acid 2n CH_3COOH and ammonium thiocyanate NH_4SCN, blood-red coloring was obtained, evidencing the presence of Fe (III). During calcination, the pigment particles changed color to a brown-red ferric oxide (III) Fe_2O_3. Having recognized the iron red Fe_2O_3, similar reactions to those with the ocher were made, but during dissolution in acids and base, the sample did not change.

Malachite $CuCO_3 \times Cu(OH)_2$, blackened during calcination as a result of the creation of cupric oxide (II) CuO. The process of dissolving the sample in acids extracted carbon dioxide $\uparrow CO_2$. During the reaction with ammonium, mercury thiocyanate $(NH_4)_2[Hg(SCN)_4]$ and presence of Cu^{2+} cation, we obtained yellow-green rosette-shaped crystals and single needles of cuprum thiocyanate (II) $Cu[Hg(SCN)_4]$. Dissolving a chalk sample $CaCO_3$ in acids, carbon dioxide $\uparrow CO_2$ was extracted. After dissolving the pigment in 3M HCl, adding sulfuric acid H_2SO_4 and heating it a little, characteristic needles and bonds of needles were crystalized $CaSO_4 \times 2H_2O$ (Rudniewski 1994, 32–33, 53–54, 69–70, 101–103).

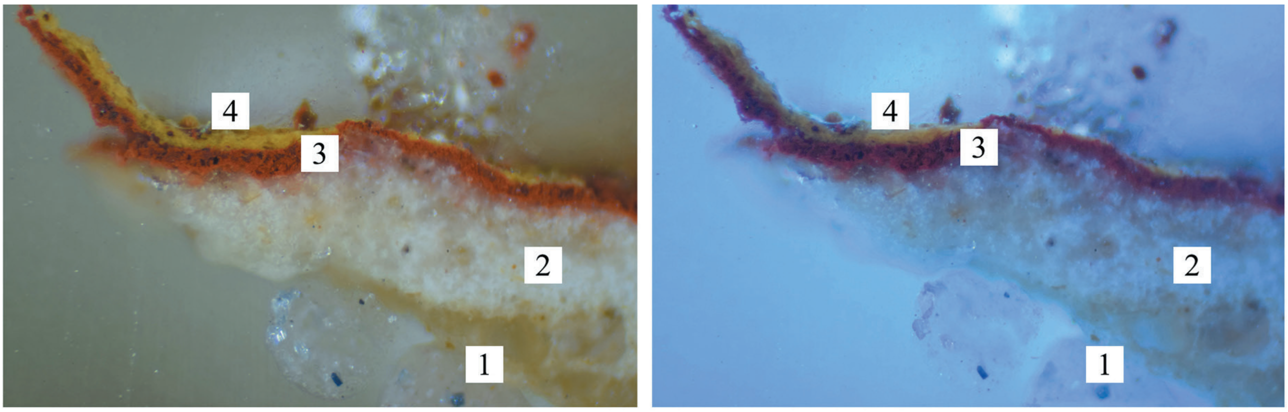
To identify protein adhesives, three basic reactions were made. The first was the biuret test, where 1% of copper sulphate (II) $CuSO_4$ and 40% of sodium hydroxide NaOH were added to the sample. In the presence of proteins, the solution was colored blue-violet. In the next reaction, the sample was completed by lead acetate (II) $Pb(CH_3COO)_2$ and 40% NaOH, and boiled in a water bath. With the presence of egg albumin, a dark coloring was obtained. In the hydroxyproline test, 6n of NaOH was added to the sample and heated in a water bath. Next, 0,01 m of copper sulphate (II) $CuSO_4$ and hydrogen peroxide H_2O_2 were added, the test tube was shaken until frothing occurred and then placed again in a water bath. 3n of sulphuric acid H_2SO_4 and Ehrlich's reagent were added, stirred and heated in the bath. The presence of a pink-red color indicated that glutin glue had been used.

A yellow layer (Fig. 11–12) contained ochre and a protein binder (probably tempera), while the green-blue (Fig. 13) had malachite and a chalk and protein



No	Color and layer type	Pigments, binder	Spectral analysis XRF	Layer specification
4	red painting layer	colcothar, binder - gluten	Ca, Fe, Mn, K, Pb, Ti	Glory ray outline. In UV light – red particles fluorescence blanked visible
3	yellow painting layer	ochre, protein binder	Ca, Fe, Mn, K, Ti	Thin ray painting
2	whitewash	lime	Ca, Fe, Mn, K	Whitewash in three layers. In UV light – blue-white fluorescence visible
1	grey-yellow mortar	lime-silt binder, quartz filling		Lime-sand plaster. Cracks visible

Fig. 11. Microscope pictures of the red cross-section from the southern 'glory' ray in VIS and UV lights, magnification 40×. The pictures show the layers of the composition of the vault's completion: 1 – lime-sand plaster, 2 – whitewash, 3 – yellow paint layer, 4 – red paint layer. The diagram contains the pigments and binding present, with the elements identified using spectral analysis XRF and the brief characteristics of a layer. Photo and compilation A. Kaźmierczak.



No	Color and layer type	Pigments, binder	Spectral analysis XRF	Layer specification
4	yellow painting layer	ochre, protein binder	Ca, Fe, Mn, K, Ti	Color of a cipher letters
3	red painting layer	iron red, binder – gluten	Ca, Fe, Mn, K, Pb, Ti	Color of solar disc with monogram. In UV light – red particles of iron red fluorescence blanked visible
2	whitewash	lime	Ca, Fe, Mn, K	Whitewash put in three layers. In UV light – blue-white fluorescence visible
1	grey-yellow mortar	lime-silt binder – quartz filling		Lime-sand plaster

Fig. 12. Microscope pictures of cross-section of yellow and red painting layers from a monogram of the southern solar disc using VIS and UV light, magnification 40×. The pictures show the composition of the layers of the vault's completion: 1 – lime-sand plaster, 2 – whitewash, 3 – red paint layer, 4 – yellow paint layer. The diagram contains the pigments and binding present, with the elements identified using spectral analysis XRF and the brief characteristics of a layer. Photo and compilation A. Kaźmierczak.

binder. The red (Fig. 11–12) represents a reddish-brown iron oxide, fixed using glue. It is difficult to establish why yellow and green were placed by using the distemper technique while only the red used glue. Both techniques are the most popular wall painting methods, apart from dry and wet frescos (Roznerska *et al.* 1995, 7).

Pigment composition analyses were made using fluorescence XRF. The tests were made by Adam Cupa at the Institute of Painting Technology and Techniques, IZiK, WSP, NCU Toruń, using a MiniPal PW 4025energy-dispersive Xray spectrometer.

Examining the whitewash (Fig. 14), the presence of Ca, Fe, Mn and K were identified. Manganese and iron may have come from lime contamination in lime pits. The yellow layer revealed Ca, Fe, Mn, K, Ti. The presence of iron was confirmed in the ochre pigment. The green-blue painting layer contained (Fig. 15): Ca, Cu, Fe, Mn, K, Si, where copper confirmed the presence of malachite green. When testing the red, we identified the presence of Ca, Fe, Mn, K, Pb, Ti, while the traces of confirmed iron red.

The pigment and whitewash tests were completed using spectroscopic infrared FTIR. Tests were made by Adam Kaźmierczak in the Institute as above in Toruń using a FT-IR Alpha-P spectometer with Quick Snap ATR, a Bruker device, and with a diamond crystal 2 ×2 mm. Spectra ATR FT-IR were registered within the range of 4000–400 cm^{-1}, at a resolution of 2 cm^{-1}, making 64 scans of every sample.

Spectrum analysis confirmed the presence of a protein binder in the ochre (Fig. 16) and malachite and bands coming from carbonates. The presence of lime was determined in every sample, disturbing practically every analysis. Undoubtedly, the test results of the XRF and FTIR were influenced by the disinfection of the whole crypt with 4-chloro-3-methylphenol (PCMC, Raszit) prior to exploration (Grupa and Nowak 2019, 6) and the taking of samples.

Microphotos of mortar, whitewash and painting material cross-sections in visible spectrum and UV (Fig. 11–13) enabled, among others, possible changes in painting to be defined which were not finally evidenced. This test suggested the kinds of pigments used, e.g. particles of iron red blank fluorescence of UV light. It also demonstrated the poor condition of the plaster with numerous cracks. We were also able to estimate the number of whitewash layers placed on the plaster: from two to three.

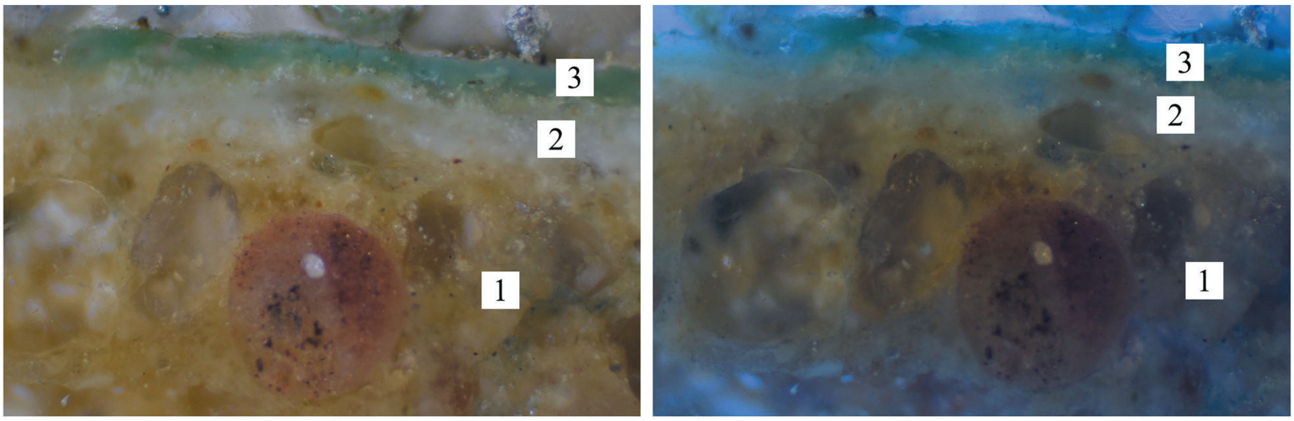
The state of the preservation of the polychrome

By blocking the crypt entrance and bricking up all of the ventilation holes, the conditions changed and led to very limited air circulation, high humidity and the capillary rise of water through the walls, resulting in destructive effects. The coffins had also been deposited in the room for decades. All these factors contributed to high levels of biological infection, with microorganism growth on practically all of the inside surfaces. Painting degradation was also generated by the binder used: protein and glue are not very resistant to humidity changes and thus this hastened the development of microorganisms. It resulted in substantial losses and the powdering of both the polychrome and whitewash. In particular, the protein binder used in the yellow and green tends to result in substantial shrinkage, microelement growth and thus the loosening of the paint (Roznerska *et al.* 1995, 13).

At present, it is impossible to decipher the whole decoration and its details. UV light helps to some extent, although the damp lime-sand mortar is strongly cracked, fragile, indicating weak adhesion to the brick base and the preserved whitewash has been subjected to carbonization.

Restoration analyses

In 2018, the southern crypt was redecorated and restored. Conservation work was supervised by Barbara Mrożkiewicz (Toruń) – a certificated art restorer of elements and architectonic details. During these works, earlier plaster, whitewash and painting layers were reported at the southern glyph of a light opening – three layers. The oldest one contained an ochre lime-sand plaster with a bright grey-yellow shade of whitewash. Mortar component tests and microchemical pigment analyses were made by the PKZLAB SC Laboratory in Toruń: Dorota Sobkowiak and Elżbieta Orłowska.



No	Color and layer type	Pigments, binder	Spectral analysis XRF	Layers specification
3	green-blue painting layer	malachite, chalk, protein binder	Ca, Cu, Fe, Mn, K, Si	In UV light – copper pigment fluorescence blanked visible
2	whitewash	lime	Ca, Fe, Mn, K	Whitewash put in three layers. In UV light – blue-white fluorescence visible
1	grey-yellow mortar	lime-silt binder, quartz filling		Lime-sand plaster. Quartz grains visible: reddish and grey

Fig. 13. Microscope pictures of the cross-section of the green from a flower petal in the vault center using VIS and UV light, magnification 100×. The pictures show the composition of the layers of the vault's completion: 1 – lime-sand plaster, 2 – whitewash, 3 – green-blue paint layer. The diagram contains the pigments and binding present, with the elements identified using spectral analysis XRF and the brief characteristics of a layer. Photo and compilation A. Kaźmierczak.

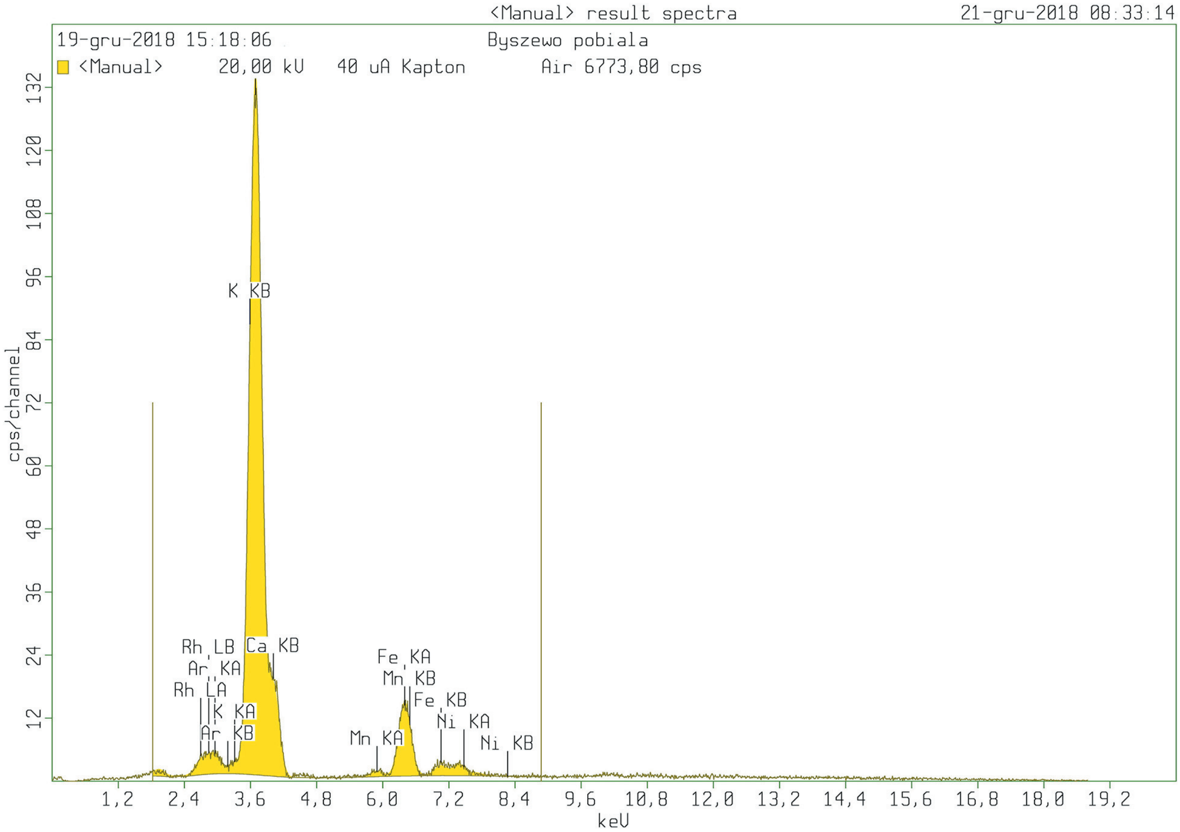


Fig. 14. X-ray fluorescence spectrum obtained from the whitewash sample, with the presence of Ca, Fe, Mn and K evidenced.

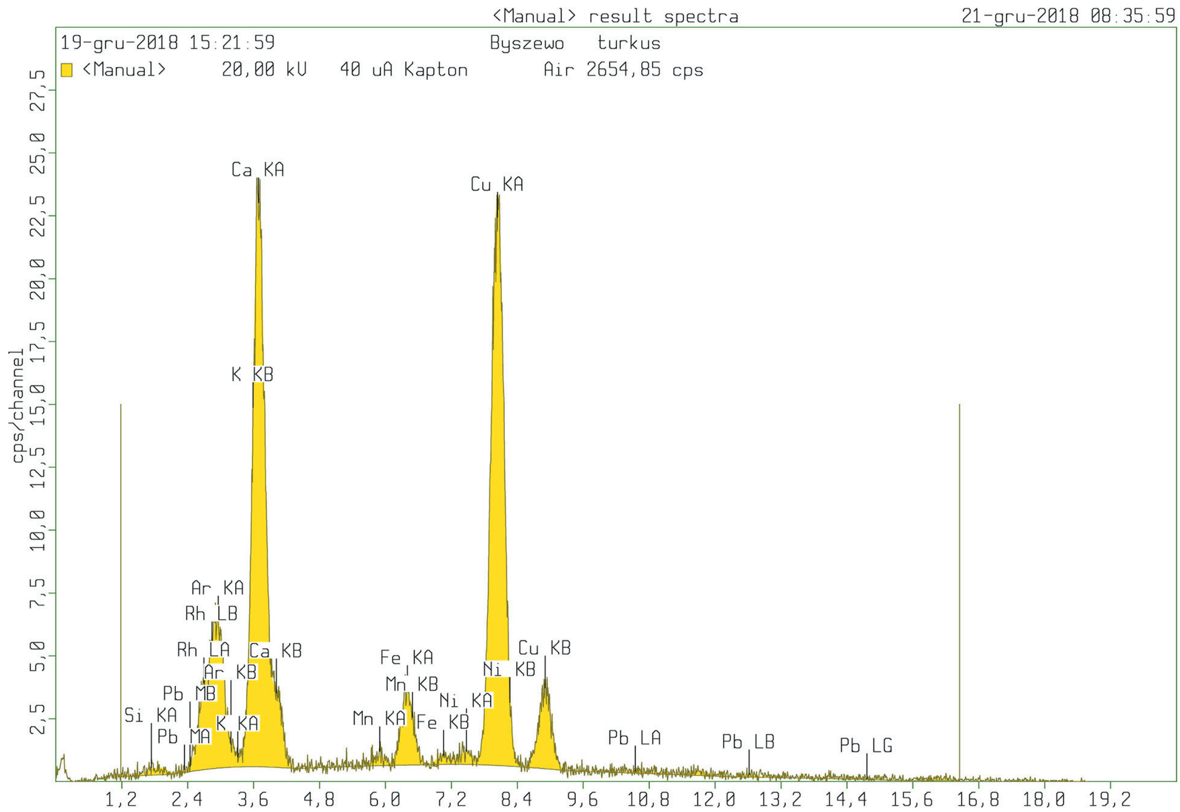


Fig. 15. X-ray fluorescence spectrum obtained from the green-blue paint layer on a leaf of the flower in the central vault section. The presence of Ca, Cu, Fe, Mn, K and Si are evidenced.

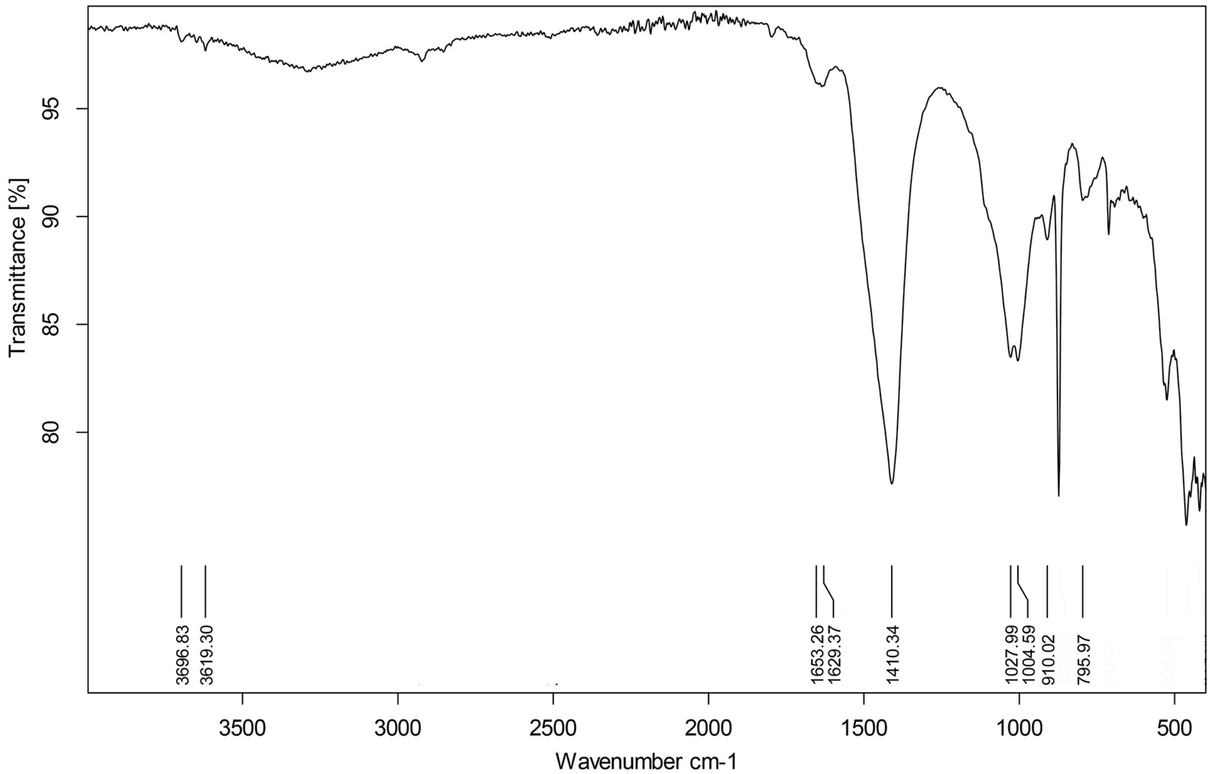


Fig. 16. Infrared spectrum of yellow from a sample in the southern glory. Amide bands identified at 1653.26 and 1629.37 cm^{-1}, confirming the presence of a protein binder. The strong band at 1410.34 cm^{-1}, can be attributed to the presence of whitewash carbonates. Bands at 3696.83, 3619.30, 1027.99, 1004.59, 910.02 and 795.97 cm^{-1} refer to an ochre spectrum pattern.

It contained lean lime and clay and filling of unselected sand aggregate (quartz with various granulation and various mineral contents, being erosion products of igneous rock). The lime binder proportion to aggregate in mass is about 1:4. The plaster has poor mechanical resistance and a high water absorption by weight – 16,5%. The whitewash also contains chalk, and an ochre admixture with a protein binder.

The next layer included lime-sand mortar and red painting, consisting of iron red with a casein binder. That layer was covered with another whitewash with bright grey-yellow paint.

The walls and vault finishing discussed here and preserved to some extent till today began by coating the surface with a number of layers of lime-sand plaster, using short trowels which left traces on the plaster: rough and wavy with a delicate fracture and shading. The lime whitewash was applied with a bristle brush in at least three coats, evidenced by the pictures of the microscopic cross-sections of the samples. The vault has signs of a hard brush having been used. (Fig. 8).

Before the particular images were painted, a composition sketch might have been made, for example on parchment at a 1:1 scale, and next placed on the vault using the pouncing technique from a pattern. It is a technique of transferring an image from cardboard or paper onto a surface of a wall or a ceiling. The contours of the pattern are created by means of the pricked marks and laid over a new surface with paint (Kubalska-Sulkiewicz *et al.* 2015, 336). Painting the sun disc first, the red dial and yellow rays were made followed by the yellow Mariogram and Christogram. The red dye, weakened with water, was used for the glaze outlines of the rays and, finally, a darker shade outlined all the composition.

With the painting of the putti, first the yellow outlines of the basic shapes were made and a weakened red paint was used for the rest and the details of the figures. The flower – the central vault decoration – was started by painting bright orange petals, with a yellow center, green leaves and red outlining all of the drawing.

There is a problem with dating the polychrome. The pigments used in this object have been known since antiquity and thus cannot be used to aid the dating in this respect. Taking into account other historical aspects, including the possible period of its erection and the fact that the crypt had been redecorated at least three times, we can suppose that the present form of the walls and polychrome could have been made between the 18th and 19th centuries.

Conclusions

Polychrome appears only rarely in grave crypts and, due to their fragile character and susceptibility to climate changes, constitute a challenge for art restorers. The capillary rise of ground water is a direct reason for the damage here. The particular grave crypt environment and the numerous microorganisms living there (Drążkowska and Grupa 1998, 122; Walczak *et al*. 2015, 327–329, 342) also affect a polychrome's condition. Destructive human activities also contribute to base and painting disintegration, e.g. intentional closing the ventilation system, not to mention the kinds of pigments used in compositions. The malachite applied in Byszewo is poorly resistant to the alkaline character of the walls and often discolors in wall paintings (Roznerska *et al*. 1995, 13).

The wall painting identified in the southern crypt of the Byszewo church of the Holy Trinity refers to images commonly used in Catholic symbols, in funeral culture, coffin decorations, epitaphs or by scapular brotherhoods (Saar-Kozłowska 2015, 50). The plaster layers on the walls and vault can be a sign of four independent redecoration works, e.g. to prepare the room for subsequent burials of eminent persons. When organizing sumptuous burial ceremonies, great sums of money were also set aside for preparing the event and places of eternal rest (Saar-Kozłowska 2015, 46–47). It is difficult to estimate how long the painting decorations lasted under grave conditions and when a crypt required redecoration. For example, the crypt under the presbytery of a church in Piaseczno, e.g. (Pomorskie voivodeship) was redecorated and reroofed from the foundation of John III Sobieski only 15 years after its erection (Nowosad 2018, 30).

The pigments and techniques used in the Byszewo crypt are defined as popular for wall painting, appearing in a wide chronological range. Due to the lack of additional source information, it is impossible to estimate precisely the time of the creation of the polychrome. It can be stated, based on archaeological evaluations concerning the burials, that it was around the turn of the 18th century.

Conservation and physicochemical analyses of plaster and paint layers from the crypt deliver important information on the techniques used in decorating sepulchral locations, indicating the local workshops' mastery of aesthetics. The interdisciplinary character of the research conducted at this site confirms the significance of the cooperation of various specialists in discovering and preserving cultural heritage components.

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