Agnieszka Kijowska
THE NATIONAL MUSEUM IN WARSAW

Aleksandra Sulikowska-Bełczowska
UNIVERSITY OF WARSAW, THE NATIONAL MUSEUM IN WARSAW

Rocznik MNW. NS | Journal of the NMW. NS
nr | no. 10(46), 2021

The Mummy Portrait of a Boy from the Collection of the National Museum in Warsaw

One of the most precious late-antiquity artefacts in the collections of the National Museum in Warsaw is a mummy portrait of a boy,[1] which, like many other objects in the collection, has returned to the permanent ancient art exhibition in the NMW main building. The portrait was purchased in the late 19th century in Egypt by Józef Pakies, an architect from Krakow, and was temporarily held at the Czartoryski Museum in the city. It joined the NMW collection in 1939, having been acquired from Władysław Kahl for 1500 Polish zlotys, and was entered into the inventory register in May of that year. Removed from the country by the Nazis during the Second World War, it was returned to the museum via restitution efforts.[2] It belongs to a category of small-format panel paintings known as Fayum portraits, a term denoting coffin portraits from Egyptian cemeteries, mainly in the region of Fayum, dating to the 1st to 3rd, and occasionally 4th, centuries AD.

A Description of the Work and the State of the Research

The portrait is a head-and-shoulders likeness of a boy in frontal view gently angled toward the right (**fig. 1**). The boy's oval face with regular features, large dark eyes, arched brows, a small straight nose, and small full lips, has an ochre complexion with a delicate rosy hue and whiteish glow (particularly on the right side). The shape of the visible right ear is elongated. The dark, somewhat tousled hair is pulled back and cinched behind the ear. The boy wears a white tunic with a vertical pink stripe on the left. Hanging from his neck is an amulet in the form of a container for an apotropaic text, and above his right shoulder is a rough likeness of a rearing horse painted in a dark rose colour. The background is grey.

The image was painted in the encaustic technique on a wooden substrate. The irregularly shaped panel (with a maximum height and width of 37 cm and 18 cm respectively), is made from a very thin (approx. 1–2 mm) linden wood board,[3] a trait characteristic of a certain

1 Inv. no. 236767 MNW (former inv. no. 127191 MNW).

2 Maria Ludwika Bernhard, "Zbiory Sztuki Starożytnej w Muzeum Narodowym w Warszawie w latach 1939–1946," *Archeologia*, 1 (1947), pp. 302–9; see also: Kazimierz Michałowski, "Galeria Sztuki Starożytnej w Muzeum Narodowym w Warszawie," *Rocznik Muzeum Narodowego w Warszawie*, Ann. 2 (1957), p. 120.

3 *Tilia sp.* Identification of the wood was performed in 2006 by Iwona Pannenko of the NMW Laboratory.

subset of mummy portraits.[4] The lower end of the board remains unpainted. Encaustic is an ancient term deriving from Greek, relating to something being warmed up or to the use of heat.[5] Currently, it most often applies to a mummy portrait painting technique in which the texture and tool markings are highly visible, evidencing a painting process using paint made by mixing hot wax as a binder with pigments, though the presence of wax ought to be confirmed via analytic study.[6] Encaustic portraits, especially early ones, are today considered to be the most precious variety artistically and are valued much more highly than later examples made via other techniques.[7]

The first scholarly treatment of the portrait from the NMW collection was an article published in 1909 in the Lviv periodical *Eos*, written by Georgius Werner, who states the artefact to be the property of the architect Pakies held at the Czartoryski Museum. The text relates that the architect had purchased it from a museum in Giza, likely in the year 1898. Werner describes the likeness as that of a young woman[8] (**fig. 2**). This description persisted in museum inventories and later publications, like the guides to ancient art at the NMW from 1949[9] and 1955[10] (**fig. 3**).

The portrait was the subject of a master's dissertation titled "Fayum Portraits in Polish Collections" written by Janusz Ostrowski under the mentorship of Maria Ludwika Bernhard in the Department of Mediterranean Archaeology at Jagiellonian University. That paper served as the basis for a 1966 monographic article[11] in which Ostrowski argues that the image shows a boy and not a woman as previously thought.[12] There, the author also fine-tunes the portrait's dating, indicating that its technical execution, realistic and individual treatment of the subject, hairstyle and depiction of the tunic, as well as parallels with other surviving artefacts, make it possible to pinpoint the work's time of creation to the mid-2nd century AD.[13] Also becoming a subject of scrutiny was the portrayal of the horse above the boy's shoulder, though it was not possible to determine the meaning of the motif definitively. In his conclusion, the researcher writes that the image depicts "most likely a Christian."[14] Similar

4 Caroline C. Cartwright, "Understanding Wood Choices for Ancient Panel and Mummy Portraits in the APPEAR Project through Scanning Electron Microscopy," in Marie Svoboda, Caroline R. Cartwright, eds., *Mummy Portraits of Roman Egypt Emerging Research from the APPEAR Project* (Los Angeles, 2020), p. 16.

5 Euphrosyne Doxiadis, *The Mysterious Fayum Portraits: Faces from Ancient Egypt* (Cairo, 1995), p. 95; John K. Delaney et al., "Macroscale Multimodal Imaging Reveals Ancient Painting Production Technology and the Vogue in Greco-Roman Egypt," *Scientific Reports*, no. 7 (2017), p. 4.

6 Ken Sutherland, Rachel C. Sabino, Federica Pozzi, "Challenges in the Characterization and Categorization of Binding Media in Mummy Portraits" in *Mummy Portraits*..., op. cit., p. 13.

7 David L. Thompson, *Mummy Portraits in the J. Paul Getty Museum* (Los Angeles, 1982), p. 6.

8 The acquisition date is approximate: "eleven years earlier," see Georgius Werner, "De imaginibus Graeco-Aegyptis in colonia cui El-Fayum nomen est, repertis et Cracoviae asservatis observationes," *Eos*, Ann. 15 (1909), p. 132.

9 Kazimierz Michałowski, *Zbiory sztuki starożytnej. Przewodnik* (Warsaw, 1949), p. 47, fig. 16.

10 Id., *Sztuka starożytna* (Warsaw, 1955), p. 152, fig. 110.

11 Janusz Ostrowski, "Portret fajumski ze zbiorów Muzeum Narodowego w Warszawie," *Rocznik Muzeum Narodowego w Warszawie*, Ann. 10 (1966), pp. 13–19.

12 Ibid., pp. 16–17.

13 Ibid., pp. 16–18.

14 Ibid., pp. 18–19.

conclusions appear in a 1970 article by the same author on portraits in Polish collections.[15] In 1966, the artefact was mentioned and reproduced in a paper on mummy portraits written by Klaus Parlasca (though it was dated to the 1st century therein),[16] and later in Parlasca's books published in 1969[17] and 2003.[18] The piece was shown in an exhibition titled *Coptic Art* at the NMW and reproduced in the publication accompanying the exhibition, where it was identified as a work from the second half of the 2nd century.[19] It was also on permanent display in the museum's Gallery of Ancient Art and became the subject of a short text by Aleksandra Majewska, the author of a text in the gallery guide published in 2007.[20] In the literature, the accepted term for the boy's hairstyle is "lock of youth," while the item hanging from his neck has been identified as an amulet worn by children of Roman citizens. The dating to the second half of the 2nd century has been embraced and is now generally accepted.

We ought to acknowledge as correct the remarks of Ostrowski, who discusses what he believes to be the problematic issue of the authenticity of parts of the artefact (**fig. 4**), pointing to the "darker patch running across the right eye ending in a horizontal crack, and the section from the horizontal crack across the neck and down to the bottom of the board." The researcher suspects that the portrait may have been discovered in pieces and assembled by an antiquities dealer. He also expresses hope that technological analysis would in the future clarify the authenticity of the parts in question. [21] In the late 1960s and 1970s, there were ongoing discussions among the staff of the NMW Collection of Ancient Art and the Ancient Art Conservation Workshop[22] regarding the fit of the boards making up the panel and the possibility of foreign additions. It was suspected that the right and left sides of the portrait consisted of sections taken from other artefacts, though this hypothesis has never been published.

The aim of the herein article is to analyse the formal, iconographic and technological aspects of the portrait studied on the basis of conservation research, especially that from the years 1998[23], 2005–6[24] and 2017–20.[25] The conclusions will be presented in the context of the broader study of mummy portraits conducted over the last few decades.

[15] Janusz Ostrowski, "Zagadnienie portretów z Fajum," *Rozprawy i Sprawozdania Muzeum Narodowego w Krakowie*, Ann. 10 (1970), pp. 79–80.

[16] Klaus Parlasca, *Mumienporträts und Verwandte Denkmäler* (Wiesbaden 1966), pp. 61, 71, no. 181, tab. 17.1.

[17] End 1st c. – 1st half of 2nd c. Klaus Parlasca, *Repertorio d'Arte dell'Egitto Greco-Romano*, series B, vol. 1 (Palermo, 1969), pp. 35–36, no. 35, tab. 10.1.

[18] Id., *Repertorio d'Arte dell'Egitto Greco-Romano*, vol. 4 (Rome, 2003), pp. 143–44, no. 131.

[19] Włodzimierz Godlewski et al., eds, *Sztuka koptyjska. Muzeum Narodowe w Warszawie* (Warsaw, 1984), p. 17, cat. no. 3.

[20] Aleksandra Majewska, "Portret chłopca," in Witold Dobrowolski, ed., *Przewodnik. Galeria Sztuki Starożytnej. Egipt, Bliski Wschód* (Warsaw, 2007), pp. 82–84, cat. no. 193. A description is also available at Digital NMW: <https://cyfrowe.mnw.art.pl/pl/katalog/611664?id=3523>, [retrieved: 3 January 2021].

[21] Ostrowski, "Portret fajumski...," op. cit., p. 19.

[22] According to an account of NMW conservator Jerzy Kozłowski.

[23] There is a lack of earlier conservatorial documentation. In 1998, overseeing the work was Jerzy Kozłowski of the NMW Ancient Art Conservation Workshop.

[24] The cleaning and undergluing of the separations was done by Agnieszka Kijowska of the NMW Ancient Art Conservation Workshop.

[25] In 2017, the portrait was submitted to the APPEAR programme led by the J. Paul Getty Museum, whose aim is to build a database of research on mummy portraits. The analysis and retouching was done by Agnieszka Kijowska of the NMW Ancient Art Conservation Workshop.

Production Techniques, Current Condition, and Conservation

The portrait's substrate is made of linden wood. Wood of this variety was used in a significant proportion of existing mummy portraits. It was an imported material and all signs point to the fact that it was a valuable one. Because of this, it was fashioned into thin and lightweight painting panels that were easily bent and affixed with bandages to the face of the mummy.[26] The upper edges of finished portraits were trimmed along rather irregular lines prior to installation and their final shape was likely determined by the tendency of a specific workshop.[27] In the portrait of a boy from the NMW, we find a line (**fig. 5**) marking where the panel was to be trimmed, made in the paint while it was still fresh. Similar lines appear on other artefacts of this kind.[28] The thin linden boards were heated during the painting process.[29] This might have made this very substrate more receptive to the application of paint produced with hot wax, seeing as portraits on thicker panels of a different wood variety, like sycamore or cedar,[30] were made in tempera.

Already in 1909, Georgius Werner made note of the significant damage to the substrate on which the portrait was painted.[31] A very thin board can undergo deformation in response to changing relative humidity levels, and is susceptible to mechanical injury. The panel was split into long vertical slats, with the central section possessing a horizontal crack running for half of its width. The vertical slat with the boy's right eye is a later addition – an element most likely originating from another portrait of this kind. Below it (in the area of the neck) two other small pieces of wood were added and retouched. The inserted fragments and their surroundings were overpainted to match them with the original painting.

On the reverse, the entire piece is supported with a cardboard backing, which is visible in the archival photos (including in the oldest known photo from 1909) where the missing fragment of wood along the left edge would be. The portrait currently still possesses the cardboard backing but the missing wood has been replaced with a contemporary filling of balsa wood. The procedure of gluing the portrait's disunited sections onto cardboard (composed of two pieces of different size) with gluten glue[32] containing sawdust likely took place in the late 19th century. The portrait was later placed in a frame (**fig. 6**), which can be seen in a photo likely taken before or in 1939, when the artefact arrived in Warsaw. In 2004, when blisters developed in the paint layer (**fig. 7**), it was also noticed that the cardboard had been gradually coming unglued from the wooden boards. It was then decided to stabilise the artefact's constituent parts. At small points, the cardboard peeling away was reattached with injections of Paraloid B-72 dissolved in acetone, with pressure being gently applied to the object each time (until the glue set fully) and with a controlled relative humidity level.

26 Cartwright, op. cit., p. 21.

27 Johanna Salvant et al., "A Roman Egyptian Painting Workshop: Technical Investigation of the Portraits from Tebtunis, Egypt," *Archaeometry*, vol. 60, no. 4 (2018), p. 6.

28 APPEAR database: e.g., a portrait of a young person with a "lock of youth," Nationalmuseet in Copenhagen <http://www.appeardatabase.org>, [retrieved: 20 December 2021]; Doxiadis, op. cit., p. 130, fig. 60.

29 Sutherland, Sabino, Pozzi, op. cit., p. 9.

30 Joy Mazurek, Marie Svoboda, Michael Schilling, "GC/MS Characterization of Beeswax, Protein, Gum, Resin, and Oil in Romano-Egyptian Paintings," *Heritage*, no. 2 (2019), p. 1966.

31 Werner, op. cit., p. 132.

32 Identification: Dr Irmina Zadrożna, FTIR analysis, 2005.

Though the portrait's surface remained uneven, that course of action reduced the wood's deformation considerably. On the basis of conservatorial experience with other museum items, it is understood that efforts to straighten objects of this kind are not advisable and that later reinforcements to the substrate ought to be flexible.[33] Other examples of mummy portraits have also been earlier outfitted with a cardboard backing.[34] At present, it is often decided to leave the cardboard attached to the back, as to attempt to remove the backing poses a certain risk to the painting layer and the wood. Moreover, straightening deformations in the wood substrate may not bring desirable or lasting effects. In the case of mummy portraits, surface deformations as well as losses in the paint layer or substrate are in most instances acceptable. In order to preserve the artefact in the best possible condition, stable storage conditions must be provided.[35]

Research into the phenomenon of mummy portraits' wax binder technology has been ongoing for years. William Flinders Petrie, who had found a large number of such portraits (in the 1880s and in the early 1910s) believed they were painted quickly (**fig. 8**), with pure molten wax, a process to which Egypt's hot climate would have been conducive[36] Described in the literature are various additives and modifications to the makeup of the binder, including punic wax.[37] Among researchers specialising in the encaustic technique, it has become popular to undertake experiments to reproduce ancient techniques.[38] Modern chemical analysis confirms the presence of other substances in the paint layer of portraits[39] having a wax binder, though no speculation as to their roles has been ventured.[40] It is worth emphasising that such analysis is rendered difficult by the presence of contaminants introduced by various actions, like the process of mummification or later conservatorial intervention (often with the use of the very substances that may have been ingredients in the binder),[41] as well as by microbiological degradation or environmental factors.[42]

In the portrait of the boy from the NMW, non-invasive FTIR infrared spectroscopy (see Annex 2) was used to identify the wax on the entire surface of the artefact, including on the added elements. Also determined was the presence of oil and proteins, though at this stage of the research it is impossible to ascertain whether these are constituents of the binder or substances introduced later. Analysis using an FTIR-ATR spectrometer (see Annex 3) revealed the

[33] Nicola Newman et al., "A Study and Conservation of Four Ancient Egyptian Funerary Portraits: Provenance, Conservation History and Structural Treatment," *The British Museum Technical Research Bulletin*, vol. 7 (2013), pp. 11–12. Information obtained via e-mail correspondence with Marie Svoboda of the J. Paul Getty Museum in 2005.

[34] Lin Spaabaeck, "Conservation of Mummy Portraits at the Ny Carlsberg Glyptotek," in Janet Picton, Stephen Quirke, Paul C. Roberts, eds, *Living Images* (New York, 2007), p. 127; Agneta Freccero, *Fayum Portraits: Documentation and Scientific Analysis of Mummy Portraits Belonging to Nationalmuseum in Stockholm* (Göteborg, 2000), p. 40.

[35] Spaabaeck, op. cit., p. 127.

[36] Sutherland, Sabino, Pozzi, op. cit., p. 11.

[37] Doxiadis, op. cit., pp. 95–98.

[38] Sutherland, Sabino, Pozzi, op. cit., pp. 9–10.

[39] Mazurek, Svoboda, Schilling, op. cit., p. 1963.

[40] Joy Mazurek, "Characterization of Binding Media in Romano-Egyptian Funerary Portraits," in *Mummy Portraits*..., op. cit., p. 146.

[41] Sutherland, Sabino, Pozzi, op. cit., p. 11.

[42] Mazurek, op. cit., p. 142.

presence of wax as well as shellac, which made its way onto the surface likely in later interventions, though shellac has also been found on other mummy portraits.[43] Analysis of the binders performed in 2005 did not provide definitive conclusions, and it was only after conservatorial care and cleaning the surface of dirt and later layers that the wax binder was identified.[44]

The composition and distribution of the pigments used in the painting was determined with the use of a portable X-ray fluorescence (XRF) spectrometer (see Annex 1). Identified was lead white, pigments of natural origin containing iron, iron yellows (ochre), iron reds, bronze and green earth. FTIR (see Annex 2) and FTIR-ATR (see Annex 3) analysis confirmed the presence of lead white and identified the use of the pigment madder lake in the pink stripe on the boy's tunic.[45] Bitumen was identified in the thin black layer visible in the unpainted section of the panel below the figure. This is presumably an area of the thin layer of ground applied to the wood before the painting was done. It is noticeable throughout the portrait, in the areas where the wood is unpainted and beneath the translucent paint layer used in certain spots (**fig. 9**).

The portrait of the boy was painted with impasto and in multiple layers (**fig. 10**). Its texture varies greatly, which is likely the result of the use of the hot wax binder and the use of varied tools in the paint's application. The paint layer emerged with the application of thick opaque paint, especially in the light areas containing lead white. In spots, however, mainly in the dark areas of the background and tunic, the paint is thinner and translucent. The multi-layered painting approach can be observed at the points where the paint has flaked away in the amulet, tunic, stripe and horse. In the areas of the white tunic and grey background, we notice texture and the direction of the brushstrokes, including signs that the field where the subject was to appear was painted around, much like we find in other mummy portraits.[46] The gap between the grey paint of the background and the boy's head near the ear (**fig. 11**) indicates that the background was painted first.[47] The hair, face and body exhibit a more varied texture, which is also characteristic of other mummy portraits.[48] It is possible that the artist used heated metal tools of the kind mentioned by Pliny the Elder in his *Natural History*.[49] During microscopic inspection of the portrait's surface, a piece of a stick (?) was noticed around the mouth (**fig. 12**), and elsewhere – short hairs that may have come from the brush (**fig. 13**) and an assortment of markings left by the hard painting tools (**fig. 14**). The painting method is clearly visible in lateral light (**fig. 15**) and via X-ray and CT imaging (**fig. 16**).[50]

Portraits painted in the wax technique generally retain their bright and fresh colours despite the passage of time, though many exhibit characteristic signs of ageing in the paint

[43] Brian Ramer, "The Technology, Examination and Conservation of the Fayum Portraits in the Petrie Museum," *Studies in Conservation*, vol. 24 (1979), p. 6; Sutherland, Sabino, Pozzi, op. cit., p. 12.

[44] GC-MS chromatographic and FTIR infrared analysis (2005, 2006) – Dr Irmina Zadrożna. Identified at that time were: protein, bitumen, bird egg, shellac, oil, rosin, Montana wax; after cleaning: wax and trace protein.

[45] See fig. 29: a characteristic glow of an organic substance. See also Hae-Min Park et al., "Findings from an Examination of Two Mummy Portraits," *The Journal of the Walters Art Museum*, vol. 74 (2019), fig. 7a-d.

[46] Thompson, *Mummy Portraits*..., op. cit., p. 7; Salvant et al., op. cit., p. 13.

[47] Jan Van Daal, *Ancient Incarnations: Depicting Human Flesh in Mummy Portraits from Roman Egypt* (Amsterdam, 2019), p. 62.

[48] Delaney et al., op. cit., p. 4; Thompson, *Mummy Portraits*..., op. cit., p. 7.

[49] Pliny the Elder, *The Natural History*, John Bostock, Henry T. Riley, eds. (London, 1855), XXXV, p. 41.

[50] The study, thanks to collaboration between the NMW and the European Health Center Otwock, was conducted by Łukasz Kownacki, M.D. Ph.D, in the Department of Diagnostic Imaging, European Health Center Otwock.

layer. They develop spot cracking in irregular, angular shapes,[51] whose emergence is presumably correlated with the amount of wax contained in the paint layer. In a single artefact, such cracks may occur in different sizes.[52] The portrait from the Warsaw collection too has large and irregular cracks in the area of the white tunic and in the background (**fig. 17**). In the darker areas, these assume simple shapes and tend to be smaller (**fig. 18**). In 2004, a blister occurred in the pink stripe on the tunic, which resulted in paint flakes breaking off (fig. 7), though their shapes and even edges made it possible to arrange, fit and affix them back in place (fig. 8). Also secured with glue were separations occurring between paint layers, mainly in the white tunic, as well as minute chipping of the paint layer off of the substrate in the area of the hair on one of the later-added slats.

A concerning issue with mummy portraits is the appearance of various kinds of white blooms.[53] Some types of these can also be observed on other artefacts in which bees wax was used.[54] The causes of these changes may include the materials used during conservation work,[55] contaminants introduced in the process of mummification or by saline soil,[56] temperature fluctuations,[57] and other, yet-to-be identified factors.[58] According to the report from the analysis conducted in 1998,[59] white blooms appeared on the portrait from the NMW as well. They clung loosely to the painting's surface and were removed. Currently, minute whitening (**fig. 19**) can be observed under magnification, most plentifully in the darker areas of the background and hair. In other spots of the paint layer it is possible to distinguish (also under magnification) minute, irregularly dispersed clusters of white grains (**figs.** 17, **20, 21**). Study aiming to explain the origin of these phenomena is currently underway (see Annex 3).

Cleaning of the wax layer entails difficulties because most available thinners affect it harshly and can cause the binder's deterioration, accelerate the emergence of blooms, or lead to softening or damage to the texture. Minimising the use of chemicals lowers the risk of damage but does not eliminate it entirely.[60]

Some of the surface dirt has at some point in the past been removed from the portrait of the boy, likely in two stages. During conservation work done in 2005–6,[61] in response to the appearance of blistering in the paint layer (in the pink stripe, white tunic, and hair), there

[51] Richard Jaeschke, Helena Jaeschke, "The Cleaning and Consolidation of Egyptian Encaustic Mummy Portraits," in John S. Mills, Perry Smith, eds, *Cleaning, Retouching and Coatings: Technology and Practice for Easel Paintings and Polychrome Sculpture* (London, 1990), p. 16; Spaabaeck, op. cit., pp. 115–16.

[52] Ibid., p. 116.

[53] Ibid., pp. 117–20.

[54] Ellen Pearlstein, "Fatty Bloom on Wood Sculpture from Mali," *Studies in Conservation*, vol. 31 (1986), pp. 83–91; C. Harley, "A Note on the Crystal Growth in the Surface of a Wax Artifact," *Studies in Conservation*, vol. 38 (1993), pp. 63–66.

[55] Richard Jaeschke, "Mechanical Cleaning and the Conservation of Portraits from the Petrie Museum of Egyptian Archaeology," in Morris L. Bierbrier, ed., *Portraits and Masks: Burial Customs in Roman Egypt* (London, 1997), p. 96; Spaabaeck, op. cit., p. 117.

[56] Ibid., pp. 117–18; Jaeschke, op. cit., p. 96.

[57] Harley, op. cit., p. 66; Pearlstein, op. cit., p. 88.

[58] Spaabaeck, op. cit., p. 117.

[59] Analysis by Ewa Wróbel at the NMW Laboratory.

[60] Jaeschke, op. cit., p. 96; Jaeschke, Jaeschke, op. cit., pp. 16–17.

[61] In 2005, the work was preceded by email correspondence with conservators specialising in the subject of mummy portraits and possessing experience with the conservation thereof: Marie Svoboda (J. Paul Getty Museum,

arose a need to stabilise all of the artefact's elements, including the peeling cardboard. At that time, the surface of the paint layer was cleaned of dirt (**fig. 22**) and overpainting. The procedure was performed under magnification, very slowly, not working too long on a single spot and avoiding friction to the surface. Used were small cotton pads moistened with distilled water, or, to remove less soluble later residue – with acetone. Most highly soiled was the left part of the face and the background around it. In several spots, especially in the dark area of the background, there were concentrations of dirt containing fine grains of sand. Spots where the paint layer was coming detached from the substrate were secured with Paraloid B-72 (diluted with acetone), which had earlier proved effective in the restoration of other encaustic mummy portraits.[62]

Following the removal of the dirt and overpainting with watercolours, delicate retouching work was done on the added board. Left unchanged, however, was the difference in the appearance of the left and right eyes made visible by the cleaning process, allowing the artefact to retain its character of a historical record of an old instance of amalgamation (**fig. 23**). It turned out, however, that the portrait was poorly received in that condition. The difference existing between the original and the additions interfered with the likeness's artistic resonance. For that reason, a decision was made to broaden the scale of the retouching work, going on the assumption that the intervention would be identifiable and easily reversable. To this end, in 2019–20, graphic retouching with watercolour paint (in the form of minute *tratteggia* lines) was done in the area of the later-added elements with the aim of minimising the difference of the eye, brow and hair on that part of the painting versus those on the original part and to fill in the missing areas of the cheek and neck. The work took cues from other, stylistically similar mummy portraits. Also retouched were losses in the paint layer in the boy's left brow and at the interface between the added board and the original part of the image. All of this served to strengthen the optical cohesiveness of the portrait's elements.

The Function of Mummy Portraits

We do not have a full understanding of the principles governing mummification and the placement of portraits on the mummified body at the time when the surviving portraits were made. Attempts to answer the question of how these portraits began, though interesting in itself, adds little to the conversation in the case of an in-depth study of a single artefact. Portraits serving as post-mortem likenesses were affixed to the previously embalmed body with bandages.[63] These two-dimensional images were something of a continuation of the three-dimensional mummy masks known from Egyptian art.[64] One hypothesis, which goes all the way back to the work of Petrie, postulates that the portraits were displayed for public viewing after death (or maybe even some time in the future) and were only later attached to the mummy and interred with it.[65] The fact that some of the portraits survive in frames suggests

Los Angeles), Richard Jaeschke (Petrie Museum), Jane Williams (freelance), Britta Nilsson (Nationalmuseum, Stockholm), Tracey Seddon (National Museums Liverpool), Nicola Newman (The British Museum).

62 Jaeschke, Jaeschke, op. cit., p. 18, see also n. 61.

63 Robin Cormack, *Painting the Soul: Icons, Death Masks and Shrouds* (London, 2013), p. 71.

64 Christina Riggs, "Facing the Dead: Recent Research on the Funerary Art of Ptolemaic and Roman Egypt," *American Journal of Archaeology*, vol. 109, no. 1 (2002), p. 86.

65 W.M. Flinders Petrie, *Hawara, Biahmu, and Arsinoe* (London, 1989), p. 15; Cormack, op. cit., pp. 67–68. "The comparison between the display of the mummy portrait for the commemoration of ancestors and the portrait

that they could first have been displayed as such and then used as mummy portraits.[66] The portrait from the NMW collection, like many other artefacts of this type, remains unpainted in the lower section. Surely this was intended, which would suggest that it was not produced for public display but rather specifically to be placed on a mummified body. This assumption seems to be confirmed by the trim line visible along the top of the panel.

Though the portraits' status, as well as the function they served, are issues that are difficult to clarify, they can be treated as a manifestation of late-antiquity customs, in which the practices of various cultures and religions intermingled.[67] Many art historians and archaeologists see them as something indicative of a turning point that occurred in the first centuries AD as a result of the coexistence of two traditions: those of Pharaonic Egypt and the classical world. They may thus be interpreted in the context of the changes taking place in Roman culture relating to, among other things, provincialisation and Roman culture's adaptation of local traditions and practices.[68] These late-antiquity works, on account of their technology and artistic character, can be linked to a new artform that would soon be born in Egypt – icon painting.[69] In the case of the portrait of a boy from the NMW, we are dealing with a technology and a treatment of the subject similar to those of the oldest surviving icons, produced three-quarters of a century later. Could it be, therefore, that the hypothesis extended by Ostrowski – that the boy in the portrait was a Christian – is correct? Without a doubt, Christians employed technologies developed in the ancient world and they adhered to the specific painting aesthetics of the time. The portrait from the Warsaw collection, however, possesses no legible signs of the new religion: neither the silhouette of the horse nor the amulet on the boy's neck have any connection to Christianity.

The facial features are delicate, harmonious and rather symmetrical, and the large, almond-shaped eyes lend the face a specific character. What we are dealing with here, however, is a spirituality that was universal to late-antiquity culture, one which was very aptly described once by Sergei Averintsev, albeit in a somewhat different context: "The body serves as only a plinth for the face, while the face merely frames the gaze, the expression of the pierced and piercing pupils."[70] This statement concerned the Palmyrene portraits, which are sculptures, though ones produced at a similar time as many mummy portraits, including the one from the Warsaw collection – that is, in the second half of the 2nd century. Scholars sometimes refer to the category of "realism" when describing mummy portraits.[71] They puzzle over when exactly these likenesses would have been painted: was it while the subject was still alive, or after their

icon in the church shows that Byzantine society did not have to invent the icon: instead, an artistic form which was already in existence was extended beyond the family to the community." Cited from R. Cormack, op. cit., p. 73. See also Dominic Montserrat, "The Representation of Young Males in 'Fayum Portraits,'" *The Journal of Egyptian Archaeology*, vol. 79 (1993), p. 216.

66 Flinders Petrie, op. cit., p. 10; Thompson, *Mummy Portraits*..., op. cit., p. 8.

67 Doxiadis, op. cit., p. 39.

68 Christina Riggs, *Beautiful Burial in Roman Egypt. Art, Identity, and Funerary Religion* (Oxford, 2005); Jaś Elsner, *The Art of the Roman Empire AD 100–450* (Oxford, 2018), pp. 107–9; John Taylor, "Before the Portraits: Burial Practices in Pharaonic Egypt," in Susan Walker, ed., *Ancient Faces. Mummy Portraits from Roman Egypt*, (London–New York, 2000), p. 9.

69 Thomas Mathews, "Pagan Icons," in *Ancient faces*..., op. cit., p. 124; See also Cormack, op. cit., pp. 70–82; Elsner, op. cit., p. 261.

70 Sergiusz Awierincew, "Na skrzyżowaniu tradycji literackich," in id., *Na skrzyżowaniu tradycji literackich (szkice o literaturze i kulturze wczesnobizantyjskiej)*, translated by Danuta Ulicka (Warsaw, 1988), p. 116.

71 See, e.g., Elsner, op. cit., pp. 107–8.

death? Robin Cormack notes that, unlike Roman portraits, mummy portraits rarely depict older individuals. In fact, they usually show people who are young or in the prime of life, attractive and well-dressed[72] – as is the case with our portrait. This would make the likenesses not "realistic," as they show the subject unaffected by the passage of time since youth. It was not, however, a means of clinging to youth but, as Averintsev interprets it, a way to make the beauty of the subject's face express their spiritual essence.

The Provenance and Original Form of the Portrait of a Boy

Where does the portrait come from? It is said to have been bought in Giza, from the Egyptian Museum, which in the years 1891–1902 was located in the palace of Isma'il Pasha. Is it possible then to determine its place of production?

To answer that question, it is necessary to look back into the history of acquiring and collecting artefacts of this kind. We know that a large set of portraits originating from er-Rubayat, found there by Bedouin salt hunters in August 1887, was purchased in Cairo by the antiquities dealer Teodor Graf. Organised soon thereafter was a travelling exhibition of about 90 of these works. After Graf's death, more than 200 mummy portraits appeared on the European antiquities market, though the authenticity of some of them has been challenged.[73] No such doubt, however, applies to the artefacts from the digs overseen by William Flinders Petrie at Hawara (1888 and 1911). Those surveys were conducted in keeping with the methodology of the day and are well-documented, which provides us with certain knowledge on the archaeological context of the discoveries. The work at Hawara was taken over by a German expedition in the 1890s but Petrie himself would return there in 1911.[74] In the ensuing years, mummy portraits were discovered at other sites: Antinoopolis, Memphis, Saqqara and Thebes.[75] It may be presumed that the artefact from the NMW collection comes from one of those sites. Noteworthy is its diagonally cut upper edge, which some scholars believe to be a feature characteristic of the local tradition in er-Rubayat.[76] Having a similar panel shape are also portraits from Tebtunis.[77] This can be taken as a clue regarding the work's origin, though it offers no definite answer. It ought to be remembered that the production location of many of the portraits remains unknown and that certain locations, among them er-Rubayat, are doubtful. As some scholars surmise, that settlement may have been nothing more than a "relay point" for such portraits en route to Cairo, in which case the object's connection to the location lays only in the fact that it had spent some time there.[78]

Removed from the moist earth and then exposed to sunlight, mummy portraits from 19th-century excavations often incurred damage. Records indicate that they underwent

72 Cormack, op. cit., p. 76.

73 Doxiadis, op. cit., pp. 129–31; Thompson, *Mummy Portraits*..., op. cit., p. 4.

74 Morris L. Bierbrier, "The Discovery of Mummy Portraits," in *Ancient faces*..., op. cit., p. 32.

75 Marie-France Aubert, "Portraits from Antinoopolis and Other Sites," in *Ancient faces*..., op. cit., p. 88.

76 Freccero, op. cit., p. 6; see Doxiadis, op. cit., pp. 129–33.

77 Salvant et al., op. cit., p. 6.

78 Paul S. Roberts, "An Archaeological Context for British Discoveries of Mummy Portraits in the Fayum," in Janet Picton, Stephen Quirke, Paul C. Robert, eds, *Living Images. Egyptian Funerary Portraits in the Petrie Museum* (London–New York, 2007), pp. 14–15.

conservation work immediately after or within a short time of being found.[79] Petrie's documentation indicates that bees wax or paraffin wax was used at the time to secure and consolidate peeling paint layers. In other cases, the paint surface was heated with a candle to soften it[80] and allow it to be reintegrated with the panel. In the process, much of the dirt and other debris on the surface, like residue from the embalming process or remnants of canvas and bandages, became incorporated into the structure of the artefact.[81] The portraits' wooden substrates, especially those made of thin linden boards,[82] were often deformed.[83] Affixed with bandages to the face of a mummy, slightly curved and snuggly fitting, they started to crack over time, usually in the vertical plane. Most of the partial portrait fragments found are long and rectangular in shape.[84] Many such portraits have survived in excellent condition, but others, especially those from Graf's collection, subjected to ill-advised conservation processes and overpainted, bred suspicion that they are forgeries.[85] There were also objects reconstituted from original ancient pieces coming from different portraits.[86] As David L. Thomson presumes, these were prepared for the collectors' market by traders in Egypt, who had easy access to a supply of "loose" fragments. The scholar refers to artefacts of this kind as "patchworks."[87] Making this kind of amalgamation all the more possible was the fact that mummy portraits all had similar dimensions on account of their function. Moreover, the individuals were predominantly shown in the same pose, their head and shoulders gently turned to one side, and the proportions and placement of the eyes, nose, mouth, chin, hair and other features tended to follow a constant formula.[88]

The portrait of a boy from the NMW likely underwent conservation even prior to its purchase by Pakies. Its condition in the 1909 photo is nearly identical to that in a photo from 1946 (fig. 4). Cracked and broken up into individual narrow boards, it was probably glued onto the cardboard still in Egypt. The slat on which the right eye is painted always differed from the others on account of its darker paint surface as well as the shape of the eye and hair outline. During the conservation work performed in 2005–06, it was discovered that its surface had been overpainted to mask a filling. The eye painted on this board was originally larger, the brow lay higher, and the hairline and height of the hair were utterly inconsistent with the rest of the portrait. The transplanted board fits neither in shape nor size, and that is why its left edge is slightly raised and rests on the unevenly cracked neighbouring board with a fragment of the original right eye. The differences in the painting approach and technology

[79] Freccero, op. cit., pp. 1–10.

[80] Jaeschke, Jaeschke, op. cit., p. 16.

[81] Freccero, op. cit., p. 5.

[82] Cartwright, op. cit., p. 21.

[83] Freccero, op. cit., p. 6.

[84] Ibid., pp. 72–101.

[85] Freccero, op. cit., p. 2; Barbara Borg, "Problems in the Dating of the Mummy Portraits," in Doxiadis, op. cit., p. 229

[86] David L. Thompson, "A Lost Patchwork 'Fayum Portrait,'" *American Journal of Archaeology*, vol. 85, no. 4 (1981), pp. 491–92; Id., "A Patchwork Fayum in Toledo," *American Journal of Archaeology*, vol. 77, no. 4 (1973), pp. 438–39, tab. 88.

[87] Thompson, *A Lost Patchwork*..., op. cit., p. 85.

[88] Jevon Thistlewood et al., "A Study of the Relative Location of Facial Features within Mummy Portraits," in *Mummy Portraits*..., op. cit., pp. 101–9.

between the connected pieces were revealed via imaging done with UV-fluorescence (**fig. 24**), infrared reflectography (**fig. 25**), X-ray and CT (fig. 16).

The transplanted piece likely comes from a different mummy portrait also produced in the encaustic technique (see Annex 2). When the paint layer was cleaned of dirt and the overpainting that unified the added piece with the rest of the composition was removed, other differences became apparent. At the edge where the portrait cracked vertically, there is no continuity in the brushstrokes, as there is at other points of contact between boards, and the neighbouring pieces are inconsistent in colour (**fig. 26**). This could be a result of overpainting and of fillings in the paint layer, or of the painting's constituent elements having been glued together incorrectly. On the basis of the run of the long cracks, which naturally form in a single line, it is clearly evident that the whole left side of the portrait with the eye and nose ought to be shifted towards the centre (**fig. 27**). If that were so, the face would be more harmonious and the lost right eye would have the appropriate size. A small fragment on the left edge was also not lined up correctly. Doubt as to the boards' alignment and their provenance should be verified with analysis of the wood grain, which is currently not possible due to the fact that the reverse is concealed by the cardboard. Despite attempts made, it has so far been impossible to achieve an image of the artefact in which the wood substrate itself is visible. Its current condition being what it is, the portrait has been accepted and has engrained itself in the minds of the viewers. It is also something of a historical record of the conservatorial practices of bygone times.[89] A digital rendering of its presumed original appearance has been produced (**fig. 28**).

The work invites questions regarding the boy's identity. In order to try to solve the mystery, it would be wise to look at the artefact in the context of the category distinguished by Dominic Montserrat pertaining to mummy portraits showing boys, which numbers about 50 artefacts.[90] The author notes a typology of traits relating to the age and sex of the individuals, all shown in a small plane and all limited to a head-and-shoulders view. The task of the painter was not only to capture the appearance of the deceased but, above all, to relate their social status. Montserrat points out that the physical features of some of the subjects make it difficult to determine their sex – they tend to have youthful qualities like the "lock of youth" and other attributes of early age.[91] Bullas – amulets protecting the wearer from the "evil eye" – were worn in Rome by free-born boys until the age of maturity, i.e., 16 years of age. At 16, the youth would partake in a ceremony in which the bulla is taken off and a toga signifying adulthood is put on.[92] We see bullas, for example, in a portrait of a boy dated to AD 150–200, likely from Oxyrhynchus (J. Paul Getty Museum, Malibu),[93] in a portrait of a boy with a garland of flowers, found presumably in er-Rubayat and dated to AD 200–230, from the Graf collection (Brooklyn Museum of Art),[94] and in a portrait from around AD 200, also discovered in er-Rubayat (The National Museum of Ireland, Dublin).[95] These likenesses, however, differ considerably from the Warsaw artefact in terms of stylistics.

[89] Freccero, op. cit., p. 3.

[90] Montserrat, op. cit., pp. 215–25.

[91] Ibid., p. 216–17.

[92] Christian Laes, Johan Strubbe, *Youth in the Roman Empire. The Young and the Restless Years?* (Cambridge–New York, 2014), p. 55; Thomas Wiedemann, *Adults and Children in the Roman Empire* (New York, 1988), pp. 114–16.

[93] *Ancient Faces…*, op. cit, pp. 99–100, cat. no. 61.

[94] Ibid., pp. 84–85, cat. no. 45.

[95] Ibid., pp. 85–86, cat. no. 46.

Also addressing the issue of social status in portraits of boys has been Barbara Borg. The scholar mainly focusses on the hairstyles, the long hair combed back and cinched in the manner referred to as the "lock of youth" (*mallos*), worn by well-born boys of the Greek community in Egypt until the age of 14. At the age of 14, the lock was ritually cut off during the *mallokouria*, a family ceremony in which the boy was presented with gifts.[96] Among the examples showing such a hairstyle, we can list a boy's portrait dated to AD 138–192 from er-Rubayat, from the Graf collection (Vorderasiatisches Museum, Berlin),[97] a portrait from Philadelphia from the same period (Nationalmuseet, Copenhagen),[98] and a portrait from the collection of Sigmund Röhrer dated to the mid-3rd century (Staatliche Museen, Berlin).[99] The hairstyle of the boy in the Warsaw portrait differs somewhat from those in the conventional aforementioned likenesses, in which the bundled hair falls to the right or is formed into a braid.[100] Here, the hairstyle is somewhat dishevelled and vague (perhaps appearing so on account of the condition of the artefact), but we do see that the hair is tied with a ribbon near the neck and hangs down behind the right ear, which may be interpreted as a *mallos*.[101] Certainly, the bulla and the lock of youth are the most characteristic iconographic traits in the portrait. Special, and in fact unique, is the horse silhouette. The absence of a fitting context for the portrait from the NMW collection, connected in particular with the lack of information on the work's provenance, stands in the way of a definitive interpretation of this element of the painting. It must, nevertheless, be kept in mind that horseback riding was among the most beloved pastimes of Greek boys in Egypt, one which was systematically engaged in by youths in the *ephebeia*, where boys from the elite class were trained from the age of 14.[102]

Conclusion

In artistic terms, mummy portraits form a cohesive category of iconographically consistent works. They always show the subject in head-and-shoulders length, usually turned at a three-quarter angle to the right. The chief traits distinguishing individual examples are the shape of the substrate, and, in terms of the portrayal of the subjects, the hairstyle, the visible clothing elements, and the jewellery. In the treatment of the subject – an idealised face of a boy – the NMW portrait seems particularly similar to two aforementioned works dated to AD 138–192: the portraits of a boy from er-Rubayat (?) (Vorderasiatisches Museum, Berlin)[103]

[96] Barbara E. Borg, "The Face of the Elite," *Arion: A Journal of Humanities and the Classics*, vol. 8, no. 1 (2000), pp. 70–71. Third Series; see also Annika Backe-Dahmen, "Roman Children and the 'Horus Lock' between Cult and Image," in Valentino Gasparini, Richard Veymiers, eds, *Individuals and Materials in the Greco-Roman Cult of Isis. Agents, Images, and Practices. Proceedings of the 6th International Conference of Isis Studies (Erfurt, May 6–8, 2013 – Liège, September 23–24, 2013)* (Leiden–Boston, 2018), p. 516; Mirko Vonderstein, "Cirrus, Mallos oder Horuslocke – Überlegungen zu einem römischen Knabenporträt in der Berliner Antikensammlung," in Oliver Pilz, Mirko Vonderstein, eds, *Keraunia. Beiträge zu Mythos, Kult und Heiligtum in der Antike* (Berlin–Boston, 2011), pp. 172–73.

[97] Doxiadis, op. cit., p. 30, p. 191, fig. 26.

[98] Ibid., fig. 60; Borg, *The Face of the Elite*..., op. cit., p. 79, fig. 3.

[99] Bernard Legras, "Mallokouria et mallocourètes. Un rite de passage dans l'Égypte romaine," *Cahiers du Centre Gustave Glotz*, vol. 4 (1993), fig. III; Backe-Dahmen, op. cit., p. 516; Vonderstein, op. cit., pp. 161–75, tab. 36.2.

[100] Backe-Dahmen, op. cit., p. 512.

[101] Ibid., pp. 516–17. Related here is also a discussion on boys' hairstyles.

[102] Laes, Strubbe, op. cit., p. 104.

[103] Doxiadis, op. cit., p. 30, fig. 26, p. 191.

and from Philadelphia (Nationalmuseet, Copenhagen).[104] On account of these works' formal parallels with the artefact from Warsaw, perhaps it is correct to deem the latter's time of creation to be the same as that of the former two. Somewhat divergent from these artefacts is a portrait of unknown provenance dated to the 2nd century showing a boy with a lock of youth and an amulet wearing a yellow wreath on his head and having golden lips (Egyptian Museum, Cairo).[105]

Though the artistic form of the portraits, the beauty of the depicted figures, and often their individual traits, makes these painting seem to belong to the realm of life, their fundamental function is to perpetuate the face, impervious to change, for all eternity. Hence the impression of timelessness and idealisation clearly coming through despite the attention to the subject's individual features. These likenesses can be considered an excellent example of the artform emerging at the turn of an era, whose aim in the conceptual sphere was to stop time. Produced as two-dimensional works, they nonetheless relate to the tradition of three-dimensional mummy masks. The manner of their attachment to the mummy necessitated a curvature to the substrate (a frequent consequence of which is the artefacts' poor condition today, the piece from the NMW being no exception). The practice also indicates that they were not thought of as flat artworks – in the literal sense they were meant to stand in for the face of the deceased.

The portrait of an unknown boy with gentle eyes from the NMW collection belongs to just this category of works. It may qualify for a slightly narrower group of portraits of under-14 youths from the elite class of Greeks living in Egypt. Its formal characteristics support the artefact's dating to the second half of the 2nd century, though perhaps on account of the analogies pointed out, it would be correct to fine-tune that to the beginning of the fourth decade of that century. Due to the shape of the panel, the portrait may be cautiously attributed to er-Rubayat, where it likely spent some time before making its way to Giza and being purchased there. Finally, technical analysis permits the conclusion that the artefact belongs to a group of works that were found in poor condition and were specially prepared for the antiquities market. The portrait was supplemented with several elements from a similar object, its current appearance, as well as condition, being the result of actions taken still in the 19th century.

Translated by Szymon Włoch

[104] Ibid., fig. 60; Borg, *The Face of the Elite*..., op. cit., p. 79, fig. 3.

[105] Doxiadis, p. 108, fig. 77, p. 209.

Aneks 1 | Annex 1

Nieinwazyjne badania składu pierwiastkowego warstw malarskich

Celem badań mumiowego portretu chłopca ze zbiorów MNW było nieinwazyjne ustalenie głównego składu pierwiastkowego warstw malarskich metodą fluorescencji rentgenowskiej w układzie przenośnym (p-XRF, portable X-Ray Fluorescence Spectrometry).

Badanie wykonano przy pomocy przenośnego spektrometru fluorescencji rentgenowskiej XRF TRACER III-SD firmy Bruker, który umożliwia wykrycie pierwiastków zajmujących w układzie okresowym pozycje pomiędzy Mg a Pu. Rentgenowska lampa z anodą Rh (45kV, 9,6 μA) pozwala na wykonywanie analizy w warunkach polowych w temperaturze otoczenia od –10°C do 50°C. Zastosowanie dodatkowego systemu pompy próżniowej o pracy ciągłej (próżnia <10Tr) umożliwiło podniesienie czułości analitycznej dla lekkich pierwiastków, przy zachowaniu stałego czasu rejestracji (t=60s) wszystkich pomiarów.

Zastosowano dwa podejścia do wyboru miejsc pomiarów XRF, z których pierwsze obejmowało celowane analizy w 34 wyselekcjonowanych miejscach (rys. 1A), a drugie polegało na wykonaniu skanu liniowego 11 pomiarów przeprowadzonych na całej szerokości portretu mniej więcej na poziomie oczu chłopca (rys. 1B). Wybór miejsc został schematycznie zaznaczony na rysunkach poglądowych, którym towarzyszy zestaw zarejestrowanych widm (rys. 1A–B). Zarejestrowane sygnały fluorescencji rentgenowskiej zostały opracowane z zastosowaniem oprogramowania S1PXRF oraz Microsoft Excel. Wyniki umieszczono w Tabeli 1 wraz z opisem i informacjami dotyczącymi opisu współrzędnych wskazujących miejsca pomiaru.

Niezależnie od położenia i koloru analizowanego obszaru, zarejestrowane widma charakteryzują się wysokim stopniem podobieństwa (rys. 1). We wszystkich zaobserwowano obecność sygnałów dwóch pierwiastków: żelaza (Fe linie Kα i K) i ołowiu (Pb linie Lα, Lβ, Lγ oraz M). Taka informacja pierwiastkowa jest spójna z doniesieniami literaturowymi, które opisują obecność bieli ołowiowej, dlatego przez analogię możemy wskazać obecność $(PbCO_3)_2 \cdot Pb(OH)_2$ w badanym portrecie. Mniej specyficzne informacje można podać na temat obecności pigmentów ziemnych, w tym różnych związków żelaza, reprezentowanego w widmach sygnałami o wysokiej intensywności (rys. 2)*.

Patrząc na wszystkie wykresy (rys. 2) wyraźnie widać odmienny charakter widm XRF zarejestrowanych dla trzech punktów pomiarowych oznaczonych jako 17 i 31 (seria A) oraz s11 (skan liniowy, czyli seria pomiarowa B). Wprawdzie rozdzielczość powierzchniowa zastosowanej metody jest niewystarczająca dla uzyskania dokładniejszej informacji, ale wymienione obszary pomiarów obejmują miejsca uzupełnień, ubytków (17 i 31) oraz częściowo obszar odsłoniętego podłoża (s11). Te trzy obszary wydają się spójne pod względem informacji pierwiastkowej, którą charakteryzuje obecność Ba, Sr, Zn i K. Pod względem głównego składu pierwiastkowego nie przypominają jednak obszaru 27 (seria A), dla którego zarejestrowane widmo miało pokazywać skład pierwiastkowy podłoża bez warstwy malarskiej.

Praktyczną rozdzielczość odzwierciedlającą możliwości wykorzystanego ręcznego spektrometru XRF do uzyskania informacji lokalnych widać na rysunku 3. Rozmiary poszczególnych obszarów pomiarowych pokazanych na tle badanego obiektu z zachowaniem skali,

* Randolph Larsen, Nicolette Coluzzi, Antonino Cosentino, *Free XRF Spectroscopy Database of Pigments Checker*, „International Journal of Conservation Science” 2016, vol. 7, no. 3, s. 659–668.

orientacyjnie zabarwione zostały zgodnie ze skalą barwną widoczną obok portretu chłopca. Skala zmian odzwierciedla względną zmienność intensywności zarejestrowanych sygnałów od najniższej (kolor czerwony) do najwyższej (kolor żółty) wysokości sygnału dla każdego pierwiastka indywidualnie. Porównując ze sobą kolejne obszary analizy, można wnioskować o wzbogaceniu lub zubożeniu w dany pierwiastek wskazanego miejsca względem pozostałych wybranych punktów pomiarowych.

Zmienne proporcje żelaza i ołowiu zarejestrowane podczas skanu liniowego można porównać z obserwowaną paletą barw reprezentowaną w poszczególnych punktach pomiarowych: od bieli, poprzez kolor ciała, szarości aż do ciemnych źrenic sportretowanego chłopca (rys. 3). Obszary najjaśniejsze charakteryzują się wysoką zawartością ołowiu, natomiast najwyższe sygnały żelaza zarejestrowane zostały w obszarze obejmującym tęczówkę i źrenice. Nie można wykluczyć w tych miejscach także obecności czerni organicznej, której dodatek umożliwia uzyskanie ciemniejszego koloru lokalnego. Niestety obecności tego pigmentu nie można bezpośrednio potwierdzić metodą XRF.

Wysokie sygnały wzbudzone obecnością żelaza można powiązać z zastosowaniem pigmentów pochodzenia naturalnego:

- ziemia zielona, której skład chemiczny to uwodnione glinokrzemiany: żelaza (II), żelaza (III), magnezu i potasu. Jest zmienny i zawiera produkty utleniania minerałów glaukonitu i seladonitu, które zostały zidentyfikowane w multiinstrumentalnych badaniach portretów fajumskich. Obecność jonów Fe^{2+} powoduje specyficzną barwę tego pigmentu, który był identyfikowany na sarkofagach egipskich i malowidłach ściennych w Pompejach;
- żółcienie żelazowe, do których zaliczyć można ochry i ugry**. Wszystkie żółcienie żelazowe zawierają uwodnione tlenki żelaza (III): ochry posiadają domieszki glinokrzemianów, krzemionki, węglanów wapnia i magnezu, a czasami gipsu, natomiast sieny występują z domieszkami kaolinu, wapieni oraz tlenku manganu (IV). Ochry i sieny są pochodzenia naturalnego, otrzymywane ze skał limonitowych z dużą zawartością minerałów ilastych i były wspominane przez Witruwiusza i Pliniusza. Otrzymywane są przez rozdrabnianie odpowiednio dobranych surowców, ucieranie, przemywanie, suszenie i odsiewanie, dlatego w zależności od miejsca pochodzenia mogą się charakteryzować zmiennym składem pierwiastkowym;
- czerwienie żelazowe to pigmenty, które mogą być pochodzenia naturalnego lub otrzymywane sztucznie. Ich głównym składnikiem jest tlenek żelaza (III), który nadaje im charakterystyczny kolor czerwony. Głównymi domieszkami mogą być glinokrzemiany, kwarc, węglan wapnia, czasem dolomity. W portretach fajumskich identyfikowano czerwienie żelazowe np. hematyt, ugry lub umbry. Pigmenty naturalne poddawano procesom mielenia, pławienia i odsiewania. Ich kolor zależy od całkowitego składu pierwiastkowego oraz od zawartości tlenku żelaza (III), który wpływa na odcień i intensywność barwy pigmentów. Pigmenty wytwarzane w wyniku prażenia żółcieni żelazowych mogą mieć różne zabarwienie: od żółtoczerwonych do czerwonobrunatnych, które zależy od składu wykorzystywanych surowców oraz temperatury i czasu prażenia;
- pigmenty brązowe to np. umbra naturalna, zawierająca głównie tlenek żelaza (III) i nawet do 20 procent tlenku manganu (IV), poza innymi domieszkami, takimi jak węglan wapnia,

** Zob. *Pigmenty. Analiza mikrochemiczna i instrumentalna*, oprac. Piotr Rudniewski et al., Warszawa 2018.

kwarc i związki glinu. Umbrę znano już w starożytności. Pigment ten występuje w naturze w formie silnie rozdrobnionej skały osadowej, a najbardziej znanym miejscem jego występowania jest Cypr. Umbra naturalna ma chłodny zielonkawy odcień, ale podczas prażenia przybiera kolor czerwonobrązowy, gdyż pod wpływem wysokiej temperatury następuje utrata wody z żółtych, uwodnionych tlenków żelaza (III) i przejście w czerwony tlenek żelaza (III).

Wyniki przeprowadzonych nieinwazyjnych badań składu pierwiastkowego warstw malarskich mumiowego portretu chłopca wskazują na obecność pigmentów (biel ołowiowa i pigmenty żelazowe), których identyfikacja została przeprowadzona również w innych portretach fajumskich.

Non-Invasive Paint Layers Elemental Composition Analysis

The aim of the study of the mummy portrait of a boy from the collection of the NMW was to establish, non-invasively, the chief elemental composition of the work's paint layers via portable X-Ray Fluorescence Spectrometry (p-XRF).

The analysis was performed with a Bruker XRF TRACER III-SD portable x-ray fluorescence spectrometer, which makes it possible to detect elements between Mg and Pu on the periodic table. The x-ray lamp with Rh anode (45kV, 9,6 μA) allows analysis in field conditions at an ambient temperature of −10°C to 50°C. The use of an auxiliary continuous-action vacuum pump system (vacuum <10Tr) makes it possible to raise the analytical sensitivity to light elements while maintaining a constant recording time (t=60s) in all measurements.

Employed were two approaches to the selection of points for XRF analysis, the first of which covered targeted analysis at 34 pre-selected points (fig. 1A), and the second of which involved performing a line scan of 11 measurements made across the entire width of the portrait at about the level of the boy's eyes (fig. 1B). The choice of points is schematically demarcated on the reference illustrations, which are accompanied by the set of recorded spectrums (figs. 1A–B) . The recorded x-ray fluorescence signals have been interpreted using S1PXRF software and Microsoft Excel. The results are presented in Table 1 along with descriptions of the measurement points and their coordinates.

Regardless of the location and colour of the analysed area, the recorded spectrums are characterised by a high degree of similarity (fig. 1). Observed in all of them is the presence of signals of two elements: iron (Fe lines Kα and K) and lead (Pb lines Lα, Lβ, Lγ and M). Such findings are consistent with accounts in the literature, which indicate the presence of lead white, making it possible to indicate by analogy the presence of $(PbCO_3)_2 \cdot Pb(OH)_2$ in the portrait. Less specific information was obtained regarding the presence of earth pigments, including various iron compounds, iron being represented in the spectrums by signals of high intensity (fig. 2).*

Looking at all of the graphs (fig. 2), clearly visible is the distinctiveness of the XRF spectrums recorded at three measurement points marked as 17 and 31 (series A) and s11 (line scan, i.e., test series B). Though the surface resolution of the method used is insufficient for

* Randolph Larsen, Nicolette Coluzzi, Antonino Cosentino, "Free XRF Spectroscopy Database of Pigments Checker," *International Journal of Conservation Science*, vol. 7, no. 3 (2016), pp. 659–68.

obtaining more precise information, the measurement points in question include instances of fillings and material loss (17 and 31) or fall within the area where the substrate is exposed (s11). These three points appear to be consistent in terms of the elemental data, which indicates the presence of Ba, Sr, Zn and K. In terms of the chief elemental composition, those points are dissimilar to point 27 (series A), whose spectrum shows the elemental composition of the substrate free of paint layers.

The practical resolution reflecting the capabilities of the handheld XRF spectrometer to obtain localised data can be seen in fig. 3. The size of the individual measurement points shown in scale against a picture of the studied artefact have been coloured according to the colour scale visible next to the portrait of the boy. The scale of the changes reflects the relative variability of the recorded signals' intensity from lowest (in red) to highest (in yellow) signal intensity for each element individually. Comparing successive analysis points, it becomes possible to extrapolate an abundance or scantness of a given element at a specified point relative to the other selected measurement points.

The varying proportions of iron and lead recorded in the line scan can be compared to the observable colour palette represented at individual measurement points: from white, to skin tone and grey, and all the way to the dark pupils of the subject (fig. 3). The brightest areas are characterised by a high lead content, whereas the highest iron signals were recorded in the area spanning the iris and pupil. Not excludable at these points is the presence of organic black, the addition of which makes it possible to achieve a darker local colour. Unfortunately, the presence of this pigment cannot be directly confirmed using XRF.

The high signals generated by the presence of iron may be tied to the use of pigments of natural origin:

- green earth, whose chemical composition consists of hydrated aluminosilicates of: iron (II), iron (III), magnesium and potassium. It is variable and contains products of oxidation of the minerals glauconite and celadonite, which have been identified in multi-instrumental analysis of Fayum portraits. The presence of Fe^{2+} ions produces the specific colour of the pigment, which has been identified in Egyptian sarcophagi and wall paintings in Pompeii;
- iron yellows, among which is ochre.** All iron yellows contain hydrated iron (III) oxides: ochres contain traces of aluminosilicate, silicon dioxide, magnesium and calcium carbonates, and sometimes gypsum; while siennas occur with traces of kaolinite, calcium and manganese (IV) oxide. Ochres and siennas are of natural origin, obtained from limonite rock with a high content of clay minerals, and mentioned by Vitruvius and Pliny. They are obtained by pulverising the correct mixture of raw materials, grinding, washing, drying and sifting, and for that reason can demonstrate variable elemental composition depending on the place of origin;
- iron reds are pigments which may be of natural origin or produced synthetically. Their main constituent is iron (III) oxide, which gives them their characteristic red colour. The main trace constituents may be aluminosilicates, quartz, calcium carbonate, and sometimes dolomites. Identified in Fayum portraits have been, e.g., hematite and ochre or umber. The natural pigments undergo a process of grinding, steeping and sifting. Their

** See Piotr Rudniewski et al., eds, *Pigmenty. Analiza mikrochemiczna i instrumentalna* (Warsaw, 2018).

colour depends on the full elemental composition and on the presence of iron (III) oxide, which influences the shade and intensity of the pigment's colour. Pigments obtained from roasting iron yellows may have varying hues: from yellowish-red to reddish-brown, which depends on the raw materials used and the roasting temperature and time;

- brown pigments include natural umber containing mainly iron (III) oxide and up to 20 per cent manganese (IV) oxide in addition to trace constituents like calcium carbonate, quartz and aluminium compounds. Umber was known already in antiquity. The pigment occurs in nature in sedimentary rock, with the most famous deposits being in Cyprus. Natural umber has a cool greenish shade but the roasting process gives in a reddish-brown colour, as high temperature causes water loss in the yellow hydrated iron (III) oxides and a transition to red iron (III) oxide.

The results of the non-invasive elemental composition analysis of the paint layers of the mummy portrait of a boy indicate the presence of pigments (lead white and iron pigments), whose identification was determined in other Fayum portraits as well.

Tabela 1 | Table 1
Wyniki analizy XRF warstw malarskich. Brak informacji o cyrkonie (Zr)
| Paint Layer XRF Analysis Results. No Data on Zirconium (Zr)

Numer i opis miejsca pomiaru | Number and Description of Measurement Site	**Wykryte pierwiastki | Elements Found**
01 włosy (czerń) x = 10,0; y = 4,0 | 01 hair (black) x = 10.0; y = 4.0	**Fe**, **Pb**, **Ca**, Sr, K, Ba/Ti?, Si, AI, P, Cu, Zn
02 włosy (czerń) x = 10,0; y = 6,0 | 02 hair (black) x = 10.0; y = 6.0	**Fe**, **Pb**, **Ca**, Sr, K, Ba, Si, AI, P, Cu, Zn
03 włosy nad brwiami (czerń) x = 11,0; y = 7,0 | 03 hair above brow (black) x = 11.0; y = 7.0	**Fe**, **Pb**, **Ca**, Sr, K, Ba, Si, AI, P, Cu, Zn
04 czoło x = 12,0; y = 9,0 | 04 forehead x = 12.0; y = 9.0	**Fe**, **Pb**, **Ca**, Sr, K, Ba, Si, AI, P, Cu, Zn
05 włosy (czerń) x = 7,0; y = 10,0 | 05 hair (black) x = 7.0; y = 10.0	**Fe**, **Pb**, **Ca**, Sr, K, Ba, Si, AI, P, Cu, Zn

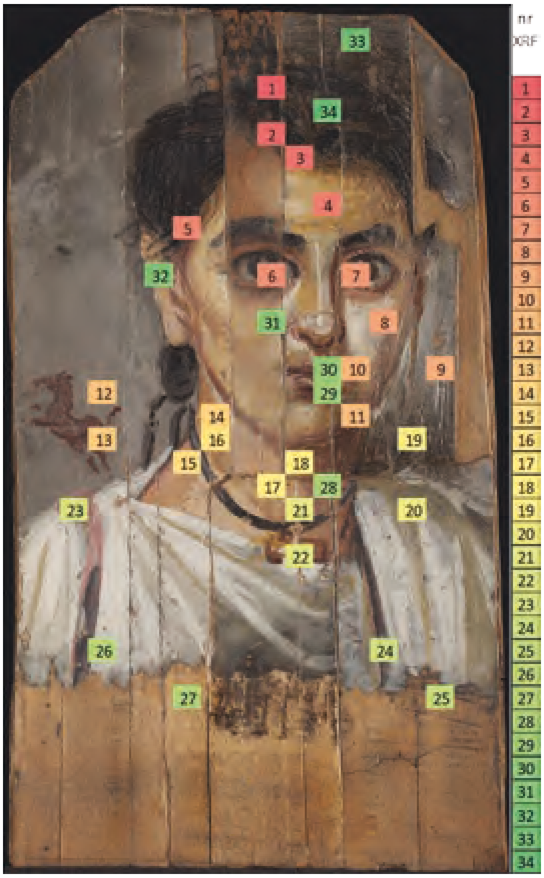
06 oko prawe (czerń/brąz) x = 10,5; y = 12,0 06 right eye (black/brown) x = 10.5; y = 12.0	**Fe**, **Pb**, Ca, Sr, K, Ba, Si, Cu, Al, Zn, P
07 oko lewe (tęczówka) x = 15,0; y = 12,0 07 left eye (iris) x = 15.0; y = 12.0	**Pb**, **Fe**, Ca, Sr, K, Ba/Ti?, Si, Al, Cu
08 policzek (róż) p=2Tr x = 15,0; y = 14,0 08 cheek (pink) p=2Tr x = 15.0; y = 14.0	**Pb**, **Fe**, Ca, K, Ba/Ti?, Si, Cu
09 tło (szarość) x = 16,0; y = 16,0 09 background (grey) x = 16.0; y = 16.0	**Pb**, **Fe**, Ca, Ba/Ti?, Si, Cu, K
10 kącik ust x = 13,5; y = 16,0 10 corner of mouth x = 13.5; y = 16.0	**Pb**, **Fe**, Ca, Ba/Ti, Si, Cu
11 broda (kolory ziemne, brąz) x = 13,0; y = 18,0 11 chin (multiple colours, brown) x = 13.0; y = 18.0	**Pb**, **Fe**, Ca, Sr, K, Ba, Si, Cu
12 tło nad koniem x = 4,0; y = 17,0 12 background above horse x = 4.0; y = 17.0	**Pb**, **Fe**, **Ca**, Sr, K, Ba, Si
13 zad konia (czerwień) x = 4,0; y = 19,0 13 horse's rump (red) x = 4.0; y = 19.0	**Pb**, **Fe**, Ca, Sr, Ba, Cu
14 szyja x = 8,0; y = 18,0 14 neck x = 8.0; y = 18.0	**Pb**, **Fe**, **Ca**, Ba
15 wstążka (czerń z białym detalem) x = 8,0; y = 19,0 15 ribbon (black with white detail) x = 8.0; y = 19.0	**Pb**, **Fe**, **Ca**, Sr, K, Ba, Si
16 szyja k/wstążki x = 7,0; y = 20,0 16 neck near ribbon x = 7.0; y = 20.0	**Pb**, **Fe**, **Ca**, Sr, K, Ba, Si, Al

17 szyja, wgłębienie x = 9,5; y =20,0 | 17 neck, depression x = 9.5; y =20.0	**Zn**, **Fe**, **Ti/Ba?**, **Pb**, Ca, Sr, K, Si, AI, P, Cu, Mn
18 szyja x = 11,0; y = 20,0 | 18 neck x = 11.0; y = 20.0	**Fe**, **Pb**, **Ca**, Sr, K, Ba, Si, AI, P, Cu, Zn
19 tło ciemne x = 15,0; y = 19,0 | 19 dark background x = 15.0; y = 19.0	**Pb**, Fe, Ca, K, Ba/Ti?, Si
20 szata (jasna zieleń) x = 22,0; y = 15,0 | 20 tunic (light green) x = 22.0; y = 15.0	**Fe**, **Pb**, Ca, Sr, K, Ba, Si, Cu, Zn
21 szyja tuż nad wstążką x = 10,5; y = 22,0 | 21 neck directly above ribbon x = 10.5; y = 22.0	**Pb**, **Fe**, Ca, Sr, K, Ba/Ti?, Si, Sn, Cu
22 ozdoba (brąz) x = 10,5; y = 23,0 | 22 ornament (brown) x = 10.5; y = 23.0	**Fe**, **Pb**, Ca, K, Ba/Ti?, Si, Al, Cu, Zn
23 szata, wstęga (róż) x = 4,0; y = 22,0 | 23 tunic, strip (pink) x = 4.0; y = 22.0	**Pb**, **Ca**, **Fe**, Sr, K, Ba/Ti?, Si, AI, Cu, Zn
24 szata, załomek x = 14,0; y = 28,0 | 24 tunic, depression x = 14.0; y = 28.0	**Fe**, **Pb**, **Ca**, Sr, Ba/Ti?, Si, P, Cu
25 podkład (czerń) x = 16,0; y = 29,0 | 25 ground (black) x = 16.0; y = 29.0	**Pb**, **Ca**, **Fe**, Sr, K, Ba, Si, AI, P, Cu, Zn, Mn
26 szata (biel) x = 4,5; y = 28,0 | 26 tunic (white) x = 4.5; y = 28.0	**Pb** (+S?), **Ca**, Fe, Si, P, Cu
27 tło dół (podłoże) x = 7,0; y = 30,0 | 27 background at bottom (substrate) x = 7.0; y = 30.0	**Ca**, **Fe**, **Pb**, **K**, **Sr**, Ba/Ti-?, Si, AI, P, Cu, Zn, Mn

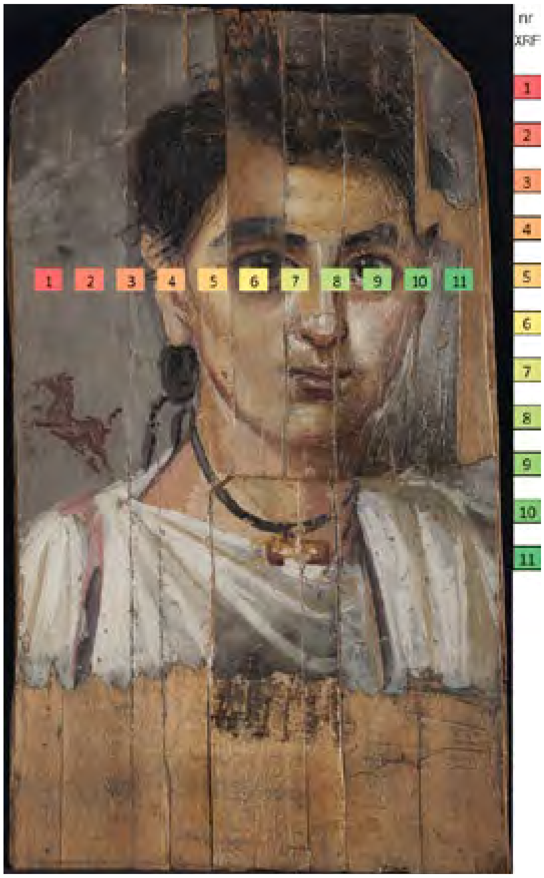
28 szyja x = 12,0; y = 21,0 I 28 neck x = 12.0; y = 21.0	**Pb**(+S?), **Fe**, Ca, Ba, Cu
29 cień pod ustami x = 12,0; y = 17,0 I 29 shadow below mouth x = 12.0; y = 17.0	**Fe**, **Pb** (**S**-?), Ca, K, Ba/Ti?, Si, AI, Cu, Zn
30 usta x = 12,0; y = 16,0 I 30 lip x = 12.0; y = 16.0	**Pb**, **Fe**, **Ca**, K, Ba/Ti?, Si, AI, Zn, Cu
31 policzek x = 10,0; y = 14,0 I 31 cheek x = 10.0; y = 14.0	**Fe**, **Zn**, **Pb**, **Ba**/+**Ti?**, Ca, Sr, K, Si, AI, P, Cu
32 ucho x = 7,0; y = 12,0 I 32 ear x = 7.0; y = 12.0	**Pb**, **Fe**, **Ca**, Sr, K, Ba/+Ti?, Si, AI, Cu
33 tło tuż nad włosami x = 13,0; y = 2,0 I 33 background directly above hair x = 13.0; y = 2.0	**Pb**, Fe, Ca, Ba, Si, Cu (S-?, Ti-?)
34 włosy (czerń) x = 12,0; y = 5,0 I 34 hair (black) x = 12.0; y = 5.0	**Fe**, **Pb**, **Ca**, Sr, K, Ba, Si, AI, P

rys. 1 | fig. 1
Zdjęcia badanego obiektu z zaznaczonymi miejscami pomiarów XRF dla serii (A) oraz dla serii (B) wraz z zestawem zarejestrowanych widm
| Photos of analysed object with XRF test sites marked for series A and series B, with the complement of recorded spectrums

(A)

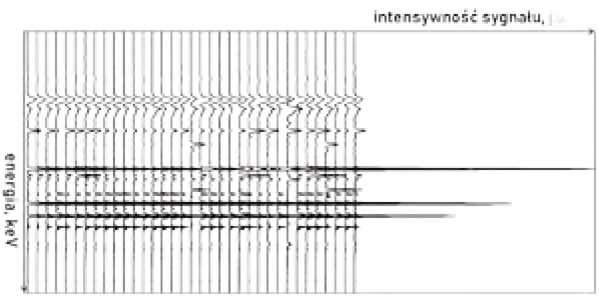


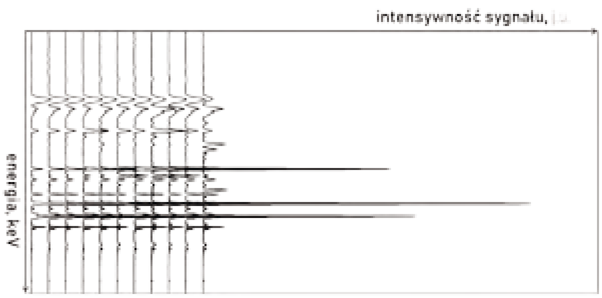
(B)



Pierwsza seria pomiarów
| First test series

Seria pomiarów „skanowanie liniowe”
| Line scan test series

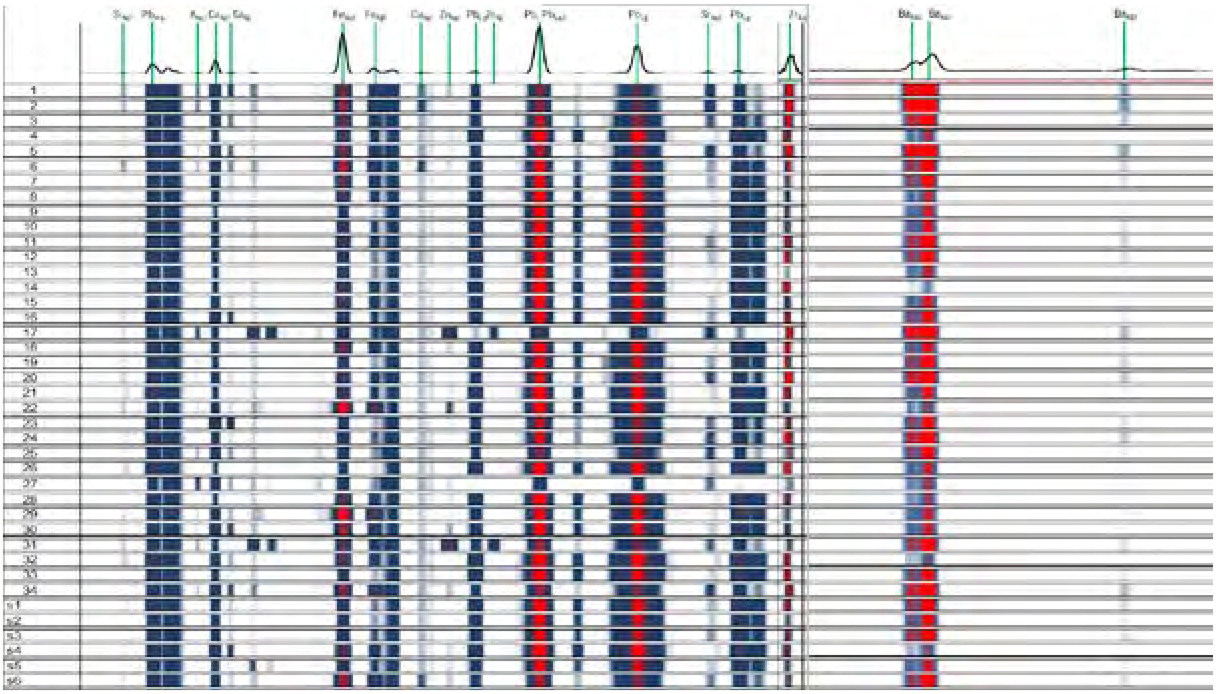




rys. 2 | fig. 2

Zestawienie wszystkich zarejestrowanych widm serii A i serii B razem. Skala barwna min max wizualizuje względne intensywności zarejestrowanych sygnałów pojawiających się w widmie. Zakresy widma dla Zr i dla linii K Ba pokazane są po znormalizowaniu do najwyższej intensywności sygnału zarejestrowanej dla obu serii.

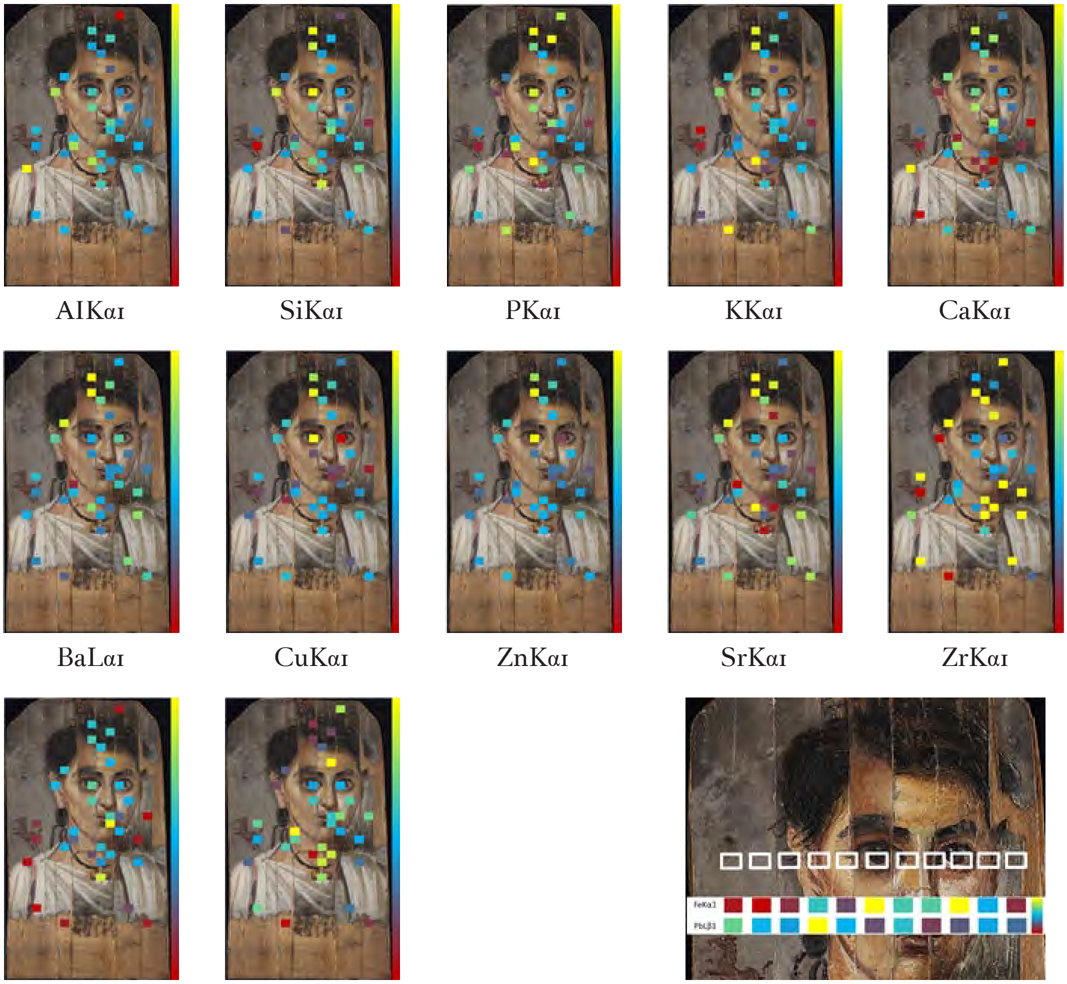
| Tabular presentation of all recorded spectrums in series A and B. The colour scale min max visualises the relative intensity of the recorded signals appearing in the spectrum. The ranges for Zr and for Ba line K are represented as normalised to the highest intensity signal for both series.



rys. 3 | fig. 3

Uśrednione informacje pierwiastkowe zarejestrowane dla wybranych punktów na powierzchni obiektu podczas serii pomiarów A i B. Skala barwna względnych intensywności sygnałów dla poszczególnych pierwiastków ulokowana jest po prawej stronie każdej fotografii. min max

| Averaged elemental data recorded at select points on the object's surface during test series A and B. A colour scale of relative signal intensity for individual elements is located along the right side of each photograph. min max



$AlK\alpha_1$ $SiK\alpha_1$ $PK\alpha_1$ $KK\alpha_1$ $CaK\alpha_1$

$BaL\alpha_1$ $CuK\alpha_1$ $ZnK\alpha_1$ $SrK\alpha_1$ $ZrK\alpha_1$

$FeK\alpha_1$ $PbL\beta_1$ $FeK\alpha_1$ i $PbL\beta_1$

Barbara Wagner (Uniwersytet Warszawski | University of Warsaw)
Olga Syta (Uniwersytet Warszawski | University of Warsaw)

Translated by Szymon Włoch

Aneks 2 | Annex 2

Odbiciowa spektroskopia w podczerwieni z transformacją Fouriera (FTIR)

Celem badań była identyfikacja spoiw w portrecie mumiowym chłopca ze zbiorów MNW metodą odbiciowej spektroskopii w podczerwieni z transformacją Fouriera (FTIR). Odbiciowa spektroskopia w podczerwieni jest jedną z nieinwazyjnych przenośnych technik, która pozwala uzyskać cenne informacje molekularne dla szerokiego zakresu materiałów malarskich przy jednoczesnym zachowaniu integralności kompozycji badanego dzieła*. Badania przeprowadzono z użyciem przenośnego spektrometru ALPHA (Bruker) wyposażonego w przystawkę do pomiarów nieinwazyjnych. Przystawkę urządzenia wyposażoną w otwór o średnicy 4 mm przystawiano do reprezentatywnych punktów na powierzchni obrazu i analizowano je za pomocą transmitowanej wiązki podczerwieni. W efekcie otrzymano widma dla zakresu 4000–400 cm^{-1}, w rozdzielczości 2 cm^{-1}, po uśrednieniu wyników z zebranych 15 skanów. Jako tło wykorzystano widmo otrzymane przy użyciu płaskiego złotego lustra. Wnioski wyciągnięto na podstawie identyfikacji zarejestrowanych pasm charakterystycznych, pochodzących od poszczególnych wiązań i grup funkcyjnych.

Przeprowadzona analiza z zastosowaniem odbiciowego FTIR miała na celu określenie grup użytych materiałów oraz wykrycie ewentualnych ingerencji w obiekt. Zastosowanie przenośnej aparatury umożliwiło zebranie informacji bezpośrednio z badanego obiektu, bez konieczności naruszania jego struktury. Zarejestrowane widma i ich pasma charakterystyczne zostały opracowane, a następnie porównane z widmami opublikowanymi w literaturze naukowej i zgromadzonymi widmami wzorcowymi. Wyniki zebrano w Tabeli 1 oraz na mapie punktów przebadanych za pomocą spektroskopii w podczerwieni (zob. il. 1).

Dzięki przeprowadzeniu wstępnej analizy możliwe było zidentyfikowanie wosku oraz białka we wszystkich analizowanych obszarach. Olej został zidentyfikowany we wszystkich miejscach poza skronią po lewej stronie przy uchu (B2), analizę utrudniała jednak obecność bieli ołowiowej, której sygnały o dużej intensywności często uniemożliwiają odczyt pasm charakterystycznych innych substancji. Tylko w jednym punkcie – źrenicy lewego oka (B3) – wykryto obecność dodatkowej substancji. Świadczy o tym fakt rejestracji sygnału przy wartości 1790 cm^{-1}, odpowiadającego drganiom rozciągającym w wiązaniu C=O (występuje ono m.in. w lipidach, terpenoidach czy węglanach). Brak analogicznych pasm w pozostałych widmach oraz wizualne różnice między tym fragmentem portretu mumiowego, a pozostałymi deseczkami pozwala przypuszczać, że wykryta substancja mogła zostać naniesiona wtórnie. Ze względu na ograniczone możliwości sprzętu nie udało się jednak dokładne określić, do jakiej grupy związków należy ten związek chemiczny. Otrzymane wyniki stanowią jednak dobry punkt wyjścia do zastosowania innej metody instrumentalnej, która pozwoli uzyskać

* Francesca Rosi et al., *Interpretation of Mid and Near-Infrared Reflection Properties of Synthetic Polymer Paints for the Non-Invasive Assessment of Binding Media in Twentieth-Century Pictorial Artworks*, „Microchemical Journal" 2016, vol. 124, s. 898–908; Chiara Zaffino et al., *Exploiting External Reflection FTIR Spectroscopy for the in-situ Identification of Pigments and Binders in Illuminated Manuscripts. Brochantite and Posnjakite as a Case Study*, „Spectrochimica Acta Part A: Molecular and biomolecular spectroscopy" 2014, vol. 136, part B, s. 1076–1085; Tanja Trafela et al., *Nondestructive Analysis and Dating of Historical Paper Based on IR Spectroscopy and Chemometric Data Evaluation*, „Analytical Chemistry" 2007, vol. 79, s. 6319–6323; Paul Garside, Paul Wyeth, *Identification of Cellulosic Fibres by FTIR Spectroscopy I: Thread and Single Fibre Analysis by Attenuated Total Reflectance*, „Studies in Conservation" 2003, vol. 48, s. 269–275.

szczegółowe informacje na temat składu cząsteczkowego spoiw (np. chromatografia, ATR-FTIR). Dzięki uzyskanym informacjom znacząco zawężono również liczbę miejsc, z których można pobrać próbki do ewentualnych badań mikroniszczących.

Fourier-Transform Infrared Spectroscopy (FTIR)

The aim of the study was to identify the binding medium used in the mummy portrait of a boy from the NMW collection via Fourier-transform infrared spectroscopy (FTIR). Infrared reflectance spectroscopy is a portable non-invasive technique which makes it possible to obtain valuable molecular information for a wide range of painting materials while preserving the compositional integrity of the work being studied.* The analysis was performed with an ALPHA (Bruker) portable spectrometer equipped with a module for non-invasive analysis. The module possessing openings with a diameter of 4 mm is placed against representative points on the surface of the painting, which are analysed with the use of a transmitted infrared beam. Obtained were spectrums for the range of 4000–400 cm^{-1} at a resolution of 2 cm^{-1} after the results of the 15 scans were averaged. Used as the control was a spectrum obtained using a flat gold mirror. Conclusions were made on the basis of the identification of recorded characteristic bandwidths produced by individual bonds and functional groups.

The analysis performed with the use of FTIR was intended to determine the material groups used and to identify possible intrusions into the object. The use of portable apparatus made it possible to collect data directly from the object being studied without the need to compromise its structure. The recorded spectrums and their characteristic bandwidths were interpreted and then compared with spectrums published in scientific literature and with collected reference spectrums. The results are presented in Table 1 and on the map of points tested with infrared spectroscopy (see fig. 1).

In preliminary analysis, it was possible to identify the presence of wax and protein at all the analysed points. Oil was identified in all areas with the exception of the area of the temple near the ear on the left (B2), though the analysis was impeded by the presence of lead white, whose high intensity signals often make it difficult to distinguish bandwidths characteristic of other substances. The presence of an additional substance was discovered only at one point – in the pupil of the left eye (B3). This is evidenced by a signal of a value of 1790 cm^{-1}, which corresponds with stretching vibrations in the C=O bond (this occurs in, e.g., lipids, terpenoids and carbonates). The absence of analogous bandwidths in the other spectrums as well as the visual differences between this section of the mummy portrait and its other boards invites the supposition that the discovered substance may have been applied at a later time. Due to the limitations of the apparatus it was not possible to determine precisely what bond group this chemical compound belongs to. The results obtained, however,

* Francesca Rosi et al., "Interpretation of Mid and Near-Infrared Reflection Properties of Synthetic Polymer Paints for the Non-Invasive Assessment of Binding Media in Twentieth-Century Pictorial Artworks," *Microchemical Journal*, vol. 124 (2016), pp. 898–908; Chiara Zaffino et al., "Exploiting External Reflection FTIR Spectroscopy for the in-situ Identification of Pigments and Binders in Illuminated Manuscripts. Brochantite and Posnjakite as a Case Study," *Spectrochimica Acta Part A: Molecular and biomolecular spectroscopy*, vol. 136 (2014), part B, pp. 1076–85; Tanja Trafela et al., "Nondestructive Analysis and Dating of Historical Paper Based on IR Spectroscopy and Chemometric Data Evaluation," *Analytical Chemistry*, vol. 79 (2007), pp. 6319–23; Paul Garside, Paul Wyeth, "Identification of Cellulosic Fibres by FTIR Spectroscopy I: Thread and Single Fibre Analysis by Attenuated Total Reflectance," *Studies in Conservation*, vol. 48 (2003), pp. 269–75.

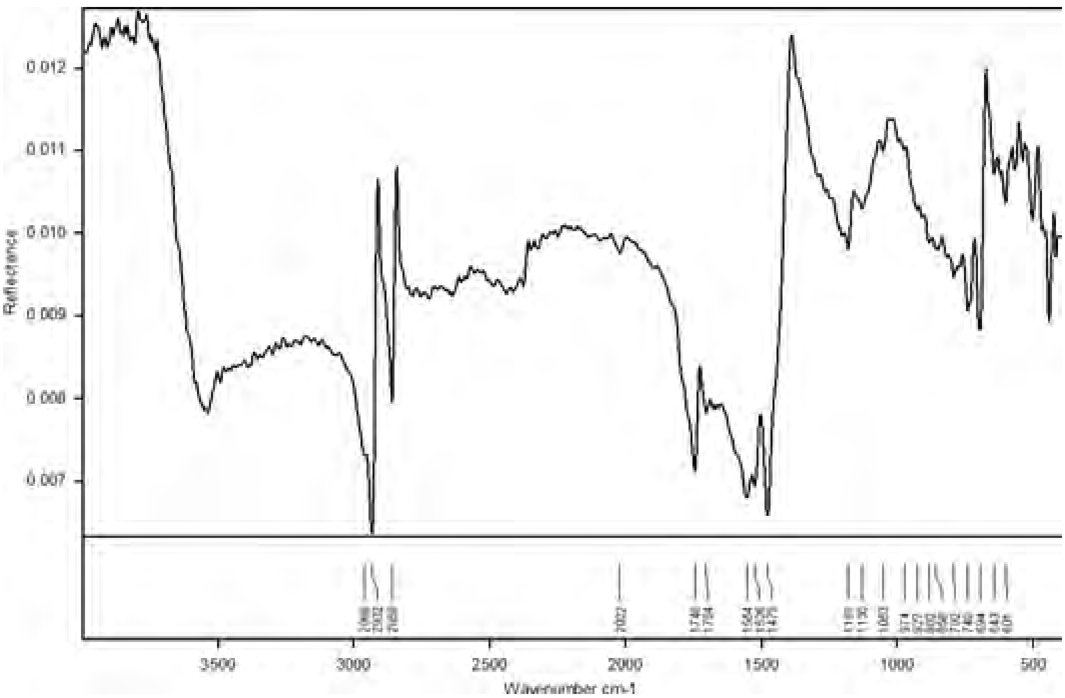
provide a sound starting point for the implementation of different instrumental methods that would make it possible to collect detailed information on the binding medium's particulate composition (e.g., chromatography, ATR-FTIR). The data collected also made it possible to significantly narrow down the number of points where samples could be taken for possible microdestructive analysis.

Tabela 1 | Table 1
Wyniki badań spoiw metodą odbiciowej spektroskopii w podczerwieni (FTIR)
| Results of Binding Media Analysis via Fourier-Transform Infrared Spectroscopy (FTIR)

	Badane miejsce | Area Tested	**Zidentyfikowana substancja | Substances Identified**
B1	ciemne tło u góry nad włosami | dark background at top above the hair	wosk, olej, białko | wax, oil, protein
B2	skroń z lewej strony przy uchu | temple by the ear at left	wosk, białko, biel ołowiowa | wax, protein, lead white
B3	źrenica lewego oka | left eye pupil	wosk, olej, białko, biel ołowiowa, nieznana substancja | wax, oil, protein, lead white, unknown substance
B4	karnacja z centrum prawego policzka | skin at the centre of the right cheek	wosk, olej, białko, biel ołowiowa | wax, oil, protein, lead white
B5	ciemna szarość tła z prawej strony | dark grey background at right	wosk, olej, białko | wax, oil, protein
B6	karnacja szyi pod naszyjnikiem z lewej strony | skin on the neck below necklace at left	wosk, olej, białko, biel ołowiowa | wax, oil, protein, lead white
B7	ciemny cień tuż pod podbródkiem | dark shadow directly below the chin	wosk, olej, białko | wax, oil, protein
B8	jaśniejszy cień pod podbródkiem | lighter shadow below the chin	wosk, olej, białko | wax, oil, protein
B9	szarość tła z prawej strony tuż nad szatą | grey background at right directly above the tunic	wosk, olej, białko, biel ołowiowa | wax, oil, protein, lead white

Wykres 1 | Graph 1

Przykładowe widmo odbiciowe FTIR zebrane z karnacji z centrum prawego policzka (B4). Na podstawie pasm charakterystycznych wykryto obecność wosku (2932 cm^{-1}, 1746 cm^{-1}, 1704 cm^{-1}), oleju (2960 cm^{-1}), białka (1554 cm^{-1}) i bieli ołowiowej (1479 cm^{-1}, 694 cm^{-1}).
| Sample FTIR reflectance spectrum from the area of the skin at the centre of the right cheek (B4). On the basis of characteristic bandwidths, identified was the presence of wax (2932 cm^{-1}, 1746 cm^{-1}, 1704 cm^{-1}), oil (2960 cm^{-1}), protein (1554 cm^{-1}) and lead white (1479 cm^{-1}, 694 cm^{-1}).



il. 1 | fig. 1
Mapa punktów przebadanych za pomocą spektroskopii w podczerwieni
A1–A4: miejsca pobrania próbek przebadanych spektrometrem FTIR-ATR
B1–B9: punkty zbadane nieinwazyjnym przenośnym spektrometrem FTIR
| Map of Points Tested with Infrared Spectroscopy
A1–A4: collection points of samples tested with ATR-FTIR spectrometer
B1–B9: points tested via non-invasive analysis with portable FTIR spectrometer

Justyna Kwiatkowska (Laboratorium Muzeum Narodowego w Warszawie | The National Museum in Warsaw Laboratory)

Translated by Szymon Włoch

Aneks 3 | Annex 3

Badania próbek za pomocą spektrometru FTIR-ATR

Pomiary wykonano metodą spektroskopii w podczerwieni z transformacją Fouriera (zob. Aneks 2) z wykorzystaniem spektrometru Alpha FTIR, firmy Bruker z wymienioną przystawką na QuickSnap ATR z kryształem diamentowym, dzięki któremu widma otrzymuje się za pomocą zjawiska osłabionego całkowitego odbicia (FTIR-ATR). Widma rejestrowano w zakresie 4000–400 cm^{-1} z rozdzielczością 4 cm^{-1}. Badanie polegało na nieniszczącej analizie 4 pobranych mikropróbek pochodzących z ubytków oraz krawędzi malowidła, zaznaczonych na fotografii jako punkty A1–A4 (zob. il. 1, s. 316). W efekcie możliwe było otrzymanie informacji o związkach chemicznych obecnych w całym przekroju danej próbki. Sygnały z substancji obecnych na powierzchni nie dominują nad sygnałami pochodzącymi z niższych partii. Metoda ta pozwala na wykrycie szerokiej gamy związków obecnych w próbce, zarówno organicznych, jak i nieorganicznych. Można ponadto uzyskać informację o produktach procesów związanych z upływem czasu, zachodzących w badanym obiekcie. Identyfikacji dokonano na podstawie porównań charakterystycznych sygnałów, które nazywane są pikami, pomiędzy widmami otrzymanymi podczas analizy próbek z widmami substancji odniesienia, pochodzącymi z katalogu firm Kremer, Maimeri, jak również samodzielnie przygotowanych mieszanek wzorców oraz na podstawie danych zawartych we wcześniejszych publikacjach*.

W próbce pobranej w miejscu widocznych zmian pojawiających się w obszarze szarości przy lewej krawędzi, w okolicach szaty (A1), podstawowym zidentyfikowanym składnikiem jest wosk, ponieważ piki pojawiające się przy 2921, 2850, 1736, 1460, 1166 oraz 721 cm^{-1} pokrywają się z widmem wzorca wosku pszczelego (zob. wykres 1). Została tu ponadto wykryta biel ołowiowa, o której świadczą piki przy 1401 oraz 683 cm^{-1}. Zatem w przypadku tej próbki potwierdzone zostały pomiary wykonane za pomocą przenośnego spektrometru (zob. Aneks 2). Ponadto piki przy 2915, 2849, 1736, 1459, 1168 oraz 720 cm^{-1} charakterystyczne dla wosku pojawiły się również w widmie próbki pochodzącej z ubytku różu w partii pasa (A2; zob. wykres 2). Jednakże w widmie wyżej wymienionej próbki pojawia się seria pików najbardziej zbliżonych do widma czerwieni roślinnej, zawierającej w swym składzie antrachinon, obecny w marzannie barwierskiej, która w starożytności była barwnikiem wykorzystywanym najczęściej**.

Widma otrzymane z próbek z dwóch miejsc o ciemniejszym zabarwieniu, tzn. brązu z górnej krawędzi z partii tła, powyżej włosów (A3) oraz czerni leżącej bezpośrednio na drewnie (A4), poniżej warstwy malarskiej, świadczą o obecności takiego samego typu żywicy, którą jest najprawdopodobniej szelak. Jako że żywicą standardowo używaną w starożytnej

* Gilliane F. Monnier, *A Review of Infrared Spectroscopy in Microarchaeology: Methods, Applications, and Recent Trends*, „Journal of Archeological Science: Reports” 2018, vol. 18, s. 806–823; Francesca Rosi et al., *Recent Trends in the Application of Fourier Transform Infrared (FT-IR) Spectroscopy in Heritage Science: From Micro- to Non-Invasive FT-IR* [online], „Physical Science Reviews” 2019, vol. 4, no. 11, <https://www.degruyter.com/document/doi/10.1515/psr-2018-0006/html>, [dostęp: 22 czerwca 2021]; Bernhard Hofko et al., *Repeatability and Sensitivity of FTIR ATR Spectral Analysis Methods for Bituminous Binders*, „Materials and Structures” 2017, vol. 50, no. 187, <https://link.springer.com/journal/11527/volumes-and-issues/50-3>, [dostęp: 22 czerwca 2021].

** David Scott, *A Review of Ancient Egyptian Pigments and Cosmetics*, „Studies in Conservation” 2016, vol. 61, no. 4, s. 185–202.

sztuce egipskiej był mastyks***, mamy tu prawdopodobnie do czynienia z ingerencją konserwatorską. Warto jednak dodać, że szelak wykryto również w portrecie fajumskim z Art Institute of Chicago****.

W obszarze próbki brązu z okolic górnej krawędzi piki pojawiające się przy 2919, 2851, 1736, 1462, 1418, 1172, 1026, 721 oraz 444 cm^{-1} pokrywają się z widmem wzorca wyżej wymienionej żywicy (zob. wykres 3).

Podobnie w odniesieniu do próbki czerni pochodzącej z obszaru poniżej partii malarskiej można zauważyć, że widmo próbki pokrywa się z widmem wzorca szelaku (zob. wykres 4). Widmo tej próbki pokrywa się również dodatkowo ze wzorcem jednego z bituminów, które były używane w starożytności również jako warstwy zabezpieczające dla mumii (zob. wykres 5).

Próbki czerni oraz szarości docelowo pobrane były w punktach, w których zauważono procesy przemian. W widmach tych próbek poza wykrytymi odpowiednio woskiem oraz żywicą pojawiły się piki w obszarze 1510–1520 cm^{-1}. Sygnały te nie pokrywają się z widmami wzorców związków standardowo używanych w starożytnym Egipcie, dlatego mogą one świadczyć zarówno o zastosowaniu niekonwencjonalnych substancji, jak również o reakcjach zachodzących potencjalnie spowodowanych przez serię czynników, w tym obecność grzybów lub interakcje z substancjami mumifikującymi*****. Zjawiska te są obszarem dyskusji w międzynarodowym gronie specjalistów. Obecnie w naszym zespole prowadzone są szersze badania analityczne nad procesami zachodzącymi na portretach mumiowych, w tym badanie dodatkowych domieszek spoiw w postaci jaj różnych gatunków ptaków hodowanych w tamtych czasach czy wpływu specyficznych rodzajów grzybów na mieszaniny związków, które wchodzą w skład badanego portretu.

W badaniach próbek za pomocą spektrometru FTIR-ATR zostały wykryte: wosk, żywica, biel ołowiowa, bitumin oraz barwnik roślinny. Dodatkowe sygnały prawdopodobnie świadczą o produktach reakcji zachodzących na obrazie.

Sample Testing with FTIR-ATR Spectrometer

Measurements were taken via Fourier-transform infrared spectroscopy (see Annex 2) using a Bruker Alpha FTIR spectrometer with a diamond crystal QuickSnap ATR sampling module, thanks to which a spectrum is obtained from attenuated total reflection (FTIR-ATR). The spectrums were recorded in the range of 4000–400 cm^{-1} at a resolution of 4 cm^{-1}. The study involved non-destructive analysis of 4 microsamples collected from points of material loss in the painting and at its edges, identified in the photograph as points A1–A4 (see fig. 1, p. 316). As a result, it was possible to obtain data on the chemical compounds present in the entire cross-section of a given sample. Signals from substances present on the surface do not overpower the signals from lower sections. This method enables the identification of a wide range of compounds present in a sample, both organic and inorganic. It is also possible to obtain

*** Paul T. Nicholson, Ian Shaw, *Ancient Egyptian Materials and Technology*, Cambridge 2000, s. 390–495.

**** Ken Sutherland, Rachel C. Sabino, Federica Pozzi, *Challenges in the Characterization and Categorization of Binding Media in Mummy Portraits* [w:] *Mummy Portraits of Roman Egypt Emerging Research from the APPEAR Project*, ed. Marie Svoboda and Caroline R. Cartwright, Los Angeles 2020.

***** Lin Spaabaeck, *Conservation of Mummy Portraits at the Ny Carlsberg Glyptotek* [w:] *Living Images*, ed. Janet Picton, Stephen Quirke, Paul C. Roberts, New York 2007, s. 127.

information on the products of processes related to the passage of time occurring in the object being analysed. Identification was done on the basis of comparison of characteristic signals, called peaks, between spectrums obtained during sample analysis versus reference substance spectrums from the catalogues of the companies Kremer and Maimeri, as well as spectrums of self-prepared reference mixtures and data contained in earlier literature.[*]

In the sample taken from the point of visible changes appearing in the grey area at the left edge near the tunic (A1), the primary constituent found was wax, as the peaks appearing at 2921, 2850, 1736, 1460, 1166 and 721 cm^{-1} correspond to those in the reference spectrum for bees wax (see Graph 1). Also found here was lead white, evidenced by peaks at 1401 and 683 cm^{-1}. Thus, in the case of this sample, confirmed here are the measurements taken with the portable spectrometer (see Annex 2). Moreover, peaks characteristic of wax at 2915, 2849, 1736, 1459, 1168 and 720 cm^{-1} also appear in the spectrum for the sample taken from the material loss in the pink of the stripe (A2; see Graph 2). The spectrum for this sample also contains a series of peaks most closely resembling those in the spectrum for plant-based red containing anthraquinone, which is present in madder lake, the most-used pigment in antiquity.[**]

Spectrums for samples taken from two areas of darker colour, i.e., the brown in the upper edge of the background above the hair (A3) and the black directly on the wood (A4) beneath the paint layer, indicate the presence of the same type of resin, most likely shellac. Seeing as the resin typically used in ancient Egyptian art was mastic,[***] it is likely that this was an instance of conservatorial interference. It is worthwhile to add, however, that shellac was also identified in the Fayum portrait from the Art Institute of Chicago.[****]

In the case of the brown sample from the area of the upper edge, the peaks appearing at 2919, 2851, 1736, 1462, 1418, 1172, 1026, 721 and 444 cm^{-1} correlate with the reference spectrum for the resin in question (see Graph 3).

In the black sample taken from the area beneath the paint layer, it was also observed that the sample spectrum is analogous with the reference spectrum for shellac (see Graph 4). This sample's spectrum also correlates with the reference spectrum of one of the bitumens used in antiquity, including as a preservative in mummies (see Graph 5).

Samples of black and grey were intentionally taken at points where change processes have been observed. In the spectrums for these samples, alongside the expected peaks for wax and resin, observed were peaks in the range of 1510–1520 cm^{-1}. These signals do not correspond with reference spectrums for compounds typically used in ancient Egypt and may thus indicate either the use of non-conventional substances or the presence of reactions possibly caused by a series of factors, like the presence of fungi or interaction with mummification

[*] Gilliane F. Monnier, "A Review of Infrared Spectroscopy in Microarchaeology: Methods, Applications, and Recent Trends," *Journal of Archeological Science: Reports*, vol. 18 (2018), pp. 806–23; Francesca Rosi et al., "Recent Trends in the Application of Fourier Transform Infrared (FT-IR) Spectroscopy in Heritage Science: From Micro- to Non-Invasive FT-IR" [online], *Physical Science Reviews*, vol. 4, no. 11 (2019), <https://www.degruyter.com/document/doi/10.1515/psr-2018-0006/html>, [retrieved: 22 June 2021]; Bernhard Hofko et al., "Repeatability and Sensitivity of FTIR ATR Spectral Analysis Methods for Bituminous Binders," *Materials and Structures*, vol. 50, no. 187 (2017), <https://link.springer.com/journal/11527/volumes-and-issues/50-3>, [retrieved: 22 June 2021].

[**] David Scott, "A Review of Ancient Egyptian Pigments and Cosmetics," *Studies in Conservation*, vol. 61, no. 4 (2016), pp. 185–202; Paul T. Nicholson, Ian Shaw, *Ancient Egyptian Materials and Technology* (Cambridge, 2000).

[***] Paul T. Nicholson, Ian Shaw, *Ancient Egyptian Materials and Technology* (Cambridge, 2000), pp. 390–495.

[****] Ken Sutherland, Rachel C. Sabino, Federica Pozzi, "Challenges in the Characterization and Categorization of Binding Media in Mummy Portraits," in Marie Svoboda and Caroline R. Cartwright, eds, *Mummy Portraits of Roman Egypt Emerging Research from the APPEAR Project* (Los Angeles, 2020).

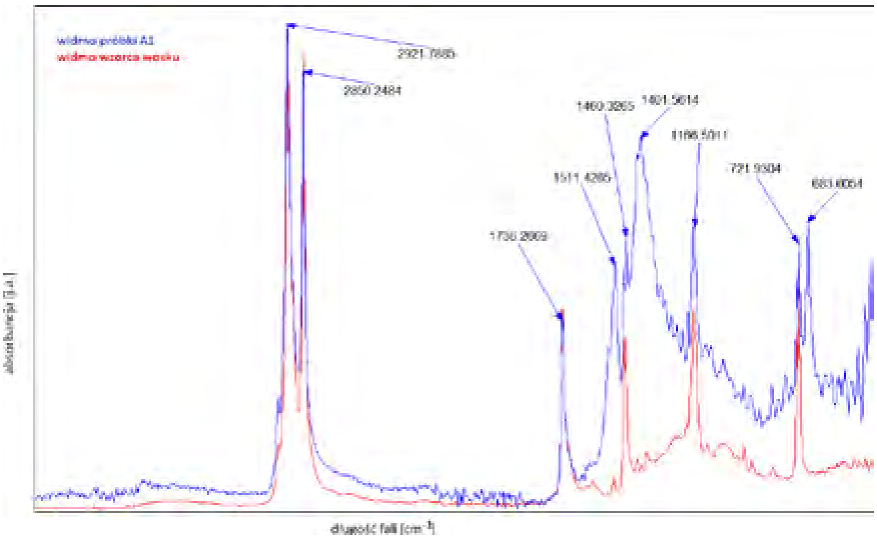
substances.***** These phenomena are a subject of discussion in the community of international specialists. Currently, our team is conducting broader analytical study of the processes taking place in mummy portraits, including the study of additional binding media additives, like the eggs of various bird species kept in that period, and of the influence of specific fungus types on the mixture of compounds used in a studied portrait.

FTIR-ATR spectroscopy sample analysis revealed the presence of: wax, resin, lead white, bitumen and a plant-based pigments. The additional signals likely indicate the presence of products of reactions taking place in the painting.

***** Lin Spaabaeck, "Conservation of Mummy Portraits at the Ny Carlsberg Glyptotek," in Janet Picton, Stephen Quirke, Paul C. Roberts, eds, *Living Images* (New York, 2007), p. 127.

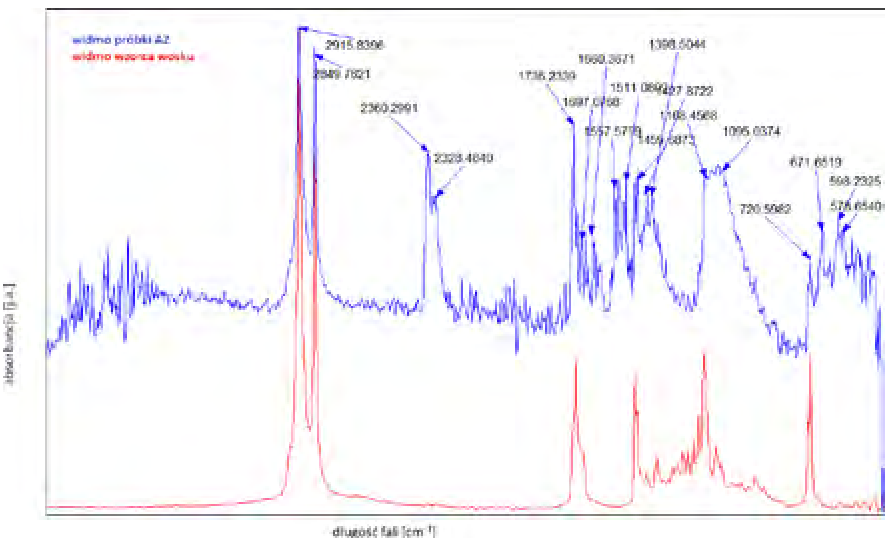
Wykres 1 | Graph 1

Widmo pochodzące z próbki z miejsca widocznych zmian, pojawiających się w obszarze szarości przy lewej krawędzi w okolicach szaty (próbka A1) oraz widmo wzorca wosku | Spectrum for the sample taken at a point of visible changes appearing in the grey area at the left edge near the tunic (sample A1) and the reference spectrum for wax



Wykres 2 | Graph 2

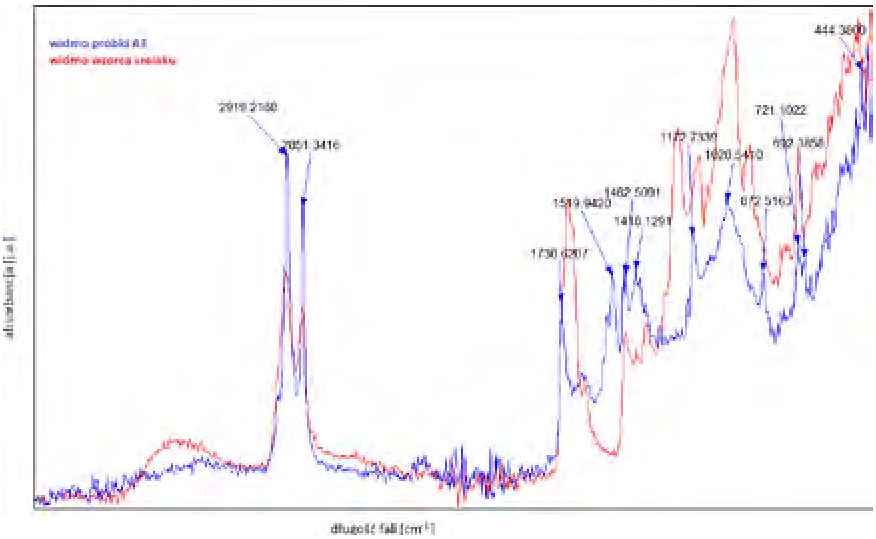
Widmo pochodzące z próbki partii różowego pasa (próbka A2) oraz widmo wzorca wosku | Spectrum for sample taken from the pink stripe (sample A2) and reference spectrum for wax



Wykres 3 | Graph 3

Widmo pochodzące z brązu z górnej krawędzi partii tła powyżej włosów (próbka A3) oraz widmo wzorca szelaku

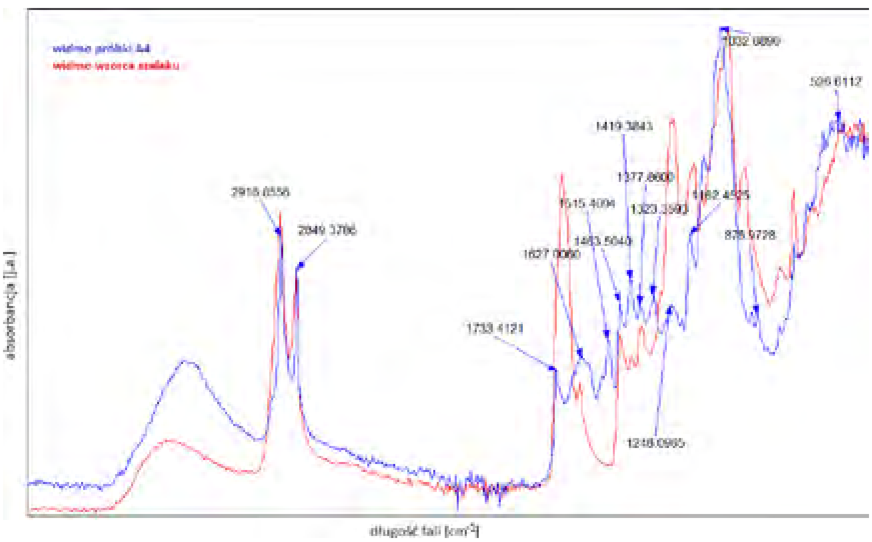
| Spectrum for the sample of brown from the upper edge of the background above the hair (sample A3) and reference spectrum for shellac



Wykres 4 | Graph 4

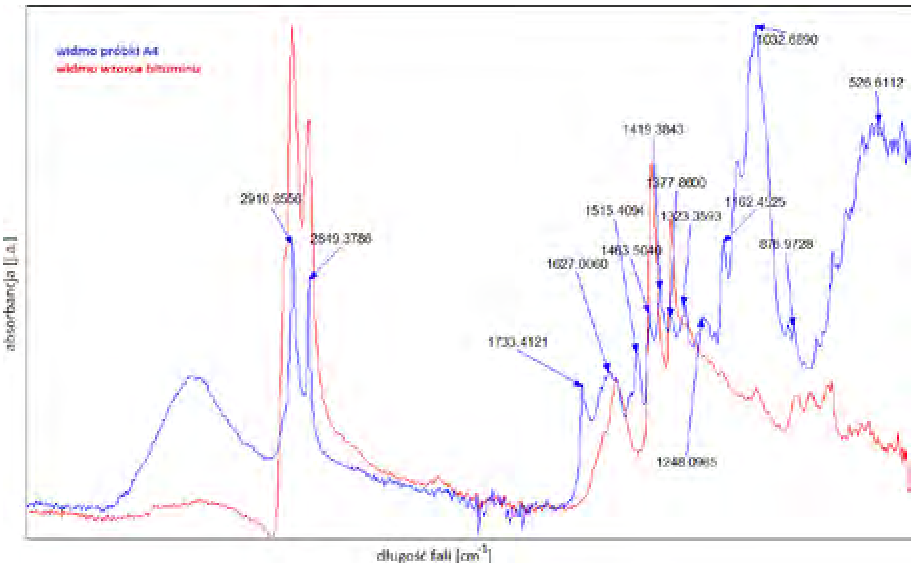
Widmo pochodzące z próbki pobranej z cienkiej czarnej warstwy widocznej na niezamalowanej partii drewna poniżej wizerunku (próbka A4) oraz widmo wzorca szelaku

| Spectrum for sample taken from the thin black layer visible on the unpainted area of wood below the likeness (sample A4) and reference spectrum for shellac



Wykres 5 | Graph 5

Widmo pochodzące z próbki z cienkiej czarnej warstwy widocznej na niezamalowanej partii drewna poniżej wizerunku (próbka A4) oraz widmo wzorca bituminu | Spectrum for sample taken from the thin black layer visible on the unpainted area of wood below the likeness (sample A4) and reference spectrum for bitumen



Magdalena Wróbel-Szypula (Laboratorium Muzeum Narodowego w Warszawie | The National Museum in Warsaw Laboratory)

Translated by Szymon Włoch