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THE HISTORY OF THE ATHENIAN HYDRIA FROM THE GOŁUCHÓW COLLECTION - A VIEW FROM THE PERSPECTIVE OF ARCHIVAL, CONSERVATION AND ARCHAEOMETRIC RESEARCH

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Abstract

This article provides a detailed examination of the provenance and historical development of a red-figure hydria hailing from an Athenian pottery workshop. The vessel originates from the nineteenth-century collection of Countess Izabela Działyńska, née Czartoryska (Gołuchów Collection), and is currently housed in the National Museum in Poznań. The circumstances surrounding the discovery of the hydria remain uncertain. The hydria has been meticulously assembled from numerous components. The state of preservation of the vessel determined the fundamental research question: whether the hydria was reconstructed from fragments of a single vessel or from multiple fragments, and in what context the damage could have occurred. Utilising a multifaceted approach encompassing macroscopic, petrographic, and chemical analyses, the article delves into the genesis of the fragments that have been integrated into the hydria. The analyses undertaken in this direction also illuminated the hydria's history as an archaeological find. The results of the research suggest that the hydria was broken in antiquity and that some of its fragments were subjected to high temperatures, presumably as part of funeral rituals.

Keywords*: Pottery; Conservation; Restoration; Archaeometry; SEM-EDS; Petrography; pXRF*

Introduction

The red-figure hydria housed in the collection of the National Museum in Poznań (MNP A 746) originates from the private 19th-century collection of Izabela Działyńska née Czartoryska. As with many artifacts acquired by collectors in the 18th and 19th centuries, there is no information about the findspot or the archaeological context of the object.

Conservation work carried out at the Applied Arts Conservation Laboratory of the National Museum in Poznań revealed a complex reconstruction process of the object. Features observed on the vessel's surface raised questions about the origin of the fragments used in its reconstruction, including whether fragments from one or several different vessels, possibly of different provenance, were used. Due to the artifact's incomplete documentation, these issues could not be clarified based on archival research or macroscopic analysis alone. Thus, detailed investigations were undertaken, including petrographic analysis, X-ray fluorescence (XRF), and scanning electron microscopy with energy-dispersive X-ray spectroscopy (SEM-EDS).

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The hydria is 27 cm high, with a rim diameter of 13.1 cm and a base diameter of 10.4 cm. Its maximum width, including the handles, measures 26.8 cm. Based on the morphological analysis of the vessel and the style of its figurative decoration, the hydria has been identified as a product of an Athenian pottery workshop. It has been attributed to the Washing Painter and dated to 430-410 BCE [1], [2]. The scene decorating the vessel depicts three women: two seated on amphorae and one standing female figure, engaged in playing the game of morra (Figs. 1 and 2).

Fig. 1. Hydria of Washing Painter (MNP A 746) side A, state of preservation: before removal of conservation layers (photo: Jakub Baszczyński)

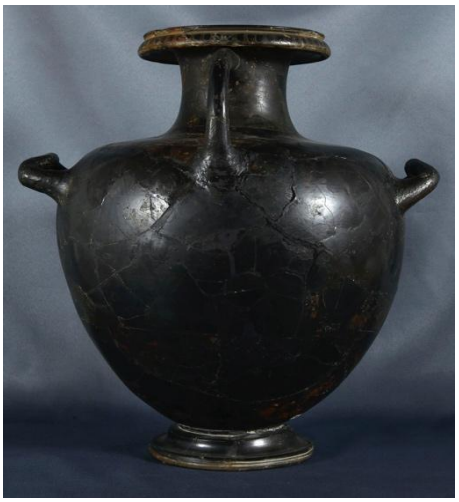


Fig. 2. Hydria of Washing Painter (MNP A 746) side B, state of preservation: before removal of conservation layers (photo: Jakub Baszczyński)

The vessel was purchased by Jean de Witte on behalf of Izabela Działyńska in 1867 from Raffaele Barone's antique shop in Naples [3]. From 1867 to 1885, the vase was kept at Hôtel Lambert in Paris [3]. After 1886, the Countess decided to relocate her collection to Gołuchów Castle [4]. The vessel remained on display at the castle until the outbreak of World War II in 1939, when items from the collection were seized by the Nazi authorities of the Wartheland and transported to Poznań [5], [6]. In 1942, the looted artworks were taken from Poznań to the salt mine in Grasleben or bunkers near Międzyrzecz and Sulęcin [5, p. 18] [7]. In 1945, the hydria, along with other artefacts, was seized by the Red Army and transported to the USSR. Most of the artefacts were sent to Leningrad, but it is believed that some vessels from the collection were transferred to Moscow, where they may have undergone conservation treatments [8]. In 1956, the hydria and other objects from the Gołuchów collection were returned to Poland by Soviet authorities [9]. The hydria was transported to the National Museum in Warsaw, where it remained until 1984 (MNW 142293). In 1984, the vessel was returned to the Gołuchów Castle Museum, a branch of the National Museum in Poznań (MNP A 746). In 2017, objects from the collection were repurchased from the Czartoryski family heirs by the Polish state. In 2018, conservation work on the artifact was conducted at the Applied Arts Conservation Laboratory of the National Museum in Poznań. The first stage involved removing external layers, reinforcing the vessel's structure, and applying secondary pigments to color-match the hydria's body. This process revealed that the hydria had been reconstructed from 208 fragments.

The preliminary analysis of the vessel's surface demonstrated that, in addition to the integration of fragments with congruent visual characteristics (e.g., gloss color, continuity of ornamentation), the hydria also contains a substantial number of ancient ceramic fragments that appear dissimilar. This observation led to the hypothesis that the hydria currently consists of

multiple ancient ceramic pieces, possibly originating from different vessels and even various production workshops. The varying types of fills used, along with different macroscopic characteristics of the ceramic restoration materials, suggest that the vessel underwent more than one reconstruction process.

The analysis of the vessel's state of preservation and the presence of various methods, materials, and intentions that may have guided the procedures performed on the hydria, in combination with the fragmentary knowledge about the vessel's past, resulted in the establishment of several research problems. A primary research objective was to ascertain the materials used for the reconstruction of the vessel. The inquiry focused on determining whether these fragments belonged exclusively to the original hydria or also comprised pieces of other ancient fine ware vessels. Furthermore, a crucial aspect was the identification of the provenance of the fragments, i.e., whether they originated from Athenian vessels or if they comprised fragments from other origins. It was established that a significant element in addressing these inquiries was to characterize the supplements utilized, which manifested features that differed from the fragments of vessels adorned with black gloss. Another research problem was to explain the macroscopic differences between adjacent fragments, starting from the different colors of fragments originating from figurative decoration and ending with neighboring fragments covered with black gloss. A further key issue was the evaluation of the interventions performed and an attempt to determine whether the condition of the vessel was the result of a one-off conservation action or whether it was possible to introduce some chronological differentiation due to the methods of reconstruction used, thereby strengthening the vessel structure and the surface treatments applied to correct the vessel's appearance.

Materials and methods

Archival research and surface analyses

The primary stage of the research was to collect data on the vessel's condition from archival sources, focusing on the state of preservation of the hydria in the period immediately preceding the acquisition of the vessel by Countess Działyńska and during her ownership. The subsequent stage entailed a meticulous examination and organization of the available information concerning the methods of reconstruction and conservation employed on the hydria. The next stage was to formulate and execute a program of archaeometric analyses to address the research challenges identified.

Technological analysis

Technological analyses of samples taken from the vessel's surface were conducted at the Technological and Conservation Research Laboratory of the National Museum in Poznań before removing color- and profile-correcting layers. Microscopic examinations were performed using Nikon SMZ 1500 microscopes (epi- and dia-techniques, magnification up to 112.5×) and Zeiss Nf (dia-technique, magnification 150×, normal and polarized light). UV light observations were carried out using a Rescolux Mini LED lamp by NOBLEX to determine the fluorescence of binders under UV light. Microscopic photographic documentation was created using a DeltaPix Invenio 5D camera and a Canon 500D camera.

Portable X-ray fluorescence (pXRF) analysis

To enhance the identification and evaluation of potential differences in the raw materials of fragments with distinct macroscopic features, several analytical methods were employed, including non-invasive portable X-ray fluorescence (pXRF) [10], [11]. The adopted methodological protocol began with collecting data using the non-destructive pXRF method from pre-selected areas characterized by different macroscopic features. Measurements were performed using a handheld Bruker Tracer III SD spectrometer with the following parameters: voltage: 15 kV, current: 25 μA, filters: none applied, vacuum pump: enabled (analytical mode: MajMudRock).

During the analyses, the spectrometer was maintained at a constant distance from the vessel. Measurements were taken from a cleaned ceramic surface free of conservation layers (Table 1). Seventeen elements were identified: Mg, Al, Si, P, S, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, and Ba. Due to the specific characteristics of the equipment used, the results presented below are semi-quantitative and expressed in weight percent (wt%).

Table 1. Results of measurements – MajMudRock mode
(Mg, Al, Si, P, S, K, Ca, Ti, and Fe expressed in wt%; V, Cr, Mn, Co, Ni, Cu, Zn, and Ba expressed in ppm)

XRF	Mg	Al	Si	P	S	K	Ca	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ba
218	2.70	8.81	22.55	0.21	1.47	2.74	6.03	0.44	121	166	804	5.27	22	96	3	121	602
219	4.51	8.58	21.16	0.12	1.63	2.04	11.40	0.34	121	93	382	3.47	14	57	37	88	833
220	2.70	9.17	22.02	0.15	1.35	2.94	5.84	0.44	88	185	733	5.01	22	98	3	143	839
221	1.17	8.59	18.82	0.07	2.55	2.73	4.58	0.36	64	153	699	5.32	21	8	n/d	4	474
222	5.33	9.65	23.37	0.14	0.74	3.41	6.17	0.43	84	149	912	5.25	23	88	n/d	104	872
223	0.65	12.03	18.00	0.13	1.11	4.46	1.39	0.39	112	131	633	8.34	33	32	38	113	n/d
224	0.50	6.71	18.53	0.07	3.30	1.67	9.40	0.29	51	84	361	3.24	13	4	58	102	573
225	2.59	7.93	20.60	0.16	2.38	1.89	11.30	0.30	39	102	381	3.54	14	51	58	82	1696
226	n/d	0.82	3.50	0.35	32.21	0.01	16.28	0.03	56	43	252	0.44	2	9	53	119	n/d
227	1.58	17.31	21.60	0.07	1.03	7.37	2.63	0.33	187	18	464	6.90	27	62	29	147	n/d
228	1.55	13.89	20.43	0.20	1.06	10.4	1.50	0.30	113	12	493	6.89	27	35	8	103	n/d
229	0.12	7.66	14.43	0.15	3.90	4.07	3.90	0.29	85	137	531	6.17	23	32	2	92	n/d
230	2.70	16.32	21.83	0.12	0.17	4.83	0.59	0.42	22	127	651	8.70	37	43	4	142	n/d
231	0.51	9.98	22.70	0.11	4.79	3.28	2.45	0.38	127	154	487	4.94	2	8	n/d	88	n/d
232	0.41	10.17	17.71	0.10	0.35	6.32	0.49	0.33	138	119	469	8.12	31	16	32	109	n/d
233	5.93	9.60	22.41	0.11	2.07	2.43	6.34	0.43	93	204	593	5.41	23	98	n/d	104	842
234	1.03	14.96	19.86	0.10	0.69	4.64	0.67	0.39	197	122	593	8.92	37	34	24	118	14
235	1.08	12.45	19.01	0.11	1.08	6.38	1.88	0.37	157	121	5	8.39	34	7	52	97	n/d
236	1.27	14.49	20.58	0.14	0.20	4.33	0.50	0.44	206	137	604	8.92	39	25	56	15	n/d
237	0.60	1.09	3.50	0.44	38.55	0.01	17.05	0.01	35	31	249	0.56	2	3	31	86	n/d
238	1.10	14.08	19.78	0.10	0.15	4.85	0.51	0.43	214	15	461	8.72	35	27	54	105	n/d
239	0.32	8.71	14.86	0.03	0.81	4.08	1.52	0.36	104	143	478	7.61	29	24	22	123	22
240	0.17	7.53	15.58	0.14	1.32	7.61	1.65	0.35	128	123	423	7.52	29	22	29	116	n/d
241	4.97	6.92	24.87	0.24	0.87	3.23	5.26	0.43	57	19	535	5.49	23	75	15	112	476
242	7.33	9.18	22.03	0.08	1.50	2.53	6.23	0.42	62	196	558	5.34	23	9	n/d	105	2030
243	0.03	2.52	8.73	0.10	15.20	0.62	8.01	0.13	47	14	271	2.41	9	22	34	95	n/d
244	1.21	14.31	18,63	0.12	1.57	3.97	2.76	0.43	239	136	464	8.05	32	31	23	9	n/d
245	0.25	12.14	16.89	0.05	0.18	5.08	0.72	0.36	157	183	358	7.87	31	39	32	146	n/d
246	0.66	14.42	19.57	0.10	0.12	5.09	0.71	0.42	217	145	535	8.21	33	42	12	104	n/d
247	1.90	9.54	22.16	0.05	0.45	2.99	4.05	0.45	128	204	543	5.49	23	88	n/d	117	892
248	3.28	11.12	23.21	0.09	1.73	3.21	3.47	0.43	133	181	646	5.93	26	88	n/d	83	1311
249	0.32	12.05	17.8	0.06	0.99	4.21	1.58	0.37	192	181	462	7.22	28	48	36	119	n/d

Petrographic and chemical analysis

Sixteen micro-samples were collected from areas with different macroscopic features, and three petrographic thin sections were prepared. The micro-samples were embedded in epoxy resin for reflected-light microscopy analysis. The three thin sections were made from a foot fragment and two horizontal and vertical handle attachments (Table 2).

Optical examinations were conducted using an Olympus AX70 Provis petrographic microscope. The texture, degree of sintering, and chemical composition of the groundmass were determined using a Hitachi 3700N scanning electron microscope (SEM) in back-scattered electron (BSE) mode, coupled with an Energy Dispersive X-ray Spectrometer (EDS) Noran Six system.

Table 2. Summary of micro-samples location and pXRF measurements

Sample No	XRF No	Vessel Part	Preservation	Fragment Description
H1	249	Foot, a fragment separated from the body	Smooth surface, compact layer of high-quality semi-matte gloss; black gloss, greyish tint of the gloss and clay	A mechanically adapted fragment of the original foot or a fragment of the foot from another hydria of similar proportions
H6	235	Lower part of the body, side B of the vessel	Flaking surface, uneven firing surface	A fragment with traces of surface destruction adjacent to a fragment with a very well-preserved gloss with traces of grinding (H7)
H7	230	Lower part of the body, side B of the vessel	Smooth surface, compact layer of well-preserved high-quality gloss	A fragment with undamaged surface with traces of grinding at the edge, joined with fragments with poorly preserved gloss (H6)
H12	229	Lower part of the body, side B of the vessel	Flaking, damaged gloss surface, gloss poorly preserved, mat with greyish tint	A fragment with traces of destruction of gloss adjacent to a fragment with a very well-preserved high-quality gloss with traces of grinding
H13	239	Bottom part of the body, side B of the vessel	A fragment with good quality but damaged gloss; there are zones of uneven firing, and the gloss matte with greyish tint	Fragment with damaged gloss surface adjacent to a fragment with a very well-preserved high-quality gloss (H14)
H14	238	Lower part of the body, side B of the vessel	A fragment with high-quality, well-preserved gloss	fragment with high-quality gloss adjacent to a large plaster restoration and a fragment with damaged, greyish matte gloss surface (H13)
H15	233	Upper part of the body, side B of the vessel	A fragment with sanded gloss	Fragment with the gloss sanded down, revealing a grey matte surface joined with plaster filling and fragment covered with black high-quality, well-preserved gloss
H19	244	Upper part of the body, side A of the vessel	Good quality gloss, compact. even layer	Fragment with a black, slightly grayish matte gloss without damages on the surface carrying a part of the figurative decoration, joined to other fragments of the same quality and appearance
H21	232	Lower part of the body, side A of the vessel	Good quality gloss flaking off in large pieces on the surface, greyish tint; it falls off in pieces but not to the level of the clay mass	Fragment damaged with traces of edge grinding. adjacent to fragments of high-quality, well-preserved gloss and a restoration made of a different type of clay mass
H22	234	Upper part of the body, side A of the vessel	Fragment with well-preserved, high-quality gloss	An asymmetrically placed fragment with a shape and profile that deviates from the actual shape of the belly; a fragment that does not come from this part of the vessel because it partially fills the space that should be covered with ornament, surrounded by fragments of poorly preserved, damaged gloss (H23)
H23	240	Lower part of the body, side A of the vessel	Flaking gloss, greyish tint, highly damaged surface	Fragment surrounded by other fragments in the same state of preservation, between the fragments asymmetrically placed another

				fragment with very well-preserved high-quality gloss (H22)
H28		Upper part of the body, side B of the vessel		An asymmetrically placed fragment with edges attached to the fragment with good quality gloss. mat with surfaces grounded (H29)
H29	242	Upper part of the body (shoulder), side A of the vessel	Gloss of good quality. compact. mat with a grayish tint, sanded gloss surface to a grey layer	Fragment with a well-preserved gloss adjacent to an asymmetrically pasted fragment in a similar state of preservation (H28), exposed grey layer in places where the surface has been ground down
H31	245	Rim	High-quality, well-preserved gloss	Fragment that was pasted from another vessel on the rim; the fragment presents smaller proportions than the rest of the rim
H32	223	Lower part of the body, side A of the vessel	Smooth surface, compact layer of high-quality, well-preserved gloss	Fragment without gloss surface damages adjacent to fragments with peeling mat, greyish gloss (H33)
H33	228	Lower part of the body, side B of the vessel	Uneven firing, large flakes of gloss, matte greyish tint	Fragment with traces of destruction of gloss adjacent to a fragment with a very well-preserved gloss with traces of grinding (H32)
746b		Handle horizontal	Smooth surface, high-quality gloss, greyish tint of gloss and clay	Handle reconstructed of multiple fragments, handle attachment supported by plaster
746s	247, 248	Foot	Smooth surface, compact layer of high-quality semi-matte gloss, greyish tint of the gloss and clay	A mechanically adapted fragment of the original footer or a fragment of the footer of another hydria of similar proportions
746p		Handle vertical	Smooth surface, high-quality gloss, greyish tint of gloss and clay	Handle reconstructed of multiple fragments, handle attachment supported by plaster

Observations were carried out under a low vacuum of 30 Pa, without a conductive coating, maintaining a constant working distance of 10 mm, and at a magnification of 500×. The semi-quantitative chemical composition was measured at an accelerating voltage of 15 kV. The analyses were performed at the Institute of Geology, Faculty of Geographical and Geological Sciences, Adam Mickiewicz University, Poznań, Poland.

Results and Discussions

Condition based on archival publications and surface analyses

The earliest known engraving depicting the figurative decoration on the vessel is documented in a publication dated 1866 [12]. It highlights damage and missing sections that correspond to the current losses observed on the vessel (Fig. 3). In the second 19th-century publication, de Witte's 1886 catalogue [3], the engravings are more detailed, indicating a significant number of losses and damages marked as empty spaces. Notable damage is clearly depicted in the lower part of the figurative composition, including the garments of all three figures, especially the seated ones, as well as the hydriae on which two women are seated. The engravings in de Witte's catalogue also show damage to the upper left arm and neck of the figure seated at the center of the composition, as well as the wreath held by the standing figure on the right. The missing sections indicated in de Witte's catalogue correspond closely to the present-day damage on the vessel (Fig. 4).

Several methods of joining and reconstructing fragments were observed. The primary technique involved joining matching fragments, some of which were closely fitted (Fig. 5A), while others were connected with visible gaps between them (Fig. 5B). Fragments joined together often differ significantly in visual quality, including the color and sheen of the gloss. For example, a smooth, shiny gloss of a dark, uniform color is adjacent to a fragment with a matte, grey gloss (Fig. 5C) or one with a brownish gloss featuring distinct brown and orange spots (Fig. 5D). In some cases, the external surface at the joints was sanded down to create a consistent profile line. Such marks are visible in areas where secondary fills were applied using plaster or ceramic material (Fig. 5E), as well as where two ancient fragments with differing macroscopic characteristics meet (Fig. 5F).

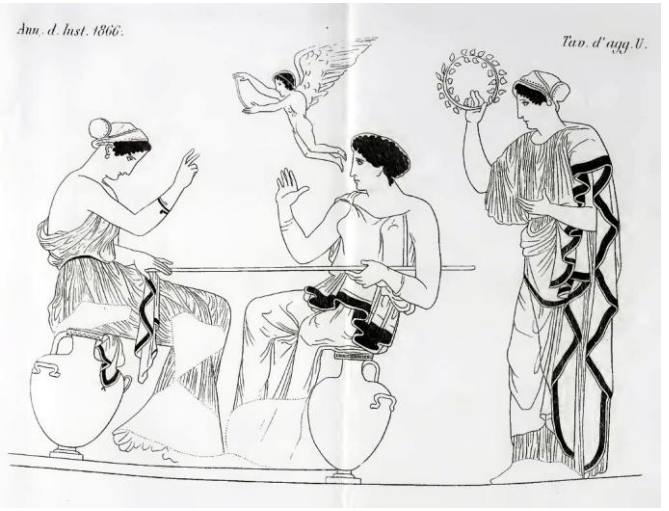


Fig. 3. The drawing of the decorated part of the hydria from the catalogue of Otto M. Jahn [12]

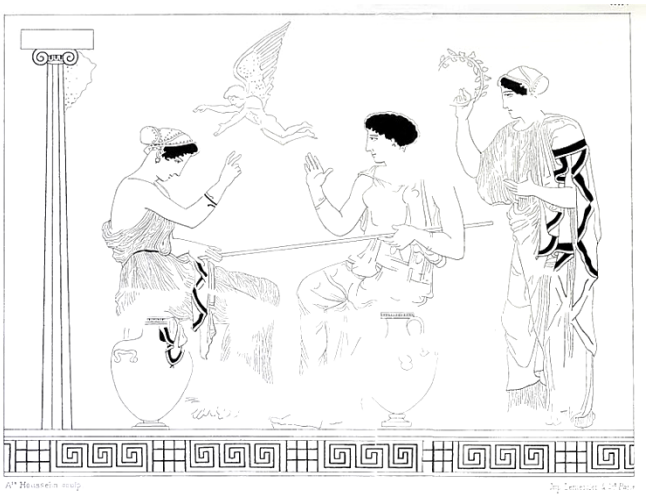


Fig. 4. The drawing of a decorated part of the hydria from Jean de Witte's catalogue [3]

Another example of intervention involves filling a gap in the vessel's body with a fragment inserted asymmetrically, misaligned with the vessel's profile line (Fig. 5G, H). The other method observed includes reconstructing the rim and foot of the vessel using fragments of different origins.

For instance, a rim fragment with smaller proportions was adjusted to align with the rest of the vessel (Fig. 5I, J). The lower fill consists of plaster combined with two ceramic fragments with distinct technological characteristics (plain, undecorated tableware). Similarly, a foot fragment was mechanically adjusted to fit the body. Due to the resulting profile misalignment, the outer surface of the added fragment was sanded down in the modeled area (Fig. 5K, L). The final example of reconstruction involves reinforcing and restoring the bases of the horizontal handles by fitting multiple small ceramic fragments to recreate their original shape (Fig. 5M).

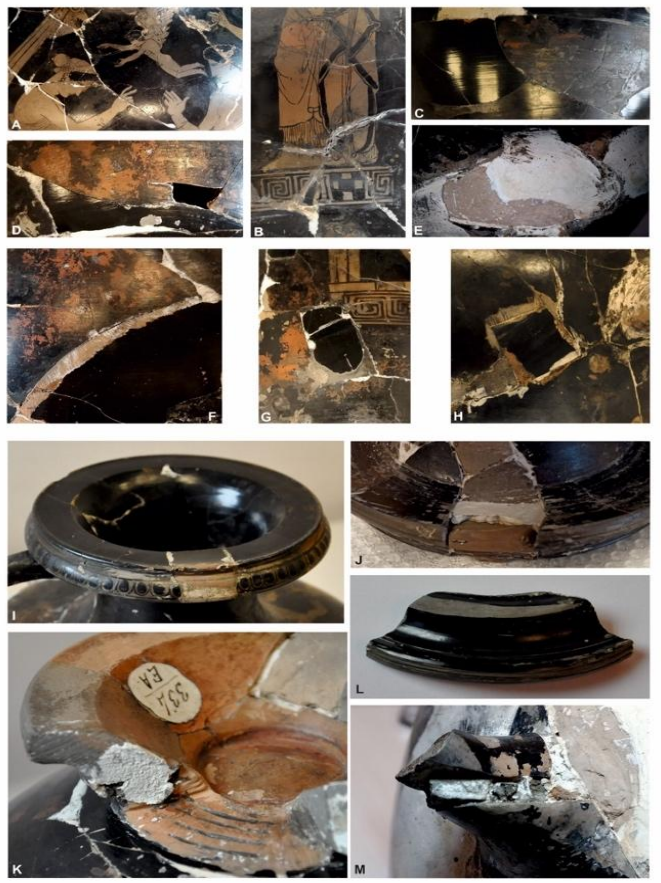


Fig. 5. Hydria MNP A 746. Examples of conservation interventions (photo: I. Głuszek)

The next category of intervention is clearly secondary and involves filling gaps with undecorated ceramic fragments (Fig. 6A), ceramic filler material (Fig. 6B, C), or plaster (Fig. 6D). Additionally, interventions aimed at reconstructing missing ornamentation from the figurative scene should be highlighted (Fig. 6E, F). The final method of restoration observed on the vessel's surface entailed not only the remediation of defects but also the replication of missing elements of composition and shape (Fig. 6G).

The assessment of the vessel's condition also revealed observations unrelated to the applied reconstruction and conservation procedures. These observations concern differences in the coloration of fragments that clearly fit together and are likely from the same vessel. In the figurative decoration zone, differences in the fired clay color were noted between fragments forming a single composition. For instance, part of the composition depicting the standing figure on the right appears in an orange-red hue of fired clay, while the adjoining fragment continues

the scene in greyish, matte tones. Similar differences, such as surface matting, are evident in fragments covered with gloss (Fig. 6H-J).

Results of technological analysis

The analysis identified two distinct groups of binders used to join ceramic fragments. One sample, 1, taken from the junction between the original Greek ceramic and a fragment of a different ceramic type, revealed the presence of natural resin (shellac). The natural resin might have been used either as a binder or as a protective coating for the vessel's surface. Since shellac (varnish) was commonly used in conservation procedures until the mid-20th century, it cannot be ruled out that it was applied during later (modern) conservation treatments. Technological analysis of the samples confirmed the use of synthetic resins with added pigments – either black or red – to achieve color integration between the binders and the outer surfaces of the vessel.

Fig. 6. Hydria MNP A 746. Examples of conservation interventions (photo: I. Głuszek)

Results of pXRF analysis

The gloss-covered surface accounts for the majority of the analyzed vessel and is characterized by a high iron content (approximately 7-8%), significant potassium levels (around 4-5%), and low calcium content (about 0.7-2.7%). No significant differences in the elemental composition ratio were observed between glossed fragments, even those potentially originating from different vessels. The chemical composition of fragments with a smooth, intact gloss layer of uniform color does not differ substantially from fragments with a delaminated, flaking gloss layer, showing varied hues from brownish-brown to dark orange. Minor differences in composition cannot definitively indicate different provenances for the fragments. A notably

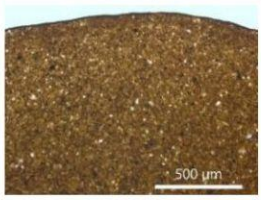
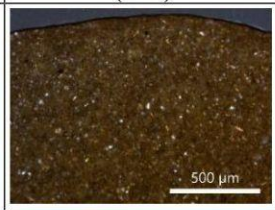
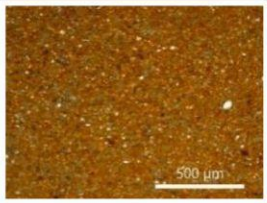
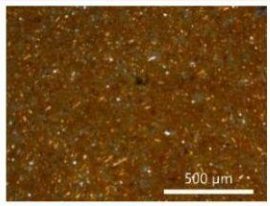
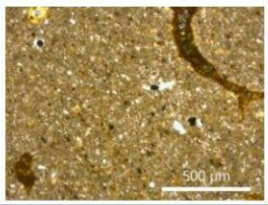
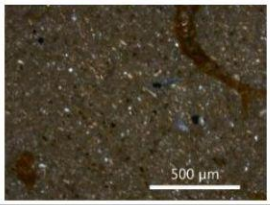
higher calcium level observed in measurement 260 may be associated with the presence of gypsum-based mortar used to fill vessel gaps between damaged gloss layers.

The values presented above distinguish the glossed surface from areas of the vessel without gloss. Sections decorated with so-called “red-figure” motifs also show high potassium content (approximately 3%) and iron content (around 5%), with a higher calcium level (approximately 5%). Beyond that, the red-figure decorated areas exhibit no distinctive features, and their elemental composition is typical of vessels thrown on a fast wheel using well-levigated clay. The clay surface measurement results are most characteristic of the foot fragments. A vessel fragment mechanically adjusted (surface sanded) during conservation to fit the reconstructed foot shows no significant differences in elemental composition compared to other non-glossed parts of the vessel. The modern fills have a completely different composition, being rich in calcium and sulfur, indicating the presence of gypsum. Simultaneously, aluminum and silicon levels are very low (Al approximately 1%, Si about 3%), while iron and titanium are present only at trace levels (>1%).

Results of thin section analysis in transmitted light

Polarized light analysis (Table 3) focused on clay body samples from the horizontal handle (Sample 746b), vertical handle (Sample 746p), and a foot fragment detached from the main vessel body (Sample 746s).

Table 3. Petrographic images of thin sections obtained in plain- and cross-polarized light (PPL and XPL) (photo J. Michniewicz)

Sample No.	Plane-polarized Light (PPL)	Cross-polarized Light (CPL)
746b		
746p		
746s		

Sample 746b (horizontal handle) – The ceramic material is classified as fine ware, with no visible temper particles under the naked eye. In transmitted light, the clay matrix appears brown with grayish edges (parallel nicols, 10× objective). Under crossed nicols, the matrix exhibits a uniform dark brown color and is partially optically active. The sample contains 10-15 vol% of silt-sized grains, predominantly quartz, with occasional alkali feldspars. Numerous milky discolorations

in the ceramic matrix indicate the presence of carbonates decomposed during firing. The matrix also contains evenly distributed, very fine, colorless mica flakes.

Sample 746p (vertical handle) - The micromass appears light red, turning brown in some areas due to variations in section thickness. Under crossed nicols, it displays a red color with milky discolorations caused by carbonate decomposition. The ceramic body shows moderate optical activity, indicating a firing temperature exceeding 750°C. Quartz silt content does not exceed 10 vol%. The quantity and form of dispersed, colorless mica flakes resemble those observed in Sample 746s.

Sample 746s (foot fragment) - Optical analysis revealed that the clay matrix of the ceramic body is grey, with distinct oval and irregular brown discolorations. These may result from either intentional addition of iron-rich *terra rossa* (approximately 5 vol%) or accidental contamination during the bisque firing process. Under cross-polarized light (XPL), the ceramic body remains grey and is partially optically active. The quartz silt content does not exceed 10 vol%. A distinctive feature is the presence of dispersed mica flakes (muscovite), which are notably more abundant compared to Sample 746b.

Results of petrographic analysis in reflected light

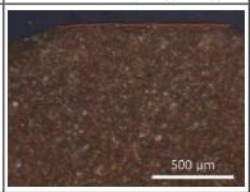
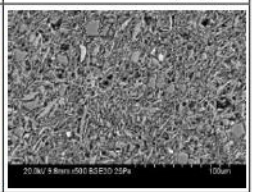
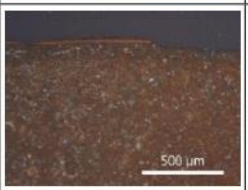
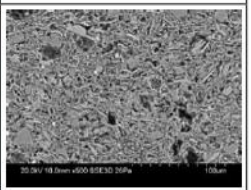
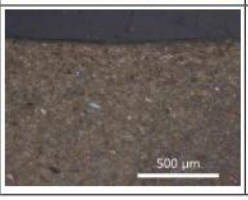
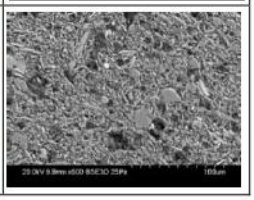
The set of 16 micro-samples differs primarily in the color. Samples H1, H12, H15*, H19, H22*, H29, and H31 exhibit cream-grey to grey micromass, while the remaining samples, H6, H7, H13, H14, H21, H23, H28, H32, and H33, display a light red coloration.

SEM-BSE imaging indicates that the mineral composition of the ceramic body, including the ratio of clay minerals to quartz and mica, as well as the form and size of the clay minerals and non-plastic inclusions, remains consistent regardless of the color. The preserved morphology of clay crystals and the significant porosity observed suggest a low degree of sintering during the firing process.

Results of SEM-BSE microstructure analysis

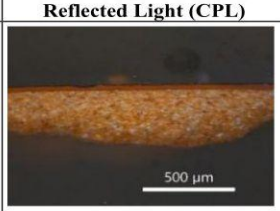
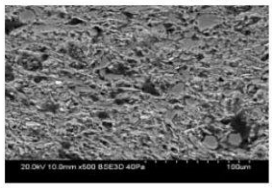
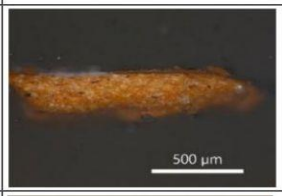
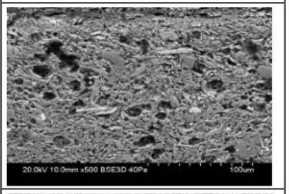
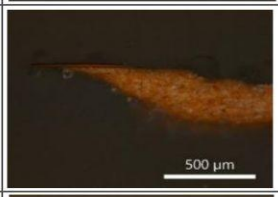
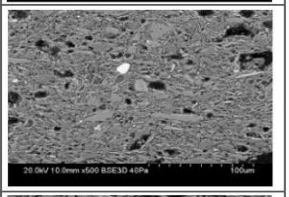
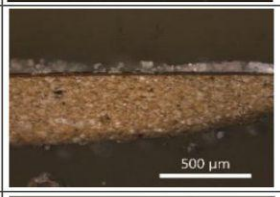
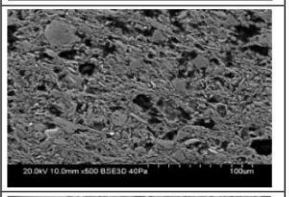
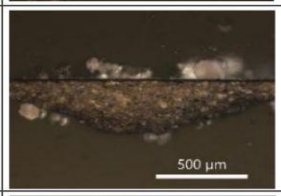
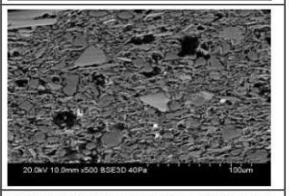
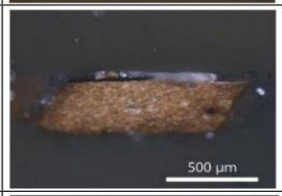
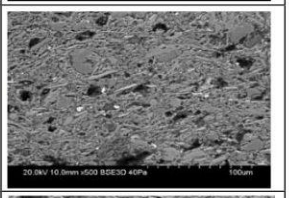
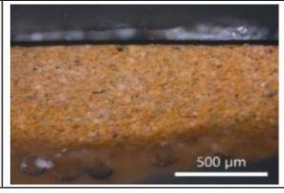
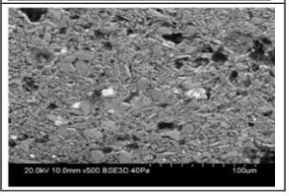
Thin sections (samples 746b, 746s, and 746p), examined in back-scattered electron (BSE) mode, exhibit a high degree of microstructural similarity (Table 4).

Table 4. Petrographic images of polished specimen sections (samples 746 b, p, s) obtained in reflected light, crossed nicols, together with SEM-BSE images (phot. J. Michniewicz)

Sample No.	Reflected Light (CPL)	SEM-BSE Imaging
746b		
746p		
746s		

The ceramic fabric consists of platey clay minerals forming a relatively coarse crystalline microstructure (0.01-0.02 mm), co-occurring with angular quartz grains (0.02-0.03 mm) and muscovite flakes (0.02 mm). A significant textural similarity is observed among the 16 micro-samples (Table 5).

Table 5. Petrographic and SEM-BSE images of seven representative micro-samples (phot. J. Michniewicz)

Sample No.	Reflected Light (CPL)	SEM-BSE Imaging
H6		
H7		
H13		
H19		
H22		
H31		
H33		

The proportion of clay minerals relative to quartz and muscovite remains consistent regardless of macroscopic features such as micromass color. The non-plastic components consist mainly of quartz silt with a minor amounts of alkali feldspars and dispersed muscovite flakes. The preserved platy habit of the clay minerals, along with the noticeable porosity, indicates a low degree of sintering. A summary of the major elements concentrations determined by SEM-EDS analysis, is presented in Table 6. The analyzed samples do not from a chemically homogeneous group, particularly with respect to the variable concentrations of SiO_2 and CaO.

Table 6. Chemical composition (wt%), mean (M) and standard deviation (SD) of hydria clay micromass determined by SEM-EDS analysis

Sample	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	Fe_2O_3	BaO
H1	0.5	2.4	28.3	46.9	4.6	0.8	1	15.4	0
H6	0.8	1.8	27.9	48	6,6	0	0	15	0
H7	1.1	2.5	27.6	46.5	6.5	1.4	0.6	13.9	0
H13	0.8	2.2	28.6	46.5	5.6	0	0.9	15.5	0
H19	0.9	3.2	27.2	46.7	6.8	0	0.7	14.5	0
H21	1	2.4	27.8	48.2	5.3	1	0	14.3	0
H22	1.1	2.4	26	45.4	7.3	0	0	17.8	0
H23	0	1.8	26.7	44	8.9	0	0	17.6	1
H29	1.3	2.2	28	45.6	7.5	1.5	0	13.9	0
H31	1.2	2.4	28.9	47.2	6	0	0	14.3	0
H32	0.8	2.2	26.3	41.3	11.6	0	1.9	16	0
H33	0.8	2.7	27.8	46.5	5.9	0	1	15.3	0
746b	1.2	2.2	27.4	46.1	9.1	0	0	13.9	0
746p	0	2.1	27.6	44.7	5.4	0	0.7	19.6	0
746s	0	2.3	29.2	48.1	5	0	0	15.4	0
M	0.8	2.3	27.7	46.1	6.8	0.3	0.4	15.5	0.1
SD	0.45	0.34	0.91	1.8	1.86	0.56	0.57	1.67	0.25

It is worth noting the chemical similarity between samples taken from both handles (746b, 746p), while the foot sample (746s) is distinguished by its lower CaO content. Moreover, the higher iron content observed in grey-colored samples relative to red ones may indicate a reduction firing process or the influence of later external factors contributing to the grey tint. Microphotographs of gloss cross-sections with marked analysis points are presented in Table 7. The chemical composition of the gloss is summarised in Table 8.

Table 7. SEM-BSE ~~M~~microphotographs of gloss cross-sections with marked analytical points (phot. J Michniewicz)

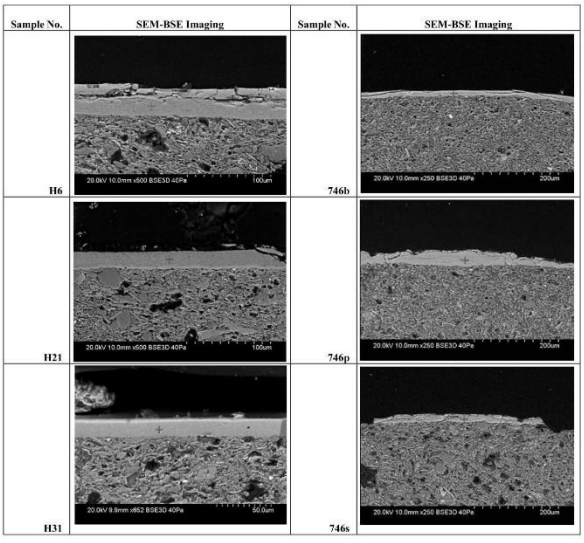


Table 8. Chemical composition (wt%), mean (M) and standard deviation (SD) of hydria gloss determined by SEM-EDS analysis. Micro-samples Nos. 12,14,15 are devoid of gloss

Sample	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	K_2O	CaO	TiO_2	Fe_2O_3
H1	0	5.91	18.88	53.64	0.84	0	3.25	7.04	0	10.45
H6	0.9	5.71	16.9	54.66	0	0	3.2	9.98	0	8.65
H7	0.69	6.01	16.53	53.25	0	0	3.28	10.07	0.82	9.35
H12	0.98	5.56	16.39	56.2	0	0	2.8	9.26	0	8.81
H13	<0.1	6.05	16.86	56.2	0	0	3.12	9.56	0	8.2
H14	1.06	6.27	18.91	52.05	0	0	3.67	8.64	1	8.4
H15	0.86	4.74	17.67	59.36	0	0	3.58	4.98	0	8.81
H19	1.11	5.73	16.45	51.17	1.59	1.24	3.81	8.8	0.76	9.36
H21	0.97	5.78	16.98	54.33	0	0	3.9	7.6	0	10.43
H22	1.04	5.35	15.83	59.32	0	0	2.57	7.27	0	8.63
H23	0.82	6.72	16.92	54.73	0	0	2.99	9.09	0	8.73
H28	1.14	5.48	17.35	54.97	0	0	3.5	5.85	1.7	10
H29	0	5.07	15.82	58.83	0	0	3.45	6.77	1.04	9.02
H31	0	5.07	18.6	55.37	0	0	3.57	6.11	0.87	10.41
H33	1.39	4.51	16.65	58.82	0	0	3.91	5	0	9.73
746b	0.77	6.52	17.35	52.75	0	0	3.51	10.33	0	8.77
746p	0.5	5.97	17.26	54.09	0	0	3.29	9.06	0.79	9.04
746s	0.77	5.41	18.04	56.02	0	0	3.64	5.31	0.92	9.88
M	0.76	5.66	17.19	55.32	0.14	0.07	3.39	7.82	0.44	9.26
SD	0.42	0.58	0.93	2.47	0.41	0.29	0.37	1.83	0.54	0.73

Notably, samples H23, H32, and 746b exhibit elevated potassium contents, whereas samples H22, H23, and 746p show higher iron concentrations. Considering the potential analytical uncertainty and the semi-quantitative nature of the measurements, the data suggest that the gloss forms a largely chemically homogeneous group.

Discussion

The pXRF analyses indicate that the gloss-covered sections of the vessel exhibit a chemically homogeneous composition. Similarly, non-glossed samples from the ornamental zone share a comparable chemical profile with the foot and rim fragment, which clearly does not belong to the examined hydria.

The presented evidence from pXRF analyses suggests that fragments of antique vessels were utilized in the reconstruction of the hydria, including both fragments from the original hydria and other vessels exhibiting similar chemical characteristics. The morphology of certain elements, such as a fragment of the rim and foot, indicates that fragments of other hydria were undoubtedly employed during the renovation process. In addition to antique fragments of Athenian provenance, fragments of undecorated fine ware and coarseware vessels, or other ceramic masses, were also incorporated. It can be hypothesized that these additions are related to the initial reconstruction of the vessel, although subsequent interventions cannot be discounted. The plaster-based fillings observed may be contemporary, with similar additions having been used in the 19th century or in a more recent period, perhaps related to the 20th-century reconstruction of the vessel, for example, following damage sustained during World War II. It can be hypothesized that the already aforementioned fragments of the rim and the foot are components of discrete vessels; however, this assertion is predicated on the observed disparities in their morphology, as opposed to any distinctions in the geochemical properties of their respective clay matrices.

The examined set of samples differs mainly in terms of ceramic body color and the content of two primary chemical components in the ceramic mass: calcium carbonate (reflected by CaO content) and silica (SiO_2). Iron content also varies but does not directly correspond to the ceramic body color. Distinct color groups include the grey and white-cream ceramics: {H1, H21}, {H22,

H29, 746s}, {H31, H28(?)}, and H33, H15. The remaining samples, characterized by a light red tint, form a particularly homogeneous set.

The chemical composition consistency among the fragments suggests that all parts were made from a raw material with similar mineral and chemical properties, even though the morphological features of the foot indicate that it belonged to a different hydria, also produced in an Athenian pottery workshop. The differences in ceramic body coloration are likely due to varying reduction-oxidation conditions the fragments experienced throughout their history, rather than arising exclusively during the initial firing process. These changes may have occurred due to later events, such as exposure to fire.

The fills interpreted as fragments from foreign vessels or intentionally crafted clay masses (measurements 219, 225 and 231) show significant variability in calcium content. Elemental concentrations vary depending on the analysis location, reflecting the inherent limitations of the applied method, which is characterized by relatively low precision.

Analogous variations were also recorded in glossed areas (measurements 234, 238 and 239), though these differences cannot be considered definitive evidence of different provenances for the ancient fragments. The analyses revealed a significant similarity in chemical composition and clay mineral development, combined with a relatively low degree of sintering.

Additionally, the chemical composition of the gloss demonstrates remarkable homogeneity, aligning closely with published data on Athenian ceramics [13]-[21]. These findings also correspond to ongoing research by the authors.

The archaeometric analyses conducted on the ancient pottery fragments employed in the reconstruction process have revealed that it is not feasible to determine whether these fragments originated from a singular vessel or multiple vessels. However, the analyses confirmed that the black gloss fragments with a high probability belong to vessels of Athenian provenience. The distinction between fragments belonging to a single vessel or originating from multiple vessels can only be determined through the meticulous observation of macroscopic characteristics. It can be hypothesized that the uniformity of shape and proportions indicates that, in the majority of cases, these are fragments of one or several Athenian hydriae from the classical period. Disturbances in the profile line may be indicative of the fragment originating from a vessel of a different, albeit similar, shape.

Based on the ceramic body characteristics, vessel shape, and key stylistic features of the hydria's painted decoration, it can be inferred that fragments from several high-quality vessels produced in Athenian workshops were used during its reconstruction. In the case of connected fragments that exhibit analogous visual surface features, such as gloss quality, density, and color, it can be postulated that they originate from one vessel. Conversely, in the case of fragments where adjacent surfaces differ visually, and the observed features on one fragment are not continued on the neighboring surface, it can be deduced that they likely belong to different vessels.

In certain instances, minor mechanical processes such as surface grinding were employed to correct the profile lines. This observation indicates that fragments of vessels with a similar overall shape, albeit from different hydrias, were incorporated into the reconstruction. The utilization of surface grinding, particularly at the juncture where fragments converge, for the purpose of leveling the profile line, may suggest the incorporation of components from disparate vessels, exhibiting varying proportions. However, mechanical corrections, incorporating substantial cutting and polishing of the surface, were employed to facilitate the integration of the fragments of the foot. These corrections can be regarded as substantiating evidence that fragments of various hydria were used in the reconstruction of this vessel. Furthermore, the presence of a smaller fragment in a rim reconstruction and asymmetrically inserted fragments within the body of the vessel indicate the employment of fragments of different vessels during the reconstruction process.

Concerning the foot fragment, it can be hypothesized that mechanical correction was required due to the erroneous integration of two fragments of the same vessel. However, significant disparities in size and proportion between the fragment and the remaining rim are evident, thereby indicating that the fragment is, in fact, that of another vessel deliberately placed as a missing part filler.

The reconstruction techniques described above were widely used in 19th-century Italian workshops specializing in restoring ancient vessels unearthed during amateur excavations. Notably, the workshop of Raffaele Gargiulo was prominent in this field [22], [23]. It is evident that a significant number of artifacts categorized as restoration works from this and analogous workshops of the period in question exhibit missing sections that have been filled with fragments from other ancient artifacts of the same class. These added fragments were sometimes aligned according to the vessel's original structure, though in other cases, they were asymmetrically inserted, as seen in the examined hydria. Restoration practices of the time also included not only color-matching the background of decorative compositions but also even recreating missing sections of figurative decorations. It is important to note that similar techniques of reconstruction of missing decorative composition were still applied in early XX century conservation and restoration projects. In the case of the hydria under investigation, it is also possible to identify missing parts in the zone of the figural decoration, which has been completed and on which the missing parts of the figural composition have been reproduced.

The observed differences in clay coloration, as well as the matte and greyish surfaces of some fragments adjoining others with typical Athenian fired clay features, require careful consideration. These characteristics cannot be attributed to fills from other vessels, as they appear within the complex and original figurative decoration of the hydria. This includes matte, greyish-surfaced fragments originally covered with high-quality gloss, as well as detached foot and handle pieces with grey clay visible on breaks. It should be noted that such features in the surface color refer both to surfaces covered with gloss, which are grey, often with cracked or flaking gloss, and are recorded within the figurative ornament. In such contexts, adjacent parts of the composition are observed to match; one fragment is grey, while the other has the color characteristics of fired Athenian clay. The recorded differences in clay coloration are likely, as suggested by archaeometric analysis, the result of varying oxidation-reduction conditions experienced during the vessel's history – not necessarily during its initial firing. Given the minimal historical data on the origin and history of hydria, only cautious hypotheses can be put forward.

One plausible explanation for the observed changes is secondary exposure to high temperatures, possibly related to ritual burning during funerary ceremonies. This phenomenon has been extensively discussed by V. Sabetai regarding lekythoi with characteristic surface discoloration, where in-depth research connected the vessels to their probable funerary context. As Sabetai emphasizes, rituals often involved breaking vessels of special significance, such as lekythoi, after use in funerary ceremonies [24]. There are also examples of hydria displaying analogous signs of secondary damage and probable burning, such as the Piraeus find [25]. Although the publication does not provide details of the context of the find, archaeological investigations carried out on the area revealed, among other things, relics of a necropolis [26].

As V. Sabetai mentioned in her work [24, p. 298], the custom of breaking and burning vessels in funeral pyres was recorded in Greek funerary practices as early as the Archaic period [27]-[31]. Broken and fire-damaged black- and red-figure vessels have been discovered at Athens' Kerameikos [32], [33], [34] and other areas in Attica [35], [36]. This practice was more common in cremation burials but also occurred in South Italian colonies, where archaeological evidence points to vessels being smashed and thrown into funeral or sacrificial pyres [37].

Considering the context of religious ceremonies held within sanctuaries dedicated to deities, the practice of offering ceramic vessels as sacrificial offerings was also observed. The figurative scene

on the hydria - likely associated with the lives of women, possibly unmarried maidens - the decoration may be connected to the cults of Hera, Demeter, Aphrodite, and Artemis [38]-[42]. Similar discoloration patterns are observed on many museum-held vessels. This includes hydria and pyxide from the Czartoryski Princes' Collection in Kraków, whose original provenance is unknown but were reportedly purchased in Athens. Archival records suggest that the pyxis originated from a funerary context [43].

However, it is possible that subsequent historical events, particularly those that occurred during World War II and the postwar period, may also have contributed to the vessel's deterioration. There are no extant conservation records from the period when the Gołuchów collection was held in the former USSR, and there is no evidence to confirm the occurrence of conservation activities in Moscow. Nor can the examined hydria be definitively linked to any such efforts. However, the absence of such data does not necessarily imply that the vessel was not damaged in some way during the war or was not subjected to conservation measures when it was held in the USSR. If conservation work was carried out, it is likely to have been limited to surface cleaning, filling of small gaps, and color matching of visible areas. However, archival documentation does not reveal any significant changes in the arrangement or conservation of the fragments since their reconstruction in the 19th century. This assumption applies only to the decoration zone, the only part of the vessel for which engravings have been published in early modern period catalogues. This supports the interpretation that damage to the vessel (including the traces of secondary burning), understood as the original Athenian hydria with figurative decoration, resulted from its ritual use and functional history rather than modern interventions.

The analysis of interventions applied to the vessel suggests at least three distinct phases of conservation aimed at reconstructing its shape and preserving the artifact in good condition. The first conservation phase likely occurred shortly after the vessel's discovery, possibly in the late 18th or early 19th century. This phase involved reconstructing the vessel's shape using fragments from the original hydria, pieces from other ancient hydriae, and fine ware ceramics. These actions also included using undecorated ceramic fragments and ceramic mass to fill gaps, such as those in the foot and belly of the vessel. The addition of gypsum fillings may belong to a later conservation phase, probably from the second half of the 19th or 20th century. The plaster fillings could have been applied either before or after Izabela Działyńska became the owner of the vessel. As mentioned above, it is possible that these reconstructions were carried out in connection with subsequent work to repair the vessel after the Second World War, a period during which the hydria was relocated several times. The question of the timing of the figurative decorations' reconstruction, including the painting of missing elements of the composition, remains unresolved. Archival catalogues of engravings show these areas as unfilled, which suggests that these spaces were filled in but the drawing was not reconstructed. It should be noted that this was a procedure rarely used by restorers in the 19th century. There are numerous documented examples of figurative ornamentation being restored to black- and red-figured vessels during the early modern period in restoration studios. Alternatively, the figurative reconstruction may have been executed during a subsequent intervention in the 20th century.

The third and most recent conservation phase is characterized by the presence of synthetic resins with iron-based pigments used as binding agents. These materials, as identified through analysis, suggest endeavors to reinforce the vessel's structure or, conceivably, a complete reconstruction. However, given that the samples were obtained exclusively from surface layers and fragment junctions, the precise extent of these repairs remains ambiguous. The use of synthetic substances indicates modern conservation activities; however, the exact timing of these interventions remains unclear due to the limited historical documentation of the vessel. According to records held by the National Museum in Poznań, the hydria underwent no conservation treatments beyond surface cleaning following its arrival at the museum. Furthermore, there is a

paucity of information regarding the conservation treatments to which the hydria was subjected during its period in the collection of the National Museum in Warsaw. According to Tomasz Dziurdzik, curator of the Ancient Art Collections of the National Museum in Warsaw, the museum certificate of the Hydria in 1967 included the information that the belly was glued together from many fragments and partially filled with plaster; the foot, rim, and handles were also glued, and one of the horizontal handles was partially filled with plaster. On the basis of the information given, it is not possible to determine whether this is the condition in which the vessel arrived at the National Museum in Warsaw or whether it is a description of the procedures carried out in the museum.

Conclusions

Analyzing the arrangement of joined fragments and their macroscopic characteristics suggests that the hydria was primarily reconstructed from pieces of a single vessel. Approximately 20% of its surface consists of foreign ceramic fragments from other hydriae or vessels of different shapes. However, the petrographic and chemical similarity between these foreign fragments and the original ceramics indicates a shared Athenian provenance.

The conservation analysis suggests that the hydria was discovered in numerous fragments, likely originating from a funerary context. It may have been broken and burned in a funerary or sacrificial pyre as part of religious burial rituals. The first reconstruction phase involved restoring the hydria's shape using original vessel fragments and parts from other vessels with similar or different shapes, all of Athenian origin. Ceramic and clay mass fills were likely applied either during this initial phase or later. Gypsum fills, characteristic of later conservation practices, were likely added in the late 19th or 20th century. The hydria might have undergone additional restoration throughout the 20th century, as indicated by gypsum fills and possibly, but unlikely, the reconstruction of the decorative ornamentation. The exact timing of these interventions remains uncertain, possibly occurring during World War II or afterward, either in Moscow or a Polish conservation laboratory. The presence of synthetic substances – modern adhesives and pigments – provides clear evidence of contemporary conservation treatments.

In summary, while the hydria's reconstruction history remains partially unclear due to limited documentation, the analyses confirm a complex conservation process involving multiple phases over a long historical period.

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