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Redakcijos adresas / Editorial Board address:
Lietuvos istorijos institutas, Archeologijos skyrius
Tilto g. 17, LT-01101 Vilnius
Tel. (+370) 5 2614436, fax (+370) 5 2611433
e-mail: lietuvosarcheologija@gmail.com;
civilytea@gmail.com

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# 14TH–15TH CENTURY POTTER'S WORKSHOP IN VILNIUS, SUBAČIAUS STREET 11: STATISTICAL ANALYSIS OF THE SHAPES OF HOUSEHOLD POTTERY

OKSANA VALIONIENĖ

Lithuanian Institute of History, Department of History of the Grand Duchy of Lithuania, Tilto str. 17, LT-01101 Vilnius, Lithuania, e-mail: o.valioniene@gmail.com

*In this article, the shape of 14th–15th century pottery from Subačiaus Street 11, Vilnius, is analyzed through the application of big data analysis techniques (relational data model, Structured Query Language (SQL), programming language Python, and statistical methods). Two main tasks were carried out as part of this study, namely, the classification of the earliest shapes of pottery found in the potter's workshop in Vilnius and the implementation of IT methods in the research of archaeological household pottery of Vilnius. A total of 1628 fragments of the upper part of vessels and complete vessels from two middens were analyzed to discern a morphological relationship of assemblages, to assess the diversity of shapes, as well as similarities and differences in techniques used during production. Further tasks include the classification of the shape of rims, profiles, and decorations. Both middens were found to contain pairs of similarly shaped sherds, leading us to conclude that although production was characterized by similar features, they were not identical—possibly due to minor differences in the chronology of the assemblages, different circumstances of artifacts' deposition in archaeological layers, or because the two middens were used by several craftsmen with a common work experience.*

***Keywords:*** pottery production, morphology, descriptive statistics, Pearson correlation coefficient, Vilnius, the Middle Ages.

*Straipsnyje, remiantis didelių duomenų analitikos metodais (reliacinis duomenų aprašymo modelis, struktūrinė užklausų kalba SQL, programavimo kalba Python, statistiniai metodai), analizuojamos Vilniuje, Subačiaus g. 11, rastos XIV–XV a. puodžiaus dirbtuvės gaminių formos. Tyrime sprendžiamos dvi užduotys: ankstyviausios mieste rastos puodžiaus dirbtuvės produkcijos formų klasifikavimas ir IT metodų diegimas Vilniaus archeologinės buitinės keramikos tyrimuose. Ištirta 1628 viršutinės indo dalies fragmentai ir sveiki puodai iš dviejų ūkinių duobių. Nustatytas kompleksų morfologinis ryšis, apibūdinta formų įvairovė, modeliavimo panašumai ir skirtumai. Klasifikuotos briaunų, ornamentų ir profilio formos. Abiejose duobėse identifikuotos vienodos formos radinių poros. Prieita išvada, kad produkcijai būdingi artimi, bet ne identiški bruožai. Tai galėjo lemti nedideli kompleksų chronologijos skirtumai, nevienodos radinių patekimo į sluoksnį aplinkybės arba duobių priklausomybė keliems meistrams, turėjusiems bendrą darbo patirtį.*

***Reikšminiai žodžiai:*** buitinės keramikos produkcija, morfologija, aprašomoji statistika, Pirsono koreliacijos koeficientas, Vilnius, viduramžiai.

## ARCHAEOLOGICAL CONTEXT

During the 14th and 15th centuries, the city of Vilnius underwent the most intense period of development, during which the individuality of the spatial framework emerged and laid the basis for its further progression. The domestic pottery of this period is a primary source for dating archaeological layers and understanding the city's historic construction phase.

In Vilnius, pottery studies have been ongoing for more than 40 years and are dominated by three main themes: a) research into production technology, b) the origin of imported vessels, and c) the shapes of locally produced pottery. Gediminas Vaitkevičius greatly contributed to the research on production technology by defining the main characteristics of 14th-17th century pottery from Vilnius. He established the dating of technological changes in production and studied characteristics of clay deposits and fabric used for making the pottery (Mikaila, Vaitkevičius, 1983; Jasiukevičius, Vaitkevičius, 1999; Vaitkevičius, 1999; 2000, 174–175; 2004; 2010b, 114–121, figs. 24–31; 2010c).

The question of imported vessels has been the focus of a number of Vaitkevičius' early works (Vaitkevičius, 1981; 1982; Mikaila, Vaitkevičius, 1984). Miglė Urbonaitė-Ubė carried out a much more detailed study on this question (Urbonaitė-Ubė, 2015; 2018; 2022). The third direction of research concerning the shapes of locally produced pottery, has also been the focus Vaitkevičius' studies. Here, he classified the artifacts according to physical attributes (such as capacity, shoulders and neck of vessels) that reflect their function.[1]

Vaitkevičius' research results served as the methodological model in a number of significant studies concerning the development of Vilnius during the 13th–17th centuries (Katalynas[2], Vaitkevičius, 1995; 2001; 2002; Vaitkevičius, 2000; 2010a; 2010b; 2010c; Vaitkevičius, Kiškienė, 2010; Jonaitis, 2013; Kaplūnaitė, 2015; Jonaitis, Kaplūnaitė, 2020; Йонайтис, Каплунайте, 2017; Каплунайте, 2013; 2017).

However, further research perspectives are still limited by the present possibilities for chronological dating of pottery and the applicability of the established classification. The vast quantities of sherds that have to be analysed in the absence of a unified database, or the lack of a system that permits searching for similar objects and meeting modern scientific standards poses a key problem. Thus, to verify the conclusions of earlier studies, sherds have to be re-examined by establishing a digitalized classification system which allows us to automatically analyse large quantities of pottery.

The issue outlined above can be solved by forming a database of morphological attributes of household pottery collected in Vilnius, an automatic system of classification of shapes, and a system that would allow the search for similar artifacts. Such tools have been in use in world archaeology since the 1970s (Hagstrum, Hildebrand, 1990; Gilboa et al., 2004; Karasik, Smilansky, 2011; Smith et al., 2014; Lucena et al., 2017) and they are becoming increasingly popular owing to the development of the internet and other information technologies (Karl et al., 2022, Fig. 5).

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1 In his thesis, the author divides the vessels into the following series: low-profiled pots (series 'T'), globular pots with an evenly tapering upper part (series 'P'), jugs with a high, distinctively profiled, rounded top (series 'U'), vessels with rounded shoulders (series 'A'), with a heavily tapering lower part (series 'S'), and pots with no neck (series 'B'). Jugs were classified according to the point of the center of gravity and the shape of the neck; classification of pans and bowls was based on the ratio of the height to the diameter; whereas the plates were classified by the shape of their lower and upper parts (Vaitkevičius 1999, 16, 65–69). A different approach to classification is presented in a later publication on the 14th–17th century pottery from Vilnius (Vaitkevičius, 2012). Here, part of the vessels was sorted according to their function: pots, vase-shaped vessels, smaller vessels, 'inkwells', the 'Krus' jugs, tankards, and cups, bowls, vessels with a function between that of a jug and a pot, jugs, drinking vessels, and vessels with a large capacity for storing and transporting liquids. The other part of the vessels was classified by Vaitkevičius according to its shape: pots with sloping shoulders, tall, wide-mouthed, round (barrel-shaped) pots, pots with straight shoulders, pots with a crease between the body and the shoulders, low-profile, and bucket-shaped pots.

2 The monograph by Kęstutis Katalynas on the development of Vilnius (Katalynas, 2006) abandons the classification of household pottery established by G. Vaitkevičius and uses data from archaeological excavation reports.

The choice of tools depends on the task at hand,[3] while the success of its performance is determined by two fundamental factors: the universal principles of the analysis of vessel geometry and the creation of a site-specific database. In the case of Vilnius, it is appropriate to start by recording the common visual attributes such as coordinates of the vessel profile and axis of rotation, dimensions and shape of the rim, neck, shoulders, firing, glaze, and so forth. The scope of such a study renders the classical typological method unsuitable for managing big data. Instead, mathematical methods of information technology, such as the relational data model,[4] Structured Query Language (*SQL*), and *Python* programming language[5] can be used.

The correlation coefficient[6] between the coordinates of the outer contours of two matched sherds and the area between their outer contour was calculated to compare vessel shapes and search for their parallels.[7] Further, in order to classify the shapes, the profile of vessels was divided into basic parts for their measurement and statistical analysis.

The remains of an exceptional archaeological object, a medieval potter's workshop at Subačiaus Street 11, is a fitting case study for starting the development of an information system. It is an enclosed archaeological context where several thousand pottery sherds of similar chronology and shape have been recovered from two middens (hereafter referred to as "Pit 1" and "Pit 2," Fig. 1). The choice of this particular archaeological site is important in several respects: it allows us to both test the capabilities of the information system under development, and assess the diversity of the products of a single workshop to determine the standard of forms and the range of errors.

As aforementioned, the archaeological site at Subačiaus Street 11 revealed two middens containing deposits of domestic pottery. Pit 1 was investigated between 1985 and 1996 (Raškauskas, 1987; Grišinas, 1995a; 1995b; Sarcevičius, 1996). It measured 5.5x4 meters in size and more than 1 meter in depth, and the bottom of the pit was not reached due to the high levels of groundwater (Grišinas, 1995b, 3). It was filled in two phases: the first, with soil and small stones, and the second with soil and animal bones, fish scales, eggshells, charcoal, burnt wood, occasional fragments of bricks, stones, and more than 10,000 sherds of unglazed pottery (*ibid*).

Archaeologists believe that the pit was not originally intended for the disposal of pottery spoilage, as the sherds were discovered alongside unused vessels. This is also evidenced by the fill that was deposited during the first phase (Fig. 2), which is almost entirely devoid of pottery sherds. Thus, it has been suggested that the pottery and burnt wood may have been deposited here after the fire in the potter's workshop (Grišinas, 1995a, 247–248).

Pit 2 was discovered in 2006, situated about 9–10 meters further to the east (Jonaitis, 2006; 2007).

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3 For instance, digital recording and classification according to vessel shape, segments and other attributes, analysis of the function and capacity of vessels, virtual reconstruction, and so on.

4 The relational model is a model for describing data based on predicate logic and set theory, developed by Edgar F. Codd in 1970. A Latin word for 'predicate' means an attribute of an object. Set theory is a branch of mathematical logic that deals with sets (collections of objects).

5 *Python* programming language libraries used in this study include: *numpy*, a package for calculations, mathematical and logical operations, data sorting and selection (available at https://numpy.org/doc/stable/ [accessed 23.03.2023]); *pandas*, a package for data analysis (available at https://pandas. pydata.org/ [accessed 23.03.2023]); *seaborn*, a statistical data visualisation library (accessed via: https://seaborn.pydata.org/ [accessed 23.03.2023]); *Pillow*, a digital illustration management library (accessed via: https://pillow.readthedocs.io/en/stable/ [accessed 23.03.2023]).

6 The correlation coefficient is a measure of the strength of the statistical relationship between variables, with values ranging from -1 to +1. The correlation between identical curves is 1. For the application of this method in household pottery, see Hristov, Agre 2013 (90–91).

7 The smaller the area, the more similar the curves. The area between identical curves equals 0.

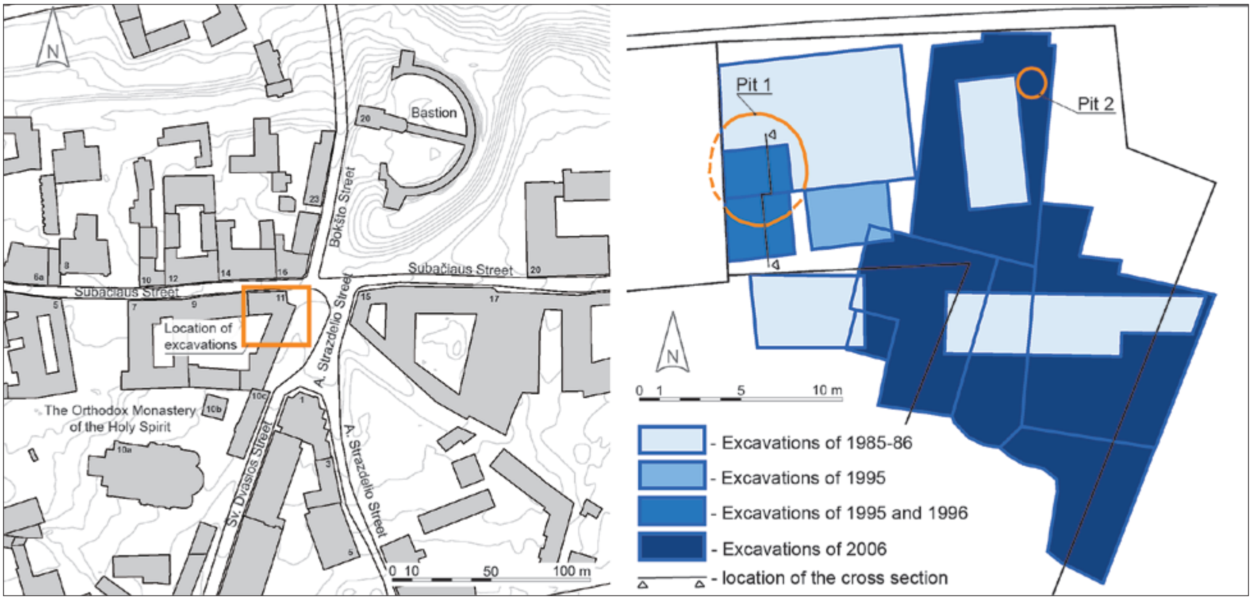


Fig. 1. Archaeological excavations at Subačiaus Street 11. Plan of the location. *Drawing by O. Valionienė* based on Raškauskas 1987, drawing No. 5; Grišinas 1995b, drawing No. 2; Sarcevičius 1996, drawing No. 1; Jonaitis 2007, drawing No. 2.
1 pav. Subačiaus g. 11 archeologiniai tyrimai. Situacijos planas. *O. Valionienės brėžinys*, sudarytas remiantis: Raškauskas 1987, brėž. Nr. 5; Grišinas 1995b, brėž. Nr. 2; Sarcevičius 1996, brėž. Nr. 1; Jonaitis 2007, brėž. Nr. 2.

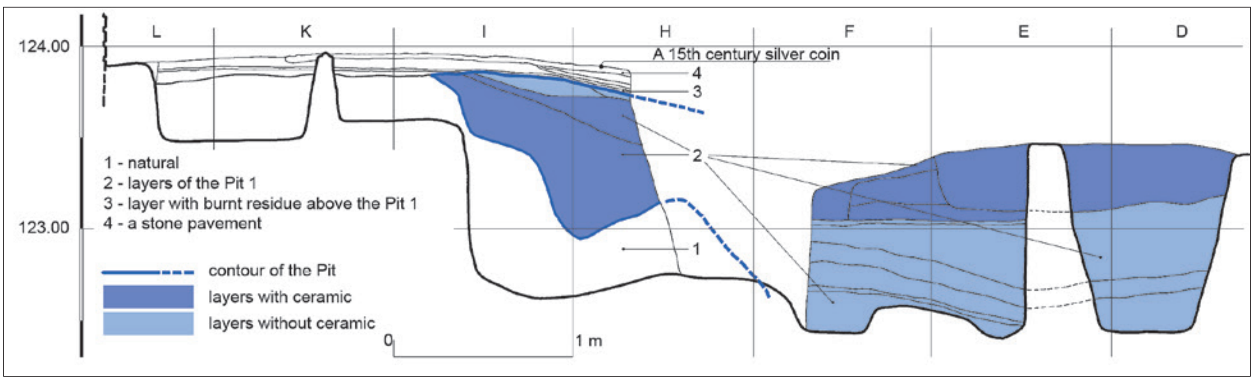


Fig. 2. Section drawing of Pit 1 (see Fig. 1 for the location of the pit and the cross section). *Drawing by O. Valionienė* based on Sarcevičius 1996, drawing No. 3.
2 pav. Duobės Nr. 1 pjūvis (duobės ir pjūvio vietą žr. 1 pav.). *O. Valionienės brėžinys,* sudarytas remiantis: Sarcevičius 1996, brėž. Nr. 3.

It measured around 1.4 meters in diameter and 0.34–0.36 meters in depth (Jonaitis, 2007, 52). The smaller midden contained a total of 1,121 finds, 1,100 of which were sherds of domestic pottery (*ibid,* 60).

The proximity and similar stratigraphy of middens suggests a possible relationship between them. Researchers who excavated Pit 2 indicated that the contained archaeological "material is younger by a quarter" [25 years? – O.V.] (*ibid*, 52) and that a "continuity of craftsmanship by the craftsman-potter is traceable in the pit" (*ibid*, 52–53). Notably, Pit 1 contained vessels with fingerprints of an adult and a child, possibly an apprentice (Sarcevičius et al., 1999, 224). Consideration of both these statements raises a question: could the grown-up apprentice have been the owner of Pit 2? Although the answer cannot be ascertained, one thing is certain: the middens were used by several craftsmen, who likely shared a common working experience.

The excavation reports and publications are not consistent in terms of the dating of middens. The latest chronological point for Pit 1 was determined by a 15th century Lithuanian silver coin of the so-called "Type 3," with Vytis on the obverse and the Columns of Gediminas on the reverse (Grišinas, 1995b, 4–5), that was discovered on the pavement which covered the pit (Fig. 2). The coin was originally dated back to the end of the 14th to the middle or second half of the 15th century (Grišinas, 1995a, 248).

Subsequently, experts in numismatics clarified that it is indeed a silver coin of Grand Duke Casimir of Lithuania (reigned from 1440–1492), and attributed to "Type 3" (Грималаускайте, Синчук, 2007, 184, 189). It is presumed that such coins were minted around 1450–1460 (Grimalauskaitė, Remecas, 2016, 150), which means that the latter coin was deposited on the pavement no earlier than the mid-15th century. The earliest chronological point for the dating of the midden is unknown.[8]

Thus, it is acknowledged that the probable date range covers the period from the formation of this particular part of the city to the point when the coin was deposited on the pavement, which is essentially some point between the 14th and 15th centuries.[9]

Pit 2 was dated to the last quarter of the 14th century and the beginning of the 15th century based on the assemblage of finds discovered inside the pit (Jonaitis, 2007, 52–53). However, no dating criteria or method were provided; as such, the chronology of Pit 2 remains debatable.

## METHODOLOGY

For the study of pottery shapes, 1,441 sherds of the upper part of vessels[10] from Pit 1 and 187 sherds[11] from Pit 2 were sampled (see Annexes 1, 2 for

[8] The pit was dug into an undated earliest surface level and reached the natural level. No informative archaeological material was found inside the pit.

[9] Archaeologists have provided varying dates for pottery recovered from the midden, ranging from the end of the 14th century to the first half of the 15th century (Sarcevičius et al., 1999, 222); from the fourth quarter of the 14th century and possibly the first half of the 15th century (Vaitkevičius, 2012); and from around the middle of the 14th century on (Jonaitis, 2007, 52–53).

[10] The sherds are stored in the National Museum of Lithuania. Inventory numbers: 2–9, 11, 12, 15, 17–25, 27, 29–32, 34–37, 39, 41, 42, 44, 46, 48, 50, 53–55, 57, 61, 63, 64, 68, 70, 71, 73–75, 78, 85, 90–94, 96, 98–101, 103–124, 126, 128–130, 132–138, 140–145, 147, 148, 150, 152–155, 159, 160, 163–165, 167–171, 173–180, 182–203, 205–208, 210, 212–240, 242–273, 276–279, 281–283, 285–289, 291–295, 297–299, 301–304, 306–309, 311–324, 327–346, 348–408, 410–446, 448–527, 529–537, 539–583, 585–606, 608–613, 615–622, 624–628, 630–652, 654–660, 662–667, 669, 671–682, 684, 686, 687, 690–698, 701–703, 705–724, 726–732, 734–745, 747–750, 754–763, 766–772, 775, 777–794, 796–812, 818–826, 828–831, 833–835, 837–839, 841–848, 851–883, 885–892, 894–900, 902–904, 906, 907, 911, 913–916, 918–930, 933–939, 941–959, 961, 962, 964, 965, 967, 968, 970–974, 976–981–997, 999, 1069, 1079, 1080, 1082, 1083, 1101–1129, 1291–1313, 1154–1171, 1137–1152, 1048–1062, 1240–1253, 1034–1046, 1193–1204, 1206–1217, 1011–1021, 1219–1229, 1324–1334, 1348–1358, 1000–1009, 1184–1191, 1315–1322, 1085–1091, 1093–1099, 1256–1262, 1264–1270, 1368–1374, 1231–1236, 1284–1289, 1024–1028, 1131–1135, 1336–1340, 1177–1180, 1343–1346, 1030–1032, 1065–1067, 1070–1072, 1075–1077, 1173–1175, 1182, 1238, 1272–1274, 1276–1278, 1280–1282, 1362–1364, 1366, 1376–1380, 1382–1397, 1399–1404, 1406–1419, 1421–1434, 1436–1446, 1448–1452, 1454, 1455, 1457–1459, 1461–1464, 1466–1471, 1474, 1476, 1478–1497, 1499–1501, 1503–1505, 1550, 2101–2105, 2107, 2108, 2110–2116, 2118, 2119, 2122–2133, 2135, 2139, 2146, 2148–2151, 2153, 2157, 2165–2169, 2171–2174, 2178, 2179, 2181, 2182, 2195, 2196, 2199, 2200, 2203, 2208, 2213, 2214, 2219, 2222, 2225, 2228, 2230, 2235, 2336, 2400, 2403–2405, 2998, 4057.

[11] The sherds are stored in the National Museum of Lithuania. Inventory numbers: 5501–5508, 5510–5522, 5524–5530, 5532–5552, 5554–5560, 5562–5576, 5578–5648, 5650–5678, 5680–5687, 5724, 5813, 5814, 5830, 5831, 5833, 6445, 6533.

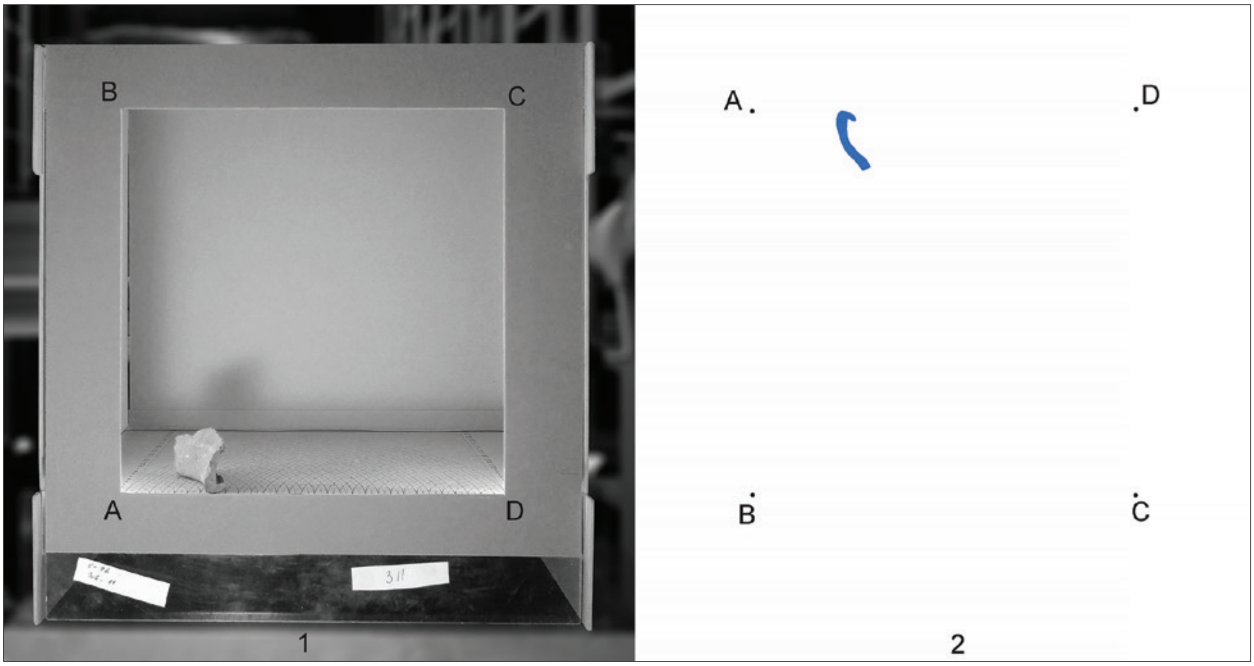


Fig. 3. 1 – The equipment for photographing the sherds; 2 – A drawing of a profile. *Photo and drawing by O. Valionienė.*
3 pav. 1 – šukių fotografavimo įranga; 2 – profilio brėžinys. *O. Valionienės nuotrauka ir brėžinys.*

statistical analysis of the shapes). The visual features of the rim shape, ornamentation, and the profile of vessels were recorded. The profile was recorded if the sherd preserved at least part of the shoulders, the diameter of the mouth was known and the angle of the curve in respect to the upper plane of the vessel was known (a total of 1,424 pieces from Pit 1 and 91 pieces from Pit 2).

Furthermore, a combined method of photography and drawing was chosen for recording. The photographs were taken using a rectangular frame in which the sherds were placed with the central axis at the edge of the frame (Fig. 3; 1). The geometry of the photographs was corrected according to the location of the corners of the frame (Fig. 3; points A, B, C, D) – revising possible errors and adjusting the size, resolution, and rotation angle of the frame.[12] Profiles were then hand-drawn on the edited photographs by using a touchscreen. The coordinates of its edges were scanned and entered into the database.[13] The center of the coordinate system is located at the intersection of the vessel's central axis and the upper plane (Fig. 3; segments AB and AD, intersection at point A). The coordinates were used to calculate the dimensions of the rim, neck, and shoulder as well as angle of inclination.

[12] Photo editing was performed using the *Python* programming language libraries *numpy* and *Pillow*. For the perspective editing of photos based on 4-point coordinates, see: https://stackoverflow.com/questions/14177744/how-does-perspective-transformation-work-in-pil [accessed 14.03.2023].
[13] For coordinate scanning, see: https://stackoverflow.com/questions/60051941/find-the-coordinates-in-an-image-where-a-specified-colour-is-detected [accessed 14.03.2023].

## THE WALL THICKNESS, THE DIAMETER OF THE MOUTH, AND THE CAPACITY OF VESSELS

Both middens were found to contain pottery with similar wall thickness. Pottery sherds from Pit 1 share a mean thickness of 7.5 mm, a median of 7.3 mm, and a standard deviation (σ) of 1.3 mm, with 73.1% of the values falling within the 1σ range of 6.2–8.8 mm. Non-standard thicknesses fall in the intervals 3.85–4.25 mm and 10.5–17.9 mm, and are present in 2.9% of sherds.

Pottery sherds from Pit 2 display a slightly higher mean wall thickness of 7.7 mm, but a lower median of 7.4 mm and a standard deviation (σ) of 1.6 mm. 72.5% of the values fall in the 1σ range 6.1–9.3 mm, with exceptional values in the range of 11.8–13.4 mm (2.2% of the sherds). A comparative analysis of these results suggests that Pit 2 is characterized by slightly thicker products and greater variation in thicknesses (Fig. 4).

In Pit 1, the mean diameter of the vessel's mouth is approximately 167 mm, its median is 164 mm, and its standard deviation is 26 mm. 75.8% of the values fall within the 1σ range of 141–193 mm. Non-standard values fall within the intervals of 104–110 mm and 221–440 mm, with 6% of the sherds exhibiting such features. A very similar average diameter of pot mouth was recorded in Pit 2, measuring 166 mm with a lower median diameter of 153 mm. The standard deviation is 46 mm (higher than in Pit 1). 72.5% of the values fall within the 1σ range 120–212 mm. Non-standard values occur in the intervals of 70–96 mm and 222–416 mm, and as many as 10% of the sherds measured to this diameter. Thus, Pit 2 evidently contained a wider range of pot sizes, with a higher proportion of smaller vessels than the finds in Pit 1 (Fig. 5). This may be related to a greater variation in the function of vessels.

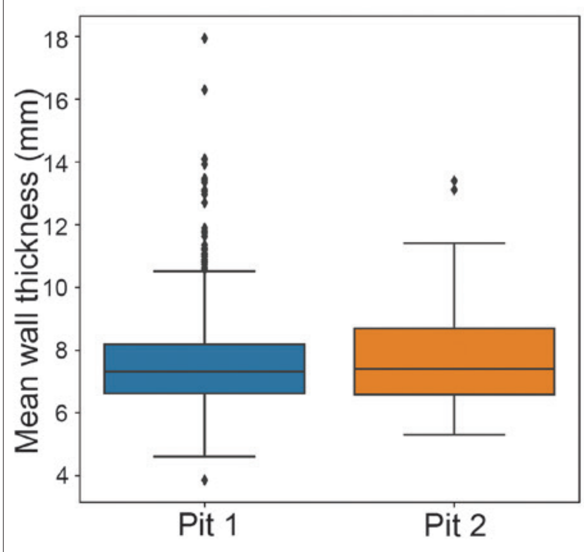


Fig. 4. Thickness of vessel walls. *Data visualisation by O. Valionienė*, using *Python* library *seaborn* (available at https://seaborn.pydata.org/).
4 pav. Indų sienelių storis. *O. Valionienės duomenų vizualizacija*, naudojant *Python* biblioteką *seaborn* (interneto prieiga https://seaborn.pydata.org/).

The capacity of vessels is another indication of their function and production standards. Vaitkevičius' publication on 14th–17th century pottery (Vaitkevičius, 2012) is helpful for the description of vessel capacity as it records 37 complete pots from Pit 1[14] (Fig. 6).

According to this publication, the mean vessel capacity is approximately 4 l, the median is 3.9 l, and the standard deviation (σ) is 1.4 l (1σ range: 2.6–5.4 l). The vessels of non-standard size have capacities of 0.77–1.1 and 7.1–7.8 l. All diagrams show a relatively wide range of values, indicating that this workshop did not follow a standard in the production of vessels.

[14] Since no complete vessels were found in Pit 2, data on their capacity is not available.

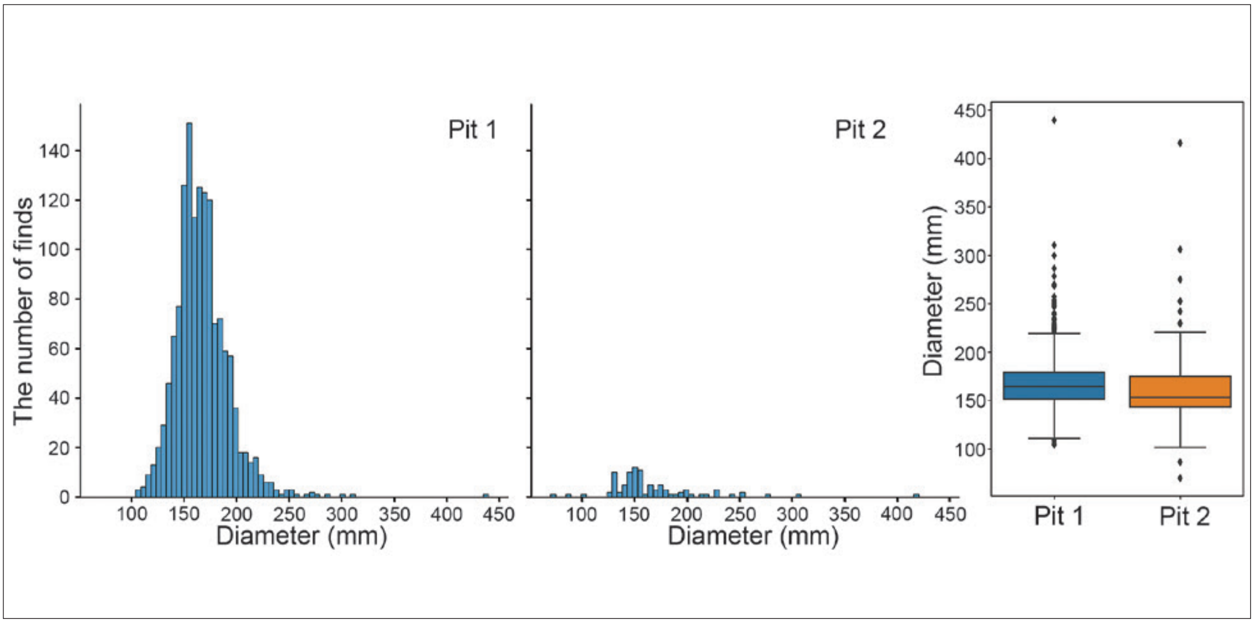


Fig. 5. Diameter of vessel mouth, measured at the top of the rim. *Data visualisation by O. Valionienė*, using *Python* library *seaborn* (available at https://seaborn.pydata.org/).

5 pav. Indų angos skersmuo, matuotas briaunos viršutiniame taške. *O. Valionienės duomenų vizualizacija*, naudojant *Python* biblioteką *seaborn* (interneto prieiga https://seaborn.pydata.org/).

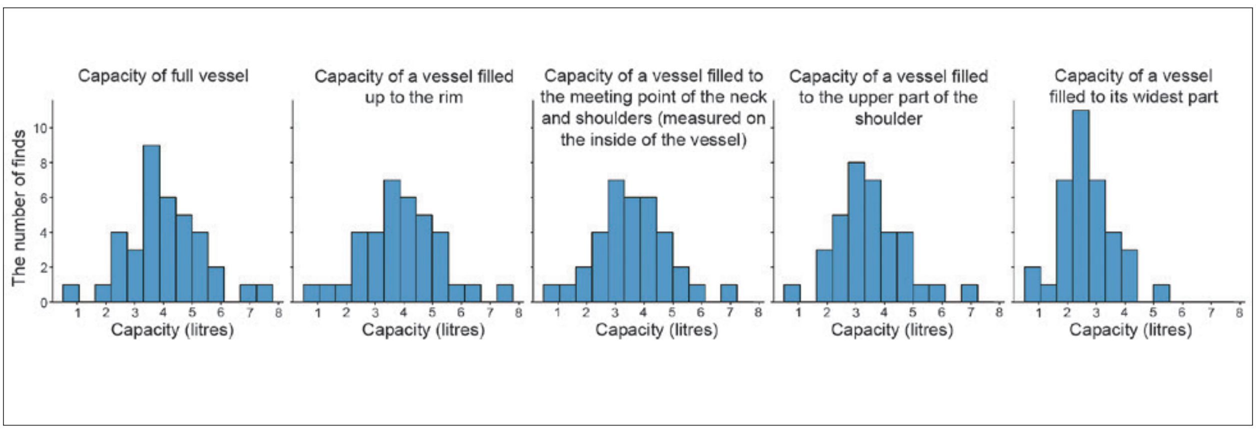


Fig. 6. Capacity of vessels, Pit 1 (based on Vaitkevičius, 2012). *Data visualization by O. Valionienė*, using *Python* library *seaborn* (available at https://seaborn.pydata.org/).

6 pav. Indų tūris, duobė Nr. 1 (remiantis: Vaitkevičius, 2012). *O. Valionienės duomenų vizualizacija*, naudojant *Python* biblioteką *seaborn* (interneto prieiga https://seaborn.pydata.org/).

## COMPARISON OF POTTERY PROFILES AND IDENTIFICATION OF SIMILAR FORMS

The similarity between pottery sherds forms was determined by calculating the Pearson correlation coefficient ($r_{xy}$) of the contour coordinates. Calculation of the coefficient returns 1 if the two vessels have the same shape, regardless of the diameter of their mouths. It returns a 0 value if the forms are completely dissimilar. The central question here becomes: what constitutes a strong correlation, and how is the accuracy of the study affected by the fact that profiles are hand-drawn?

To find the answer, profiles of pottery recovered from Pit 1 were drawn by two different authors and then compared.[15] 798 pairs of drawings illustrating the same sherd were examined and found to have a mean correlation coefficient of 0.976, a median of 0.989, and a standard deviation of 0.07. This means that drawing by hand is a fairly reliable recording method.

Furthermore, the experimental mean of the coefficient also revealed the limits to the accuracy of such studies. When comparing hand-drawn profiles, the upper limit of the strength of their correlation remains between 0.97–0.98. Higher values are considered unreliable because they fall within the error range. The experiment showed that $r_{xy}$=0.98 can be considered as evidence of similarity between profiles form. However, it became apparent that such a correlation would still be subject to some error. It was, therefore, decided to refine the results by calculating the area between the superimposed contours. After analysing pairs of images, the similarity of profiles was confirmed when the upper limit of the strength did not exceed 0.2*S (S is the mean of the calculated areas with a correlation coefficient of $r_{xy}$≥0.98).

A total of 1,515 profiles of sherds from both of the middens were compared by using the above-outlined method.[16] In Pit 1, the following dispersion of the correlation of pottery profiles was observed: the mean measured 0.925, the median 0.964, and the standard deviation 0.124. This gives us a minimum value of -0.954 (pots and bowls); whereas the maximum value reached 0.999 (nearly identical sherds, possibly fragments of a single vessel), and the non-standard coefficient values ranged from -1 to 0.824.

These figures confirm once again that the pit was filled with artifacts of very similar shapes. However, the situation was found to be different in Pit 2; here, the mean correlation of the studied pottery sherds is only 0.62, the median is 0.95, and the standard deviation is 0.64. The minimum value is -0.967 (correlation between pots and bowls), and the maximum is 0.999 (nearly identical sherds). Non-standard values cluster in the range of -0.967 to 0.33. In this case, the data (especially a bigger difference between the mean and the median) reflects a considerably greater diversity of product shapes than that of Pit 1.

The comparison of pairs of sherds from different pits returned a mean correlation of 0.65, a median correlation of 0.865, a standard deviation of 0.49, and a maximum correlation of 0.999. In other words, the pits contained assemblages of vessels that were similar in shape, albeit not identical. Similarly shaped profiles are shown in Figure 7.

The blue and orange contour lines indicate sherds from Pit 1 and Pit 2 respectively. The upper

[15] Drawings made by the author of this article were compared with the profiles drawn by R. Liutkevičius in 1996 during the archaeological excavations of Pit 1, which were not included in the report (Sarcevičius, 1996, 2). The author of this article would like to thank the research supervisor, Saulius Sarcevičius, for the opportunity to use this material.

[16] 1,146,855 variations were calculated using the *Python* programming language library *pandas*, see https://pandas.pydata.org/docs/reference/api/pandas.DataFrame.corr.html [accessed 15.03.2023].

and middle rows not only have a similar profile but also the same type of rim, while the lower rows have similar profiles but different rims. As no remains of the same vessel were found among the pairs of similarly shaped sherds from different pits, their similarity does not prove the same chronology of the pits. Nor can it be stated that these artifacts were made by a single craftsman, although this possibility should not be ruled out. However, it is possible that such similarity illustrates the continuity of production observed by other researchers, whereby one craftsman passed on his skills to another (Jonaitis, 2007, 52–53).

## THE DISTRIBUTION OF SHAPES OF POTTERY PROFILES IN PITS 1 AND 2

The Figures 11–13 (see Annex No. 2) reveal that the sherds recovered from the two pits are distributed more or less evenly in the overall diversity of shapes. Once again, this demonstrates a possible relationship between these two middens, which can likely be attributed to a shared work experience.

On the other hand, sherds of distinctive shapes are unique to only one of the middens and probably reflect the individuality of a craftsman or a different function of these vessels. The most distinct examples of such production are the vessels without a neck (Groups I-11, II-11) from Pit 1 and bowls from Pit 2 (Group IV-1).

The distribution of sherds in different size groups is as follows, the group of exceptional size contains 29.9% of the analyzed sherds from Pit 1 and 11.4% from Pit 2. The large groups consist of 40.3% and 40.2%, the medium-sized group of 21.4% and 25.2%, and the small group of 8.3% and 22.9% respectively. It can be seen that artifacts from both pits have a similar distribution of profile shapes. More significant differences in proportions are only seen in the exceptional and small groups, which represent sherds of standard and non-standard shapes. As the majority of the studied sherds come from Pit 1, it is characterised by a higher proportion of standard-shaped profiles. Pit 2, on the other hand, contained more non-standard shapes, which reflects the individuality of this line of production.

## THE SHAPE OF POTTERY RIMS

The rim is the upper profiled part of the vessel above the neck, which frames the mouth of the vessel. In this study, the features of rims are described by considering processes of production. Different attributes were recorded by focusing on the angle of curvature of the wall and the position at which it was shaped either by fingers or flat tools (see Annex No. 2, Fig. 14). The aim of expanding the description of the process of rim formation was to reveal the individual craftsmanship and, in this respect, to describe the similarities and differences among the sherds recovered from the two middens. This approach allowed the identification of 25 different rim variations, which were divided into 5 groups according to the most characteristic feature; namely, the curvature of vessel walls.

Group 1 is the largest, consisting of 1,274 sherds. Of these, as many as 1,223 pieces were found in Pit 1, while Pit 2 contained 51 sherds. This group of rims was combined with profiles of various shapes (see Fig. 14 for a correlation diagram of rim and profile groups; Fig. 11–13 for the shapes of profiles). All the variations of the rims share the fact that the wall of the vessel was formed at an angle of 90–180° in relation to the neck and was not attached to it (in this way, the rim received the shape of a hook).

The group consists of eight variations, differing in the processing methods used (smoothed, indented, with narrowed areas). Five of the eight variations were found in both of the pits (marked light grey in Fig. 14), while the remaining three were found exclusively in Pit 1. Variation 1 occurred in most of the cases, with the rim having been shaped from the

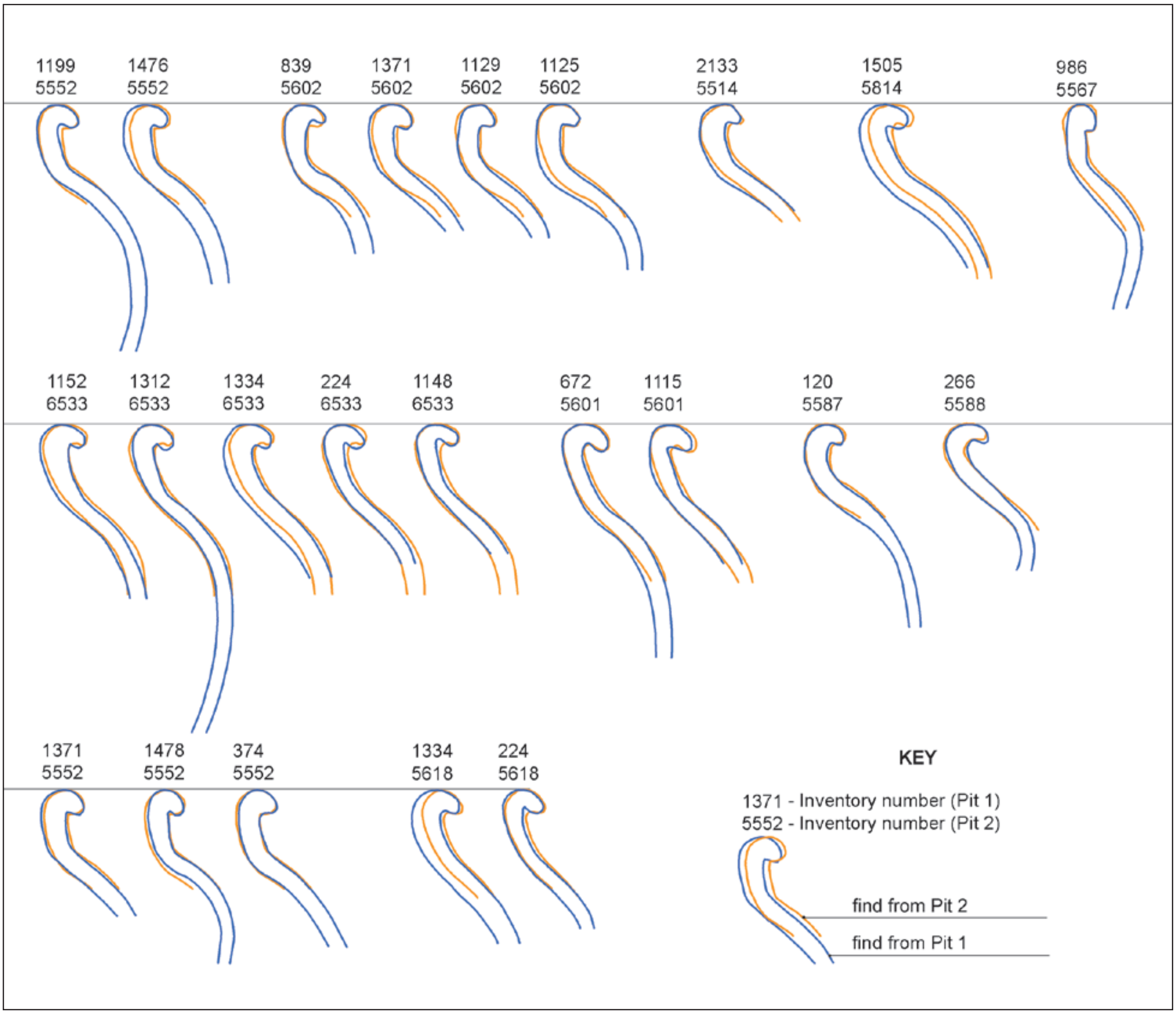


Fig. 7. Pairs of similarly shaped sherds from pits 1 and 2. *Drawing by O. Valionienė.*
7 pav. Panašios formos šukių poros iš duobių Nr. 1 ir 2. *O. Valionienės brėžinys.*

wall without making any other markings (Fig. 14, Group 1, Drawing 1 on the left). There were 657 such sherds, 637 of which were recovered from Pit 1. However, there were also cases whereby the rim was smoothed with a tool on the side and/or bottom (Fig. 14, drawings 3, 6, 7 from the left, 515 sherds in total).

Group 2 is the second largest, with 302 sherds. Of these, 194 sherds were found in Pit 1 and 108 sherds came from Pit 2. Rim of this group were combined with profiles of various shapes. All the rims are folded at an angle of 180° and pressed at the neck. Visible subtleties of the shaping process include tool marks in different places. A total of 7 variations have been identified, of which 5 occur in both pits, and 2 in Pit 2 only. Variations 1, 2, 4, and 5, are the most common (Fig. 14, Group 2, drawings 1, 2, 4, 5 from the left). Variations 1, 2 and 3 are more typical of sherds from Pit 2. The same applies to Variation 5, as the second midden contained a higher percentage of such sherds than Pit 1.

In contrast, Variation 4 was more commonly seen among the sherds from Pit 1. It is possible that this is a version of Variation 6 from Group 1 since the same steps were taken in the process of their production, except for the part when the rim is neatly pressed at the neck.

Group 3 is small, with 26 sherds. 4 sherds were found in Pit 1 and 22 in Pit 2. The rims are curved at an angle of 45–90° in relation to the neck. There are 4 rim variations in the group, mostly seen in vessels with non-standard profiles.

Group 4 is similarly small. All of the 17 sherds came from Pit 1. The group is characterised by the wall, pressed against the neck, which resulted in a cavity inside (a loop-shaped rim). There are 3 variations, combined with different shapes of vessel profiles, including non-standard production. The most striking examples are the vessels without a neck (Fig. 12; Groups I-11, II-11).

Group 5 is the smallest, consisting of 5 sherds. One piece was found in Pit 1, and 4 pieces were found in Pit 2. These rims have only been seen on vessels of a non-standard shape. The walls of such vessels have been curved twice in opposite directions to form a wave. Three variations with tool marks in different spots have been distinguished.

As is evident, the two middens contained most of the variations of rims and examples of groups distinguished above. It can, therefore, be presumed that these vessels were made by a single craftsman. Alternatively, these vessels may have been produced by several craftsmen who shared a common working experience and skills, which is supported by the fact that the groups of rims are distributed in very different proportions (Fig. 14, see diagrams below).

Namely, Group 1 is more typical of Pit 1, Group 2 is more typical of Pit 2; Group 4 is found only in Pit 1, and almost all of the sherds from Group 5 came from Pit 2. Most notably, the differences in rim shapes do not necessarily reflect the authorship of a particular craftsman. Craftsmen could share skills and experiment. Thus, these differences likelier reflect shape preferences.

## ORNAMENTATION

The assemblage consists of 86 decorated sherds (see Annex No. 2, Fig. 15). Of these, 67 were found in Pit 1 (i.e., 4.6% of the studied sherds from this pit), and 19 (10.1%) in Pit 2. Twelve decoration variations were recorded; in turn, they were divided into four groups.

Group 1: incisions. A total of 60 sherds were examined, all from Pit 1. The ornament was placed on the upper part of the shoulders. The dash was drawn from top to bottom at different angles of inclination, using tools of different thickness. Incisions were mostly used to adorn the rims of Group 1 (55 pieces) but were also found on five examples of Group 2. It was also seen that such markings were used in the decoration of various shapes of profiles (see Fig. 15 for correlation diagrams of ornamention and profile groups, Fig. 11–13 for shapes of profiles).

Group 2: dots or short incisions. Four sherds from Pit 1 were analyzed. The decoration was applied to vessels of various shapes and on pot rims typical of groups assigned to the ornamentation Group 1.

Group 3: horizontal waves. 19 sherds were examined, 3 of which were recovered from Pit 1 and the remaining 16 from Pit 2. The ornamentation was predominantly placed on the neck and, in two cases, on the shoulders. It was most often used in combination with rims assigned to Groups 2, 3, and 5.

Group 4: horizontal lines. Three sherds were examined, all from Pit 2. This particular ornamentation was used to decorate bowls.

In terms of production techniques, all ornaments can be divided into two types, including rhythmically repeated dashes (incisions and dots) and continuous lines (wavy and horizontal lines). It was observed that their distribution strongly correlates with the find spot: all the ornaments of the first type were found in Pit 1, wavy lines of the second type were found mainly in Pit 2, and the horizontal lines were found only in Pit 2. Hence, the ornaments may reflect individual craftsmanship.

## IMPRESSION OF A FINGERTIP AT THE BASE OF THE NECK

About 13.9% (211 pieces) of the studied sherds have an impressed mark of a fingertip at the point where the neck of vessels meets the shoulder. The presence of these marks, which have been placed during the shaping of vessels, are distributed relatively evenly: 191 were found on sherds from Pit 1 (accounting for 13.3% of the studied sherds from this particular midden), and the remaining 20 (10.7%) in Pit 2. The impression was present on profiles of various shapes, as well as on rims assigned to Groups 1 and 2, 81% and 18.9% respectively. 19 sherds were decorated with incisions and wavy lines (15 from Pit 1 and 4 from Pit 2). This indicates that the impression left by fingertips was accidental as opposed to the intentional design of a particular craftsman.

## CONCLUSION

The two middens found at Vilnius, Subačiaus Street 11, which were filled with sherds of pottery, were initially hypothesized as belonging to the same workshop dating back to the 14th–15th centuries. This was evidenced by the proximity of their location and chronology as well as the similarities in the shape of their products. However, the analysis of profiles and rims did not reveal any distinct stylistic differences between artifacts recovered from the two middens. Furthermore, even though pairs of similarly shaped sherds were found in these pits, the assemblages were not identical. Pottery of specific profile and rim shapes was not evenly distributed in the middens and each pit contained unique vessel forms.

Contents of pits present several presumptions about their purpose and chronology. If they were contemporaneous and belonged to the same workshop, the differences in attributes of pottery might be a result of circumstances in which the assemblages formed. It is likely that the small Pit 2 was used for the storage of production waste and contained a wider variety of shapes of sherds.

Meanwhile, the large Pit 1 may have originally been used for the extraction of raw materials (sand or clay, which in this area, lie at a depth of 0.5– 1 m), and the bottom of the pit was used for the disposal of waste from this extraction. Pottery may have been deposited in the pit either because of fire or as production waste. The first hypothesis is contradicted by the fact that most sherds were not damaged by fire, and the charred residues mixed among pot sherds were likely the result of heating in a kiln.

Another hypothesis suggests that the two middens discovered at Subačiaus Street 11 belonged to a single craftsman but were used at different times. Differences in pottery styles would then indicate changes in craftsmanship and approach to vessel shapes. However, a more plausible version could be that the differences in style reflect not only the circumstances in which the pits were used, but also the collaboration and exchange of experience between several craftsmen. For example, it could have been a master and his apprentice. Spoilage may have been disposed of into the pit when more than one individual utilized the same pit simultaneously. The identical shapes of the sherds would then indicate individual craftsmanship. Conversely, a uniform standard of forms reflects the experience gained from the other person, while non-standard products reflect individuality of a craftsman.

## Annex No. 1
## ANALYSIS OF VESSEL SHAPE

A complex curved shape can be described by breaking it down into simpler shapes and measuring them. The resulting measurements can then be used to compare and classify a series of curves. The conventional approach to the study of pottery is to distinguish between parts such as the rim, neck, shoulders, and main body of the vessel. The same methodology is also applied in this particular study (Fig. 8).

For data analysis, the classical descriptive statistics method was used. I.e., the sample was divided into quartiles and the range of anomalous values was calculated (Fig. 9; Table 1). Once the intervals were defined, the relative frequency was calculated; i.e., the proportion of the studied sherds that have an attribute in a given interval (Fig. 10). This allowed the ranges of values to be sorted in descending order of relative frequency, distinguishing the most common attributes from those that were not typical of the assemblage, and shedding light on what type of production was typical of the workshop.

The standard of production is the shape of the sherd that combines the most frequently occurring attributes (see Table 1, column c). In contrast, the sherds with the most anomalous features are regarded as non-standard, experimental, or accidental (ibid, columns a and e).

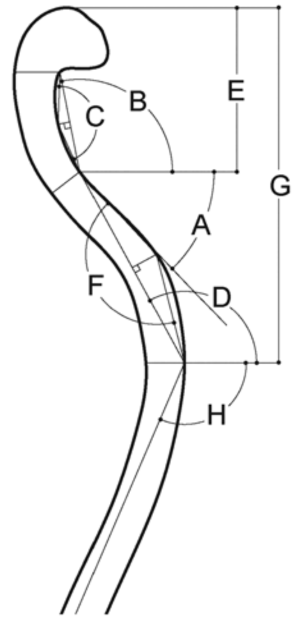


Fig. 8. Analyzed attributes of vessel shapes (see Table 1 for explanation of attributes). *Drawing by O. Valionienė.*
8 pav. Analizuoti indo formos požymiai (požymių apibūdinimą žr. 1 lentelėje). *O. Valionienės brėžinys.*

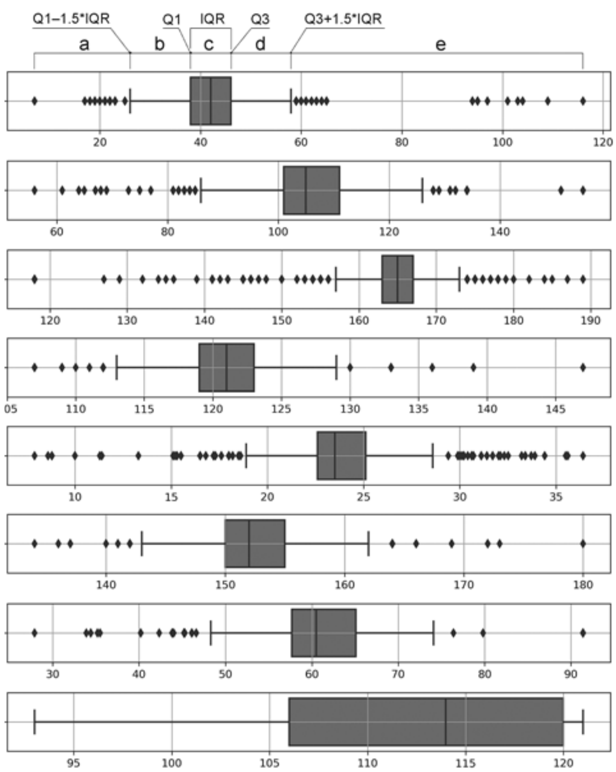


Fig. 9. Distribution of attributes of analyzed vessel shapes: box plots. *Data visualization by O. Valionienė*, using Python library seaborn (available at https://seaborn.pydata.org/).
9 pav. Analizuotų indų formos požymių sklaida: stačiakampės diagramos. *O. Valionienės duomenų vizualizacija*, naudojant Python biblioteką seaborn (interneto prieiga https://seaborn.pydata.org/).

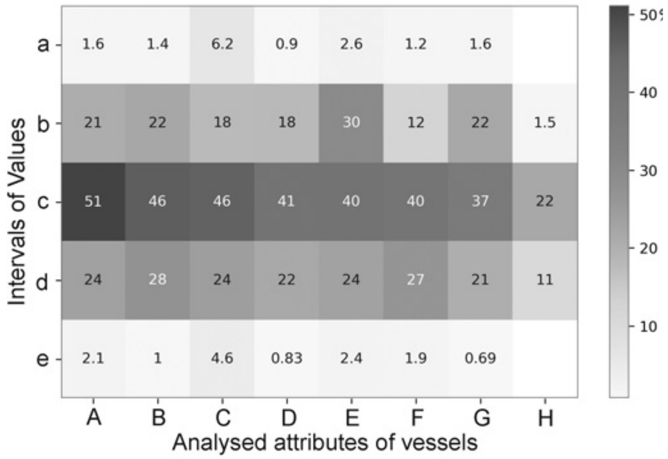


Fig. 10. Diagram of the distribution of attributes. Data visualization by O. Valionienė, using Python library seaborn (available at https://seaborn.pydata.org/).
10 pav. Požymių sklaidos diagrama. O. Valionienės duomenų vizualizacija, naudojant Python biblioteką seaborn (interneto prieiga https://seaborn.pydata.org/).

Shades of grey and numbers in the windows indicate relative frequency, that is, what proportion of the analyzed sherds have the attribute within the specified range.

| **Attribute** | | **Intervals of Values** | | | | |
|---|---|---|---|---|---|---|
| | | **a (anomalous lower quartile data, exceptions)** | **b (lower quartile data)** | **c (interquartile range data)** | **d (upper quartile data)** | **e (anomalous upper quartile data, exceptions)** |
| **A** | The angle of the slope of the upper part of the shoulder (degrees) | [7, 26) | [26, 38) | [38, 46) | [46, 58) | [58, 116] |
| **B** | The angle of the slope of the neck (degrees) | [56, 86) | [86, 101) | [101, 111) | [111, 126) | [126, 155] |
| **C** | The angle of the curve of the neck (degrees) | [118, 157) | [157, 163) | [163, 167) | [167, 173) | [173, 189) |
| **D** | The angle of the slope of the shoulders (degrees) | [107, 113) | [113, 119) | [119, 123) | [123, 129) | [129, 147] |
| **E** | The height of the neck (mm) | [7.9, 18.9) | [18.9, 22.7) | [22.7, 25.1) | [25.1, 28.6) | [28.6, 36.4] |
| **F** | The angle of the curve of the shoulders (degrees) | [134, 143) | [143, 150) | [150, 155) | [155, 162) | [162, 180] |
| **G** | The height of the shoulders (mm) | [27.9, 48.1) | [48.1, 57.8) | [57.8, 65.1) | [65.1, 74) | [74, 91.4] |
| **H** | The angle of the slope of the body (degrees) | | [93, 106) | [106, 120) | [120, 121] | |

Table 1. Distribution of attributes of analysed vessels shapes (see Fig. 9 for a graphic representation).
1 lentelė. Analizuotų indų formų požymių pasiskirstymas (žr. 9 pav.).

## Annex No. 2
## CHARACTERISTICS OF POTTERY SHAPES

Figures 11–13 present pottery profiles in order of decreasing relative frequency of attributes (frequency decreasing from left to right and from top to bottom). The samples of sherds are divided into groups that share specific attributes, of which the most frequent that determine the shape of the upper part of the vessel are: (A) the angle of the slope of the upper part of the shoulder, (B) the angle of the slope of the neck, and (C) the angle of the curve of the neck. The other attributes (Fig. 8; D, E, F, G, and H) were not assessed. Experimentation with the data has shown that using more than three attributes does not generate groups.

The groups of profiles are divided into four types based on size:

- Exceptional size (131–284 sherds, upper quartile range);
- Large (45–130 sherds, upper quartile range);
- Medium (12–44 sherds, interquartile range);
- Small (1–11 sherds, lower quartile range).

Exceptionally large and large groups include standard profile shapes, medium sized groups include sherds with slight deviations from the standard shape, and small groups made up of sherds of non-standard shapes.

Figures 11–13 divide the profile shape groups into five clusters. The first cluster consists of 739 profiles with the most frequent upper shoulder slope (angle A, 38–46°, interquartile range, relative frequency 50–51%). Groups I-1 to I-5 in this cluster show sherds with a standard slope and a slightly higher inward slope of the neck (angle B, 101–126°). Groups I-6 to I-8 list sherds with an upright neck (angle B, 86–101°). Groups I-9 and I-10 consist of sherds with a heavy inward curve of the neck (angle B, 111–155°). Group I-11 include two non-standard sherds without a neck. Finally, groups I-12 and I-13 list sherds of non-standard shapes. Below, are the characteristics of the groups in **Cluster I:**

| Group No. | Size | Quantity | Intervals of Values (see Annex No. 1) | Description |
|---|---|---|---|---|
| **I-1** | exceptional | 284 | The values of the angle of slope A of the upper part of the shoulders are located in the interquartile range c, in the interval 38°–46° (see Table 1 for the values of the intervals, hereafter referred to as A:c). Angle B of the slope of the neck is within the interquartile range c, which lies between 101° and 111° (B:c). Angle C of the curve of the neck is located in the interquartile range c between 163° and 167° (C:c). The other attributes – angle D of the slope of the shoulder, neck height E, shoulder angle F, shoulder height G, body angle H – fall within the range of standard values ((D–H):(b–d)). | This group does not contain any sherds with anomalous attributes. Furthermore, this group can be considered a standard for workshop production, where most of the standard attributes of shape come together. |
| **I-2** | exceptional | 131 | A:c, B:d, C:c, (D–H):(b–d) | A group of vessels resembling the standard shape, with a slightly deeper curve of the neck. |
| **I-3** | large | 86 | A:c, B:c, C:(c, d), (D–H):(a–e) | The sherds have a standard shape of the neck and upper part of the shoulders, but some of their attributes may fall in the range of anomalous values. |
| **I-4** | large | 66 | A:c, B:c, C:(b,e), (D–H):(a–e) | The neck of vessels has a standard slope and varying degrees of curvature. |
| **I-5** | large | 62 | A:c, B:d, C:d, (D–H):(b–d) | This group consists of sherds with straight necks. |
| **I-6** | medium-sized | 37 | A:c, B:b, C:c, (D–H):(a–e) | Sherds with necks with a high slope and a standard curvature. |
| **I-7** | medium-sized | 28 | A:c, B:b, C:b, (D–H):(a–e) | Includes sherds with a neck of a distinct bow shape. |
| **I-8** | medium-sized | 25 | A:c, B:b, C:d, (D–H):(a–e) | This group consists of sherds with straight necks. |
| **I-9** | small | 8 | A:c, B:e, C:(a, b, e), (D–H):(a–e) | The sherds have strongly inwardly curved necks. A group consisting of sherds that display many anomalous features, with the majority of the sherds originating from Pit 2. |
| **I-10** | small | 8 | A:c, B:d, C:(a, b, e), (D–H):(a–e) | Sherds with a strong inward curve of the neck. |
| **I-11** | small | 2 | A:c, (B–H): data not available | The group includes sherds without a neck. |
| **I-12** | small | 1 | | The group includes only one uniquely shaped sherd from Pit 1. |
| **I-13** | small | 1 | | A small sherd of a vessel with attributes that are difficult to distinguish. |

Table 2. The characteristics of the groups of ceramic profiles in Cluster I.
2 lentelė. I klasterio keramikos profilių grupių charakteristikos.

In the second cluster, 346 profiles with a higher-than-average slope of the upper part of the shoulders are listed (angle A values are in the upper quartile of the standard range of 46–58°, with a relative frequency of 24%). In groups II-1–II-8, a higher proportion of the attributes lies within the range of the standard values. Sherds in groups II-9–II-11, on the other hand, exhibit more anomalies.

| **Group No.** | **Size** | **Quantity** | **Intervals of Values (see Annex No. 1)** | **Description** |
|---|---|---|---|---|
| **II-1** | large | 80 | A:d, B:b, C:c, (D–H):(a–e) | Sherds with upright necks with a slight curve. |
| **II-2** | large | 50 | A:d, B:c, C:d, (D–H):(a–e) | Sherds with straight necks with a standard slope. |
| **II-3** | large | 46 | A:d, B:b, C:d, (D–H):(a–e) | Sherds with upright, straight necks. |
| **II-4** | medium-sized | 37 | A:d, B:c, C:c, (D–H):(a–e) | Sherds that exhibit standard neck shape and slope. |
| **II-5** | medium-sized | 33 | A:d, B:b, C:(a, b, e), (D–H):(a–e) | Sherds with upright necks with either an exceptionally small or a very large curve. |
| **II-6** | medium-sized | 27 | A:d, B:d, (C–H):(a–e) | Sherds with a strong inward curve of the neck. |
| **II-7** | medium-sized | 26 | A:d, B:b, C:d, (D–H):(a–e) | Sherds with upright, straight necks. |
| **II-8** | medium-sized | 12 | A:d, B:c, C:b, (D–H):(a–e) | Sherds that have a neck with a standard slope and a strong curve. |
| **II-9** | small | 11 | A:d, B:c, C:(a, e), (D–H):(a–e) | Sherds that have a neck with a standard slope and a curve of an anomalous degree. |
| **II-10** | small | 10 | A:d, B:(a, e), (C–H):(a–e) | Sherds of various shapes with anomalously sloping necks. |
| **II-11** | small | 7 | A:d, (B–H): no data available | Sherds without a neck, reminiscent in shape to sherds in Group I-11 in Cluster I. |

Table 3. The characteristics of the groups of ceramic profiles in Cluster II.
3 lentelė. II klasterio keramikos profilių grupių charakteristikos.

The third cluster consists of 303 profiles with a lower-than-average slope of the upper part of the shoulder (angle A values in the lower quartile of standard values, in the range 26–38°, with a relative frequency of 21%).

| **Group No.** | **Size** | **Quantity** | **Intervals of Values (see Annex No. 1)** | **Description** |
|---|---|---|---|---|
| **III-1** | large | 80 | A:b, B:c, C:(a, b), (D–H):(a–e) | Sherds that have a neck with a standard slope and a heavily curved neck. |
| **III-2** | large | 60 | A:b, B:d, C:c, (D–H):(a–e) | Sherds that have a sharply sloping neck with a standard curve. |
| **III-3** | large | 51 | A:b, B:d, C:b, (D–H):(a–e) | Sherds that have necks with a sharp slope and a heavy curve. |
| **III-4** | medium-sized | 37 | A:b, B:d, C:a, (D–H):(a–e) | Sherds that have a neck with a sharp slope and a very pronounced (anomalous) curve. |
| **III-5** | medium-sized | 26 | A:b, B:b, C:(b–d), (D–H):(a–e) | Sherds with upright necks of varying (standard) curvature. |

| | | | | |
|---|---|---|---|---|
| **III-6** | medium-sized | 17 | A:b, B:c, C:(c, d), (D–H):(a–e) | Sherds that have a straight neck of a standard slope. |
| **III-7** | small | 11 | A:b, B:b, C:(a, e), (D–H):(a–e) | Sherds with upright necks of anomalous curvature. |
| **III-8** | small | 9 | A:b, B:d, C:d, (D–H):(a–e) | Sherds that have a straight neck of a sharp slope. |
| **III-9** | small | 6 | A:b, B:(a, e), (C–H):(a–e) | Sherds of various shapes with anomalously sloping necks. |
| **III-10** | small | 4 | A:b, B:d, C:e, (D–H):(a–e) | Sherds that exhibit necks with a sharp slope and an anomalous, slight outward curve. |
| **III-11** | small | 2 | A:b, B:c, C:e, (D–H):(a–e) | Sherds that have a neck with a standard slope and an anomalous, slight outward curve. |

Table 4. The characteristics of the groups of ceramic profiles in Cluster III.
4 lentelė. III klasterio keramikos profilių grupių charakteristikos.

The fourth cluster lists 30 profiles with a very high slope of the upper part of the shoulders (angle A values in the upper quartile of the exceptions, in the range of 58–116°, with a relative frequency of 2.1%). Only small groups with sherds exhibiting anomalous features are listed here.

| **Group No.** | **Size** | **Quantity** | **Intervals of Values (see Annex No. 1)** | **Description** |
|---|---|---|---|---|
| **IV-1** | small | 10 | A:e, (B–H): no data available | The sherds in this particular group are bowls. Almost all the sherds, with the exception of one item, were found in Pit 2. |
| **IV-2** | small | 9 | A:e, B:a, (C–H):(a–e) | Sherds with atypically shaped necks curved outwards. |
| **IV-3** | small | 6 | A:e, B:b, (C–H):(a–e) | Sherds with upright necks and near upright shoulders. |
| **IV-4** | small | 5 | A:e, B:(c, d), (C–H):(a–e) | Sherds with necks of a standard slope. |

Table 5. The characteristics of the groups of ceramic profiles in Cluster IV.
5 lentelė. IV klasterio keramikos profilių grupių charakteristikos.

The fifth cluster includes 23 profiles with a very low upper shoulder slope (angle A values are in the lower quartile of the exclusion range, 7–26°, relative frequency 1.6%). This particular cluster lists small groups with anomalous attributes.

| **Group No.** | **Size** | **Quantity** | **Intervals of Values (see Annex No. 1)** | **Description** |
|---|---|---|---|---|
| **V-1** | small | 10 | A:a, B:c, (C–H):(a–e) | Sherds with necks of a standard slope. |
| **V-2** | small | 8 | A:a, B:d, (C–H):(a–e) | Sherds with necks of a pronounced slope. |
| **V-3** | small | 4 | A:a, B:b, (C–H):(a–e) | Sherds with an upright neck. |
| **V-4** | small | 1 | A:a, B:e, C:c, D:e, E:a, F:a, G:a, H: no data available | One exceptional sherd with features atypical to the rest of the assemblage. It was discovered in Pit 2. |

Table 6. The characteristics of the groups of ceramic profiles in Cluster V.
6 lentelė. V klasterio keramikos profilių grupių charakteristikos.

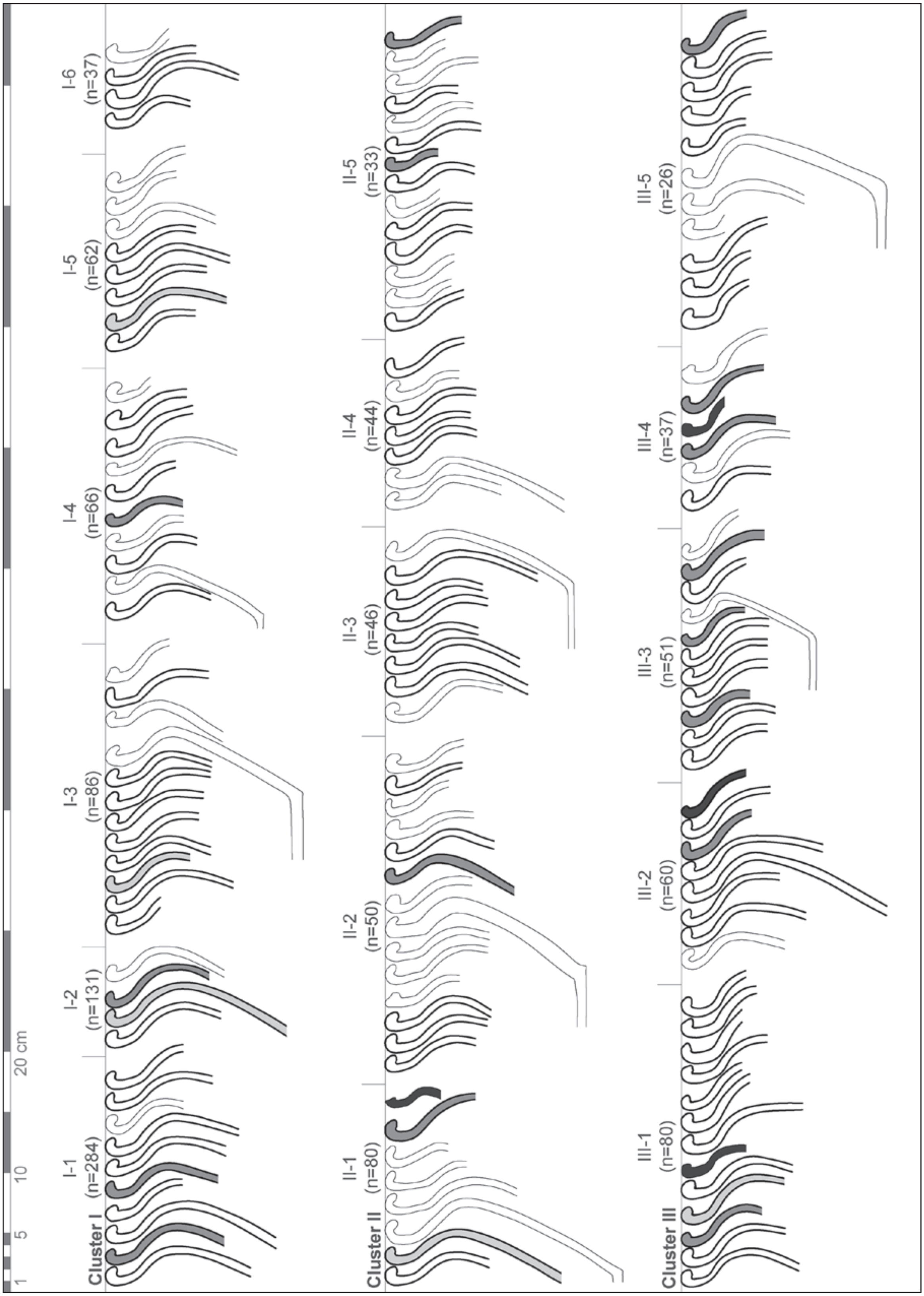


Fig. 11. Shapes of profiles. Clusters I–III (part 1). *Drawing by O. Valionienė.*
11 pav. Profilių formos. I–III klasteriai (1 dalis). *O. Valionienės brėžinys.*

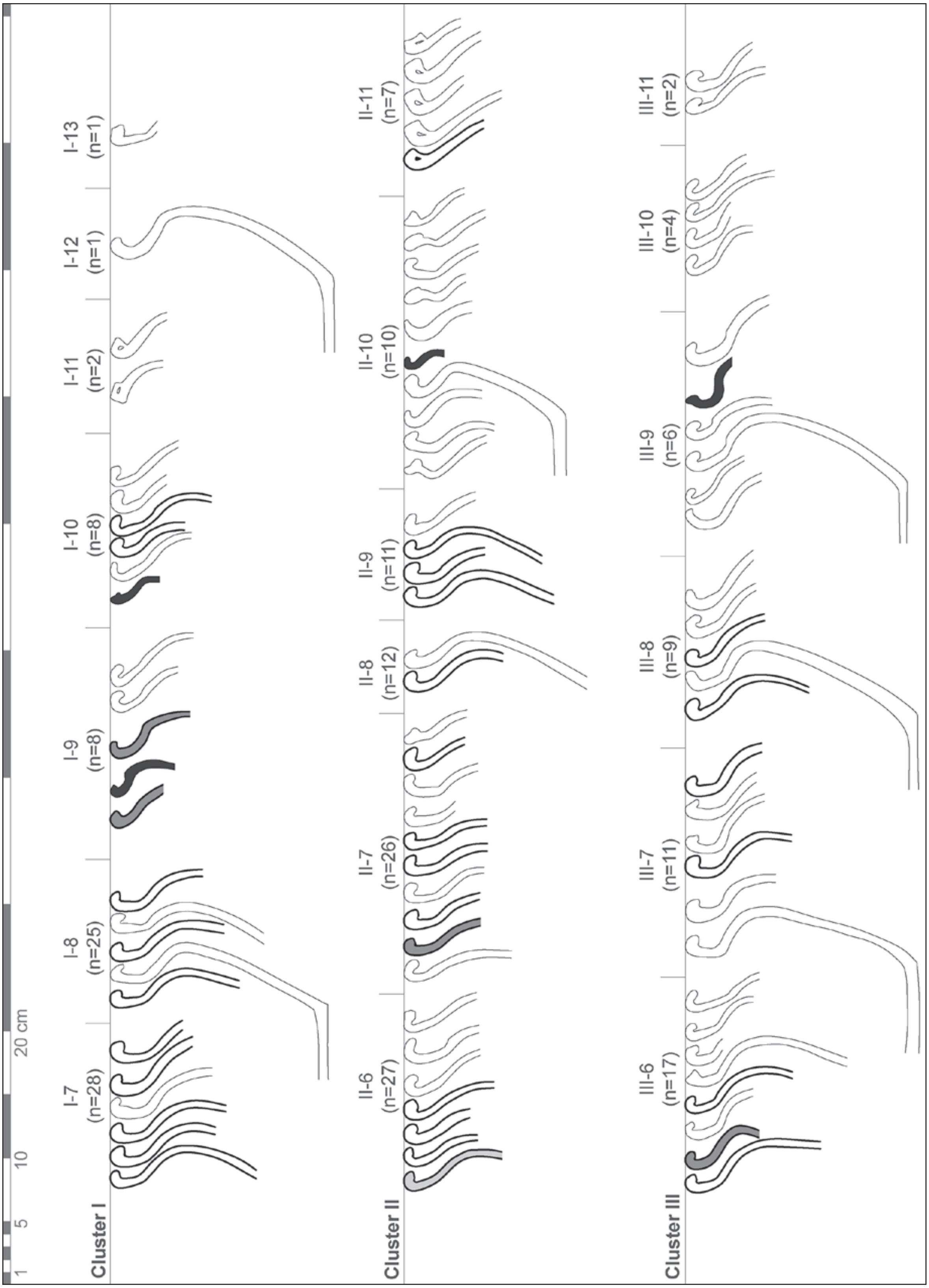


Fig. 12. Shapes of profiles. Clusters I–III (part 2). *Drawing by O. Valionienė.*
12 pav. Profilių formos. I–III klasteriai (2 dalis). *O. Valionienės brėžinys.*

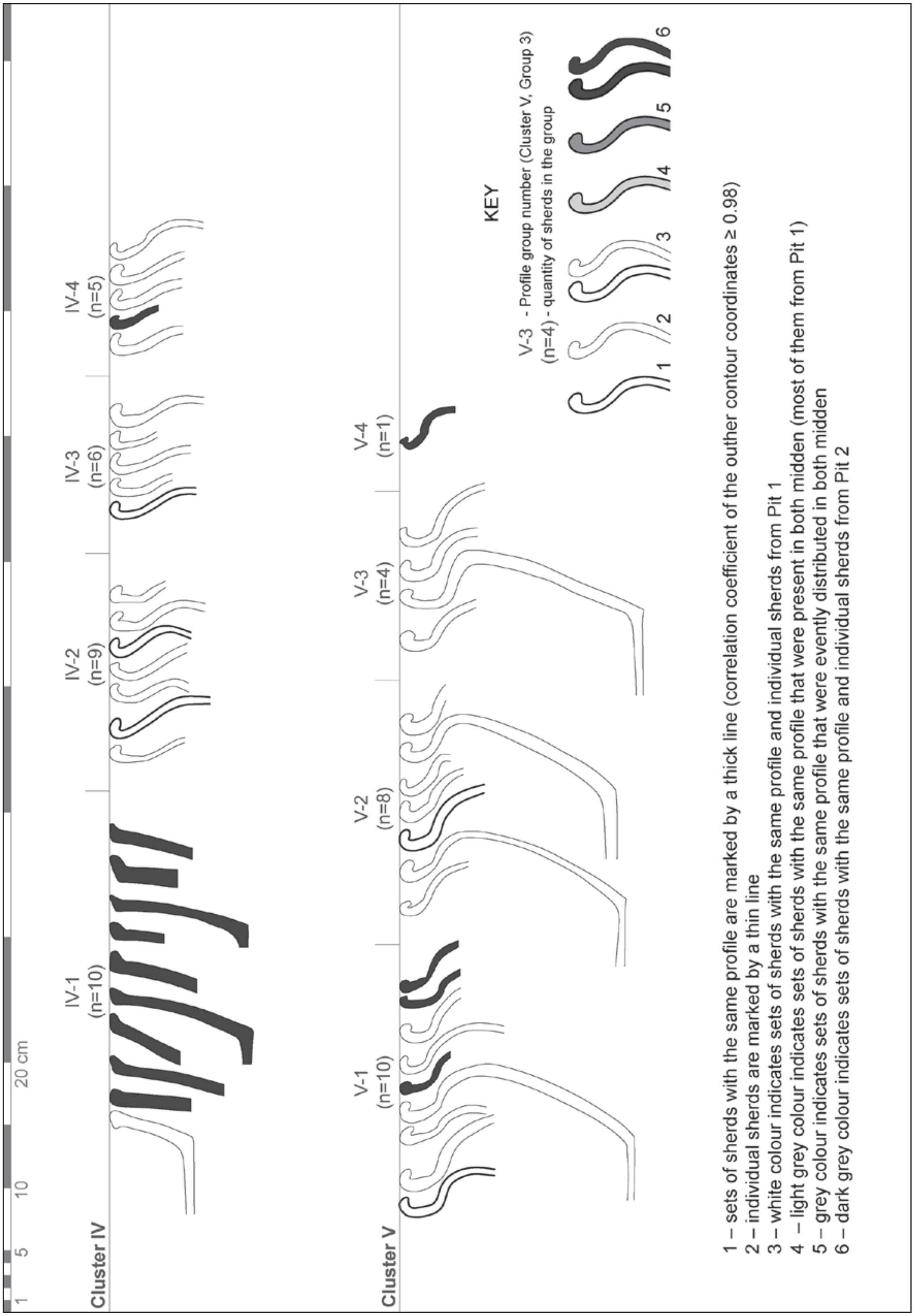


Fig. 13. Shapes of profiles. Clusters IV, V. *Drawing by O. Valionienė.*
13 pav. Profilių formos. IV, V klasteriai. *O. Valionienės brėžinys.*

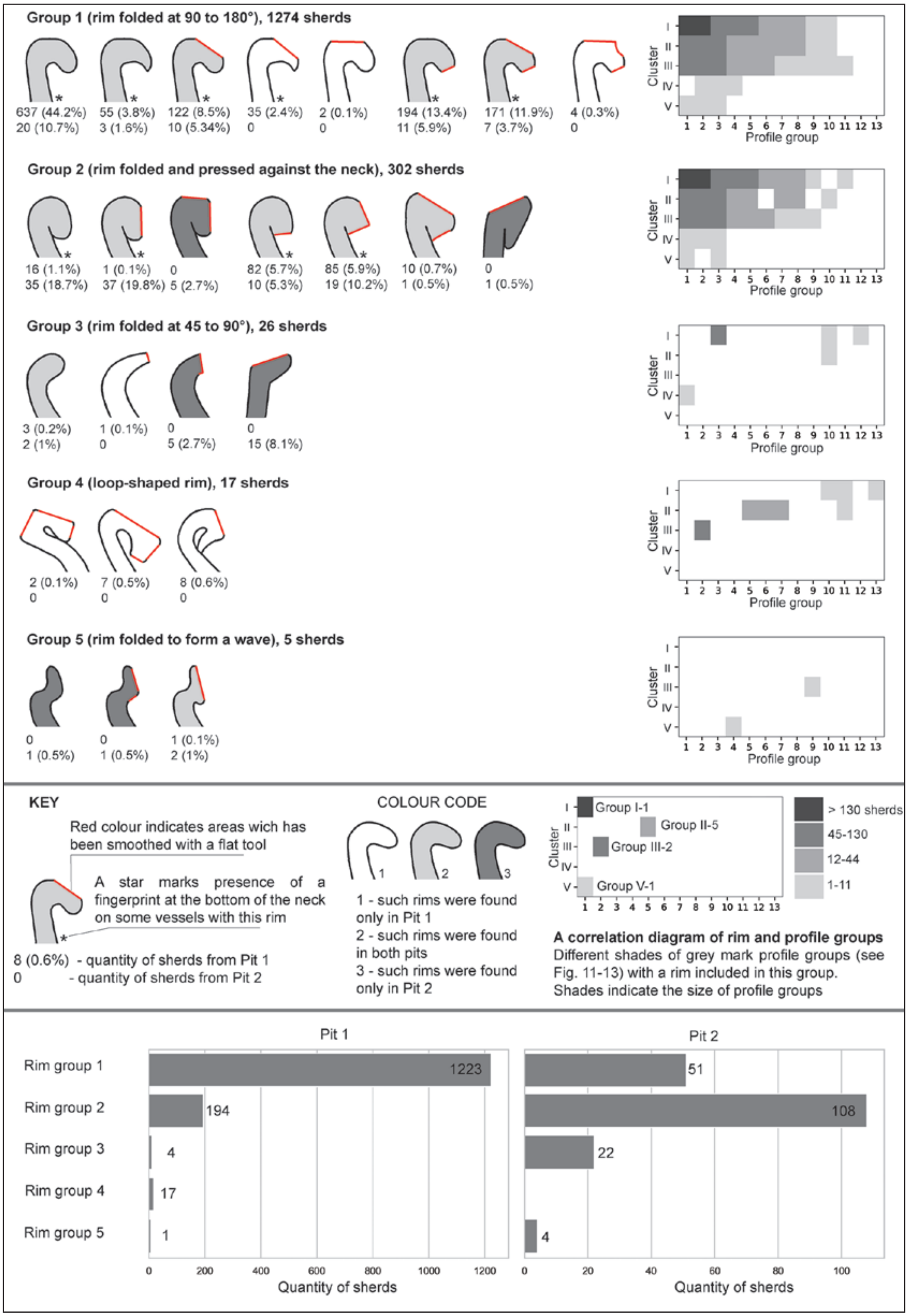


Fig. 14. Shapes of rims. *Drawing by O. Valionienė.*
14 pav. Briaunų formos. *O. Valionienės brėžinys.*

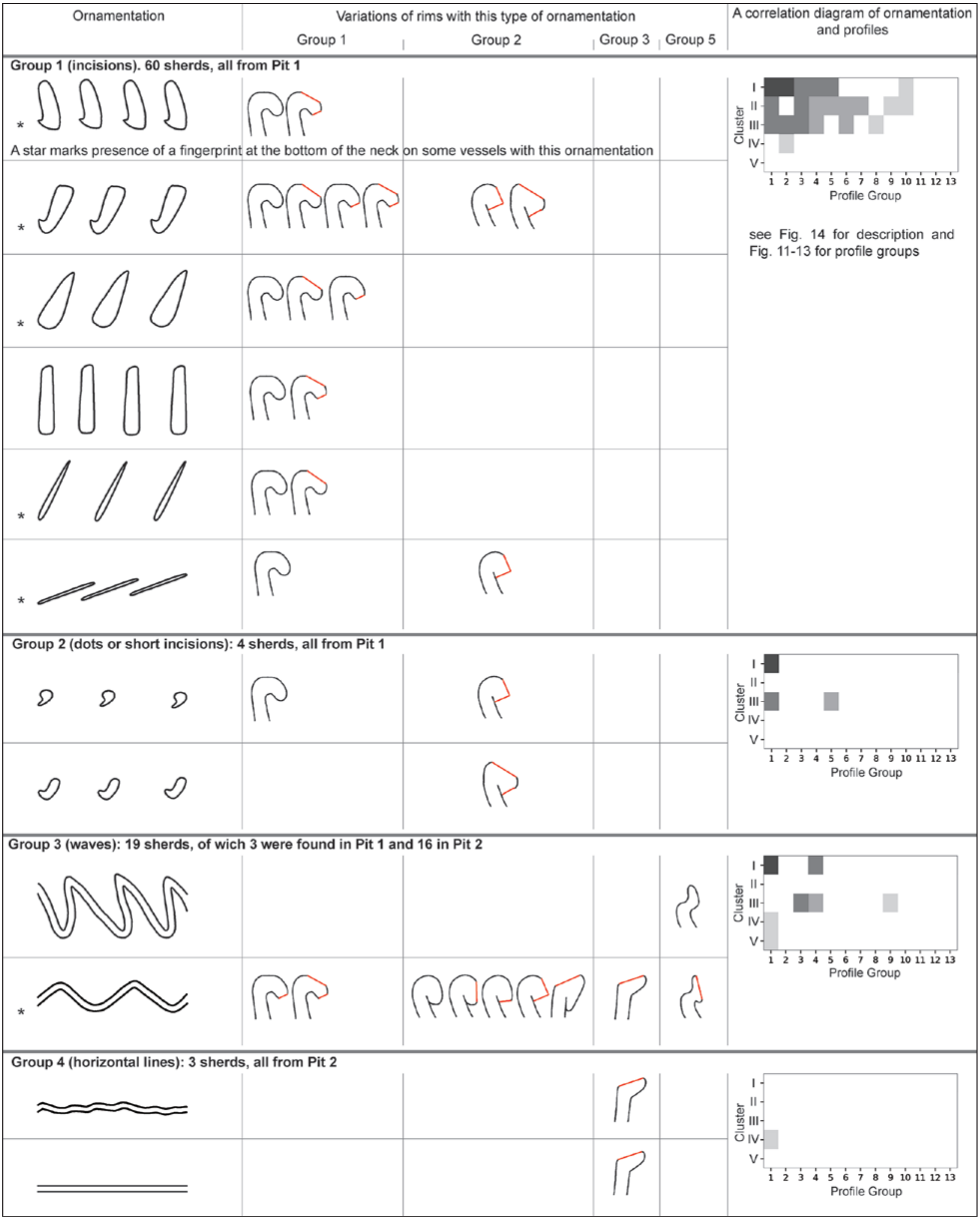


Fig. 15. Ornamentation. *Drawing by O. Valionienė.*
15 pav. Ornamentai. *O. Valionienės brėžinys.*

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# XIV–XV A. PUODŽIAUS DIRBTUVĖ VILNIUJE, SUBAČIAUS G. 11: BUITINĖS KERAMIKOS FORMOS

OKSANA VALIONIENĖ

Santrauka

Archeologinė buitinė keramika jau beveik pusę amžiaus lieka pagrindiniu datavimo šaltiniu Vilniaus erdvinės raidos ankstyvojo etapo tyrimuose. Tai suponuoja spręsti jos požymių klasifikacijos ir datavimo optimizavimo problemą. Iki šiol daugiausia mokslininkų dėmesio buvo skirta gamybos technologijai, importinių indų kilmei ir vietinės gamybos keramikos formoms. Tačiau tolesnes tyrimo perspektyvas komplikuoja rezultatų praktinio pritaikymo galimybės, nes didžiulius radinių kiekius tenka analizuoti neturint vienos automatizuotos informacinės sistemos, atitinkančios šiuolaikinio mokslo standartus. Problemą galima spręsti atsisakius klasikinio tipologinio metodo ir taikant didelių duomenų analitikos metodus: reliacinį duomenų aprašymo modelį, *SQL* – struktūrinę užklausų kalbą, *Python* programavimo kalbą, statistinę analizę.

Informacinės sistemos rengimą tikslinga pradėti nuo išskirtinio archeologinio objekto – viduramžių puodžiaus dirbtuvės liekanų Subačiaus g. 11. Dviejose ūkinėse šio uždaro komplekso duobėse rasta keli tūkstančiai panašios chronologijos ir formos keramikos dirbinių. Toks objekto pasirinkimas svarbus keliais aspektais: jis ne tik leidžia įvertinti kuriamos informacinės sistemos galimybes, bet ir reprezentuoti vienos dirbtuvės gaminių įvairovę, nustatyti formų standartą ir jo paklaidas. Straipsnyje aptariami dirbtuvės produkcijos tyrimo rezultatai.

Buvo ištirtas 1441 viršutinės indo dalies fragmentas iš didžiosios duobės Nr. 1 ir 187 fragmentai iš mažosios duobės Nr. 2. Nustatytas kompleksų morfologinis ryšis, apibūdinta formų įvairovė, modeliavimo panašumai ir skirtumai. Klasifikuotos briaunų, ornamentų ir profilių formos. Abiejose duobėse identifikuotos vienodos formos radinių poros.

Prieita išvada, kad Subačiaus g. 11 rastos dvi ūkinės duobės su buitinės keramikos radiniais greičiausiai priklauso vienai dirbtuvei, datuotai XIV– XV a. Tai rodo ne tik vietos ir chronologijos artumas, bet ir akivaizdus morfologinis kompleksų ryšys. Analizuojant profilių ir briaunų formas nepastebėta ryškių stilistinių skirtumų, ir nustatytos vienodos formos radinių poros iš dviejų duobių. Tačiau tai neidentiškas indų kompleksas, nes profilių ir briaunų formos pasiskirsto nevienodomis proporcijomis, be to, kiekvienoje duobėje yra išskirtinių, tik jai būdingų formų indų fragmentų.

Duobių turinio bruožai suponuoja iškelti kelias prielaidas apie jų paskirtį ir chronologiją. Jeigu jos buvo vienalaikės ir priklausė vienai dirbtuvei, galima spėti: požymių skirtumus sąlygojo nevienodos kompleksų susiformavimo aplinkybės. Tikėtina, kad mažoji duobė Nr. 2 visą laiką naudota gamybos atliekoms sandėliuoti, todėl į ją pateko įvairesnių formų radinių. Didžioji duobė Nr. 1 iš pradžių galėjo būti

skirta žaliavų gavybai, o į jos dugną buvo suverčiamos šios gavybos atliekos. Keramika galėjo patekti į duobę arba po gaisro, arba kaip gamybos brokas. Dar viena hipotezė – Subačiaus g. 11 buvo rastos vienam amatininkui priklausiusios nevienalaikės duobės. Tada stilių skirtumai rodytų, kaip keitėsi jo meistriškumas ir požiūris į indo formą. Tačiau patikimesnė versija – stilių skirtumai atskleidžia ne tik duobių eksploatavimo aplinkybes, bet ir kelių amatininkų bendradarbiavimą ir dalijimąsi patirtimi. Pavyzdžiui, galėjo būti meistras ir jo mokinys. Jeigu jie naudojo abi duobes vienu metu, tikėtina, kad vienas žmogus į bet kurią galėjo mesti savo gamybos broką. Tada vienodos radinių formos rodytų jo individualų braižą. Bet gali būti ir kitaip: vienodas formų standartas rodo iš kito žmogaus įgytą patirtį, o nestandartiniai gaminiai – amatininko individualumą.

# 14TH–15TH CENTURY POTTER'S WORKSHOP IN VILNIUS, SUBAČIAUS STREET 11: STATISTICAL ANALYSIS OF THE SHAPES OF HOUSEHOLD POTTERY

OKSANA VALIONIENĖ

Summary

Archaeological household pottery has remained the primary source of dating in the study of the early spatial development of Vilnius for almost half a century. This fact makes it necessary to solve the problem of optimising the classification of its attributes and the possibility for accurate dating. Thus far, the main focus has been on production technology, the origin of imported vessels, and the shapes of locally produced pottery. Further research perspectives, however, are hampered by the practical application of results, as vast quantities of sherds have to be analysed in the absence of a unified automated information system that would meet the standards of modern science. The problem can be solved by abandoning the classical typological approach and applying big data analytical methods instead, these would include the relational data model, Structured Query Language (*SQL*), programming language *Python*, and statistical analysis.

The remains of an exceptional archaeological object, a medieval potter's workshop at Subačiaus Street 11, is a fitting case study for starting the development of an information system. It is an enclosed archaeological complex where several thousand pottery sherds of similar chronology and shape have been recovered from two middens. The choice of this particular archaeological site is important in several respects: not only does it allow the testing of capabilities of the information system under development, but it also enables us to assess the diversity of the products of a single workshop and to determine the standard of shapes and the range of errors. This article presents the results of the analysis of workshop production.

A total of 1,441 sherds of the upper part of vessels from Pit 1 and 187 sherds from Pit 2 were analysed to discern a morphological relationship of assemblages, assess the diversity of shapes, as well as the similarities and differences in forming techniques used in production. Further tasks included the classification of rim shapes, profiles, and decoration. Both middens were found to contain pairs of similarly shaped sherds.

It was concluded that the two middens discovered at Subačiaus Street 11 were probably used by the same workshop dating back to the 14th-15th centuries. This is evidenced both by the proximity of their location and chronology and the similarities in the shapes of their products. The analysis of the profiles and rims did not reveal any distinct stylistic differences between the sherds recovered from the two middens. Furthermore, even though pairs of similarly shaped sherds were found in these pits, these assemblages were not identical. Pottery profiles and rim shapes were not evenly distributed in the middens and each pit contained unique vessel forms.

The content of the pits presents several presumptions about their purpose and chronology. If they were contemporaneous and belonged to the same workshop, it can be presumed that the differences in the attributes of pottery were due to circumstances in which the assemblages formed. It is likely that the Pit 2 was used for the storage of production waste and contained a wider variety of shapes of sherds. Meanwhile, the Pit 1 may have originally been used for the extraction of raw materials and the bottom of the pit was used for the disposal of waste. The pottery could have been deposited in Pit 1 either as a result of a fire or as spoilage.

Another hypothesis suggests that the two middens discovered at Subačiaus Street 11 belonged to a single craftsman but were used at different times. Differences in pottery styles would then indicate changes in craftsmanship and approach to vessel shapes.

However, one may more plausibly submit that the variation in style reflects not only the circumstances in which the pits were used but also the collaborative nature of relationships between craftsmen as one may expect from a master and his apprentice. If they used both pits at the same time, it is likely that one person could have disposed spoilage into either pit. Identical sherd shapes may indicate individual craftsmanship. However, an inverse explanation may also hold true – in that a uniform standard of forms may be the product of a collaborative effort, while non-standard products speak of the individuality of a craftsman.