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SIZE CLASSIFICATION OF GLASSWARE FRAGMENTS — INTRODUCTION TO A NEW METHODOLOGY OF GLASSWARE RESEARCH

Abstract: The objective of the present paper is to propose the introduction of a new methodology of archaeology of glass in the form of a size classification of glassware. It has been conducted on the glassware collection from the excavation XXII. The proposed methodology may be applied to any given collection of late medieval and early modern glassware from archaeological excavations. It allows for conclusions regarding stratification and deposition thanks to ordering the collection by state of fragmentation and use of statistical tools such as the chi-squared test.

Key words: size classification, glassware, glass archaeology, late medieval and early modern, Elbląg

The finds of late medieval and early modern glassware from the archaeological site of the Elbląg Old Town [Fig. 1] signal the need for a renewed discussion of the methodology of glass research since the existing framework was developed in the 1970s and 1980s.[1] Based on statistical and technological analysis, it overlooks the state of preservation of the material. State of research on the latter issue has been treated as marginal with the processes of stratification and deposition overlooked altogether.[2]

Insufficient data regarding fragmentation of the glassware, found in publications to date, have convinced the present author to undertake an attempt at size classification of late medieval and early modern glassware fragments. The attempt has been carried out on the material found at the XXII excavation[3] in the Elbląg Old Town and based on a modified project by Andrzej Buko,[4] which applied to the state of fragmentation of ceramics found at Gostomianum in Sandomierz. The proposed methodology can also find application to glassware from the late medieval and early modern period, as demonstrated by the author in a master's thesis.[5] It allows not only for a re-ordering of the material from the point of view of fragmentation, but also for application of statistical tools, such as the chi-squared test, which in turn leads to conclusions regarding stratification and deposition of material at individual structures.[6] It may also be used to order any given collection of glassware from the point of view of fragmentation, which in turn allows for application

[1] Ciepiela 1971a; Ciepiela 1971b; Ščapova 1973; Dekówna 1980.

[2] Nawracki 1999; Biszkont 2005.

[3] Excavation XXII is the name for the cluster of structures by the market square in the Elbląg Old Town between the streets: Bednarska, Stary Rynek, Rybacka and Ścieżka Kościelna. It contains the other excavations: 10B, 14, 15, 16S, 26, 27, 28H, 31, 33, 34, 35, 36.

[4] Buko 1990, pp. 235–244.

[5] Grosicki 2014.

[6] For "archaeological structure" in this context, read: latrine.

of more advanced statistical methods. The objective of the paper is to propose the introduction to "archaeology of glass" of a new project of size classification of glassware and to point out the far--reaching benefits thereof.

Fig. 1. Drinking glassware from the Elbląg excavations, latter half of 14th – 15th century (Elbląg, Muzeum Historyczno-Archeologiczne)

Rules of classification

The material from the excavations at the Elbląg Old Town (excavation XXII) consists primarily of fragments of various types of drinking glasses, mostly of the Czech type. It has been subjected to size classification on the basis of morphological features of glassware fragments and divided into ten categories grouped by the three basic parts: neck, belly and bottom/foot[7] [Fig. 2]. The classification also includes the category "intact vessels", which is not further subdivided.

Fragments of necks and bottoms, as characteristic elements, have been divided by size into three categories. The first includes elements of the neck and upper part of the belly and of the bottom or foot that are not smaller than one-third of the respective total. The second category includes parts of the neck and in the lower part, a whole foot or bottom or foot/bottom with a fragment of the body allowing for each fragment's placement within the whole. The third category includes non-diagnostic shards, which contain only the upper or the lower edge of the vessel.

[7] The term "bottom/foot" has been created by the author for the purposes of size classification due to frequent co-existence of these parts in one fragment, which renders their separate quantification impractical. The catalogue will distinguish bottoms, feet and dual fragments.

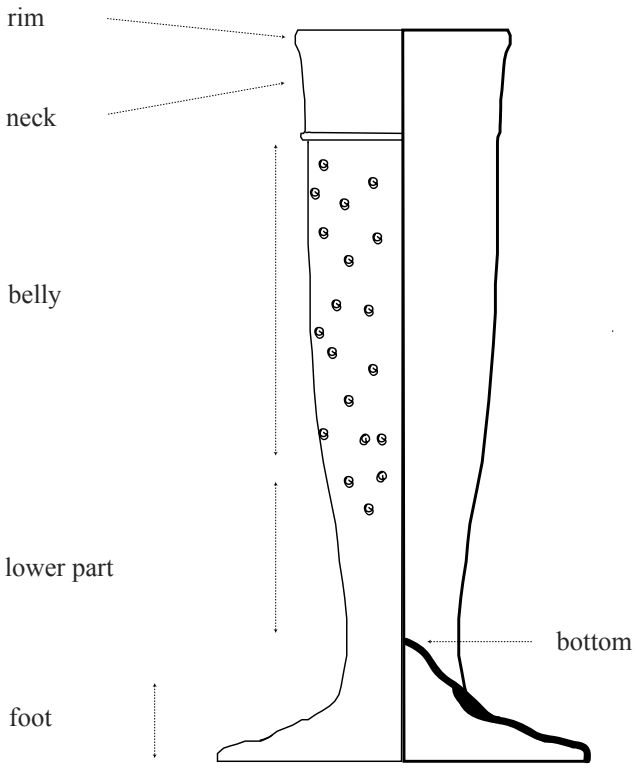

Fig. 2. Diagram of fluted glass morphological elements marked out
(drawing M. Janson)

For non-characteristic shards, namely bellies, a similar division has been applied based on surviving morphological characteristics. Fragments in category I display two morphological elements, for example the upper and lower part of the belly or the neck and a belly fragment. Single-element fragments, on the other hand, are more difficult to classify due to large variation in size. According to Andrzej Buko, further subcategories, IIa, IIb and III, can be identified thanks to a definition of the maximum radii of the fragments, which can then be plotted on a histogram. After performing these actions, one arrives at values on the basis of which it is possible to classify the fragments into relevant categories.[8]

The histogram arrived at in this way and based on the maximal radius of each belly fragment from excavation XXII at Elbląg can be seen in Fig. 3. The categories identified on its basis fit into ranges: III < 30 mm, IIb < 60 mm, IIa > 60 mm. This reasoning would be applicable to ceramic vessels, where variation in thickness is not significant. That is not, however, the case with glass objects due to clear differences in thickness, which can vary from 0.35 to 2.35 mm (that is, the highest value can be six times higher than the lowest). For that reason, the above comparison does not reflect objectively on the state of fragmentation of glassware. The fragments are qualitatively different and thus incomparable.

[8] Buko 1990, pp. 237–241.

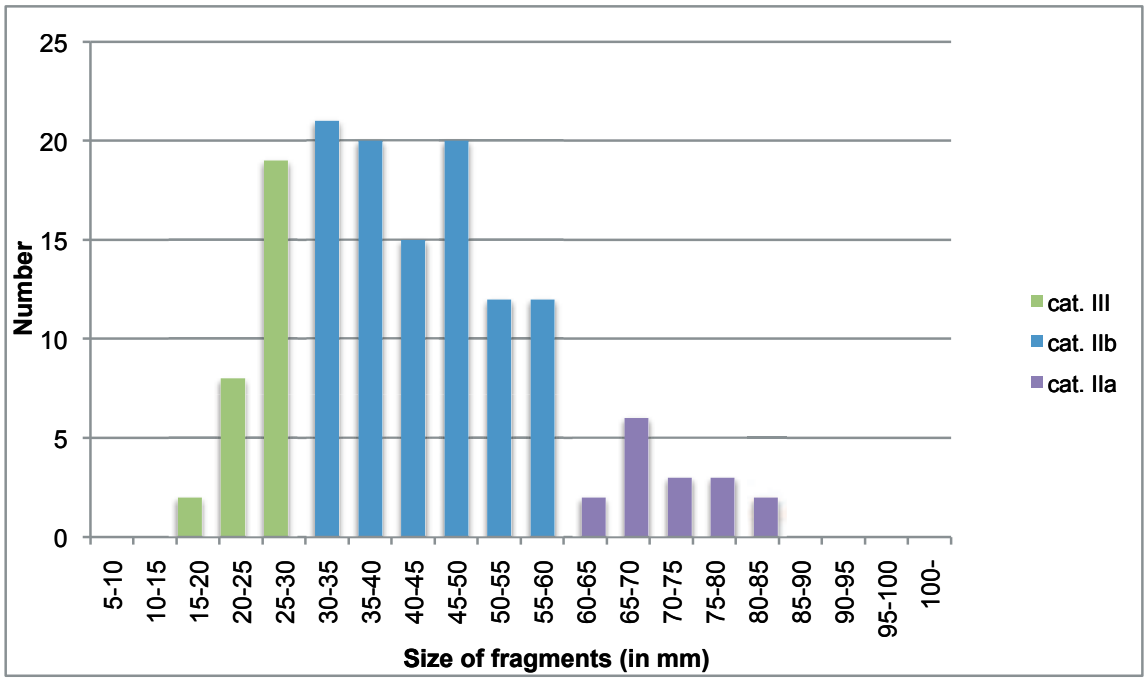

Fig. 3. Histogram I illustrating size ranges of belly categories, based on maximum radius

Classification becomes possible, and its results less arbitrary, when a histogram is based on the relative size ratio (W_W), which may be calculated by dividing the maximal radius of the fragment by its thickness. Such data are more objective. Thanks to this procedure, the ranges of size categories shift. The share of non-diagnostic shards of category III declines in favour of category IIa with the share of IIb roughly unchanged. The author considers thickness of glass to be very significant for the state of fragmentation of glassware found in archaeological excavations, as it is obvious that thinner glass is more destructible than thicker vessels. This is borne out by the histogram model on the basis of the W_W ratio [Fig. 4]. The categories it contains undergo a shift with

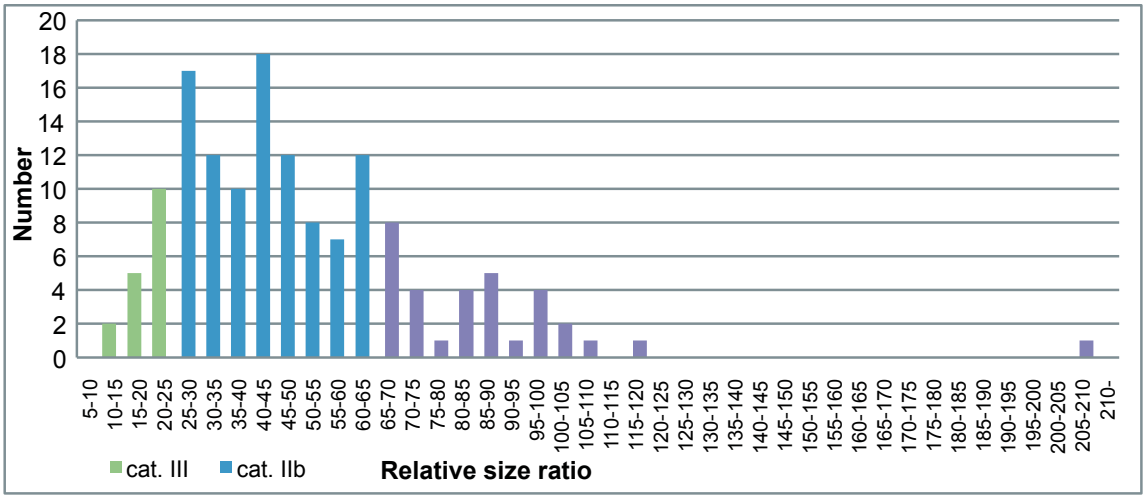

Fig. 4. Histogram II illustrating size ranges of belly categories, based on Ww ratio

the non-diagnostic proportion of the collection shrinking. The procedure is not arbitrary since a large proportion of category III fragments in histogram I met criteria necessary for various kinds of analysis. Thanks to the introduction of thickness as a criterion of classification, the subdivision of the collection becomes more realistic. In the author's opinion, it is histogram II that ought to be used for classification of bellies. Qualitative differences between the histograms are laid out in Table 1. It should be noted that each collection of glassware fragments is unique and must be approached individually. That means that the proposed method may be applied to any given glassware collection, but calculations for categories IIa, IIb i III must be carried out on a case-by-case basis.

Category	IIa	IIb	III
Histogram I	16	100	29
Histogram II	31	103	13

Tab. 1. Qualitative differences between belly categories in histograms I and II

Qualitative-quantitative analysis

The greater part of fragments from excavation XXII at the Elbląg Old Town consists of bellies, which make up 59.51 % of the total. Bottom/foot fragments make up 21.48 % of the collection, followed by necks (18.66 %). The least numerous category is what of "whole vessels" (0.35 %). The collection's qualitative and quantitative make-up is represented in Fig. 5.

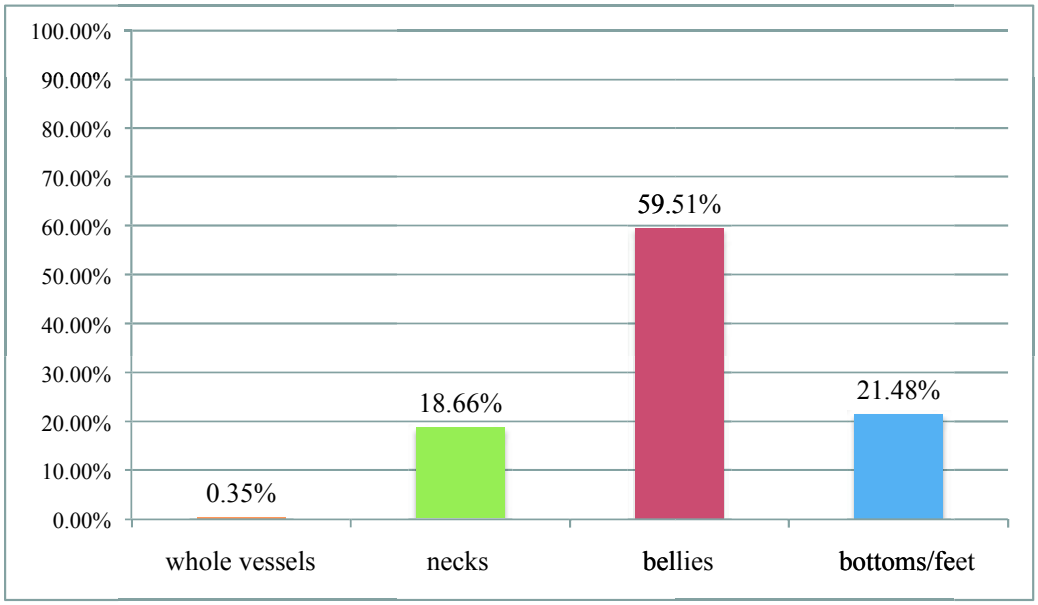

Fig. 5. Percentage distribution of glassware fragments from excavation XXII

Analysis of the collection's qualitative distribution reveals domination of the middle parts of vessels (169 fragments) due to the belly being the largest part at roughly 2/3 of each vessel's surface. The share of necks (53 fragments) and bottom/foot fragments (61) is much lower. The single "whole vessel" makes up the smallest category.

The next stage of analysis is to study the share of size categories in each group. Necks break up into: category I (24 items), category II (24 items), category III (5 items) [Fig. 6]. The distribution indicated shows that the edges of glass vessels are not greatly fragmented and are mostly diagnostic. In the group "bottom/foot" the shares of individual categories are the following: I — 16 items, II — 12 items, III — 33 items [Fig. 7]. The dominant position of non-diagnostic glass fragments testifies to a high degree of fragmentation and low analytical value of the material. Belly category distribution is the following: category I — 22 items, category IIa — 31 items, category IIb — 103 items, category III — 13 items [Fig. 8]. Analysis of the shares of individual fragments in the above categories is more difficult, as they are defined statistically. The division of category II into two subcategories also distorts the evaluation of the degree of fragmentation of the collection. In the case of earlier characteristic parts of the vessel, it was easy to find that the prevalence of the categories I and II testifies to a low degree of fragmentation. For categories IIa and IIb, with just one morphological element, that is not so easy. In this case, the main determinant is the W_W ratio.

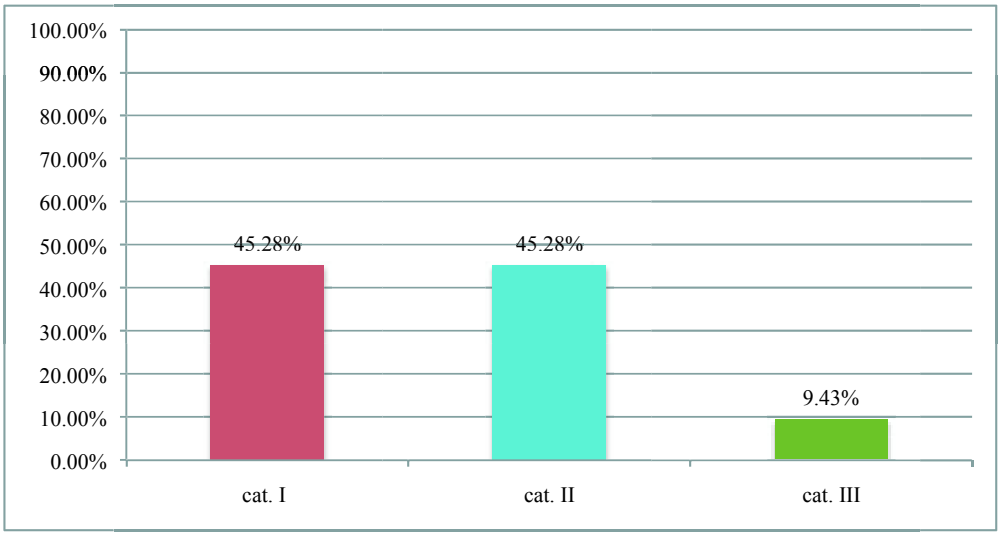

Fig. 6. Percentage distribution of neck categories from excavation XXII

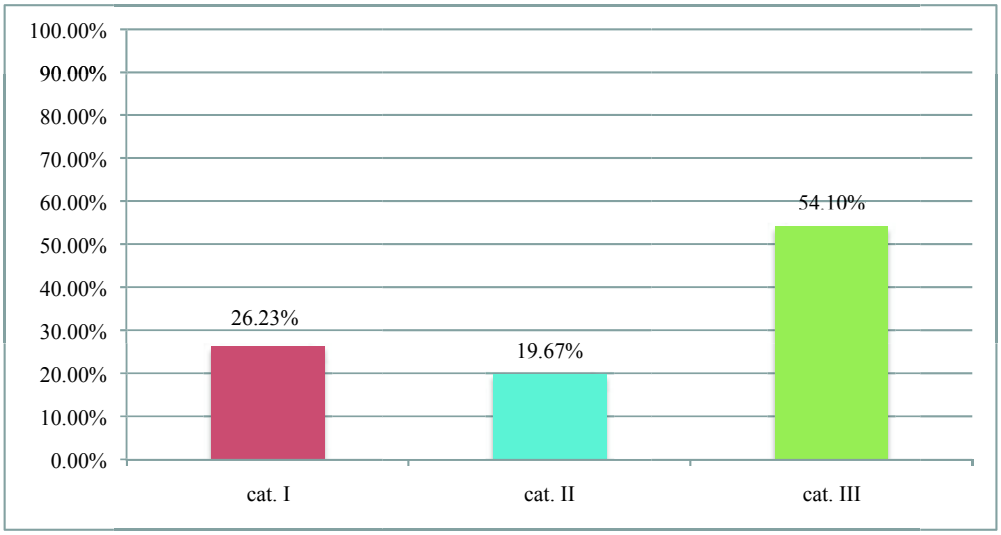

Fig. 7. Percentage distribution of foot/bottom categories from excavation XXII

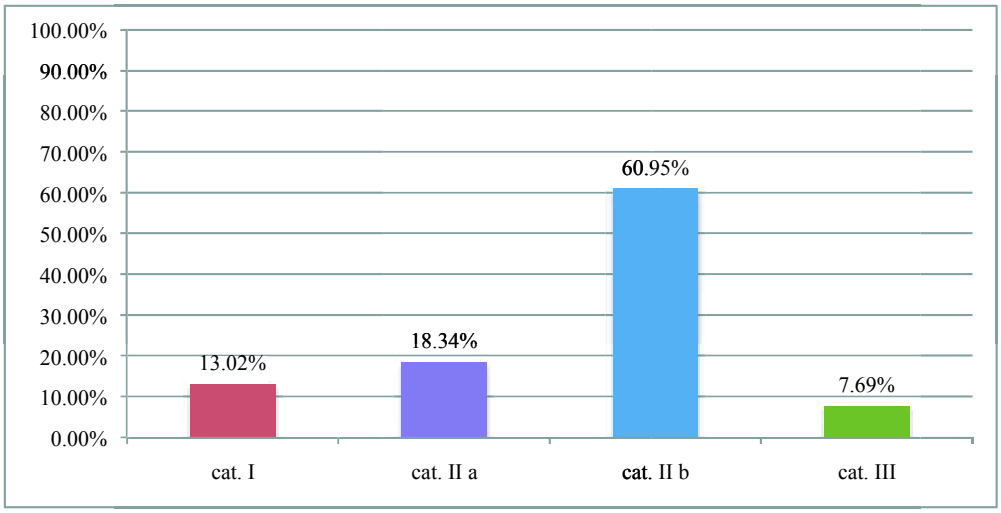

Fig. 8. Percentage distribution of belly categories from excavation XXII

In the author's opinion, the above categories should not be treated separately, but should be compared to category I due to a different definition. Taking into account the collection of the middle parts of vessels, it may be noted that it is fragmented to a high degree, but most fragments are not useful in some aspects of formal analysis.

The next stage in researching the state of fragmentation of glass vessels is to determine whether items in individual trenches are similar or dissimilar. In order to carry out the comparison, the basic statistical tool of the chi-squared test is used. The data regarding distribution of glass fragments in individual structures are found in Table 2. The chi-squared test serves to determine whether there is a relationship between distributions of a variable by comparing real data with a theoretical distribution. It must be borne in mind that the test can only be used when the minimum size of the sample (the number of fragments of a given type at the structure) is at least five.[9]

Size category	NUMBER OF TRENCH AND STRUCTURE																					Total
	10B		14	15		16s		26	27			28H	31	33	34			35		36		
	I	II	II	I	III	I	II	II	I	II	III	I	I	I	I	II	III	I	II	I	II	
I	1	0	0	3	0	2	7	1	0	2	9	1	0	0	0	1	0	0	3	27	3	60
II	4	0	1	2	0	0	3	8	0	1	4	0	0	0	0	1	0	0	1	9	2	36
II a	9	1	0	0	0	0	0	2	0	0	4	0	0	0	0	1	0	0	0	9	5	31
II b	7	0	1	0	1	0	12	3	0	0	16	1	6	0	1	5	0	1	6	35	8	103
III	1	3	0	2	0	0	1	5	2	2	6	0	1	3	0	1	1	1	2	14	8	53
Total	22	4	2	7	1	2	23	19	2	5	39	2	7	3	1	9	1	2	12	94	26	**283**

Tab. 2. Distribution of fragment numbers from trenches and structures they contain

[9] Jóźwiak, Podgórski 2012, p. 239.

For the purposes of the test, size categories including items from different structures are combined [Tab. 3]. Categories I and II are combined into a "low degree of fragmentation", while categories IIa, IIb and III into "high degree of fragmentation", in accordance with analysis carried out on the basis of histogram II. The criterion of at least five data points for each sample was met by just six structures in five trenches. For the purpose of the test, the structures lacking in sufficient numbers for analysis are combined into a single category, "other". Thanks to this procedure, the chi-squared test can be carried out on the whole collection, thus increasing its value. In addition, a separate analysis is carried out for trench 36, which alone contains all the structures that fit the test criteria, making it unique in the collection.

Degree of fragmentation	**NUMBER OF TRENCH AND STRUCTURE**																				
	10B		**14**	**15**		**16s**		**26**	**27**			**28H**	**31**	**33**	**34**			**35**		**36**		**Total**
	I	II	II	I	III	I	II	II	I	II	III	I	I	I	I	II	III	I	II	I	II	
Low	5	0	1	5	0	2	10	9	0	3	13	1	0	0	0	2	0	0	4	36	5	96
High	17	4	1	2	1	0	13	10	2	2	26	1	7	3	1	7	1	2	8	58	21	187
Total	22	4	2	7	1	2	23	19	2	5	39	2	7	3	1	9	1	2	12	94	26	283

Tab. 3. Combined distribution of fragment numbers from all trenches and structures they contain (latrines). In blue, trench 36, which is subject to further research in addition to general analysis. In green, structures that meet the criterion of at least five samples. In red, structures that do not contain sufficient material for chi-squared test and will thus be grouped as "other"

Below are found Tables 4 and 5 with a real and theoretical distribution for trench 36. The value for the chi-squared test is 3.29. The value of the test statistic for one degree of freedom and significance level of 0.05[10] amounted to 2.71. That indicates that from a statistical point of view, the structures have different distribution of fragment sizes.

Degree of fragmentation	Trench 36		Total
	Structure I	Structure II	
Low	36	5	41
High	58	21	79
Total	94	26	120

Tab. 4. Real distribution of fragment numbers from structures in trench 36

Degree of fragmentation	Trench 36		Total
	Structure I	Structure II	
Low	32,12	8,88	41
High	61,88	17,12	79
Total	94	26	120

Tab. 5. Theoretical distribution of fragment numbers from structures in trench 36

[10] In practice, the significance level used is typically lower than 0.1 and the level of 0.05 is recommended.

Tables 6 and 7 set out the real and theoretical distribution for all structures. The value of the chi-squared statistic amounts to 7.42. The value of the test statistic for six degrees of freedom and significance level of 0.05 amounts to 12.59. The result indicates that from the statistical point of view the structures under study have uniform distribution of fragment sizes. It should also be noted that on the basis of the test there is a 70 % probability (significance level of 0.3) that structures in all trenches differ amongst themselves. For this kind of test, however, the required level of significance is higher.

Degree of fragmentation	Structures from trench							Total
	10B(I)	16s(II)	26(II)	27(III)	36(I)	36(II)	other	
Low	5	10	9	13	36	5	18	96
High	17	13	10	26	58	21	42	187
Total	22	23	19	39	94	26	60	283

Tab. 6. Real distribution of fragment numbers from structures in all trenches

Degree of fragmentation	Structures from trench							Total
	10B(I)	16s(II)	26(II)	27(III)	36(I)	36(II)	other	
Low	7,46	7,80	6,45	13,23	31,89	8,82	20,35	96
High	14,54	15,20	12,55	25,77	62,11	17,18	39,65	187
Total	22	23	19	39	94	26	60	283

Tab. 7. Theoretical distribution of fragment numbers from structures in all trenches

In summarising the results of size classification carried out on glass vessels from the urban quarter in the vicinity of the Elbląg central square, known as excavation XXII, it should be noted that the state of fragmentation of the excavated material is relatively high. Only necks, which represent 18.66 % of the collection, are well preserved. The chi-squared test demonstrates that all structures display a similar distribution of glassware fragmentation. That indicates that sedimentation processes took a similar course in each of them. Attention should, however, be drawn to some of them. As pointed out before, there is a 70 % probability that structures in the trenches differ — that their distribution is different. Trench 36, for which a separate analysis has been carried out, stands out. In this case the state of fragmentation of the preserved material in the two excavated latrines is very different. This could be the result of different periods and intensity of their use. One of the two is designated as structure I (it is earlier — ceramic allows to date to the 14th/15th–17th centuries). Structure II, found in another part of the courtyard, can be interpreted as a later latrine (from the 16th/17th–19th centuries). A distribution different from theoretical can also be found for structure II from trench 26.

The visible difference in fragmentation at some of the structures under study may be due to uneven pace of residue removal from different latrines. Faeces and waste removal in the medieval and early modern city was a matter for private citizens with the authorities staying away unless neighbour rights were violated. There existed prohibitions of throwing the waste into the streets during the day, onto a neighbour's plot or of spraying mulch onto the streets. Cleaning up latrines, on the other hand, was a matter outside public interest and was left to private citizens.[11] The data above indicate, however, that latrines within XXII were cleaned out fairly regularly with few exceptions, which may have resulted in the small differences in the state of fragmentation of glassware remains.

[11] Czaja 2005, pp. 345–348.

It is interesting that none of the latrines under study displays signs of stratigraphic distortion due to later digging. The latrines were mostly used for an extended period of time, from the fourteenth/fifteenth century all the way to the nineteenth. The exception is structure III from trench 27, which was only in use until the end of the fifteenth century, when it was filled in. The lack of stratigraphic distortions coincident with a high degree of fragmentation of glassware remains may point to two facts. First, periodic cleaning undoubtedly disturbs the process of layer formation in such structures. Such interventions must impact completeness of glassware preservation. Second, such a high degree of fragmentation may result from a prolonged period that objects would remain in the context where damage originally occurred. The process of deposition of a vessel may have been extremely complex — from the damage, to throwing it into the courtyard to eventual deposition in the latrine during cleaning.

As can be seen, the project of size classification of glassware remains is extremely interesting and could make a significant contribution to methodology of "glass archaeology". Most of all, it offers a new outlook on fragmentation late medieval and early modern drinking vessels found in the course of archaeological excavations. It may serve to order any given collection of the type. On that basis, it is possible to implement a more sophisticated statistical analysis in the form of the chi-squared test, whose key findings allow for conclusions on stratification and deposition of the material.

Bibliography

Biszkont 2005	J. Biszkont, *Późnośredniowieczne szklarstwo na Śląsku*, Wrocław.
Buko 1990	A. Buko, *Ceramika wczesnopolska: wprowadzenie do badań*, Wrocław.
Ciepiela 1971a	S. Ciepiela, "Ozdoby i naczynia szklane odkryte w Nakle nad Notecią", *Wiadomości Archeologiczne* 36, fasc. 2, pp. 203–212.
Ciepiela 1971b	S. Ciepiela, "Zabytki szklane ze Świecia nad Wisłą", *Pomorania Antiqua* 3, pp. 479–496.
Czaja 2005	R. Czaja, "Troska o stan sanitarny w miastach pruskich w XIV i XV wieku", *Kwartalnik Historii Kultury Materialnej* 53, fasc. 3–4, pp. 343–349.
Dekówna 1980	M. Dekówna, *Szkło w Europie wczesnośredniowiecznej*, Wrocław – Warsaw – Cracow – Gdańsk.
Grosicki 2014	P. Grosicki, *Późnośredniowieczne i wczesnonowożytne naczynia szklane z wykopu nr XXII w Elblągu* (unpublished MA thesis, Institute of Archaeology, University of Warsaw, supervisor: Prof. Joanna Kalaga).
Jóźwiak, Podgórski 2012	J. Jóźwiak, J. Podgórski, *Statystyka od podstaw*, Warsaw.
Nawracki 1999	M. Nawracki, "Późnośredniowieczne i nowożytne szkła z terenu zamku krzyżackiego w Toruniu", [in:] *Archeologia szkła*, VIII, ed. J. Olczak (= *Acta Universitatis Nicolai Copernici*, *Archeologia* 27), Toruń, pp. 53–132.
Ščapova 1973	J. L. Ščapova, "Zasady interpretacji analiz składu szkła zabytkowego", *Archeologia Polski* 18, fasc. 1, pp. 15–72.

Streszczenie

Klasyfikacja wielkościowa fragmentów naczyń szklanych — wstęp do nowej metodyki badań nad szkłem

Dotychczasowa metodyka badań naczyń szklanych okresu późnośredniowiecznego i wczesnonowożytnego opiera się na założeniach z lat siedemdziesiątych – osiemdziesiątych XX wieku, całkowicie pomijając problematykę fizycznego stanu zachowania materiału, a w szczególności rozkład wielkościowy fragmentów. Celem artykułu jest propozycja wprowadzenia do „archeologii szkła" projektu klasyfikacji wielkościowej naczyń szklanych i wskazanie daleko idących korzyści z niej wypływających**.** Po wykonaniu wyżej wspomnianej klasyfikacji na zbiorze 283 ułamków naczyń szklanych pozyskanych z badań wykopaliskowych w wykopie XXII na Starym Mieście w Elblągu możliwe stało się wnioskowanie o przebiegu procesów stratyfikacyjnych i depozycyjnych. Na podstawie wykonanych analiz statystycznych pod postacią testu zgodności chi-kwadrat stwierdzono, że procesy te przebiegały w 21 obiektach w sposób podobny. Jednakże, mimo że są one pod względem statystycznym takie same, niektóre z nich mają odmienny rozkład, na co zwrócono szczególną uwagę.

Wprowadzenie nowego zagadnienia do metodyki badań nad szkłem umożliwi uporządkowanie dowolnego zbioru naczyń pod względem stanu rozdrobnienia materiału, a co za tym idzie — stworzy możliwość wdrożenia bardziej zaawansowanych metod statystycznych.

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