# THE CAPACITY OF NORTHERN PONTIC AMPHORAE OF THE 8th-10th CENTURIES

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**ABSTRACT**

The article deals with study of capacity of medieval amphorae that are spread over sites of the 8th — 10th centuries in the Northern part of the Black Sea region. Such vessels were manufactured in pottery centers of Byzantine Taurica. The task complexity is related to lack of written sources on regulation of the Black Sea amphorae production in Taurica and on the state control of volumetric standards applied to ceramic containers. 176 intact vessels found at monuments of Crimea, Taman peninsular, the Sea of Azov basin, the Don river basin and the Caucasus served as the material for this study. The method of 3D modeling (with use of Autodesk 3Ds Max computer program) was employed for solution of the task. The results of the study suggest that some amphorae groups can be associated with at least five capacitive standards based on Byzantine volume units of wine.

## 1. INTRODUCTION

Amphorae are ones of the most informative archeological sources for study of economic history of the Antiquity and the early Medieval epochs. Stuffs carried in amphora containers comprised a considerable part of trade turnover in the Ancient World. However, comprehensive amphorae studies are impossible without consideration of varying capacities of ceramic vessels. The thesis is confirmed by numerous studies made, in the main, on antique amphorae material (Grace, 1949, 1971; Wallace Matheson and Wallace, 1982; Opait, 1987; Brashinskij, 1976, 1984; Monahov, 1980, 1989, 1992, 2003; Vnukov, 2003).

The interest to study of Byzantine amphorae capacities emerged relatively recently (Garver, 1993; Van Doorminck, 2015; Van Alphen, 1996, 2015).

Amphorae found at the 8th-10th centuries sites in the Northern part of the Black Sea region, predominantly in Crimea, Taman, the Sea of Azov basin and the Don river are still uncovered by metrological studies. These amphorae constitute the subject of the current study. In the Russian and the Ukrainian scientific literature this kind of pottery is traditionally designated as the «pontic» amphorae (Figure 1). Centers of these amphorae production are located in Crimea (Parshina et al., 2001). Similar vessels are known at other sites of the East Mediterranean region. However so far it is not quite clear whether it is possible to identify these amphorae with the «pontic» ones (Arthur, 1989, fig.5,7; Hayes, 1992, fig. 25, 1-9, 12-15, 23, 2-6, 6-12; Sagui et al., 1997, fig. 6, 2-3; Vroom, 2005: 60−61).



*Figure 1. «Pontic» amphorae of 8th-10th centuries (A.N. Sviridov excavations on the «Gora Chirkova» settlement).*

The «pontic» amphorae are the principal source. This source reflects commercial and economic relations in the Black Sea region and adjacent territories in the 8th-10th centuries. Therefore, the urgency of these vessels' volumes investigations is beyond any doubt.

## 2. MATERIALS AND METHODS

There are different ways of ancient vessel capacities determination. The most common methods are filling of vessels with liquid or bulk material and performing mathematic calculations on the ground of vessels' trace drawings, with representation of

their capacities as sets of certain geometric configurations (Ericson, 1973; Nikolaenko, 1974; Barabanova and Platonov, 1982; Rice, 1987; Monahov, 1992; Orton, 1993). The first method is usually available only in cases when vessels are studied *de visu*. Condition of vessels far from always allows employing this method. It is difficult to consider the second method as suitable for practical calculations. The final result depends on specific design schedule. Depending on a number of tentative geometric configurations, values for the capacity of the same vessel under reconstruction may vary within 15-20% range (Rodriquez et al., 2013, p. 1188).

Therefore at the current up-to-date level of study techniques computer and automatic methods of research play an important role for investigation of vessel volumes (Karasik and Smilansky, 1996; Engels et al., 2009). In this study 3D modeling by means of Autodesk 3Ds Max software is used. Procedure of vessel volumes calculation was developed and published by E. P. Zagvazdin and N. P. Turova (Zagvazdin and Turova, 2011)[1]. Calculation of vessel capacities in 3D editing program is divided into two stages. Stage one is the preparatory stage. At this stage a vessel image is represented in a form available for processing in 3D editor. The principal task to be solved at this stage is adjustment of a subject image scale. The task can be solved in different programs, i. e. Adobe Photoshop, CorelDraw etc. In this study CorelDraw software is used. Amphorae images scale was worked out to 1:1. The second stage is the direct work in 3D editing program. To calculate capacity of every vessel trace drawing of a vessel configuration was stretched over with use of the "spline" tool. Then "Lathe" modifier was employed. Volumes of such vessel were determined with help of "Measure" built-in option.

A series of amphorae investigated comprises 176 vessels found at different sites of Crimea, Taman peninsular, the Sea of Azov basin, the Don river basin, and the Caucasus. These amphorae survived either totally intact or intact up to neck. 64 amphorae have been studied by the author personally in the Russian museums' collections and in the process of work at ArchAeological expeditions. Other 112 amphorae have been studied in the basis of their images published in Russian and Ukrainian scientific literature.

## 3. RESULTS

In the paper, the following tasks are consistently addressed:

1) The study of vessels with known thickness of walls. When studying published images of vessels, we do not always have information about the thickness of their walls. Although this is necessary to obtain data on actual capacity of the vessel. Our experience of studying «pontic» amphorae shows that the real thickness of the walls is usually about 1 cm. Nevertheless, it is necessary to mathematically check the possibility of using this assumption in further calculations of the amphorae capacity. For this purpose, the restored vessels with known wall thickness were used.

2) The calculation of the volume of all the other amphoras and the definition of the common capacity values;

3) Comparison of the most common values with Byzantine volume units of wine.

1) We began with study of a series of vessels with known thickness of walls. Capacities of these amphorae were calculated on the grounds of their inner and outer contours. The difference between these two values made it possible to establish the volume occupied by vessel walls. The value of the walls' volume comprises from 8 to 32% of the total capacity. On the average it comprises 18% (Figure 2). It should be emphasized that this value is obtained provided amphorae were filled either up to their necks or the total capacities are taken into account.[2]

Now it is necessary to find out whether value of volume occupied by vessel walls depends on the total capacity of a vessel. Data on dependence of vessel walls' volume on the total capacity of vessel are adduced in graph (Figure 3). Two sets of vessels are presented on the graph. The left set is related to amphorae with 5-15 l capacity, the right set is related to amphorae with capacity in excess of 15 l. Nearly in 90% of vessels from the left set "volume of walls" accounts for 12-24% of the vessel total capacity, i. e. about 18% on the average. The right set that includes vessels of more than 15 l capacity seems to be less compact. In this set major part of amphorae has the "walls volume" share within 11-19% range, about 15% on the average.

Thus it has been established that the "walls volume share". This value depends on a vessel size. The size of the vessel and the proportion of the volume of the walls are inversely related. That confirms hypothesis that absolute thickness of walls is stable. Therefore, for further volume calculations of all other amphorae it is legitimate to assume that they have the same wall thickness (about 1 cm).

2) The next step in our study was calculation of all other amphorae capacity. Upon synthesis of data on all vessels it was established that the «pontic» amphorae volumes varies within the range of 3.38-41.57 l (Figure 4). Values of amphorae capacities were tested for «normal distribution» (Kolmogorov-Smirnov and Shapiro-Wilk tests). Results on the graph indicate that the hypothesis of the normal distribution of the volume values cannot be accepted ($p < 0.05$). It follows that the values of «pontic» amphorae capaci-

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[1] The author is grateful to E. P. Zagvazdin for invaluable advice on assimilation of the vessel volumes analysis by dint of 3D modeling.

[2] We hold on the opinion that the physical volume of a container has to exceed the volume standard it contains (Brashinskij, 1976: 95; 1984: 75; Monahov, 1989:37). So hereinafter values of amphorae volumes are adduced provided amphorae were filled up to their necks.

ty are unevenly distributed. Therefore, it is necessary to consider the histogram in more detail.

The most common amphorae had volume of 5 to 10 l. Among the amphorae with the volume up to 10-11 liters (Figure 5. I) there are several clusters with visible peaks around 5-6.5 l, 6.5 to 7.7 l, 7.8 to 8.9 l,

9.2 to 11 l. Similar situation is observed in the set of greater amphorae (more than 10-11 l). We can define groups 12-17 l and 19-27 l (Figure 5. II). In the last group two peaks at marks around 20 and 26 l are observed.
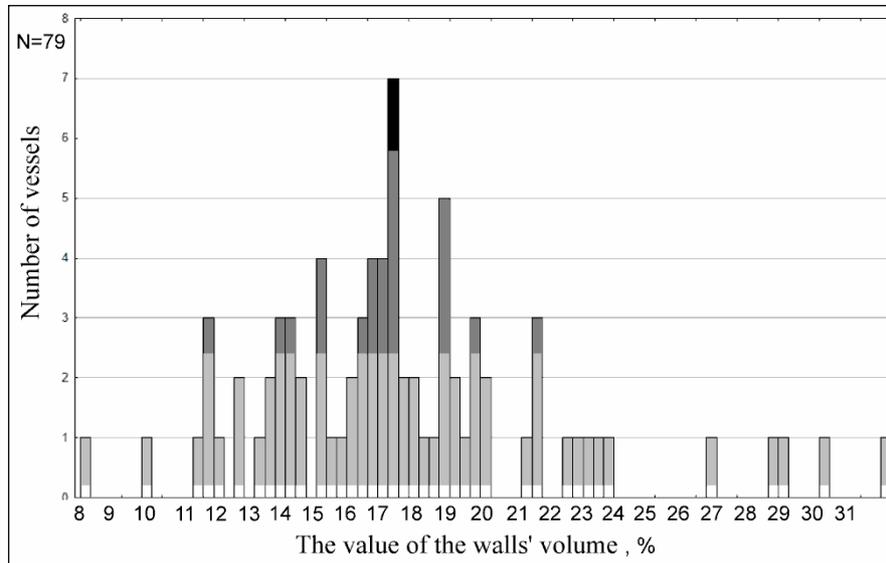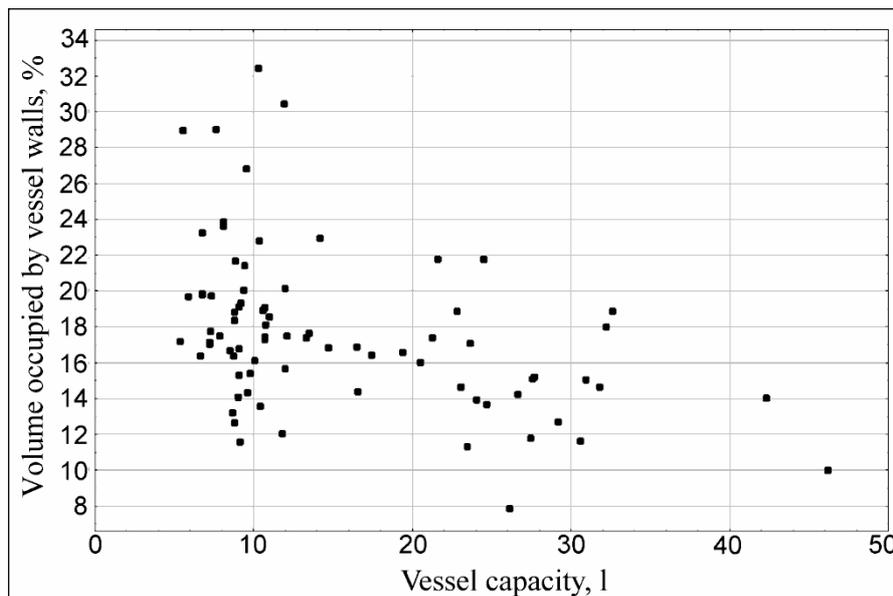


*Figure 2. Vessel volume occupied by vessel walls.*



*Figure 3. Dependence of vessel walls' volume on the total capacity of vessel.*

3) Thus, analysis of data obtained indicates that all investigated amphorae are divided into several groups according to their volume (up to 5 l, 5-6.5 l, 6.5 to 7.7 l, 7.8 to 8.9 l, 9.2 to 11 l, 12-17 l and 19-27 l).

Can these groups reflect the different standards of amphorae capacity that existed in the pottery production of Byzantine Taurica? The issue's complexity is connected with the lack of written sources data about state control of capacity standards of ceramic containers in this region.

First of all, it is necessary to understand what products could be carried in the «pontic» amphorae and what measures could be used as the basis of amphorae volume. It is known that production of grapes and winemaking were developed in the region where the «pontic» amphorae has been made (Vejmarn, 1960: 113−116; Jakobson, 1970: 153; Danilenko, 1994: 133−140). In this connection it can be assumed that amphorae production in the Crimea could serve interests of local wine makers. Therefore, if the «pontic» amphorae were regulated with some

standards, these standards had to comply with Byzantine volume measures.

Studies of E. Schilbach (1970) demonstrated that the most widespread Byzantine volume capacity measures were the anonnican metron (6.83 l), the monasterikon metron (8.2 l) and the thalassion metron ( 10.25 l).
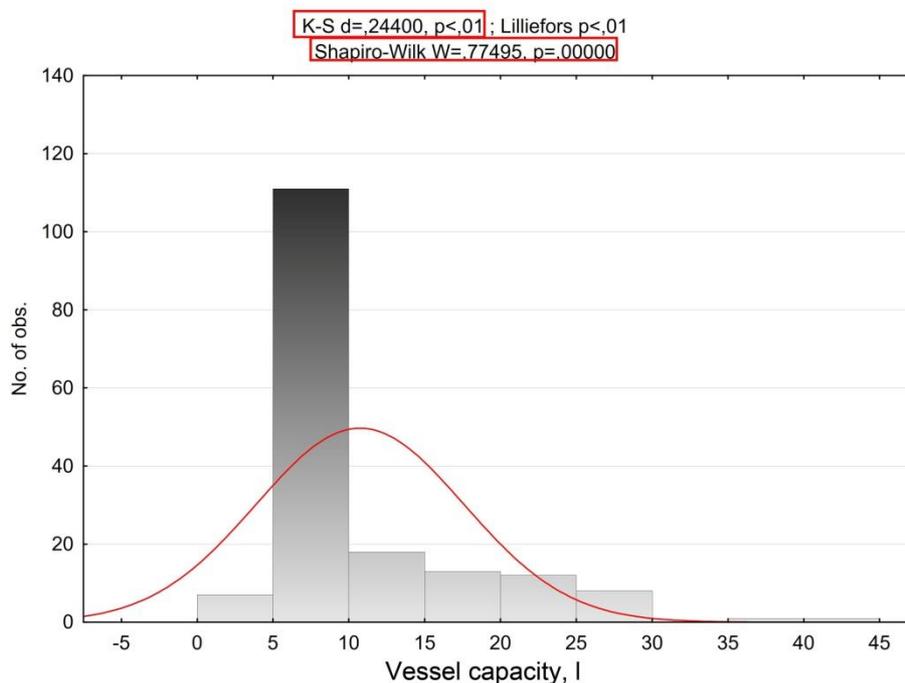


K-S d=,24400, p<,01 ; Lilliefors p<,01
Shapiro-Wilk W=,77495, p=,00000

*Figure 4. The histogram with the results of the tests for normality of distribution.*

All three measures are mutually convertible. For instance, 1 thalassion metron is equal to 1,5 anonnican metron. In result of this conversion the measures mentioned above can be used as half-measures, as it was established by E. Garver in the process of Byzantine amphorae study (Garver, 1993).

If capacities of the most common groups of amphorae are compared with Byzantine standards of volume their considerable similarity is discovered:

— measure equal 0.5 of monasterikon metron (i.e., to 4.1 l) may corresponds, approximately, to the group of amphorae of up to 5 l capacity (Figure 5. I);

— measure 0.5 of thalassion metron (5.13 l) may correspond, approximately, to the group of amphorae of 5-6.5 l capacity (Figure 5. I);

— measure 1 anonnican metron (6.83 l) corresponds to the group of amphorae of 6.5-7.7 l capacity (Figure 5. I);

— measure 1 monasterikon metron (8.2 l) corresponds to group of amphorae of 7.8-8.9 l capacity (Figure 5. I);

— measure 1 thalassion metron (10.25 l) corresponds to group of amphorae of 9.2-11 l capacity (Figure 5. I);

— measure 1.5 thalassion metron corresponds to group of amphorae of 12−17 l capacity (Figure 5. II);

— measure 2 thalassion metrons (20.5 l) correspond to group of amphorae of 19-27 l capacity (Figure 5. II).

For checking possibility of recognition of these standards we have used discriminant analysis. The aim of the method is verifying of intuitional classification based on some quantitative data. The most common and obvious linear measurements were used for this procedure: the height of the amphora, the maximum diameter of the amphora and the diameter of the base of the neck. Hypothetically, these parameters are the most available for control by the potter during the molding of the vessel.

The table with results of discriminant analysis shows that some dimensional groups of vessels are successfully recognized (Table 1). Firstly, there is one of the smallest capacitive group - 0.5 of thalassion metron (100 % identified). Secondly, there are two the largest groups of amphorae - 1.5 thalassion metron (95,2 % identified) and 2 thalassion metrons (100 % identified). Two amphorae groups are recognized slightly worse - 1 anonnican metron (77,1 % identified) and 1 monasterikon metron (78,3 % identified). Finally, two amphorae groups are recognized least accurate - 0.5 of monasterikon metron (62,5 % identified) and 1 thalassion metron (66,7 %% identified).

Thus, if assume that ancient potters established amphorae capacity through linear dimensions, at

least five standard capacities of «pontic» amphorae may be recognized (according to discriminant analysis):

   -0.5 of thalassion metron (up to 5 l);

   -1 anonnican metron (6.5-7.7 l);

   -1 monasterikon metron (7.8-8.9 l);

   -1.5 thalassion metron (12−17 l);

   -2 thalassion metrons (19-27 l).

The accuracy of recognizing of two vessel groups, originally associated with the measures 0.5 of 0.5 monasterikon metron (4.1 l) and 1 thalassion metron (10.25 l), was not confirmed statistically.
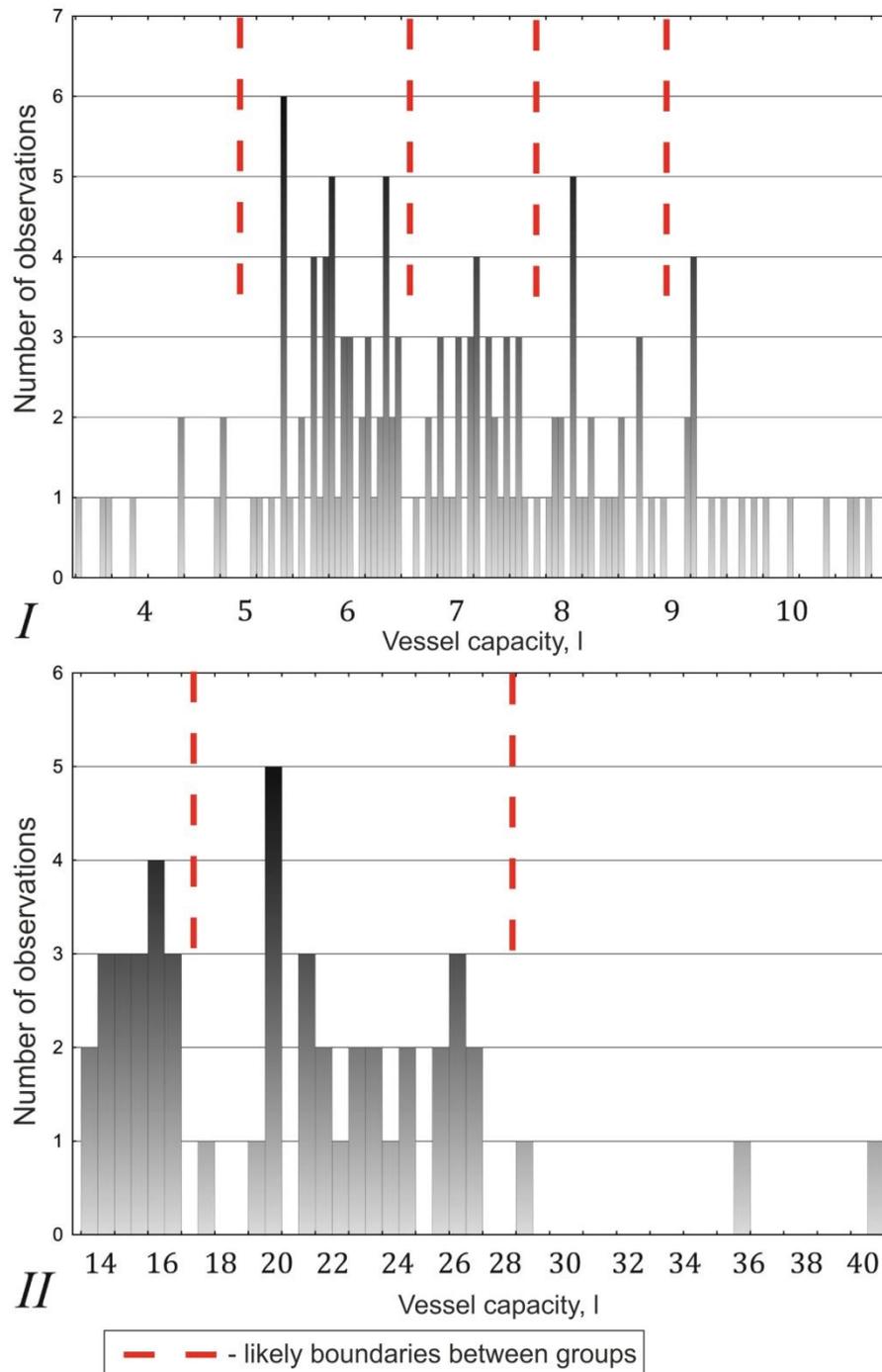


*Figure 5. Histogram of amphorae capacity.*

## 4. CONCLUSION

In the 8th-10th centuries in the Black sea region a variety capacity of amphorae was used. The results of the study show that the actual volume of amphorae ranges from 3-4 to almost 40 liters. However, most of the «pontic» amphorae were intended for transportation of 5-10 liters of wine. A wide range of volume variety is reason to assume that several capacity standards were used in amphorae production of Taurica of the 8th-10th centuries. But the issue of

the allocation of specific standards cannot yet be resolved definitively. A comparison of some groups of amphorae with the Byzantine volume units of wine shows that these groups can be associated with at least five capacitive standards, which could be used by the Byzantine potters. It is natural that the boundaries between these groups are quite blurred because clay vessels are the results of handcraft. The deviations from a pre-planned size standard of the vessel are the consequence of qualification of potter, physical properties of clay and random factors related to the physiology of manual craft. The above factors are the main reasons for the lack of clear boundaries between different groups of amphora volume in the sample of archaeological material.

Nevertheless, the data obtained are the basis for assuming the existence of several possible standards that were used in the production of medieval «pontic» amphorae. The results of this study could be the subject of discussion among researchers of medieval amphorae and maritime trade in the Eastern Mediterranean. Further researches in this direction should be aimed at the development of methods for determining the volume of «pontic» amphorae through a vessel fragment.

*Table 1. Results of discriminant analysis (the table of «observed classification»).*

| | Percent of correct defenitions | 0.5 of monasterikon metron | 0.5 of thalassion metron | 1 anonnican metron | 1 monasterikon metron | 1 thalassion metron | 1.5 thalassion metron | 2 thalassion metrons |
|---|---|---|---|---|---|---|---|---|
| 0.5 of monasterikon metron | 62,5 % | 5 | 3 | 0 | 0 | 0 | 0 | 0 |
| 0.5 of thalassion metron | 100 % | 0 | 48 | 0 | 0 | 0 | 0 | 0 |
| 1 anonnican metron | 77,1% | 0 | 6 | 27 | 2 | 0 | 0 | 0 |
| 1 monasterikon metron | 78,3 % | 0 | 0 | 5 | 18 | 0 | 0 | 0 |
| 1 thalassion metron | 66,7 % | 0 | 0 | 2 | 3 | 12 | 1 | 0 |
| 1.5 thalassion metron | 95,2 % | 0 | 0 | 0 | 0 | 1 | 20 | 0 |
| 2 thalassion metrons | 100 % | 0 | 0 | 0 | 0 | 0 | 0 | 23 |
| TOTAL | 82,8 % | 5 | 57 | 33 | 23 | 13 | 21 | 23 |

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