

Review of sixteen Pskov churches equipped with acoustic vessels

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ABSTRACT

A lot of worship spaces with acoustic cavities of different sizes and forms are known today due to a number of reviews and studies published last decades. Pots, jars and other vessels were used in church architecture of the Middle Ages in many European countries. During this period the practice of using such devices was widespread in Russia as well, but the most impressive heritage was given by the Pskov architectural tradition. The churches built there from the 13th to 16th centuries were equipped with hundreds of the acoustic vessels. For various reasons, many churches have not survived to this day, but a significant number of them still exists. This paper reviews sixteen Orthodox churches in Pskov, which were built from 1243 till 1586 and have a lot of acoustic vessels. The biggest number of vessels is observed in the Peter and Paul Church. In spite of its small volume which is only about 1300 m³, there are 326 vessels installed in the drum, pendentives and walls. Ten churches have more than 100 vessels, the smallest number is 42. Description of the churches and analysis of the location of the vessels on inner surfaces are presented.

Keywords: resonator, archaeoacoustics, medieval architecture

1. INTRODUCTION

The idea of using large vessels to influence the acoustics of rooms dates back to antiquity. Aristotle or another unknown author of the *Problemata* [1] states that buildings have more resonance if there are large jars, earthenware or bronze vessels and cisterns inside. Vitruvius [2] recommends to arrange bronze vases or clay jars in theatres. The use of the resonant cavities in the history of architectural acoustics is reviewed in the study [3]. Today we can meet the vessels primarily in worship places. Many churches distributed throughout Europe [4,5], mosques [6] and synagogues [7] are equipped by different types of pots, amphorae and hollow vessels.

In Russian architecture, the acoustic pots have been installed in the construction of churches since the Christianization in 988 [8]. Since then, a lot of churches were build following the Byzantine traditions, however national architecture styles were being developed as well. One of the most interesting is the Pskov school of architecture reached its peak in the 15th and 16th centuries. A feature of the school was the application of the built-in pots orderly arranged on inner surfaces [9]. This paper briefly describes the unique acoustic heritage of Pskov monuments.

Sixteen existing and functioning churches are surveyed here. Without being able to describe each of them in details, we review only one taking into account that all medieval Pskov churches have a lot in common. The church of Peter and Paul was chosen as an example

because it has the biggest number of the acoustic pots. Then we provide and analyze data on the pots in other churches.

2. CHURCH OF PETER AND PAUL

2.1 History

The church of Peter and Paul s Buya (Figure 1) was built in 1540 in the place of an earlier church known since 1373. The name “s Buya” might mean that there used an old Russian burial mound nearby.



Figure 1 – Church of Peter and Paul s Buya

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By the beginning of the 17th century, the church was in a very bad state. The old clergy bulleting reported that in 1610 its walls were rebuilt, as well as vaults, iconostasis, roof and cupola. In 1713 and 1810 the roof and outer walls were renovated. In 1920-1930 the church was closed. During the occupation of Pskov in 1941-1944 the building was not damaged. In 1989-1995 a series of restoration works followed to make the church fit for service.

So, we can be sure that the original building including acoustic vessels has been almost completely preserved since 1540 or at least since 1610.

2.2 Interior description

Figure 2 shows the interior of the church. The inner volume is cubic with dimensions 11x11x11 m. There are three apses at the eastern wall and four piers with the rectangular cross-sections (1.7x1.5 m). The high drum is cut by eight slots of windows. In the western part there are two small chambers on the first floor. All surfaces except the floor are covered with plaster and painted.

The iconostasis is a solid screen of wood separating the sanctuary from the nave and decorated by icons. It is partially visible in Figure 2a. In all churches reviewed in this paper the iconostasis is located in the same place from the northern wall to the southern one without gaps, but their heights are different. In the church of Peter and Paul its height is 5 m or about half the room height. But in some other churches the iconostasis height is close to the room height, therefore the sanctuary and the nave are acoustically separated. Probably, this point should be taken into account in the further acoustic analysis.

2.3 Acoustic vessels

In Figure 2a we can see numerous holes which are necks of clay pots. There are several pots in the drum between the windows and in the pendentives, whereas most of the vessels are placed on the walls. All walls have two groups of the vessels, which are periodically arranged. The example of one group on the northern wall is in Figure 2b, this group has five rows with 8, 10, 11, 12 and 13 pots. So, the group contains 54 pots. The average distance between the pots is approx. 0.3 m; in other words, the density is 11 pots per 1m². Total number of vessels in the church is 326. It is the largest number among all Pskov churches.

As noted in [8] the regular positioning of the vessels could be applied for decoration. Usually, the Pskov churches had no murals or frescos and their surfaces were white, and the pot arrays provided a contrast pattern. However, some churches are known, where the murals and the pots are used together.

Unfortunately, we have no reliable information about the sizes of the pots. Based on the old review [10] we can assume that a diameter of the neck is about 10 cm and a volume of the pot is about 10 L. There is no any information about their resonant frequencies and Q-factors.

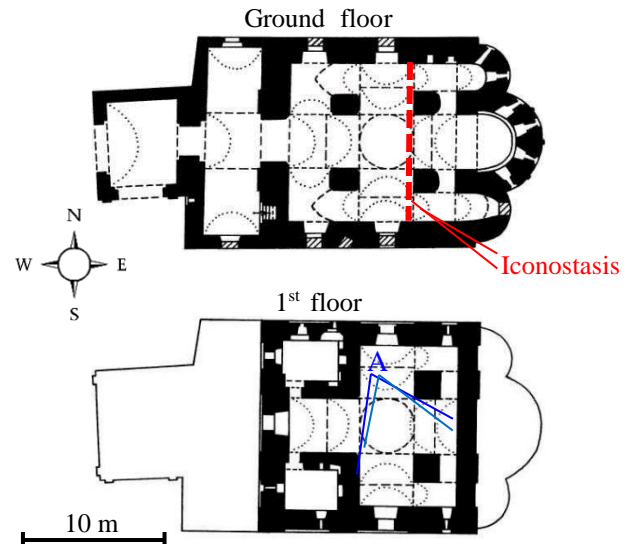


Figure 2 – The plans and interior of the Church of Peter and Paul's Buya. View of the eastern and southern walls (a); a fragment of the northern wall (b).

3. PSKOV CHURCHES

3.1 List of the churches

Table 1 contains the list of the churches ranked in decreasing order of the number of vessels. The period of their building is 1243-1582, but only one of them was built earlier than 1400. The volume of the main room including both the sanctuary and the nave is given as well. One can note that they are unusually small chambers, if they are compared with most of Russian or European churches. The reason is the small churches were one of features of the Pskov school. Ten monuments of the school were included in the World Heritage List of UNESCO in 2019 and seven of them are presented here.

Table 1 – Reviewed churches

No.	Name	Year	Volume, m ³
1	Peter and Paul	1540	1330
2	Nicholas (from the dry place)*	1536	1700
3	Zhen-Mironosits	1546	810
4	Pokrova ot Proloma*	1582	170/190
5	Theophany*	1496	1600
6	Assumption of the Virgin	1521	1750
7	Clement	~1500	370
8	Basil (on the hill)*	1413	680
9	Kozma and Damian*	1463	1370
10	Ascension	1467	620
11	Resurrection	~1586	860
12	John the Apostle	1547	370
13	Sergey	~1582	330
14	George*	1494	850
15	Varlaam	1495	750
16	John the Baptist*	1243	1200

* included in the World Heritage List of UNESCO

The smallest church should be noted especially, because in spite of its size it contains two small churches connected together. As shown in Figure 3 the church of Pokrova ot Proloma has two chambers, which are the church of Intercession of the Virgin (a) with a volume of 170 m³ and the church of Nativity of the Virgin (b) with a volume of 190 m³. Both of them have arrays of the vessels on the western and eastern walls as well as some vessels in the drums. Further we will consider these churches separately, however the rank in the Table 1 is defined by the total number of vessels, since they form the single building.



Figure 3 – Church of Pokrova ot Proloma.

Also, some details about the church of St. Nicholas from the dry place and the church of Theophany (No. 2 and 5 in Table 1) with their pictures can be found in [9].

3.2 Acoustic vessel

The acoustic pots are distributed on upper parts of the inner surfaces like in Figure 2. To characterize this distribution Table 2 shows the numbers of pots placed on different parts of the churches as well as their total number. Most churches have the vessels in the drum and pendentives. The church of Theophany has the extremely large number in the drum. There are the pots on the walls in all churches, in most cases the eastern wall has the largest number.

It is interesting that only two churches have the pots on the apses. If the iconostasis is not very high, they can be seen and create a peculiar interior solution. To demonstrate it the eastern wall of the Clement church (No. 7 in Tables 1 and 2) is shown in Figure 4. We can see large numbers of pots in the drum and pendentives as well.



Figure 4 – The Clement church.

In all churches except the church of John the Baptist the pots form the regular pattern like in Figures 2 and 4. The exception is the oldest building in the list in Table 2. The vessels are chaotically distributed on the surfaces, moreover some vessels are built in the columns. This church was built much earlier than the others and probably the Pskov style was not yet fully formed at that time. The churches equipped with the vessels and build during the period 1250-1400 have not been preserved today. So, it is impossible to trace the development of the style at this period. We can assume that architects were transforming their approaches on the design of the acoustic vessels.

Table 2 – Distribution of the vessels

No.	Drum	Pend.	Apse	Walls				Total
				East	South	West	North	
1	3	4	0	91	73	62	93	326
2	0	29	36	84	63	20	74	306
3	0	0	0	70	79	65	71	285
4a	19	0	0	58	0	43	0	120
4b	15	0	0	52	0	38	0	105
5	95	39	0	27	26	5	33	225
6	0	0	0	18	81	36	52	187
7	76	13	42	30	0	19	0	180
8	0	0	0	43	47	25	44	159
9	8	4	0	29	35	25	35	136
10	0	0	0	39	40	19	28	126
11	0	39	0	15	15	15	15	99
12	0	0	0	27	23	11	31	92
13	8	12	0	0	22	5	19	66
14	0	4	0	0	14	16	14	48
15	0	0	0	45	0	0	0	45
16	0	13	0	0	3	0	8	42*

*includes 18 vessels built in the columns

3.3 Originality of the vessels

A quick glance at Table 2 shows the variety of the patterns created by means of the pots. The architects might apply different distributions of the vessels to design a unique pattern. On the other hand, several reconstructions and repairs have taken place over the long history of the buildings. The vessels could be covered with layers of plaster applied to the ceilings and walls. Furthermore, some churches were partially destroyed and restored after decades. The recovery could miss some vessels. So, we can not be sure that the current interior corresponds to the original one. For example, only one wall in the Varlaam church has the pots. Highly likely the pots on other surfaces are closed.

The oldest detailed description of the vessels in six Pskov churches can be found in [10], which contains the sketches with the vessel distribution on the walls. Comparing data from 1861 with current information we can conclude that there is no difference for the George church and the church of Theophany. The slight difference in the number of pots is for the church Pokrova of Proloma and the church of Kozma and Damian. Today we can see more vessels in the church of Basil and in the church of Assumption of the Virgin. It seems that the pots were closed by plaster in 1861 and opened later.

3.4 Comparison with French churches

A similar number of churches in France is analysed in [4], that makes it possible to compare the Pskov and French experience. The mean number of pots by church is about 150 for the considered Pskov churches. The same value for French churches given in [4] is about 25.

Figure 5 shows no trend in dependence of the number of vessels on the church volume, the distribution of points seems to be chaotic. Analytical law found in [4] for French churches is shown by the red line. All points are much higher than the line, and no correlation between the points and line can be suspected. We can state that the Pskov and French churches are very different.

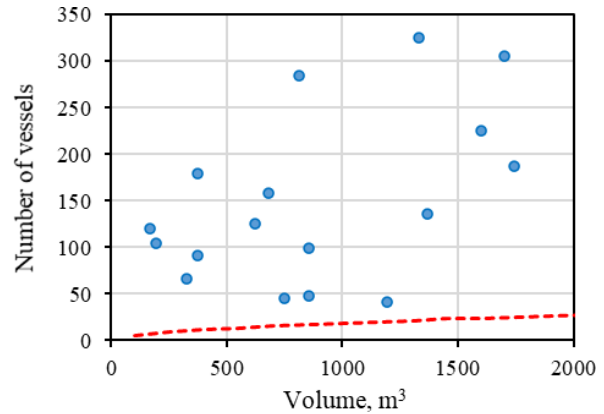


Figure 5 – Number of acoustic vessels in Pskov (points) and French (line) churches.

4. SUMMARY

A unique feature of the Pskov school of architecture is the use of numerous acoustic vessels in the churches. It is demonstrated by means of sixteen buildings of the 13th to 16th centuries that have survived to the present day. The vessels are clay pots, and they are placed in upper parts of the churches. The number of pots is extremely high in comparison with other known buildings around the world [3-7]. So, the Pskov monuments are very important for archaeoacoustics.

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