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## **Silver vessels - clepsydras from the Maykop kurgan**

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### **Abstract**

The article examines silver vessels from the excavations of the Maykop kurgan, analyzes the images on them, their sizes and shapes, and also provides calculations of the volume of one of the vessels. The article briefly describes the parameters and characteristics of the supposed clepsydras discovered earlier in the Northern Black Sea region and compares the parameters of Maykop silver vessels with them. Based on the results of calculations and comparison of the volume of these vessels, it is concluded that the technology of measuring time using water clocks was introduced to the Northern Black Sea region from Mesopotamia by representatives of the Maykop culture and existed as a stable tradition in this region until the Late Bronze Age.

**Keywords:** clepsydra, water clock, silver vessels, Maykop culture, kurgan, volume, standard, Bronze Age, Northern Black Sea region.

The most famous type of ancient measuring vessels, with vertically located marks, are water clocks – clepsydras. The oldest mention of a water clock was found in the texts of the Mesopotamian cuneiform tablets of the Enuma-Anu-Enlil collections (XVII-XII centuries BC) and the MUL.APIN tablets (VII century BC). An ancient water clock was found in Egypt in Karnak and dates back to the 14th century BC. In Egypt, a description of a water clock was also discovered in the tomb of Amenemhat (XVI century BC). Fragments of Egyptian clepsydras dating from the Hellenistic and Roman periods have also been discovered. The earliest evidence of the existence of water clocks in Europe is the mention of the use of clepsydra by Empedocles in Ancient Greece in the 5th century BC.

Ancient water clocks could have different shapes and measured the volume of water flowing out or flowing in. Instruments of the first type, called flowing type water clocks, were filled with water to the maximum level before starting measurements, and the second type, called accumulative type water clocks, on the contrary, were completely empty of water. Water clocks were used to measure time in enclosed spaces, most often in churches during worship, when it was necessary to strictly take into account time. Water clocks were also an important device for determining time at night, necessary for astronomical observations.

In 1985, near the Staropetrovskoe settlement in the vicinity of the town of Yenakievo, a unique Srubnaya culture vessel was found with marks on the inside of the vessel, which were a

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vertical row of indentations made by a human fingernail (Klimenko, Usachuk, Tsymbal, 1994, pp. 102 -108).

In the process of studying the vessel, it turned out that the Staropetrovskoe vessel has a volume between the outer marks of  $\approx 1098,4 \text{ cm}^3$ , and each layer between adjacent marks has a volume  $V_{sl}=136,2\pm 21,7 \text{ cm}^3$  (Vodolazhskaya, Usachuk, Nevsky, 2015a, pp. 65-87; Vodolazhskaya, Usachuk, Nevsky, 2015b, pp. 23-42; Vodolazhskaya, Usachuk, Nevsky 2015c, pp. 43-60; Vodolazskaya, Usachuk, Nevsky, 2018, pp. 24-48).

Assuming that the vessel could be a storage type water clock, each layer between the marks was assigned one hour lasting 60 minutes or 3600 seconds. In this case, a time period equal to one second will correspond to a volume of water  $V_{1sec}\approx V_{sl\_avg}/3600=0,04 \text{ cm}^3$ . The volume of an ordinary water drop is on average:  $0,03-0,05 \text{ cm}^3$ , and the drop itself for a long time, until the 19th century, was the smallest unit of pharmaceutical measure. Thus, in order to be able to measure time using the Staropetrovskoe vessel, and each mark corresponded to one hour, equal to 1/24 of a day, then water had to flow into the vessel at a rate of one drop per second. However, the second as a unit of measurement of time has been reliably known only since 1000 AD, although the lack of reliable evidence does not mean the impossibility of the existence of this unit of measurement in earlier eras. The existence in earlier periods and the very origin of the unit of time - the second - could well be associated with observation of the pulse of an adult healthy person in a calm state, which, as a rule, is equal to 60 beats per minute or one beat per second.

It is known that in ancient Babylon the weight of water in a water clock was measured in mina (mana). Based on the length of the day equal to 6 mina and the weight of one mina in the range from 460 g to 540 g, it can be calculated that the weight of water for measuring one hour was in the range from 115 g to 135 g, and one second corresponded to a weight in the range of 0,03 g to 0,04 g.

Considering that the average density of fresh water is  $\approx 1 \text{ g/cm}^3$ , the volume of fresh water corresponding to one mina ranges from  $460 \text{ cm}^3$  to  $540 \text{ cm}^3$  (hence, on average, the volume of one mina is  $\approx 500 \text{ cm}^3$ ). The volume of water required to measure one hour ranges from  $115 \text{ cm}^3$  to  $135 \text{ cm}^3$ , and to measure one second – from  $0,03 \text{ cm}^3$  to  $0,04 \text{ cm}^3$ , which also corresponds to the volume of one drop of fresh water. The volume of water for measuring one hour using the Staropetrovskoe vessel exceeds the upper limit of the volume for one hour within the traditional mina by only  $1,2 \text{ cm}^3$  (0,9%), i.e. practically coincides with it. Thus, the Staropetrovskoe vessel has a volume between the extreme marks approximately equal to 2 mina and with its help it was possible to measure eight hours of equal duration, similar to the Babylonian water clock.

In Ancient Egypt there was a unit of volume hinu or hin (jar), equal to  $480 \text{ cm}^3$ . The weight of fresh water of this volume is approximately equal to the weight of one Mesopotamian mina. It is possible that hinu and mina have a common origin, and hinu was used in a water clock, similar to the mina, but in simpler versions of the water clock than the Karnak clepsydra. Thus, in the writing of the Egyptian name for the unit of volume hinu and in the writing of the hour, in contrast to the writing of other units of volume and time, there is a hieroglyph interpreted as a vessel (jar, pot) Nou (nu pot; jar).

It is believed that exactly Nou vessels are often depicted in frescoes or sculptures of pharaohs bringing sacrificial gifts into them.

The dimensions of the spherical part of the vessel in all images are approximately the same and comparable to the palm of a person's hand, so knowing the volume of even one vessel

could make it possible to estimate the standard volume of such vessels. The Nou vessel made of Egyptian alabaster, which belonged to Pharaoh Unis, is kept in the Louvre. The published exact dimensions of this vessel made it possible to calculate the internal volume of the spherical part of the vessel. Calculations showed that the volume is  $\approx 1047 \text{ cm}^3$ . It is roughly equivalent to 2 hinu.

The volume of the Staropetrovskoe vessel between the extreme marks is only 5% greater than the volume of the spherical part of the Nou vessel from the Louvre. Thus, the volume of the spherical part of the Nou vessel corresponds to the volume of water required to measure eight hours of time in the Mesopotamian tradition, similar to the Staropetrovskoe vessel. The main idea of the entire set of images on the surface of the Nou vessel from the Louvre is interpreted as “eternal renewal of life”.

“Eternal renewal of life” resembles the well-known ancient phraseological unit: “*πάντα ρεῖ καὶ οὐδὲν μένει*” – “Everything flows, everything changes”. It is believed that its primary source was the words of the ancient Greek philosopher Heraclitus from Ephesus. The literal translation is “it always flows and nothing remains”. It is possible that this phrase is an echo of the ancient Egyptian “eternal renewal of life”, associated with water clocks and the measurement of time.

In the fall of 1982, near the village of Pyatikhatki, Anapa region, a slab with knocked out holes and grooves was found (Novichikhin, 1995, pp. 25-27). She was found near a heavily plowed kurgan. The find was handed over to the Anapa Archaeological Museum. On one of the flat sides of the slab there are round holes with a diameter of 2,5 to 11,5 cm and a depth of 1 to 4,6 cm, many of which are connected to each other by shallow grooves with a depth of 1 to 3 cm.

During the study, the slab was attributed to the dolmen archaeological culture of the Bronze Age and dated in the range from 2500 to 1500 BC. The main feature of the slab is the holes arranged in a semicircle. During the research, it turned out that most of the holes on the slab are associated with the markings of analemmatic sundials (Vodolazhskaya, Novichikhin, Nevsky, 2021, pp. 73-86; Novichikhin, Vodolazskaya, Nevsky, 2022, pp. 4-20). Calculations of the volumes of five large holes L11÷L15, located in a semicircle between the hour marks of 10 o'clock and 15 o'clock of the analemmatic sundial, showed that the average volume of each such hole is equal to  $V_{av}=162,7 \text{ cm}^3$  and is close to the volume of water for measuring one hour using the Staropetrovskoe vessel. That is large holes L11÷L15 could serve as a water clock and be used for sequential measurement of time from 11 o'clock to 15 o'clock. Most likely, a metal vessel or vessels with a rounded bottom, similar in shape and size to the holes, was placed in these holes. It could be used as a water clock to measure time of one hour.

In the summer of 1897, on the eastern outskirts of the city of Maykop, Nikolai Ivanovich Veselovsky excavated the Oshad kurgan (Maykop kurgan). Two unique silver vessels with images of animals were discovered in the burial of this kurgan. The silver vessel “with a landscape” has a spherical body with a rounded bottom and a low, slightly flared neck (fig. 1a). The images fill the entire surface of the body, bottom and neck of the vessel, forming a complex composition. The second silver vessel “with a rosette” has a similar but not identical shape (fig. 1b). Images of animals occupy only part of the body of the vessel, and “ornamental” compositions are located at the base of the neck and at the bottom of the vessel. Two unique silver vessels - a vessel with a landscape and a vessel with a rosette - have a height of 9,8 cm and 10,2 cm, respectively (Munchaev, 1975, p. 218). Calculations of the volume of the body of the vessel “with a rosette” showed that it is equal to  $\approx 164 \text{ cm}^3$ . The volume of a vessel ‘with a

landscape' is more difficult to calculate, because the vessel is quite damaged. However, given that its shape and height are close to the shape and height of the vessel "with a rosette", it can be argued that the volume of its body will also be close in size to the volume of the body of the vessel "with a rosette". The calculated volume of the body of the vessel "with a rosette" (in approximation that the body has the shape of a ball with the outer radius equal to  $\approx 4$  cm) is  $\approx 164$  cm<sup>3</sup> and is close to the average volume of large holes on the Pyatikhatki slab of 162,7 cm<sup>3</sup>, corresponding to 11÷15 o'clock markings of the sundial. The difference in volume is less than one percent (Vodolazhskaya, 2024, pp. 71-73).



**Figure 1.** Maykop kurgan. Silver vessels: **a** – vessel "with a landscape" (Korenevsky, 2021, fig. 4-2), **b** – vessel "with a rosette" (Korenevsky, 2021, fig. 5-2).

Thus, we can conclude that the silver vessels "with a landscape" and "with a rosette" from the N.I. Veselovsky excavations of Maykop kurgan, was a storage type water clock, the volume of which corresponded to the volume of water for measuring one hour in accordance with the Mesopotamian tradition. In fact, these vessels were measuring standards of a unit of volume for measuring one hour using a water clock. The image of a reservoir on the bottom of a vessel "with a landscape" and the rivers flowing into it, as well as the image of a rosette resembling a stylized reservoir on the bottom of a vessel "with a rosette" can also be considered as indirect evidence in favor of the version of a water clock.

The shape of the silver vessels is close to the shape of the Egyptian Nou vessels, which apparently represent a standard water clock volume for measuring eight hours. On Egyptian frescoes and sculptures of the 3rd÷2nd millennium BC the pharaohs are depicted with two Nou vessels in their hands, and in the burial of the Maykop kurgan, silver vessels with images, which are also standards of volume, although for measuring one hour, were similarly found in a pair.

Thus, the discovery of the water clock described above makes it possible to recognize the fact of the existence of clepsydras in the Northern Black Sea region during the Bronze Age. All discovered water clocks are based on the Mesopotamian metric tradition, and the oldest discovered examples belong to the Maykop culture. Therefore, we can conclude that the technology of measuring time using water clocks was originally brought to the Northern Black

Sea region from Mesopotamia in the Early Bronze Age by representatives of the Maykop culture. This technology became established as a tradition and continued to exist in the Northern Black Sea region until the Late Bronze Age.

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