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The refined method for calculating the volume of a silver vessel from the Maykop kurgan

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Abstract

This article describes a method for calculating the volume of a silver vessel "with a rosette" from the Maikop burial mound using a refined geometric model. It is concluded that the calculated volume is close to the upper limit of the volume of the large holes on the Pyatikhatki slab, and corresponds to the volume of the holes L11 and L12, which could serve to measure time between from 10 o'clock to 11 o'clock (10 a.m. - 11 a.m.) and from 11 o'clock to 12 o'clock (11 a.m. - 12 p.m.). Thus, the calculations using the refined model confirm the conclusion based on approximate calculations of the volume of the vessel body as a sphere, that the silver vessels from the Maykop kurgan could function as accumulative water clocks. And their volume corresponded to the volume of water for measuring one hour in the Mesopotamian metric tradition.

Keywords: geometric model, calculation method, clepsydra, water clock, volume, vessel, Maykop culture, Mesopotamian tradition.

In 1897, during excavations of the Maykop / Maikop kurgan (Oshad kurgan) (Maykop / Maikop, Adygea, Russia), two unique silver vessels with images of animals were discovered. The first vessel, a silver vessel “with a landscape”, has a spherical body with a rounded bottom and a low, slightly widening 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, a vessel "with a rosette", has a similar shape. The images of animals occupy only part of the body, and at the base of the neck and on the bottom of the vessel there are “ornamental” compositions (Fig. 1b).

The vessel “with a landscape” and the “vessel with a rosette” have a height of 9,8 cm and 10,2 cm, respectively (Munchaev, 1975, p. 218). Approximate calculations of the body volume of the vessel “with a rosette” using the formula for the volume of a sphere showed that it is equal to $V \approx 164$ cm^3, which is close to the volume of water required to measure one hour (Vodolazhskaya, 2024, pp. 71-73, Vodolazhskaya, 2024, 167-172). However, the shape of the body of the vessel "with a rosette" is not an ideal sphere, therefore, for a more accurate calculation of the body volume, an attempt was made to use a refined geometric model consisting of two fragments: spherical cap and spherical segment (Fig. 3).

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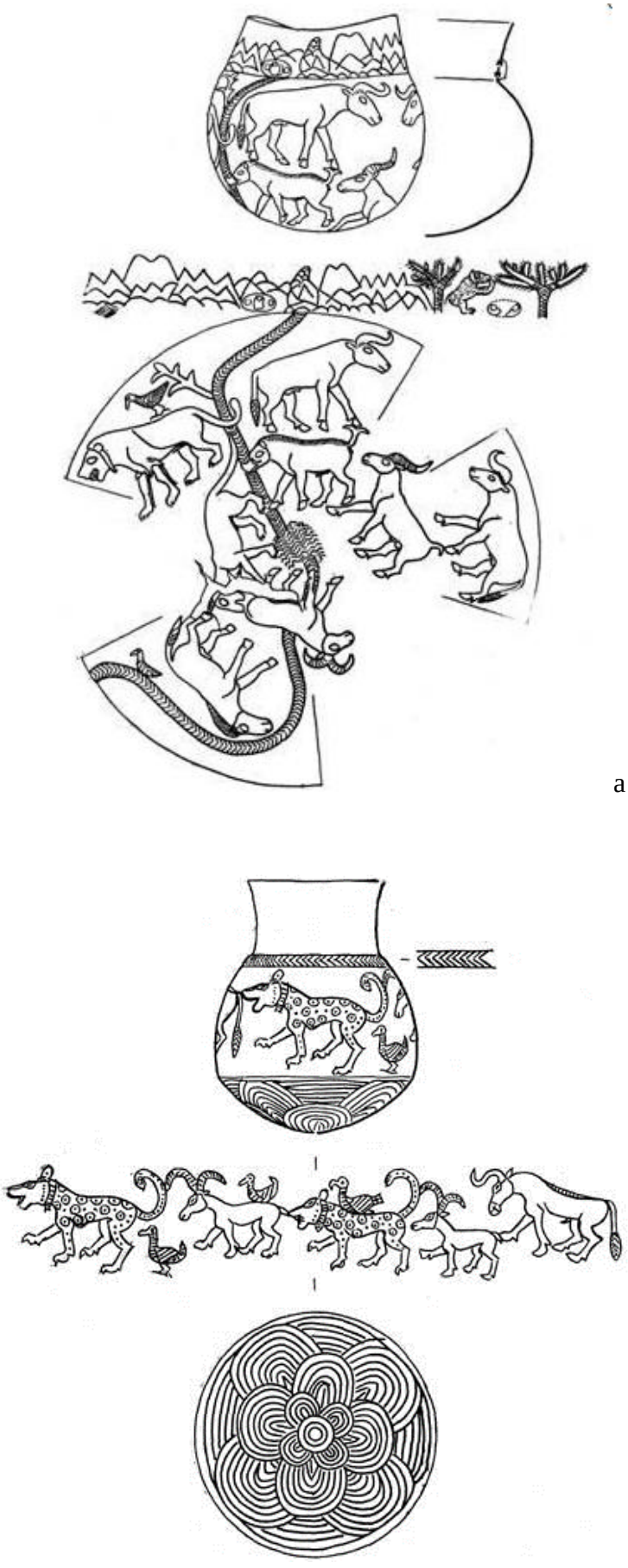


a

b

Figure 1. Maykop kurgan. Silver vessels with images: a – vessel "with a landscape" (Piotrovsky, 1994, Fig. 1), b – vessel "with a rosette" (Piotrovsky, 1994, Fig. 2).

The spherical segment of one base or spherical cap modeled the bottom “with a rosette”. The spherical segment modeled the upper part of the body from the border of the “rosette” to the base of the neck of the vessel. The volume of the spherical cap V_{cap} was calculated using the formula 1:

$$V_{cap} = \frac{\pi h}{6}\left(h^2 + 3r^2\right), \quad (1)$$

where r - the radius of the base of the spherical cap, h - the height of the spherical cap, V_{cap} - the volume of the spherical cap (Fig. 2).

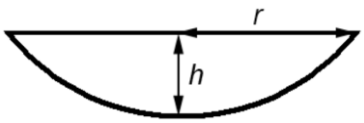
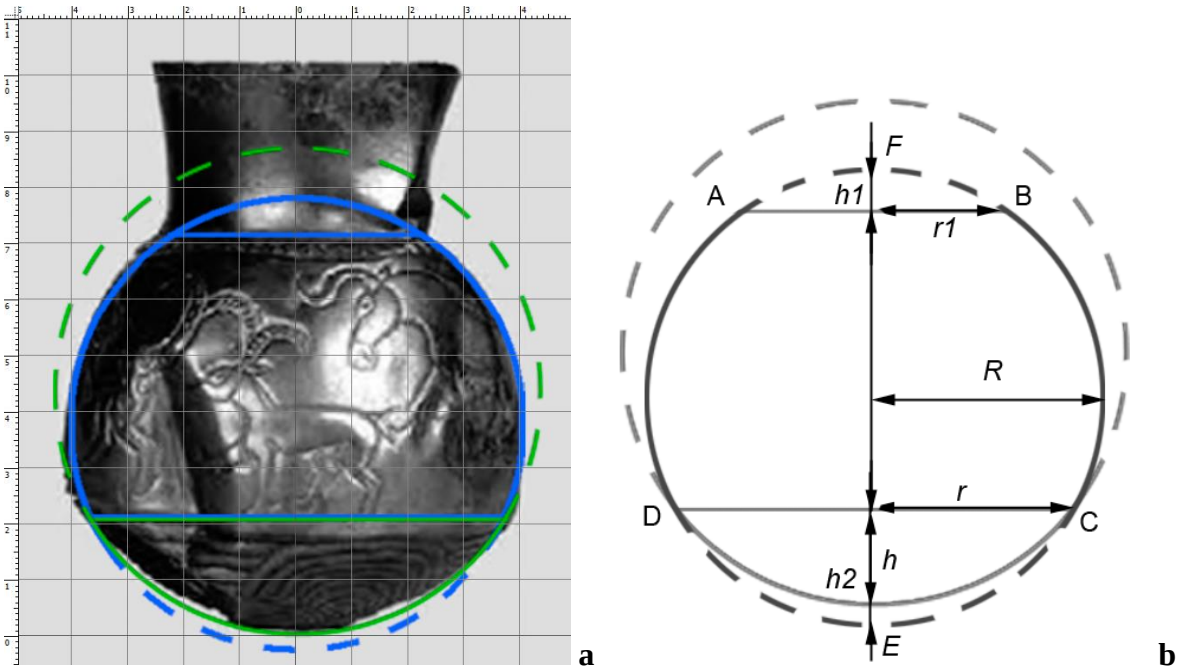


Figure 2. Spherical segment of one base (spherical cap).

The volume of the spherical segment was calculated using formula 2, in which the volumes of the upper spherical cap ABF and the lower spherical cap CDE were subtracted from the volume of the sphere of which spherical segment ABCD is a part:

$$V_{seg} = \frac{4\pi R^3}{3} - \frac{\pi h_1}{6}(h_1^2 + 3r_1^2) - \frac{\pi h_2}{6}(h_2^2 + 3r^2) \quad (2)$$

where V_{seg} - the volume of the spherical segment; R - the radius of the sphere modeling the upper part of the body; r and r_1 are the radii of the bases of the lower and upper spherical cap; h_2 and h_1 are the heights of the lower and upper spherical caps.



a **b**

Figure 3. Silver vessel “with a rosette” from the Maykop kurgan: a – photograph of the vessel (Chernykh, 2014, Fig. 4) with the contours of circles modeling the profile of the body; b – drawing of the profile of the vessel body.

The total volume of the vessel body V_{bod} is equal to the sum of the volume of the upper part of the vessel body V_{seg} and the volume of the bottom "with rosette" V_{cap}. The vessel parameters were measured according to the drawing (Fig. 3) and were summarized in the table (Table 1). The thickness of the vessel walls was taken to be 3 mm.

Table 1. Parameters of a vessel “with rosette” with and without taking into account the thickness of the vessel walls: *R* - the radius of the sphere modeling the upper part of the body; *r* and r_1 - the radii of the bases of the lower and upper spherical caps of this sphere; h_2 and h_1 - the heights of the lower and upper spherical caps of this sphere; *h* - the height of the spherical cap modeling the bottom of the vessel.

	R, cm	h, cm	r, cm	h_1, cm	r_1, cm	h_2, cm
Without taking into account the wall thickness	4,3	2,0	3,7	0,7	2,2	2,3
Taking into account the thickness of the walls	4,0	1,7	3,4	0,7	1,9	2,3

According to the calculation results, the volume of the body bottom, calculated using formula 1, is V_{cap}=33,4 cm^3, and the volume of the upper part of the body, calculated using formula 2, is V_{seg}=159.8 cm3. The total volume of the body is $V_{bod} = V_{cap} + V_{seg}$ =193,2 cm^3.

The obtained value of the body volume V_{bod} differs from the average value of the volume of large holes on the slab from Pyatikhatki *Vav*=162,7±27,7 cm^3 by approximately 30 cm^3 (Novichikhin et al., 2022, pp. 4-20; Vodolazhskaya et al., 2021, pp. 73-86), i.e. it is close to the upper limit of their volume, and most closely corresponds to the volume of holes L11 (207,10 cm^3) and L12 (187,60 cm^3), which could have served to measure the time between from 10 o'clock to 11 o'clock (10 a.m. - 11 a.m.) and from 11 o'clock to 12 o'clock (11 a.m. - 12 p.m.), respectively.

The volume of the vessel “with a landscape” is more difficult to calculate, since the vessel is quite badly 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”.

Thus, the results of calculations of the body volume of the silver vessel “with a rosette” using a refined geometric model also confirm the hypothesis that both vessels are measuring vessels with a volume corresponding to the volume of water for measuring one hour in the water clock (clepsydra) of the Mesopotamian measuring tradition.

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