

## BERUNI'S WORK ON THE DETERMINATION OF SPECIFIC WEIGHTS

**Siyakhakov Safarali Mirzoevich**

*graduated from the Shevchenko State Pedagogical Institute (1989), Ph.D., Head of the Department of General Physics of the Tajik State Pedagogical University named after Sadriddin Aini, tel.: (+992) 934087746. E-mail: [safar-1965@mail.ru](mailto:safar-1965@mail.ru)*

**Muslihiddinov Zuhuriddin Mastakovich**

*Physics teacher of the 9th school of Sariosia district – researcher of the Tajik State University named after Sadriddin Aini; Тел.: (+992)770 07 50 60;(+998) 91 511 10 54, E-mail: [zmuslihiddinov@mail.ru](mailto:zmuslihiddinov@mail.ru)*

**Annotation:** *According to stories and legends, it is known that the Greek scientist of antiquity Archimedes managed to solve the question posed by the Syracuse king Hieron (250 BC) by weighing that one of his golden crowns was made of an alloy of gold with copper, lead and others. metals. The weighing method was later called the Archimedes method. At the installation of bernoui, his contemporaries dealt with the same problem as "Sind ibn Ali, Yuhani ibn Yusuf, Ahmad ibn al-Fadl, Al-Bukhari and Muhammad ibn Zakariy AR-Razi", identifying the specific weights of minerals and metals with the help of his tools, Beruu said, "we start with the heaviest metal, then move on to the lighter metal, so that the amount of water because the amount of water corresponds to the volume of bodies."*

**Keywords:** *Greek scientist Archimedes, Sind ibn Ali, Yuhani ibn Yusuf, Ahmad ibn al-Fadl, Al-Bukhari and Muhammad ibn Zakariy ar-Razi, (unity), "Mineralogy", hydrostatic tarzu, Miskal, DaNik, tassuja, G. G. Lemmlein, yellow copper weight, Berunium, pure turquoise.*

The year 1050 separates us from the period in which Abu Rayhol Muhammad ibn Ahmad Beruniyy lived. Abu Rayhan Muhammad ibn Ahmad al-Beruni was born on September 4, 973 in the ancient city of Kot. In his pedigree, the word "berun" means "outer city", and "Beruni" means "the one who lives in the outer city." Such bright stars as representatives of Science and culture, great scientists with world names, illuminate the path of all mankind. They are the founders of world civilization and, therefore, they belong to all peoples and nationalities.

One of the general characteristics of bodies, the definition of which is the specific gravity, founded by the Greek scientist Archimedes, allows us to identify the qualitative and quantitative differences of bodies, and from it we can talk about the purity of materials, their varieties, density, etc.. reasons: first of all, this is a sign that the layers of pearls are close to each other and firmly fit together.... Secondly, it indicates the size of the Pearl-because the weight corresponds to its size .

The Archimedes method was of great importance, so its study and application began in ancient times and continued throughout the Middle Ages.

From the point of view of Beruni, this problem was studied by the Greek scientist Manalaus (menelaus – I AD) and devoted the work known to Bernoui to this issue. In addition to manalaus, at the installation of Bernoui, his contemporaries dealt with the same problem as "Sind ibn Ali, Yuhani ibn Yusuf, Ahmad ibn al-Fadl, Al-Bukhari and Muhammad ibn Zakariy AR-Razi". Although these scientists were engaged in the determination of specific weights, they could not give an exact answer to determine the relationship between a pure body and an alloy with an equal volume to it, or which bodies float, which sink into water, etc. Therefore, having studied all his existing works, Beruni, having eliminated their shortcomings, wrote a treatise on this issue based on his own experiences and observations, where he said: "and I really wanted to take on what they did not do, to build relationships between metals, that is, soluble minerals in volume and weight."

Indeed, one of the personal and undeniable qualities of Beruni for physics is the determination of the specific weights of a number of minerals and metals for the first time. During his observations and experiments, Beruni was not limited to the data of one experiment, but spent them several times with various devices created by him until he was satisfied with the results. "And after that I did not stop producing one device (alat) one after another, and later, until I made a cone-shaped container, I destroyed what interfered with me in the first one-wide at the base with a narrow hole, the same width as a hole at the end of the neck.....»[1].

"...then I tested it ten times, weighed it with different weight units, and matched the results, bringing it to a single number, that is, one hundred Micals. Despite the special thoroughness of the work, the amount of water in all (repeated cases) (displaced) turned out to be different ... caution forced me to stop at the average figure ..." [1].

During his experiments, Beruni used his contemporary method Ahmad ibn Al-Fadl [1] to determine specific weights, he used a mold to cast metals.

Beruni, with the help of his tools, determined the specific weights of minerals and metals, took gold for metals as a standard for comparison and a blue yacht for minerals.

"Therefore, we chose the face (Unit) blue (yacht) scale (letters.: axis), for comparison with the rest of the minerals, and we refer to this as a law...". "So, for metals, we took a hundred (units) of solid, many times refined gold."

Before berunius identified specific weights, he first chose crystals without cracks, thoroughly cleaning them from various impurities so as not to reduce its specific weight. To determine the specific gravity, he " cut large and small pieces from each metal; at the same time, the size of large (pieces) did not exceed the width of the neck of the vessel... (small pieces) reached the size of a millet grain ... I started throwing pieces into the hole of this container because they caused the excitement of the water and raised it from a large container with more force than necessary. But I immediately corrected it with forceps so that the surface of the water almost did not respond to it, and no movement was felt. The water undoubtedly rose according to what I threw into it and poured in an

amount equal to the volume thrown through the tube, while the remaining water remained in the same position in the tank.

With the help of his device, Beruni determined the specific weights of various metals and minerals. At the same time, he began with heavy elements, since they pumped out a little water from the device. "We start with the heaviest metal, then move on to the lighter metal, so that at the beginning the amount of water (flowing out of the container) is the smallest, and then it becomes more and more. because the amount of water corresponds to the volume of bodies."

Beruni's results on the identification of specific weights, which he gave in the mineralogy treatise and the treatise on specific weights, are incomprehensible to us without hydrostatic scales, although of great interest. For example, he says about determining the specific weight of Mercury: "I checked it several times in a container and increased its number to one hundred calories. And (displaced by him) the first limit of water was seven Miskals one daniku and one tasuju and one quarter tasuja, while the last limit of seven Miskals was two danikami and two tasuja and five sixth tasuja. But in most cases, two Danica and seven bowls of one tasuj came out. And we received this number"[1. 255]. G. G. According to Lemmlein [1. 310] and [2. 106-127].. it is very easy to transfer them from yacht or gold standards to water. In the experiments that Beruni described in his book on specific weights, it is easy to determine the specific weights of his samples, knowing that the Blue yacht replaced 100 misguided (i.e. 2,400 tasuji) 606 tasuji water and 100 misguided gold 126 tasuji water.he accepted as standards.

Specific gravity of sapphire (blue yacht)  $\frac{2400}{606} = 3,96$ , and gold  $\frac{2400}{126} = 19,05$ , in the buyer if indicated by specific gravity  $d$ , the weight of the water replaced by the Blue yacht-via standard  $P$  and the weight of the water thrown into the water by the body  $P_1$ , then the above can be mathematically written as follows:

1 Miskal = 6 Danik, 1 Danik = 4 tassuja, 1 tasuja = 0.18 g.

$$d = \frac{P}{P_1}$$

Tassuj for mercury according to Beruni., then (1) its specific gravity.

For mercury according to Beruni  $P=177$  tassoc., then (1) its specific gravity  $d = 13,50$ .

It follows from this that in order to find the specific weight of this element (in the treatise on specific weights), it is necessary to divide the weight of the water replaced by the standard by the weight of the water thrown into the water thrown into the body.

G. G. As Lemmlein noted, based on these data, the calculation of the figures of the specific weights of minerals and metals listed in "Mineralogy" in Beruni is carried out according to its standards. To do this, according to the proportionality rule, it is necessary to multiply the Beruni number by the specific weight of the standard allocated to water (i.e. 3.96 or 19.05) and divide by 100. For example, the relative weight

of the rock crystal-bulur in mineralogy is determined by 64 and 1/4 and 1/6 and 1/8, that is, 64.54. When recalculating, this will be [1. 310].

$$\frac{64,54 \cdot 3,96}{100} = 2,56$$

Thus, to find the specific weight  $d$  of certain elements, its relative share is needed  $d_1$ , multiply by the specific gravity of the standard  $d_2$  and divide the result by 100.

$$d : d_1 = d_2 : 100 \text{ or } \frac{d}{d_1} = \frac{d_2}{100} \text{ from this place } d = \frac{d_1 \cdot d_2}{100}$$

Table 1 shows the specific weight according to Beruni and modern data.

**Table 1**

1	2	3	4	5
Hematite	4,11	4,9-5,3	+0,79	+1,19 16 28,9
Sapphire	3,96	3,97-4,12	+0,01	+0,16 0,25 3,8
Ruby	3,84	3,94-4,08	+0,10	+0,24; 2,6 6,2
Lal (spinel Badakhshan)	3,58	3,50-4,10	-0,08	+0,52; 2,28; 12,7
Lal (Tourmaline)	2,90	2,98-3,20	+0,08	+0,30; 2,75; 9,37
Emerald	2,75	2,67-2,77	-0,08	+0,02; 3 0,72
Lapis lazuli	2,69	2,40-2,90	-0,29	+0,21; 1,2 7
Rock crystal (quartz)	2,50	2,59-2,66	+0,09	+0,16; 3,47 6
Carnelian	2,56	2,55-2,63	-0,01	+0,07; 0,39; 2,66
Onyx	2,50	2,55-2,63	+0,05	+0,1; 3, 196; 4,94
Salt (halite)	2,19	2,17	-0,02	0,92
Clay	1,99	1,80-2,60	-0,19	+0,61; 9,55; 30,65
Jet	1,11	1,10-1,40	-0,01	+0,29; 0,9 2;6,11
Asphalt	1,04	1,00-1,10	-0,04	+0,06; 3,84; 5,77
Amber (kahraba)	0,85	1,05-1,10	+0,20	+0,25; 20,35;29,41
Gold	19,05	19,25	+0,20	1,05
Mercury	13,56	13,55	-0,01	0,07
Lead	11,32	11,34	+0,02	0,18
Silver	10,30	10,50	+0,20	1,94
Copper	8,66	8,89	+0,23	2,65
Iron	7,74	7,86	+0,12	1,54
Tin	7,32	7,30	-0,02	0,27
Brass	8,55	8,40-8,50	-0,15	-0,05; 1,75; 0,58
Glass (porcelain)	2,12	2,20-2,40	+0,08	+0,28; 3,77; 13,2

1-minerals and metals; 2 – Berunium Data; 3 – Modern Data; 4 – difference between modern and Berunium data; 5 – berunium uncertainty %.

As can be seen from the table, in addition to hematite, clay, asphalt, gagat, Amber and glass, Berunis, where the specific weights of the remaining metals and minerals are

found, are very close to modern data. Particular weights of mercury, lead, tin, Sapphire and some other substances can be noted, which differ very little from modern data, from 0.07% to 0.27%.

Some deviations that we observed in the table we can assume that Beruni could not properly clean them from various impurities, in addition, he may have experimented at different temperatures, since currently experiments are usually carried out at 200C.

Some of Beruni's data in Mineralogy fully correspond to the information in the pamphlet tables about specific weights, for example, Emerald, Carnelian, Onyx and others. however, some of them differ from each other in both works, as evidenced by the table below:

<b>Metals and minerals</b>	<b>In the treatise on specific weights</b>	<b>In Mineralogy</b>
Lead	11,32	11,47
Silver	10,30	10,41
Copper	8,66	8,70-8,90
Iron	7,74	7,87
Lapis lazuli	2,69	2,70

Beruni could not determine the specific weights of some metals and minerals: rhinoceros horn, Jade, Amethyst, blood, bezoar, diamonds, emeralds, etc., due to their great value and non-existence, and for other reasons. "Pure turquoise is found without a mixture of others (stones), weighing no more than five dirhams (in pieces), and their price reaches one hundred dinars. And this (I) prevented the determination of the weight of turquoise in relation to the Blue yahont" [1. 158]; or says of a diamond: "but Mercury is heavier than it (Diamond)..." [1. 84]. Indeed, mercury is 4.2 times heavier than diamonds.

Beruni doubts their accuracy by passing some numbers. "Weight of yellow copper (soufflé.) gold in relation to the comparative axis - 46 and 5/8 (8,90-N. m gives). But I have doubts about this, the elimination of which could have been an experiment ... but time did not give me the opportunity to do it "[1. 247].

Beruni's statement about the difference in the specific weights of a yacht of different colors is of great importance. "...if we take pieces of the same size, but of different colors, then according to our study and the tests carried out (the following is determined); the Blue yacht is a little heavier than the red one, this is the reason; the red yacht has holes, which, due to their narrowness, did not allow water to enter there and was.." [1. 70]. The correctness of this statement is confirmed by the above information in the table of specific weights (Table 1).

Despite having carried out many experiments in determining the specific weights of berunium bodies, in the results obtained he sometimes identified a discrepancy, so in these cases he carried out experiments in reverse order to clarify, as evidenced by this: "during the many studies mentioned above, we did not follow only one method in each

individual case. if there is disagreement in shares and parts, and in some cases we have done the work in reverse order" [1. 256].

Beruni, using the example of Silver, says about his reverse experiments: "we noticed the amount of its weight unknown at Will, and then began to increase its amount a little, and at this time the weight of water (water) flowed into the mountain of scales until it reached this amount. a hundred bowls give gold, and we know this, and it is clear that the volume of silver that replaced this water is equal to the volume of gold that replaced the same (amount of water); then we removed it (Silver) from the bowl and wiped it with a cloth and dried it in the sun... then we determined how many hundredths (Miskals) of this amount and compared it with what was obtained by other methods; then we put this silver back in the container and determined its water (weight) - whether it corresponds to the first result"[1]. 256-257].

Currently, this view of Beruni can be expressed mathematically as follows:

$$P_1 : P_2 = P_3 : P_4 \text{ or } \frac{P_1}{P_2} = \frac{P_3}{P_4}$$

$$\text{from this place } P_1 = \frac{P_2 \cdot P_3}{P_4}$$

Here:  $P_1$  is the weight of silver, which displaces as much water as it squeezes out 100 bowls of gold.

$P_4$  is the weight of water replaced by Silver, which weighs 100 microns.

$P_3=10$  is the weight of Water replaced by misaligned gold.

$P_2$ -the weight of Silver is equal to 100 miscals.

From the data of Table 4 we find  $P_1=100$  moscalei,  $P_3=126$  tassuj and by substituting these values (2) we find, what  $P_1=54.08$  mezcil.

It follows that if any body contains 100 Micals of gold, then 54.08 Micals of silver, that is, 1.84 times less. This is easy to verify, because according to the table, the percentage of gold (19.05) is 1.84 times the specific gravity of silver (10.30), and all this confirms Beruni's statement.

Beruni, the results of measuring specific weights are given by fractional fractions. For Carnelian, for example, " Mineralogy " gives 1/4, and for coral-1/8, which suggests that for accuracy the scientist received them hundredth, or even a thousandth of a unit, and sometimes gave them 1 tosuja. Thus, Beruni always sought to increase the accuracy of specific weights, which now remained constant.

Aburayhan also determined the specific weights of different liquids in a special container, not limited to determining the specific weights of Berunium metals and minerals. In his experiments and observations, he made sure that the specific weights of different waters and the specific weight of cold water are greater than that of hot water. At the same time, he received 1200 tosuja key water holding tank, which became the standard for him.

According to the results of the resulting Beruni (Table 3), we can determine the specific weight of each liquid. To do this, select as a unit for measuring the specific weight of 1200 tosuja key water per unit volume, ya

$$\text{unit of specific gravity} = 1200 \frac{\text{tassudj spring water}}{\text{unit of volume}}$$

Now we find the specific weights of the remaining liquids, for which we find how many times the weight of this liquid  $P_1$  is less (or more) than the weight of the key water  $P$ . I. e.  $P_1 : P$ ; then  $P_1 : P = 1,041$  and others.

Then, multiplying this relationship by the specific weight of the water, we find the specific weight of this liquid. We put all this into the table and at the same time compared it with modern data to determine the uncertainty perceived by Beruni. Thus, to find the specific weight of liquids, the following ratio should be used:

$$d : d_1 = P_1 : P$$

from this place:  $d = \frac{P_1}{P} \cdot d_1$  here

**Table 3**

1	2	3	4	5	6
Main water	1200	1	1	1	
Hot water	1150	0,959	0,959	0,958	0,001
Melt water	1158	0,965	0,965		
Salt water	1361	1,134	1,134	1,108	0,026
Sea water	1249	1,041	1,041	1,030	0,011
Indian melon juice	1219	1,016	1,016		
Cucumber water	1221	1,017	1,017		
Mutlak melon juice	1236	1,030	1,030		
Wine vinegar	1232	1,027	1,027		
Wine	1227	1,022	1,022	0,996	0,065
Sesame oil (simsim)	1098	0,915	0,915		
Olive oil	1104	0,920	0,920	0,920	0
Honey	1687	1,406	1,406		
Cow's milk	1332	1,110	1,110	1,03	0,08
Egg white	1242	1,035	1,035	1,085	0,050
Human blood	1240	1,033	1,033	1,050	0,017

Urina is warm	1222	1,018	1,018		
Cold urine	1230	1,025	1,025		

1 is the name of liquids; 2 is the weight in tasuja R ; 3 is the ratio of how many times the weight of a liquid is (or) more( P1:P) than water; 4 is the specific gravity according to Beruniy data in Tasuja; modern data in 5 – g/cm<sup>3</sup>; difference between units 6.volume between modern data and Beruni data.

(3) it follows from the table that a change in the density of water over the Beronian seasons was known, therefore, during the definitions, he recommends taking into account the specific gravity, as well as experimenting with the same liquids. "For the learner of what we have brought and established with water, it is necessary to pay attention to the (quality) of the water due to the conditions that change its condition, such as: Origin, channels, swamps and also due to its influence on its characteristics. four seasons depending on the weather, because all our research was carried out in one place ... and whether it will be drinking water or not, it will not hurt us, if all the work is done with some kind of it.... However, if we do part of the work in fresh water and the other in salt water, it is important not to miss balancing the difference in their condition" [1. 263-264]. These opinions of the scientist are confirmed at the moment, when the temperature of the liquid and the uniformity of the standard are taken into account when determining specific weights.

Beruni correctly writes that due to the difference in the specific weight of water, ships in salt waters sink less than in fresh waters.

It is known that it was taught by ancient Greek scientists, but they could not reveal the main reason for the danger to ships entering the Bay, connecting them with the current and the current.

Beruni writes: "the danger to ships in the estuary is that fresh water does not support as much weight as salt water supports them" [3. 203-204].

Beruni, clearly criticizing those who believe that one body is immersed in another during attraction or attraction and examination from direct experiments, proved that diving depends on the weight of the bodies, i.e. according to modern concepts, the specific gravity of bodies. "all stones float without sediment on the surface of mercury, not counting gold, because it precipitates."it was not because he contacted Mercury and attracted him, but because, as some thought, we tested it in (different) conditions, and it became clear that this would only happen because of the weight characteristic. 217].

In fact, the specific weight of gold (19.25) exceeds the specific weight of mercury (13.55), so gold is immersed in mercury.



**LITERATURE:**

1. Aburaykhan Beruni "Minealogy", A. M. Translated by belenitsky, G. G. Edited by Lemmlein, M. 1963 year
2. Berony, Sat. articles in the edition S. P. Tolstoy, M-L, 1950
3. Aburaykhan Beruni, India, Izb. Production., Volume II, A. B. Khalidov and yu. N. Translated by zavadovsky, Tashkent, 1963
4. Omar Khayyam, treatises, B. A. Translated by Rosenfeld, M-L, 1961
5. K. M. Bykov and others textbook of Physiology, M. 1955 year
6. N. I. Koshkin and M. G. Shirkevich, Handbook of elementary physics, Ed. 2. M. 1962 year
7. A. Beruni "Jawahirnome" (in Arabic), Hyderabad, 1957
8. I.Yu.Krachkovsky, Izbrannie Sochineniya v 6 tomakh, M.- L., Izdatelstvo akademii nauk, 1957
9. S.A.Akhmedov, N.S.Akhmedova, Urta the history of arithmetic and its teaching in Asia, Tashkent, ukitici, 1991
10. Abu Rayhan Beruni" Legal Response " S.H.Sirajiddinav .Publishing House "Science", 1976
11. S.Frederick, the discovery of America, tarj. Turgunova Sh, Spiritual Life, №2, 2014
12. X, dasanov, Sayyakh scholars, Tashkent, Uzbekistan, 1981
13. Abu Raykhan Beruni, selected works, tom II, X, indistan, Tashkent, Uzbek SSR science publishing house, 1965