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Positive Views on Scientific Work Contributed to the Development of Metrology by the Great Scientists of Central Asia

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Abstract: *It is known that in the Middle Ages in Central Asia, scientists of world renown made their contribution to the development of science, including the development of metrology.*

In addition to being a great astronomer, mathematician, geographer and engineer who lived in 797-861 with melodic calculation, the great scientist Ahmed al-Fargani made a great contribution to the development of metrology.

Keywords: *Metrology, Bait-ul-Hikma, observatory, astronomy, meridian, astrolabe, azimuth, zenith, nilometer, cubit, mathematics, geography, engineer, calendar, seven climates.*

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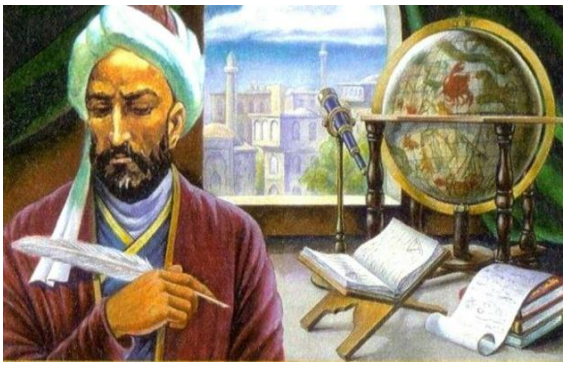


Ahmed al-Fargani lived and worked in 797-861 AD. Besides the fact that Ahmed al-Farghani was a great astronomer, mathematician, geographer and engineer, he made a great contribution to the development of metrology.

It is known that in the Middle Ages in Central Asia, scientists of world renown made their contribution to the development of science, including the development of metrology.

In addition to being a great astronomer, mathematician, geographer and engineer who lived in 797-861 with melodic calculation, the great scientist Ahmed al-Fargani made a great contribution to the development of metrology.

He owned all astronomical measuring instruments. The theory and practice of astrology tools are fully analyzed in the work “The Perfect Book of Fargani” (“Kitab al-Kamil, al-Fargani”) or “The Book of the Construction of Olabiya” (“Kitab Finas al-Astrulab”).

The creativity of Central Asian scientists began to spread widely both in the East and in the West through the Great Silk Road. It is known that the works of our compatriots Muhammad Musa al-Khwarizmi and Ahmed Fargani, who led, in particular, Bayt-ul-Hikma, ensured the development of world science. The books of Ahmad al-Farghani were translated into Latin in Spain and Italy from the 12th century onwards, and many copies were copied and used as textbooks in universities. Al-Farghani's Book of the Celestial Movement and the Complex Science of the Stars was translated twice into Latin in the 12th century and into another European language in the 12th century. At that time, this book served as one of the main textbooks in European universities. A unique encyclopedia of astronomical knowledge, it also describes observatories and sundials, and its Latin translation, published in 1493 in Ferrari, Italy, is one of the first printed books.

Ahmad Farghani was the first who opened the way to the creation of accurate geographical maps. It is believed that Christopher Columbus used the maps of Arab navigators to discover America. The Arabs sailed the Atlantic Ocean and dominated the Indian Ocean and the White (Mediterranean) Sea for several centuries. It is known that they were experienced sailors. Representatives of all peoples living around the sea served on Arab ships. The daughter of a Portuguese sailor kept maps made by Arab scientists, and later Christopher Columbus of Genoa married her daughter and inherited these maps. Columbus attempted an expedition based on these maps and kept it a secret from others. Such information is given by St. Petersburg scientists, in particular, determined by I. Y. Krachkovsky.

Fargani studied lunar and solar eclipses to perfection. Two observatories were built during the reign of Al-Ma'mun. These observatories were to be built under the direction of Ahmad al-Farghani on the orders of al-Ma'mun. At one time, the construction of two observatories was prompted by the method of observation developed by Ahmed al-Farghani. This method served to reduce the errors in astronomical measurements. That is why these observatories lie on the same parallel, that is, they are built on the same geographical latitude. Ferghani was in charge of the administrative affairs of the observatories along with scientific work. Ahmad al-Farghani predicted the solar eclipse of 842 as a result of research and measurements and made scientific observations.

Ahmad al-Fargani is one of the first scholars to give a detailed account of the Muslim calendar. He added to the calendar and described the method of making a sundial. Also known is Ahmad Farghani's excellent commentary on the "Ziji" of Muhammad al-Khwarizmi ("Talil li zij al-Khwarizmi").

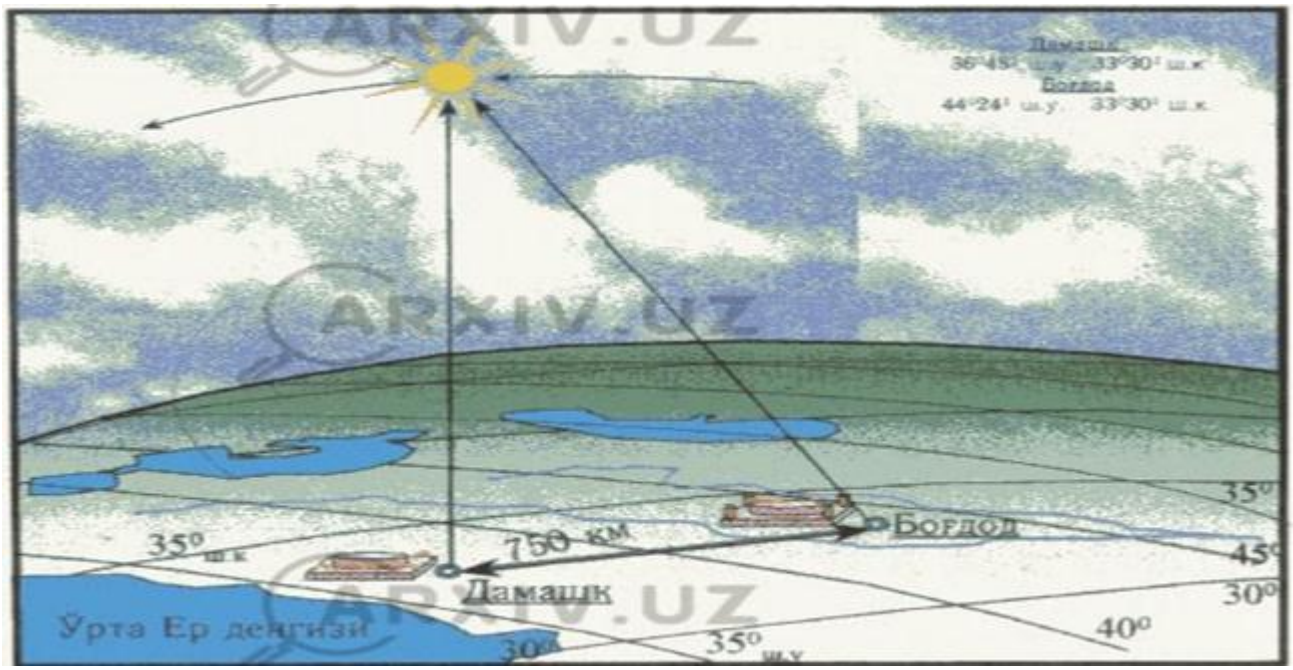
The accuracy achieved by the scientists of "Bayt ul-Hikma" in their scientific measurements, we can see in the results of measuring the degree length of the earth's meridian under the leadership of Ahmed al-Fargani. By order of Caliph Al-Mamun in 824, two groups (expeditions) were formed from the members of Bayt ul-Hikm, who were instructed to accurately measure the length of the earth's meridian in order to eliminate the discrepancy in information about the size of the Earth. Al-Fargani and al-Khwarizmi were entrusted with the management of geodetic work. They made a measurement plan.

The measurements were carried out in the Sanjar desert in the Mosul region. After determining the coordinates of the chosen point, a group led by Khalid al-Marwarrudi measured the meridian to the north, and a second group led by Ali al-Asturlabi to the south. These groups pulled the rope in straight and horizontal directions for a distance corresponding to one degree of the arc of the earth's meridian.

To correctly measure the direction of the measuring line along the meridian, the measurement was continued by pulling one rope straight along the meridian, without tying the second rope from the end of the first rope, starting from the middle of the first rope.

On this basis, it was determined that the length of an arc of one degree is equal to 57.67 Arabian miles (one Arabian mile is equal to 1972 m.) or equal to 111.8 kilometers in the current unit of measurement. After calculating the measurement results, it was found that the length of the meridian is 40253.28 kilometers.

This meridian measurement work carried out in Arabia was considered the most methodologically and scientifically accurate of the measurement work carried out up to that time, because this measurement was re-measured using a special method. As a result of the development of science in later works, or 1000 years after the measurement of Ahmed al-Fargani, F. N. Krasovsky, as a result of measurements with modern instruments, it was shown that astronomical measurements left by our ancestors in the 9th century were carried out with high accuracy. Studying the regions of the Eastern Hemisphere in seven climates and measuring the coordinates of more than a thousand places allowed them to make accurate geographical maps.



The location of the observatories in Baghdad and Damascus (drawn according to the description of Prof. R. Zh. Tajiev)

The great engineering potential of Ahmad al-Farghani is manifested in the creation of an instrument based on the properties of liquids in neighboring vessels that measure the water of the Nile. When creating these devices, we see full compliance with engineering requirements at all stages, from idea to device.

Another great work by Ahmad al-Farghani is The Complete Book of Astrolabes, dedicated to the manufacture and use of astrolabes. Apparently, interest in astronomy grew and the need for astrolabes increased, so he wrote several more works on this topic. It can be seen that the scientist attached great importance to the instruments that form the basis of astronomical research. Although much is said about the importance of Ptolemy and his Almagest in the history of science, it is not an exaggeration to say that Renaissance European scientists studied astronomy with al-Farghani. Although all "astronomy" and "astrolabe" are Greek words, the Arabic terms in this science, such as "alidada", "almukantarat", "azimuth", "zenith", "nadir", the Arabic names of the vast majority of stars are mainly through books al-Farghani, there is no doubt that it was mastered.

a) **b)** **v)**

Measuring instruments based on technical principles developed by Ahmad al-Farghani:

a – an Arab astrolabe instrument for measuring height and astronomical distances (beginning of the 15th century);

b - an astronomical instrument for measuring the heights of the constellations and determining the time of the Sun and the Star - the astorlabe, 1568;

v — "Geometric square", a geodetic device for measuring angles and distances, Augsburg (Germany), 1569.

It is known that Ahmed al-Fargani was a great scientist in the field of water sciences - hydrology, among many other sciences. A clear proof of our opinion is that the water-measuring structure built under his leadership on the Nile River reached our era, i.e. for 1150 years.

Almost all studies devoted to the study of this structure, the scientific heritage of Ahmad al-Fargani, mention that "Ahmad al-Fargani went to the city of Fustot (now Cairo) in 961 to build and operate a structure that measures the water level of the Nile River at the direction of caliph al-Mutawakkil. According to the English hydrologist A. Biswas, Europeans, namely Le Par and Marseilles, got acquainted with the "Nilometer", built on the island of Ravas in the Nile during Napoleon's campaign against Egypt (1798-1800). According to their description, the water-measuring structure was in the form of a square well connected to the Nile by three underground waterways. An octahedral pillar, covered with white marble, installed in the center of the well, made it possible to measure the water level in large and small segments equal to the unit of an Arab cubit (54 cm) and its 1/24 carat (2.25 cm). For this, special ladders were used, built in the form of a viewing loop. On the inside of the walls of the building were written in the Arabic alphabet the scriptures about the Islamic religion. In the center of the square well, a beveled measuring column lined with white marble was built in the construction system to compensate for fluctuations in the water level. More precisely, if the well was dug at least 10 m, then the height of the column was no less.

Regardless of the number of groundwater streams, Ahmed al-Fargani solved the important problems associated with ensuring the ability to accurately measure the water level as a result of the use of the Nilometer system on the roads. The first of them is to see the structure from a certain distance from the riverbed, to protect it from erosion and erosion on the banks, to ensure its operation for many years. The second and most important problem is to achieve the accuracy of measuring the water level in the river.

It is known that the level of moving water in the riverbed differs by a certain amount from the level of water in a calm (static) state. When a stick is thrown vertically into moving water, the higher the flow velocity, the higher the water that hits the stick rises.

If this law of hydrodynamics had not been taken into account by Alloma, then certain errors would have been made in the process of measuring the water level. Therefore, it is more realistic to have three watercourses connecting the structure's well with the river: the first of them should be along the course of the river, and the rest should be connected vertically (perpendicular) from both sides. position to the first.

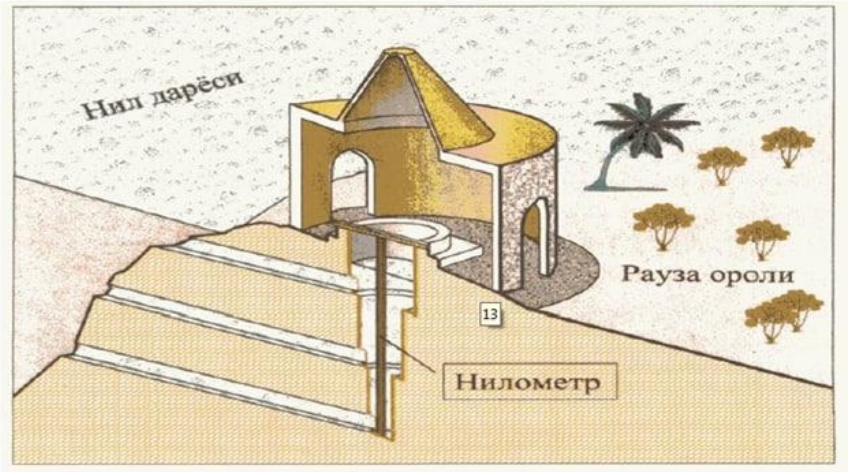
Ahmed al-Fargani has another scientific characteristic, which is that underground waterways were used in the construction system. That is, in this way, the negative effect of wind on the accuracy of measuring the water level in the river is completely excluded. Another suggestion is that the underground waterways must have run at a certain slope from the well to the river. After all, this is the only way to protect them from flooding with mud from river water.

So, Ahmed al-Fergani positively solved the problem of measuring the water level in the river using the Nilometer, taking into account everything: a well in the construction system, underground waterways connecting it with the river, measuring columns and dividing it into parts with centimeter accuracy.

Ahmad al-Fargani's centimeter-precision water level measurement method is currently used worldwide. In countries that are members of the World Metrology Organization (WMO), the water level in water bodies (rivers, lakes, reservoirs, even seas and oceans) is measured with such accuracy. Allom's method of using underground watercourses is also widely used in world water metering practice.

Ahmad al-Farghani solved many of the problems associated with the use of water in rivers by accurately measuring the water level. Therefore, Alloma did not limit itself to designing a water metering unit, participating in inspection work and putting it into operation. He developed a special manual for its practical use - "Miқёsi zhadid".

One of the main and at the same time extremely urgent tasks solved by Ahmed al-Fargani with the help of Mikyosi Jadid is to determine the relationship between the change in the water level in the Nile River, that is, the calculation received from the Nilometer - books and performance.



A device for measuring the water of the Nile River (according to the description of Prof. A. Akhmedov).

Ahmad al-Farghani, using the "Miqyosi Jadid" composed by him, said that when the water level in the Nile rises to 16 cubits, the harvest is plentiful, up to 15 cubits - good, up to 14 cubits - medium,

at 13 cubits - bad, and, finally, there is little water on 12 cubits and there is a threat of famine, they determined that this is possible.

There was also a limit to the rise, for example, a rise in the water level above 17 cubits (9 meters according to current calculations) from the measuring column of the Nilometer allom, that is, an increase in the water in the river at this level will cause flooding of many places. As a result, this condition is considered to have a negative impact on performance.

Most importantly, Ahmed al-Fargani objectively assessed the relationship between water level and productivity, determined by the Nile river nilometer. As a result, Alloma developed a fair tax system for farmers and eliminated injustice in this area.

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