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# DENDROCHRONOLOGICAL ANALYSIS OF ARCHAEOLOGICAL WOOD FROM MONUMENTS OF PAZYRYK CULTURE

**Abstract.** The article is devoted to the dendrochronological analysis of archaeological wood from the monuments of Pazyryk culture.Relative dendrochronological Dating was performed on the basis of the obtained tree-ring chronologies.There were also conducted studies of cores from live trees, which were harvested in the sample areas Tuyuksu, Big Almaty lake and Gorelnik. The species composition of wood and the possibility of using the obtained chronologies for the reconstruction of the climate were studied.The absolute radial increment graphs for each radius were plotted from the annular chronologies, which are used to accurately date the annual rings. The maximum age of the studied plants living trees spruce spruce is 229 years pertaining to the sample area Tuyuksu.The maximum width of the annual rings for all the studied objects is 9.4 mm, which indicates good weather conditions during the active growth and development of the plant. Average width of annual rings for spruce Shrenk in plots of Big Almaty lake is of 2.15 mm.Logs from the scientific-restoration laboratory "Island of Crimea" were processed and studied. 124, 130 and 141 year tree-ring chronologies were found on the sawn trees, the age of the trees is from 124 years to 141 years.

**Key words:** dendrochronology, archaeology, methods of dendrochronological analysis, modern tree, core, archaeological tree, tree-ring chronology, radial growth.

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## Пазырық мәдениет ескерткіштерінен алынған археологиялық сүректерінің дендрохронологиялық талдауы

**Аңдатпа.** Мақалада Пазырық мәдениетінің ескерткіштерінен алынған археологиялық сүректі дендрохронологиялық талдау бойынша материалдар келтірілген. Алынған ағаш-сақиналы хронологиялардың негізінде салыстырмалы дендрохронологиялық даталау орындалды. Сондай-ақ, Тұйықсу – TUY сынақ алаңдарында дайындалған тірі ағаштардан керндер, Үлкен Алматы көлі – BAO және Горельник – GOR зерттелді. Пайдаланылған сүректің тұқымдық құрамы зерттелді, салыстырмалы түрде ежелгі орман пайдалану және климаттық қайта құру үшін алынған хронологияларды пайдалану мүмкіндігі қорытындылары жасалды. Сақина хронологиясының деректері негізінде әр сақинаның абсолютті радиалды өсу графигі жасалды, олар жылдық сақиналарды дәл анықтауға қолданылады. Шренка шыршасының зерттелген тірі ағаштарының ең үлкен жасы – 229 жас, бұл Тұйықсу сынақ аймағына сілтеме жасайды. Барлық зерттелетін

 

объектілер үшін жылдық сақиналардың максималды ені – 9,4 мм, бұл өсімдіктің белсенді өсуі мен дамуы кезеңіндегі ауа-райының жақсы екендігін көрсетеді. Үлкен Алматы көлінің 7 сынамалық учаскесінде Шренк шыршасы үшін жылдық сақинаның орташа ені 2,15 мм құрайды. «Остров Крым» ғылыми-реставрациялық зертханасының жазбалары өңделді, сақталды және зерттелді. Ара кесулерінде 124, 130 және 141 жастағы ағаш-сақиналық хронологиялар табылды, ағаштардың жасы 124-тен 141-ге дейін.

**Түйін сөздер:** дендрохронология, археология, дендрохронологиялық талдау әдістері, заманауи ағаш, керн, археологиялық ағаш, ағаш-сақиналы хронология, радиалды өсім.

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**Дендрохронологический анализ археологической древесины из памятников пазырыкской культуры**

**Аннотация.** Статья посвящена дендрохронологическому анализу археологической древесины из памятников Пазырыкской культуры. На основе полученных древесно-кольцевых хронологий выполнено относительное дендрохронологическое датирование. Также были проведены исследования кернов с живых деревьев, которые были заготовлены на пробных площадях Туюксу, Большое Алматинское озерои Горельник. Изучен породный состав древесины и возможности использования полученных хронологий для климатической реконструкции. По данным кольцевых хронологий были построены графики абсолютного радиального прироста для каждого радиуса, которые используются для точной датировки годичных колец. Максимальный возраст исследуемых растений живых деревьев ели Шренка составляет 229 лет, относящийся к пробной площади Туюксу. Максимум ширины годичных колец по всем исследуемым объектам составляет 9,4 мм, который говорит о хороших погодных условиях в период активного роста и развития растения. Средняя ширина годичного кольца для ели Шренка на пробных площадях Большого Алматинского озера составляет 2,15 мм. Бревна из научно-реставрационной лаборатории «Остров Крым» были обработаны, сохранены и исследованы. На спилах обнаружены 124-, 130- и 141-летние древесно-кольцевых хронологии, возраст деревьев составляет от 124 лет до 141 года.

**Ключевые слова:** дендрохронология, археология, методы дендрохронологического анализа, современное дерево, керн, археологическое дерево, древесно-кольцевые хронологии, радиальный прирост.

## Introduction

The founder of dendrochronological studies is an American scientist A. Douglas (A. Douglass 1919; 1928: 1936, etc.), already in the early 1900s collected and analyzed samples of “yellow pine” to study the fluctuations of its annual growth and establish their relationship with the cycles of solar activity. And in 1920, he first used this method to date Indian settlements in the southwestern United States. Published in 1914, the work interested archaeologist Wissler, which initiated the use of the method of cross-Dating in archaeology for Dating fossil wood. Dating annual layers is the most important and time-consuming part of dendrochronological studies. The quality of the obtained tree-ring chronologies depends on the correctness of Dating and accuracy of measurements (Chernyih, N.B., 1996, Slyusarenko, I.Yu., 2010, Kolchin, B.A., 1972, Solomina O.N., 2012, Shiyatov S.G., Huber B. 1967).

## Research methods

The method of cross-Dating allows to make relative and absolute Dating of time of formation of layers of growth of wood. Relative Dating is to determine the pairs of rings in the compared samples, which were formed in the same year, but their calendar date is still unknown. It allows, for example, to determine how many years later or earlier was cut down (or died) a particular tree compared to another, based on the calculation of the difference in years, the formation of subcortical rings. Moreover, if the

sub-crust ring is preserved (this can be established by careful examination of the outer surface of the sample and the detection of bark or bast residues on it), it is possible to determine the season of felling or death of the tree. For example, if podkrovie ring is fully formed, then the death of the tree occurred during the growth period, i.e. during the summer months (Chernyih, N.B., 1996, Slyusarenko, I.Yu., 2010, Kolchin, B.A., 1972, Solomina O.N., 2012, Shiyatov S.G., Huber B. 1967)

Dendrochronological methods are labor-intensive, but the use of modern tools can greatly simplify the work. The LINTAB device is currently the most successful modern modification of the machine, the principles of which were invented by the swedish forester Eklund.It was developed by F. Rinn in the German firm RINNTECH in 1991 and continues to be improved to the present time.In 2015, the device LINTAB-6 was certified in RSE "Kazakhstan Institute of Metrology" of the Ministry of investments and development of Republic of Kazakhstan on the results of tests were registered in the register of the state system of ensuring the uniformity of measurements in the Republic of Kazakhstan and approved for use on the territory of the Republic (Zhantlesova Sh., 2015, Baygazakova Zh.M., Kentbaeva B.A., 2019).

Dendrochronology deals with wood of various species and ages. Modern wood, logs of buildings excavated during archaeological excavations, wooden details of architectural structures existing to this day, as well as boards of icons, etc., are used as objects of research.Very often, organic matter is perfectly preserved in the cultural layers of ancient and medieval settlements, which is facilitated by a large moisture saturation of the cultural layer, low acidity or neutrality of its environment, slow movement of internal water flow, almost complete absence of water and air exchange and, finally, small temperature fluctuations (ВихровВ. Е. 1959).Wood is well preserved in permafrost.An example of this construction of Mangazeya or logs from Altay burial mounds. Anaerobic conditions contribute to the preservation of organic matter in peatlands and coastal river sediments in some areas of Eastern Europe – in the Urals, Karelia, Arkhangelsk region, Belarus and Lithuania. In Veliky Novgorod found twenty layers of pavement, laid one above the other, scientists have concluded that it was built by Novgorod for five hundred and fifty years (Chernyih, N.B., 1996, Slyusarenko, I.Yu., 2010, Kolchin, B.A., 1972, Solomina O.N., 2012, Shiyatov S.G., Huber B. 1967).

The object of the study were the cores of living trees and also sawn archaeological tree. Cores from live trees were taken on the test areas Tuyuksu-TUY, Big Almaty lake- BAL and Gorelnik-GOR.

Wood samples (cores) were collected with a haglof age drill from living trees and a circular chainsaw from dead trees.The cores were taken at a height of 1.0-1.3 m from the Ground surface. To construct a generalized chronology, tree samples were taken from 15-30 trees of the same species, and from each tree by two radiuses. Drilled cores were placed in specially prepared paper or polyethylene containers (in containers samples are convenient to transport, dry and store until the work on the Dating and measurement of the rings), the inner diameter of which is 2-3 mm larger than the diameter of the sample.

By its origin, the collection of samples of archaeological wood has several sources: monuments that have become the object of excavations at the present time; monuments excavated earlier, but in which the wood was left by researchers at the site, which required repeated work; Museum collections.

Studies of archaeological wood was conducted on samples harvested earlier in the "Scientific-restoration laboratory ""island of Crimea", as well as cuttings from the archaeological wood obtained in the excavations of Korgan Shilikti and Berel in 2019.

**Research result**

To the Treasury.Al-Farabi in The international laboratory "Geoarchaeology" on the project "History and culture of the great steppe" on the topic "Study of the possibility of applying the methods of natural Sciences in archaeological research" on the measuring complex LINTAB, measured the growth of cores and determined their characteristics. This device is accompanied by a computer program TSAPWin Professional 4.70 d, which allows you to enter measurement data into the computer, correct and analyze the data, to present them in tabular and graphical forms.

Absolute Dating includes the precise determination of the calendar date of all year rings in the samples studied. It can be carried out only if the calendar date of taking a sample of wood is known, at least from one living tree, the annular chronology of which is cross-dated with other annular chronologies. As you compare the pictures of the rings for the purpose of their Dating on the samples difficult due to their large size and uneven width of annual rings, the rings extracted from the information easier to apply and analyze in the form

of graphs on the paper on which the abscissa shows the delayed calendar time in years (left to right) and y-axis – the value of the annual increment and other characteristics of annual rings.

The study of cores from live trees, which were harvested in the sample areas Tuyuksu-TUY, Big Almaty lake-BAL and Gorelnik-GOR (table 1). The specific name of the investigated plants include Schrenk's Spruce (A. Utebekova, Adilbaeva Zh., Maisupova B., B. Kentbayeva 2019).

One of the most important, if not the main, is the study of the influence of climate on tree growth. The width of the growth rings, the shape of the cells, the chemical composition of the wood can tell the researcher a lot about what the weather conditions were at the time when they were formed.

**Table 1** – Characteristics of the location of the test areas

| Sample areas | Width (N) | Longitude (E) | Direction | Altitude above sea level | Number of rings, pcs |
|---|---|---|---|---|---|
| TUY | 43°03′ | 77°00′ | N | 2200 | 8 |
| BAL | 43°04′ | 77°00′ | NE | 2125 | 30 |
| GOR | 43°08′ | 77°04′ | N | 1868 | 22 |

**Table 2** – Characteristics of individual chronologies in tree-ring width of Shrenk spruce trees on the sample area Tuyuksu

| № | Number of trees | Interval, y y | Number of rings, pcs | Average width of rings, mm | Maximum and minimum limits of the width of the rings, mm |
|---|---|---|---|---|---|
| 1 | TUY 1A | 1901-2019 | 118 | 2,62 | 9,40 |
| 2 | TUY 1B | 1953-2019 | 66 | 2,07 | 3,27 |
| **3** | **TUY 2A** | **1790-2019** | **229** | 5,42 | 1,14 |
| 4 | TUY 2B | 1810-2019 | 209 | 6,13 | 1,42 |
| 5 | TUY 3A | 1947-2019 | 72 | 4,13 | 2,74 |
| 6 | TUY 4A | 1886-2019 | 133 | 5,70 | 1,51 |
| 7 | TUY 4B | 1912-2019 | 107 | 6,50 | 1,79 |
| Subtotal: | | | 934 | ave. 1,71 | ave.9,40 |

**Table 3** – Characteristics of individual chronologies in tree-ring width of spruce spruce trees on the sample area of Big Almaty lake

| № | Number of trees | Interval, y y. | Number of rings, pcs | Average width of rings, mm | Maximum and minimum limits of the width of the rings, mm |
|---|---|---|---|---|---|
| 1 | BAL 1A | 1861-2019 | 157 | 2,18 | 4,53 |
| 2 | BAL 1B | 1887-2019 | 131 | 2,57 | 7,05 |
| 3 | BAL 2A | 1955-2019 | 63 | 2,47 | 5,05 |
| 4 | BAL 2B | 1949-2019 | 69 | 2,98 | 5,46 |
| **5** | **BAL 3B** | **1813-2019** | **205** | 1,35 | 5,64 |
| 6 | BAL 4A | 1907-2019 | 111 | 1,37 | 3,07 |
| 7 | BAL 4B | 1845-2019 | 173 | 1,67 | 4,66 |

**Table 4** – Characteristics of individual chronologies in tree-ring width of spruce spruce trees on the sample area "Gorelnik"

| № | Number of trees | Interval y , y. | Number of rings, pcs | Average width of rings, mm | Maximum and minimum limits of the width of the rings, mm |
|---|---|---|---|---|---|
| 1 | GOR 1A | 1960-2019 | 59 | 2,97 | 5,58 |
| 2 | GOR 1B | 1958-2019 | 61 | 3,63 | 6,24 |
| 3 | GOR 2A | 1954-2019 | 65 | 2,66 | 5,29 |
| 4 | GOR 2B | 1913-2019 | 106 | 1,36 | 3,93 |
| 5 | GOR 3A | 1979-2019 | 40 | 4,41 | 6,42 |
| 6 | GOR 3B | 1971-2019 | 48 | 4,56 | 6,99 |
| **7** | **GOR 11A** | **1893-2019** | **126** | **1,38** | **2,97** |

Each annual ring is a layer of wood, which managed to appear during one growing season (from spring to autumn). All of them have clear boundaries, which gives an unprecedented opportunity for very accurate Dating.

A characteristic of the individual chronologies for tree-ring width of spruce spruce trees on the sample area Tuyuksu following: the average width of annual rings of 1.71 mm, average maximum 9.4 mm (Utebekova A., Adilbaeva Zh., Maisupova B., B. Kentbayeva, 2019).

According to these data, we can say that in the period 1912-2019 y.y. was the best conditions for the growth and development of plants for sample area TUY 1A in terms of climate-and weather factors (Utebekova A., Adilbaeva Zh., Maisupova B., B. Kentbayeva, 2019).

Plants in the TUY 4B trial area, age 107 years, planting time 1912 have a maximum annual ring width of 6.5 mm. This width is the maximum for plants from the Tuyuksu trial sites. According to the obtained results of width measurements of annual rings with a precision of 0.01 mm on the sample areas Tuyuksu (table 2), the Big Almaty lake (table 3) and Gorelnik (table 4) given the characteristics of individual chronologies in tree-ring width of spruce trees spruce (Utebekova A., Adilbaeva Zh., Maisupova B., B. Kentbayeva, 2019).

The absolute radial increment graphs for each radius were plotted from the measurements, which are used to accurately date the annual rings.

Average width of annual rings for spruce spruce in plots of Big Almaty lake is of 2.15 mm. Maximum radial growth of 7.05 mm.

According to the characteristics of individual chronologies in tree-ring width of spruce spruce trees on the sample area Tuyuksu, it is evident that sample No. 3 TUY 2a is the largest number of rings (229pcs.).

Age of Shrenkspruce is 229 years old, the beginning of the formation of rings dates back to 1790 with an average ring width of 5.42 mm. the Maximum width was % to 9.40 mm in sample No. 1 1a Tuy. TUY in sample 3a were measured one radius, 3b is missing. The average ring width of all samples was 1.71 mm.

On this sample area, the «Big Almaty lake» measurement subject 7 samples, and of these, the maximum width made up 7.05 mm for sample No. 1 BAL 1b. The average width of all samples amounted to 2.15 mm.

In the samples taken at the BAL trial areas it is seen that the tree number 3 BAL 3b has the largest number of rings – 205 pcs., the formation of rings began in 1813, only one radius was measured. The rest of the samples cores were taken by two radii. On the test area «Gorelnik» 20 samples were subject to measurement. Of these, the maximum width made up 6.99 mm in sample No. 6 GOR 3b. The average width of all samples made up 2.89 mm.

**Analysis of results**

The data of table 4 show that the tree number 17, sample GOR 11a, which is considered the oldest tree, the number of annual rings is 126 pcs., the formation of rings began in 1893.


**Figure 1** – Samples of archaeological wood from Korgan Shilikti

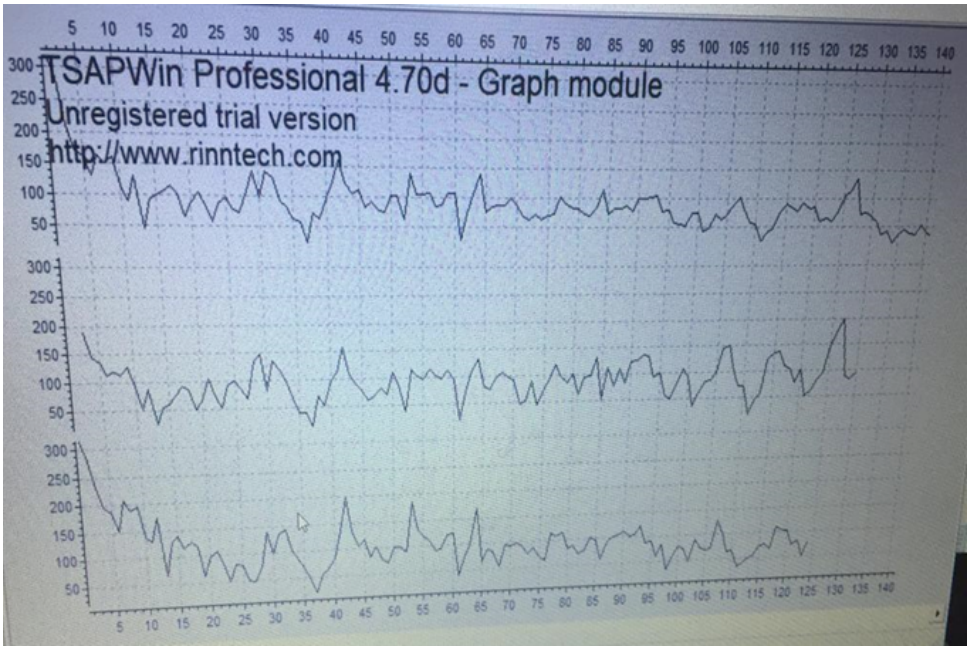


**Figure 2** – Cross-Dating of samples from Korgan of Shilikti


**Figure 3** – scientific and restoration laboratory «Island of Crimea»
(cut from Korgan of Shilikti and Berel)


**Figure 4** – Archaeological specimens, (not to be dated)

An important part of the work was the formation of a collection of wood samples from archaeological monuments of Pazyryk culture. Not only the principal possibility of the study itself, but also the accuracy and reliability of the conclusions depended on the quantitative and qualitative completeness of the materials. Due to different sampling methods, the samples were of two main varieties: cross-cut and age-related cores. Cross cuts allow you to choose the most convenient radii for measuring, facilitate the detection of falling rings, have greater physical strength, etc. In the case where it was impossible to take a full cut, the sample was taken in the form of a core using an age drill.

Collection of dendro specimens, which is investigated in the work, happen with 2 of the excavations, which were processed in 2019 in the International laboratory "Geoarchaeology" in the measuring system LINTAB.

Fig 1 shows the cuttings of an archaeological tree from the Corgan of Shilikta. Saw cut of coniferous

species, in this case Shrenk spruce, have good safety and are to be investigated.

The main problems of historical research include the chronology of historical and archaeological sites. For Dating archaeological sites from the second half of the XX century are widely used scientific methods of determining the absolute age, including dendrochronology. The main product of office processing are tree-ring chronology (TRC) on width of annual rings of trees that is the averaged sizes of indexes of increase.

Fig 2 shows a graph of construction of the annular chronologies of the studied archaeological samples. According to the carried out researches it is possible to say that 124, 130 and 141 pieces of wood-ring chronologies were revealed on the saw blades. Consequently, the age of trees ranges from 124 years to 141 years.

In The scientific restoration laboratory "Island of Crimea" there are collections of archaeological logs collected in different expeditions and for different years, in particular from Corgan Shilikti and Berel. The logs were processed and preserved and were subject to research and processing.

It should be noted that a large number of archaeological wood is not subject to processing and study of annual rings (Fig. 4). These specimens are not subject to Dating and it is very difficult, in some cases impossible to determine the type of tree.

**Summary**

Thus, it is possible to say that dendrochronology as a method of determining the Dating of tree, is widely used in many Sciences, in particular in forestry, climatology, archaeology, etc. On the basis of archaeological materials and living trees were constructed chronology for spruce spruce, which uses the so-called "cross-Dating". According to the obtained results of width measurements of annual rings with a precision of 0.01 mm on the sample areas Tuyuksu, Big Almaty lake and Gorelnik of the characteristics of individual chronologies in tree-ring width of trees Shrenk. The absolute radial increment graphs for each radius were plotted from the measurements, which are used to accurately date the annual rings.

According to the characteristics of individual chronologies in tree-ring width of spruce Shrenk trees on the sample area Tuyuksu selected core samples, where the number of rings is 229 units and samples on sample areas of BAL age of the oldest tree is 205 years old. The maximum and minimum limits of the width of annual rings in all of the investigated objects is 9.4 mm. According to the data, we can say that in the period 1912-2019 gg was the best conditions for the growth and development of plants for sample area TUY 1A in terms of climatic and weather factors.

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