Artículo de investigación

Modern studies of the resources of fossil mammoth tusks in the Arctic zone of Yakutia (northeast Siberia, Russia)

Современные исследования ресурсов бивней ископаемого мамонта в арктической зоне Якутии (Северо-Восточная Сибирь, Россия)

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Written by:
Gennady G. Boeskorov[102]
ORCID: 0000-0002-2360-7740
Marina V. Shchelchkova[103]
ORCID: 0000-0002-4566-3487

Abstract

Mammoth tusk is an important material for the economy of the Republic of Sakha (Yakutia), in which bone carving is historically widespread. In addition, in recent decades, Yakutia is the largest exporter of mammoth tusks abroad. The Arctic part of Yakutia is the only region of Russia and the World where a long and steady mining of fossil mammoth bones and tusks has taken place. In this regard, the question of assessing the resources of the mammoth tusks in the Arctic zone of Yakutia is actual. To calculate the annual collection amounts of the mammoth tusks in the Arctic zone of Yakutia, we used various sources. In order to determine the prognostic resources of the mammoth tusks in the Arctic zone of Yakutia, we calculated the area of Yedoma sediments, containg the mammoth tusks. According to recent estimates, based on new data on the melting of Yedoma sediments in the north of Yakutia and the level of collection of mammoth tusks in last years, Yedoma sediments in the Arctic zone of Yakutia can contain from 143, 539.03 to 170,220.7 tons of mammoth tusks. These calculations are very rough, but in general they are very close to the results of our previous calculations (maximum about 140 thousand tons) and calculations of other researchers (N. Vereshchagin - 150 thousand tons, A. Smirnov - 184 thousand tons). Thus, Yedoma sediments of Northern Yakutia can contain from 140 thousand tons to almost 200 thousand tons of mammoth tusks. Large amount of this valuable raw material

Аннотация

Бивень мамонта является немаловажным сырьем для экономики Республики Саха (Якутия), в которой исторически широко распространено косторезное искусство. Кроме того, в последние десятилетия Якутия является крупнейшим экспортером бивней мамонта за рубеж. Арктическая часть Якутии является единственным регионом России и мира, где ведется длительная и устойчивая добыча бивней ископаемого мамонта. В связи с этим вопрос оценки ресурсов мамонтовых бивней в Арктической зоне Якутии является актуальным. Для расчета годового сбора количества бивней мамонта в арктической зоне Якутии мы использовали различные источники. Чтобы определить прогнозные ресурсы бивней мамонта, мы рассчитали площадь верхнеплейстоценовых едомных отложений, содержащих бивни мамонтов. По последним оценкам, основанным на новых данных о таянии и разрушении едомных отложений на севере Якутии и уровне сбора мамонтовых бивней в последние годы, в отложениях едомы в Арктической зоне Якутии может содержаться от 143539,03 до 170220,7 тонн бивней мамонтов. Эти расчеты приблизительные, но в целом они очень близки результатам наших предыдущих расчетов (максимум около 140 тысяч тонн) и других исследователей (Н. Верещагин - 150 тысяч тонн, А. Смирнов - 184 тысяч тонн),

[102] Doctor of Sciences (Dr. habil.), Diamond and Precious Metals Geology Institute, Siberian Branch of RAS, Yakutsk, Russia.
[103] Ph.D., Associate Professor, Institute of Natural Sciences, M.K. Ammosov's North-Eastern Federal University, Yakutsk, Russia.

can play a significant economic role for the Republic of Sakha (Yakutia)in future.

Keywords: Mammoth tusk, licensed collection of tusk, annual collection amounts, mammoth tusk resources, Yakutia.

основанных на других подходах к подсчетам. Таким образом, едомные отложения Северной Якутии могут содержать от 140 тысяч тонн до почти 200 тысяч тонн бивней мамонтов. Значительный ресурс этого ценного сырья может сыграть в дальнейшем существенную экономическую роль для Республики Саха (Якутия).

Ключевые слова: мамонтовый бивень, лицензированный сбор бивня, объемы ежегодного сбора, ресурсы мамонтового бивня, Якутия.

Introduction

In the north of Siberia, and particularly, in Yakutia, significant areas of loose icy Upper Quaternary sediments, also called Icy complex (or Yedoma sediments), are preserved. Frozen remains of animals of mammoth fauna are preserved in significant amounts in these sediments, including such valuable raw materials as mammoth tusks, commonly called “mammoth bone”. Mammoth bone (or mammoth ivory) is a valuable and expensive material for carving intricate products. Its quality is not inferior to elephant or walrus ivory. In different countries of the world there are long traditions of bone carving, while mammoth bone is in great demand for the manufacture of jewelry, souvenirs, furniture and weapon inlays.

The Arctic part of Yakutia is the only region of Russia and the World where a long and steady mining of fossil mammoth bones and tusks has taken place (Vereshchagin, 1979; Smirnov, 2003; Boeskorov et al., 2008; Kirillin, 2011). In these territories of Russia, licensed collection of mammoth tusks is permitted for official collectors of tusks in the permafrost.

Analysis of literary sources and archival materials on locations where mammoth tusks and bones have been collected, reveals that in the territory of Yakutia, the amount of the mammoth tusks collected has remained at a high level for more than 200 years and is recently at least 20-30 tons annually. In the past few years, even more than 100 tons of tusks are collected here annually. There are several dozens of very fossil-rich locations in the Arctic zone of Yakutia where thawing permafrost reveals from several hundred kilograms to several tons of mammoth tusks almost annually.

Attempts to estimate the reserves of the mammoth tusks contained in the Upper Pleistocene Yedoma sediments (Icy complex) of the Arctic of Yakutia have yielded somewhat contradictory results: 495,000 tons (Kirillin, 2011), 184,000 tons (Smirnov, 2003), 150,000 tons (Vereshchagin, 1979), from 34,000 tons to 139,100 tons (Boeskorov et al., 2008). This biogenic resource is important for the economy of the Republic of Sakha (Yakutia), in which bone carving is historically widespread. In addition, in recent decades, Yakutia is the largest exporter of mammoth tusks abroad. In this regard, the question of assessing the resources of the mammoth tusks and a comprehensive study of the mammoth fauna localities in the Arctic zone of Yakutia, are actual.

Methods and Materials

To calculate the annual collection amounts of the mammoth tusks in the Arctic zone of Yakutia, we used various sources: archival materials, reports of various organizations on the collection of mammoth tusks, the results of expeditionary works, the results of the work of Government commissions for inspection of the activities of collectors of mammoth tusks, reports of licensed collectors of mammoth tusks, examinations of mammoth tusks lots, various literary sources.

In order to determine the prognostic resources of the mammoth tusks in the Arctic zone of Yakutia, we calculated the area of Yedoma sediments. For this, we used the “Map of the Quaternary sediments of the USSR. Scale 1: 5,000,000” (1966) and data of N. N. Romanovsky (1993) on the distribution of Yedoma sediments.

Results and Discussion

As an analysis of the available data shows, the most promising localities of the mammoth fauna remains containing mass accumulations of mammoth tusks are located on the New Sibirien Islands (Bolshoy Lyakhovsky Island) and on the Primorsky Lowlands (basins of the lower reaches of the Yana, Indigirka, Alazeya and Kolyma rivers).

Certain representations about the resouces of this raw material give information on the volumes of the annual collection of the tusks. In the first half of the 19th century, from 16 to 32 tons of mammoth tusks passed through the Yakutsk Fair. In the 60s of the 19th century, up to 40 tons of tusks a year came to Moscow. Most of them were exported from the north of Yakutia. From 1891 to 1913, between 11.2 and 32 tons of tusks were sold annually at the Yakutsk Fair (Zenzinov, 1915; Vereshchagin, 1979; Testsov, 1997). Thus, during the 19th century, the level of “mammoth bone” harvest in Yakutia was stable and averaged 20–25 tons per year, rarely dropping to 10–15 tons. In the Soviet period, the organized collection of the tusk significantly decreased and in some years almost stopped, during all this time until 1979 the volume of its harvesting hardly exceeded 10 tons (Testsov, 1997; Kirillin, 2011). In the 70s of the 20th century, the amounts of the mammoth tusks collection in Yakutia began to increase due to the revival of bone carving art, the establishment of the official purchase prices and requests from the aviation industry. Since 1979, the Primorskaya geological exploration party of the “Severkvartzsamotsvety” Company began systematic specialized mammoth tusks collection and exploration on the coast of the Primorsky Lowland on the mainland of northeast Yakutia and the islands of the New Sibirien archipelago (Testsov, 1997) According to incomplete data, from 10 to 30 tons of tusks were annually mined from the 80s of the 20th century to 2013 year (table 1).

As a result of legal regulation of the collection of the mammoth tusks in Yakutia in 2003 - 2013 years, the accounted collection of this raw material shows stabilization of collection at the level of 15 - 33 tons depending on the "harvest" of the year and the completeness of the reports (table 1).

Table 1. Amount of the mammoth tusks collection in the territory of Yakutia according to data from reports of tusk collectors

Years	The amount of collection, tons	Number of tusk collecting licenses issued
2003	14.7	23
2004	23.1	28
2005	29.3	28
2006	28.1	36
2007	33.4	23
2008	15.7	25
2013	20.3	217
2014	73.4	251
2015	108	383
2016	103.2	431
2017	120.8	78
2018	147	509

23

N.K. Vereshchagin (Vereshchagin, 1979), roughly estimated possible number of existing mammoths and suggested that about 150 thousand tons of mammoth tusks remained buried in the Primorsky Lowland, between the Yana and Kolyma rivers. Exploring the potential resource of the fossil mammoth bone, A.N. Smirnov (Smirnov, 2003) identified in the north of Yakutia the "North Yakutia bone-bearing province", i.e. area containing "placers" of mammoth tusks. The area of the terrestrial part (including islands) of this province is defined by him in 4,000,000 km^2. This author calculated the potential resources of mammoth tusks biomass in this area of 184,000 tons. Moreover, he proceeded from data on the density of population of elephants in the African savannah, the number of adult males with full-growed tusks, and other data.

The maximum estimate of the potential resource of the mammoth tusks in the north of Yakutia is 495,000 tons, given by N.D. Kirillin (2011).

In order to determine the prognostic resources of the mammoth tusks in the Arctic zone of the republic, we, firstly, calculated the area of Yedoma sediments, as: S_{Yedoma} = 290,813 km^2. For this, we used the "Map of the Quaternary sediments of the USSR. Scale 1: 5,000,000 "(1966) and data of N.N. Romanovsky (1993) on the distribution of Yedoma sediments. The stable annual level of mammoth tusks collection in northern Yakutia for about 200 years undoubtedly indicates a fairly even distribution of mammoth tusks among the Upper Quaternary Yedoma sediments, as many researchers noted (Vereshchagin, 1979; Testsov, 1997; Smirnov, 2003).

In our previous calculations (Boeskorov et al., 2008), we proceeded from the fact that each year, when thawing and erosion of Yedoma sediments by the summer positive temperatures and aquatic environment along the shores of the northern seas, rivers and lakes, from 11 to 30 tons of tusks come to the surface. Further, it was known that thermoabrasive destruction of coasts in the north of Yakutia is quite intense: the coastline (and also, Yedoma sediments) melts, recedes and destroys at a speed of 2-12 m, an average of 4-6 m per year (Are, 1980; Romanovsky, 1993; Testsov, 1997). Based on this, we calculated in 2008 (Boeskorov et al., 2008) the average area of annual destruction of the Yedoma sediments ($S_{Yedoma\ destruction}$) as a product of the following indicators:

$L_{shore\ lines}$ - the length of the coastline of Yedoma sediments (seas, rivers and lakes) and
$W_{coastal\ destruction}$ - the average width of annual coastal destruction.

$L_{shore\ lines}$ was determined by us on the maps using a curvimeter and is equal to 15,675 km.
With a minimum average coastline destruction (4 m):

$S_{Yedoma\ destruction\ area\ min.} = L_{shore\ lines} \times W_{coastal\ destruction}$ = 15,675 km × 0.004 km = 62.7 km^2.

With a maximum average destruction of the coastline (6 m):

$S_{Yedoma\ destruction\ area\ max.}$ = 15,675 km × 0.006 km = 94.05 km^2.

Further, if we assume that the annual minimum destruction area of the Yedoma sediments ($S_{Yedoma\ destruction\ area\ min.}$ = 62.7 km^2) may contain 11 tons of mammoth tusks, then the area of the whole Yedoma (S_{Yedoma}) can contain the following weight (mass) of tusks (M_{tusks}):

M_{tusks} = (S_{Yedoma} × 11 tons): $S_{Yedoma\ destruction\ area\ min.}$= (290,813 km^2 × 11 tons): 62.7 km^2 = 51,019.8 tons.

If we accept that the annual minimum destruction area of the Yedoma sediments ($S_{Yedoma\ destruction\ min.}$= 62.7 km^2) can contain 30 tons of mammoth tusks, then the area of the whole Yedoma (S_{Yedoma}) can contain the following weight amount (mass) of the tusks (M_{tusks}):

M_{tusks} = (S_{Yedoma} × 30 tons): $S_{Yedoma\ destruction\ area\ min.}$ = (290,813 km^2 × 30 tons): 62.7 km^2 = 139,145 tons.

If we accept that the annual maximum destruction area of the Yedoma sediments ($S_{Yedoma\ destruction\ area\ max.}$ = 94.05 km^2) can contain 11 tons of mammoth tusks, then the area of the whole Yedoma (S_{Yedoma}) can contain the following weight amount (mass) of the tusks (M_{tusks}):

M_{tusks} = (290,813 km^2 × 11 tons): 94.05 km^2 = 34,013.2 tons.

If we assume that the annual maximum destruction area of the Yedoma sediments ($S_{Yedoma\ destruction\ area\ max.}$ = 94.05 km^2) can contain 30 tons of mammoth tusks, then the area of the whole Yedoma (S_{Yedoma}) can contain the following weight amount (mass) of the tusks (M_{tusks}):

M_{tusks} = (290,813 km^2 × 30 tons): 94.05 km^2 = 92,763.3 tons.

Thus, in 2011, based on data on the destruction of Yedoma and the annual collection of mammoth tusks in amount from 11 to 30 tons, we estimated the prognostic resources of tusks in the Arctic zone of Yakutia from 34,013.2 to 139,145 tons (Boeskorov et al., 2008).

However, in recent years, due to climate warming in the Arctic, it has been noted that thermal abrasion destruction of coasts in the north of Yakutia is more intense and reaches 8–19 m per year (Razumov, 2018; Razumov, Grigoriev, 2017). Accordingly, a larger number of mammoth tusks are melting out of permafrost. In addition, in recent years, the Government of the Republic of Sakha (Yakutia) has begun to

issue more licenses to collect mammoth tusks (table 1).

As a result of the intensification of thermal erosion processes and an increase in the number of licenses for collecting a tusks, the annual collection amounts in Yakutia has increased several times, to 73.4 - 147 tons (table 1).

These circumstances forced to make a modern prognostic calculations of the mammoth tusks resources in the Arctic zone of Yakutia. Which was done by us on the basis of the above mentioned formulas.

In the new calculations, we were guided by the following numerical values:

With a minimum recent coastline destruction (8 m):

$S_{Yedoma\ destruction\ area\ min.} = L_{shore\ lines} \times W_{coastal\ destruction}$ = 15,675 km × 0.008 km = 125.4 km^2.

With a maximum recent destruction of the coastline (19 m):

$S_{Yedoma\ destruction\ area\ max.}$ = 15,675 km × 0.019 km = 297.825 km^2.

If we accept that the recent annual minimum destruction area of the Yedoma sediments ($S_{Yedoma\ degradation\ min.}$= 125.4 km^2) can contain 73.4 tons of mammoth tusks (the minimum level of collection of mammoth tusks in recent years), then the area of the whole Yedoma (S_{Yedoma}) can contain the following weight amount (mass) of the tusks (M_{tusks}):

M_{tusks} = (S_{Yedoma} × 73.4 tons): $S_{Yedoma\ destruction\ area\ min.}$ = (290,813 km^2 × 73.4 tons): 125.4 km^2 = 170,220.7 tons.

If we accept that the recent annual maximum destruction area of the Yedoma sediments ($S_{Yedoma\ destruction\ area\ max.}$ = 297.825 km^2) can contain 147 tons of mammoth tusks (the maximum level of collection of mammoth tusks in recent years), then the area of the whole Yedoma (S_{Yedoma}) can contain the following weight amount (mass) of the tusks (M_{tusks}):

M_{tusks} = (290,813 km^2 × 147 tons): 297.825 km^2 = 143, 539.03 tons.

Conclusion

Thus, according to recent estimates, based on new data on the melting of Yedoma sediments in the north of Yakutia and the level of collection of mammoth tusks in last years, Yedoma sediments in the Arctic zone of Yakutia can contain from 143, 539.03 to 170,220.7 tons of mammoth tusks. Of course, these calculations are rough, but in general they are very close to the results of our previous calculations (maximum about 140 thousand tons) and calculations made by other researchers, based on other calculation approaches (N. Vereshchagin - 150 thousand tons, A. Smirnov - 184 thousand tons). Thus, Yedoma sediments of Northern Yakutia can contain from 140 thousand tons to almost 200 thousand tons of mammoth tusks. Large amount of this valuable raw material can play a significant economic role for the Republic of Sakha (Yakutia) in future.

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