# DETERMINATION OF THE ABSOLUTE AGE OF THE FOSSIL REMAINS OF MAMMOTH AND WOOLLY RHINOCEROS FROM THE PERMAFROST IN SIBERIA BY THE HELP OF RADIO CARBON ($C_{14}$)*

By

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**Abstract:** Six samples of mammoth and one of woolly rhinoceros from the permafrost in Siberia were determined by the help of radio carbon ($C_{14}$) in Laboratoriet for Radiologisk Datering in Trondheim, Norway. The determined age varies in five of the mammoth samples and the rhinoceros sample from 44,000 ± 3,500 to 33,500 ± 1,000 years. However, one of the samples of mammoth (from Tajmyr) was considerably younger — only 11,450 ± 250 years old.

During a visit to the USSR in 1959, one of our authors — Professor A. Heintz, Oslo — proposed to the Zoological Institute of A. N. USSR in Leningrad, and the Paleontological Museum of A. N. USSR in Moscow, that some samples of the soft tissues of the mammoth *Mamuthus primigenius* (Blumbach) and the woolly rhinoceros *Coelodonta antiquitatis* (Blumbach) from the permafrost in Siberia, be sent to Norway for radiocarbon determination of their age. Thanks to the kindness of the director of the Zoological Institute, Professor E. N. Pavlovskij, and of the Paleontological Museum, Professor K. K. Flerov, the request was granted. The samples were processed in Laboratoriet for Radiologisk Datering, Fysisk Institutt, N.T.H., Trondheim, Norway, during the years 1960–62 by Dr. Reidar Nydal.

* Slightly changed translation by one of the authors (A. Heintz) of the Russian article, published in «Доклады Академии Наук» СССР, 1964, Tom 154, No. 6, pp. 1367–1370.

## Methods

The surface of the samples was first mechanically cleaned, then the samples were pulverized and treated with dilute hydrochloric acid (5%) to remove possible contamination by other carbonates. Some of the samples were also treated with NaOH to neutralize any traces of humic-acids. The above-mentioned treatment was used for all samples, but in some cases during the control determinations special methods were applied.

The carbon in all samples was burnt in pure oxygen to give $CO_2$. The registering of $C_{14}$ was made with the help of a proportional counter (NYDAL 1960–62).

The absolute age of the samples is calculated from the time when the organic carbon absorption was stopped, i.e. at the death of the animals, until 1950. The errors in measurements of $C_{14}$ are given as statistical standard deviations, and show that the age of the samples lies between given limits with a probability corresponding to 2/3. In the determination of the standard deviations the errors caused by the contamination of the samples with other carbon were not taken into consideration. The half-life period for $C_{14}$ used is 5,570 years. By treating the samples with NaOH the age becomes higher after each new treatment. This can probably be explained by the circumstance that the more recent humic-acids become gradually removed from the samples.

Thus, the age of the mammoth and the woolly rhinoceros determined by $C_{14}$ cannot be regarded as absolutely exact, as contamination of the samples can affect the determinations. This applies especially to the oldest samples, where the activity of $C_{14}$ was very small so that even insignificant contamination with other organic C may influence the determination of the age. Thus the final ages for most of the samples are given above a lower limit, which is calculated with an accuracy of 2 standard deviation (95% probability for a greater age than this limit) (NYDAL 1962, pp. 178–180).

## Determination of samples

SAMPLE T-170. Skin and hypodermic adipose tissue of a female mammoth discovered in 1908 near the river Sanga-Jurjak (Yakutia) (K. VOLLOSOVICH 1909). Four age determinations were performed

on the sample. The first determination showed an age of 29,500 ± 3,000 years, the second 32,650 ± 2,500 years and the third 31,500 ± 2,000 years. Finally the age of fat alone, separated by boiling, was determined. The result was 44,000 ± 3,500 years. From calculation based on the last measurement, the age is greater than 39,000 years.

SAMPLE T-299. Dried blood and adipose tissue of a male mammoth discovered in 1900 near the river Berezovka (Yakutia) (O. HERZ 1902). The first determination gave an age of 31,750 ± 2,500 years and the second 44,000 ± 3,500 years. From calculation based on the last measurement, the age is greater than 39,000 years.

SAMPLE T-172. Skin and hypodermic adipose tissue of woolly rhinoceros, discovered in 1948 near the river Indigirka (J. N. POPOV 1949). The first determination showed an age of more than 32,000 years and the second 45,000 ± 6,000 years. Calculation based on the last result gave an age more than 38,000 years, which is the most plausible result.

SAMPLE T-169. Skin, hypodermic adipose tissue and sinew of a mammoth discovered in 1909 on the river Mokhovaja (G. N. KUTOMANOV 1914). The first determination showed the age to be more than 33,000 years, the second 35,800 ± 2,700 years. As the found activity may be due to contamination, the age is here calculated to be more than 32,500 years.

SAMPLE T-171. Skin and hypodermic adipose tissue of a male mammoth discovered in 1799 in the delta of the river Lena (V. DUBININ and V. GARUTT 1954). The determination gave an age of 35,800 ± 1,200 years. As the activity in the sample may be due to contamination, the age is calculated to be more than 33,000 years.[1]

SAMPLE T-298. Skin and hypodermic tissue of a male (?) mammoth discovered in 1864 on the river Gyda (F. SCHMIDT 1866). The first determination gave an age of 30,250 ± 1,800 years. The second was made on a sample treated only with HCl, and the third with both HCl and NaOH. In both cases the results were the same — 33,500 ± 1,000 years.

SAMPLE T-297. The skin, hypodermic adipose tissue and sinew

[1] The skin of the same mammoth was studied in the Laboratory of Yale University, U.S.A., and there also the age was determined to be more than 33,000 years.

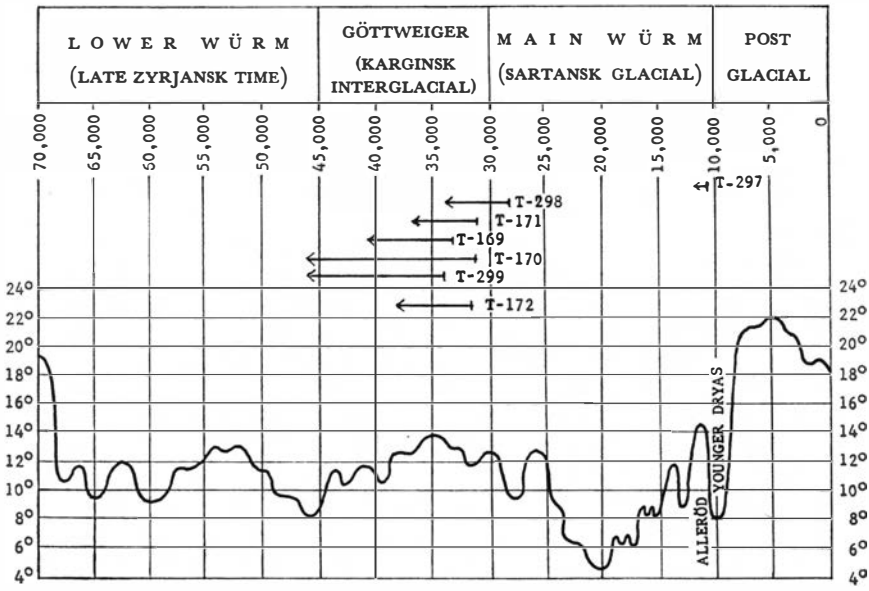


Fig. 1.

of a male mammoth discovered in 1948 on the river Mamontova on the Tajmyr peninsula (E. N. PAVLOVSKIJ 1950; L. PORTENKO, B. TIKHOMIROV and L. POPOV 1951). Determination has given an age of 11,450 ± 250 years.[1] This sample is thus different from all the others in being much younger. This, according to Dr. NYDAL, cannot be explained only by contaminations, as the activity of this sample exceeds the activities of all the others by 10 to 20 times.

## Conclusions

H. GROSS (1958), in his paper on the results of the determinations of the organic remains from the late Quaternary deposits in Europe using $C_{14}$, has given a hypothetical curve showing the middle temperature of July in Central and Northern Europe during the last (Würm) glaciation. With regard to Siberia, GROSS' curve cannot be accepted

[1] The soft parts of this mammoth were studied for the first time in 1954 by A. V. TROFIMOV in the Geochemical and Analytic-chemical Institute of Akad. Nauk. USSR (A. P. VINOGRADOV 1954) and the determination gave an age of about 12,000 years.

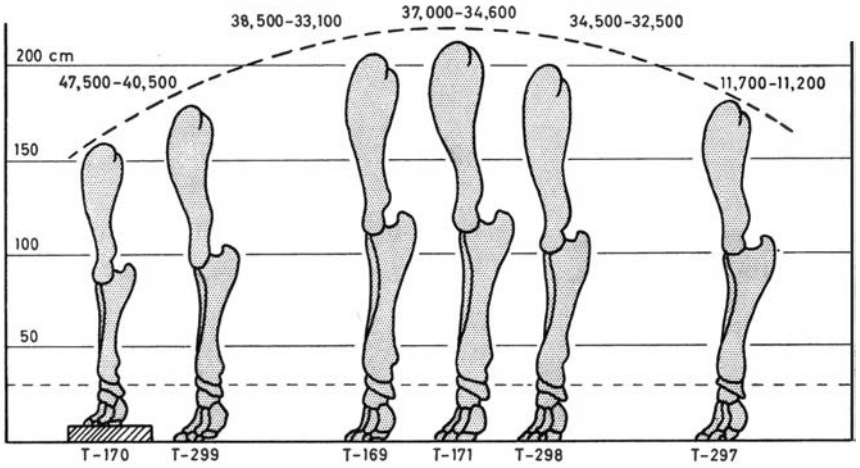


Fig. 2.

completely, but nevertheless it gives a characteristic of the general climatic changes.

If, on this curve (Fig. 1), we mark the age of the mammoths and the woolly rhinoceros mentioned in this paper, we obtain the following picture:

The two most ancient of our mammoths (T-170 and T-299) have lived in Siberia during a period of falling temperature before the Göttweiger interstadial in Europe (late Zyrjansk time[1]).

The three other mammoths (T-169, T-171, T-298) and perhaps also the woolly rhinoceros (T-172) have lived in Siberia during the Göttweiger interstadial in Europe (Karginsk interglacial). Finally, the Tajmyr mammoth (T-297) — the youngest in age — lived during the new decline of the temperature after the Alleröd interstadial in Europe (Sartansk glacial).

It is very interesting to observe the correlations between the morphological features of the Siberian mammoths — particularly their sizes — and the changes in climatic conditions. To show this correlation we have taken the size of the bones of the front legs of the investigated mammoths and drawn them on the same scale in chronological order

[1] The authors used the same terminology for stadials and interstadials as used in Europe. The name of the corresponding periods in Siberia are mentioned in parentheses.

(Fig. 2). By this means we have obtained a curve which recapitulates the main features in the temperature curve given by GROSS. The largest mammoths lived during the period corresponding to the favourable Göttweiger interstadial in Europe, when the rich vegetation of grasses and bushes on the endless Siberian plains gave plenty of food to many herds of mammoth.

The cause of the extinction of the mammoth is probably connected with strong climatic (= temperature) variations during a relatively short time. During the passage from the Riss-Würm interglacial to the Würm glacial period, the herds of mammoth could easily migrate to the south. However, during the long, favourable Göttweiger interstadial (Karginsk interglacial) the mammoth again migrated north. The rapid deterioration of the climate which took place about 25,000 years ago, strongly decreased the herds of mammoth and only a few animals migrated southwards, where they survived the coldest period of the Würm (Brandenburger interstadial). During the Alleröd interstadial in Europe, small herds of mammoth could again migrate northwards. The third climatic decline in the period, corresponding to the younger Dryas period in Europe, probably resulted in a complete extinction of the mammoth.

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