PALEONTOLOGY

C^{14} DATING OF MAMMOTH AND WOOLLY RHINOCEROS REMAINS FROM THE PERMAFROST OF SIBERIA[1]

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Abstract: C^{14} dating of fossil remains from the permafrost zone of Siberia cannot be considered fully reliable. With the exception of one specimen dated as 11,450 ± 250 years, the ages indicated range from 32,500 to over 39,000 years. Due to extraneous sources of carbon, the specimens may actually be older than the ages given.

The radioactive determination of the age of fossil remnants (soft tissues, hide) of the mammoth Mammuthus primigenius (Blum.) and the woolly rhinoceros Coleodonta antiquitatis (Blum.) from the permafrost of Siberia was made in the Laboratory for Radiological Dating of the Physics Institute of the Norwegian Higher Technical School in Trondheim (Laboratoriet for Radiologisk Datering, Fysisk institutt N. T. H. Trondheim, Norge), in the period of 1960-1962, under the direction of Dr. Reidar Nydal.[2]

Method. The specimens were first scraped and comminuted and then, to eliminate possible contamination by carbonates, were treated with dilute (5%) hydrochloric acid. Some of the specimens were also treated with NaOH to neutralize possible contamination by humic acids. Subsequent treatment was the same for all specimens, although in some instances special methods were used to check the determinations. The carbon of all the samples was burned in pure oxygen to CO_2. The C^{14} registration was accomplished with the aid of a proportional counter.

The absolute age of a specimen is defined as the time elapsed from the moment when organic carbon ceases to be absorbed to the moment when the C^{14} is determined (1950). The errors in the measurement of C^{14}, given in the form of a statistical standard deviation, show that the age of the specimens lies within the above-mentioned limits with a probability of approximately $^2/_3$. In ascertaining the standard deviation, no account was taken of errors that may result from contamination of the specimen by extraneous carbon. The half-life of C^{14} is generally taken to be 5570 years. As the specimens were treated with alkaline solutions, their ages appeared to be older with each successive determination; this is evidently explained by the constant removal of younger humic acids from the specimens.

Thus the ages of the mammoth and the rhinoceros, as determined by means of C^{14}, cannot be considered fully reliable, inasmuch as contamination of the specimens affects the accuracy of the determinations. This applies particularly to the older specimens, in which the C^{14} activity is slight, with the result that even a very small contamination by extraneous organic carbon can affect the final age determination. Hence the data cited below may indicate an age younger than the true age of the specimen.

Specimen T-170. Hide and subcutaneous fatty cellular tissue of a female mammoth found in 1908 in the channel of the Sanga-Yuryakh River (Yakutiya) [1]. The specimen was investigated four times. The first determination gave an age of 29,500 ± 3000 years, the second 32, 650 ± 2500 years, and the third 31,500 ± 2000 years. The fourth time the age was determined for only the fat, which was separated by boiling; the result was 44,000 ± 3500 years. From all the above data, Nydal reckons the age of this mammoth as more than 39,000 years.

[1]Translated from: Opredeleniye absolyutnogo vozrasta iskopayemykh ostakov mamonta i shersti-stogo nosoroga iz vechnoy merzloty Sibiri pri pomoshchi radioaktivnogo ugleroda (C^{14}). Doklady Akademii Nauk SSSR, 1964, Vol. 154, No. 6, pp. 1367-1370.

[2]One of the present authors, Prof. A.E. Heintz, Director of the Paleontological Museum of the University of Oslo, during his visit to the Soviet Union in 1959 requested the Zoological and Paleontological Institutes of the USSR Academy of Sciences to send some specimens of soft tissues of fossil mammals from the permafrost of Siberia for investigation to the Radiological Dating Laboratory at Trondheim. At that time, with the approval of Ye.N. Pavlovskiy, Director of the Zoological Institute of the USSR Academy of Sciences, some specimens of mammoth tissues were sent to Trondheim, as were samples of rhinoceros tissues, with the permission of Prof. K.K. Flerov of the Paleontological Institute of the USSR Academy of Sciences. The results of this investigation, which was conducted under the direction of Dr. R. Nydal, are published here with his kind permission.

Specimen T-299. Dried blood and fatty tissue of a male mammoth found in 1900 in Yakutiya, on the bank of the Berezovka River [2]. The first determination yielded an age of 31,750 ± 2500 years, and the second 44,000 ± 3500 years. Nydal reckons the age of this mammoth also as more than 39,000 years.

Specimen T-172. Hide and subcutaneous fatty tissue of a woolly rhinoceros found in 1948 in the Indirgirka River region [3]. The first determination yielded an age of more than 32,000 years, the second, which Nydal considers more correct, more than 38,000 years.

Specimen T-169. Hide, subcutaneous fatty cellular tissue and sinews of a mammoth found in 1909 on the Mokhovaya River [4]. The first determination yielded an age of more than 33,000 years, the second 36,950 ± 4300 years, and the third (which Nydal considers the most reliable) 35,800 ± 2700 years. Hence Nydal reckons the age of this mammoth at more than 32,500 years.

Specimen T-171. Hide and subcutaneous fatty tissue of a male mammoth found in 1799 in the Lena River delta [5]. The age determination gave a figure of 34,450 ± 2500 years the first time and 35,800 ± 1200 years the second time. Nydal considers the age of this mammoth to be more than 33,000 years.[3]

Specimen T-298. Hide and subcutaneous fatty tissue of a male (?) mammoth found in 1864 on the Gyda River [6]. The first determination gave an age of 30,250 ± 1800 years. The second determination was made on a specimen treated only with hydrochloric acid, and the third on one treated also with NaOH; in both cases the results of the age determinations were the same 33,500 ± 1000 years.

Specimen T-297. Hide, subcutaneous fatty tissue and sinews of a male mammoth found in 1948 on the Mamontovaya River, on the Taymyr Peninsula [7, 8].[4] This determination resulted in an age of 11,450 ± 250 years. This specimen differs from all the others in its much younger age, which, in Nydal's opinion, cannot be due to contamination alone. Its radioactivity exceeds that of all the other specimens by a factor of some 10-20, and contamination thus cannot play as great a role here.

In his publication on the results of age determinations of organic remains from Late Quaternary deposits by the C^{14} method, H. Gross [10] presents a hypothetical curve of mid-July temperatures in Central and Northern Europe during the last (Würm) glaciation. The absolute values of Gross's curve cannot be accepted for the territory of Siberia; the curve can be used here only to characterize the general course of paleoclimatic events. If the ages of the mammoths and the rhinoceros (taking the maximum age values as the most likely) are plotted on this curve (Fig. 1), the following picture results. The two oldest mammoths studied by the present writers (T-170 and T-299) existed in Siberia during a time of decreasing temperatures which preceded the Hettweg Interstadial of Europe (Late Zyryan time),[5] Three other mammoths (T-169, T-171, T-298) and the rhinoceros (T-172) inhabited Siberia during the Hettweg Interstadial itself in Europe (the Karga Interglacial), and, finally, one of the mammoths, the Taymyrian (the youngest, T-297) lived during the period of a new lowering of the temperature which preceded the Allerød Interstadial in Europe (Sartan Glaciation).

[3]The hide of this same mammoth was also investigated in the laboratory at Yale University in the USA, where indications of an age of more than 33,000 years were also obtained.

[4]The soft tissues of the Taymyr mammoth were investigated as early as 1954 by A.V. Trofimov at the V.I. Vernadskiy Institute of Geochemistry and Analytical Chemistry of the USSR Academy of Sciences [9], and yielded an age of about 12,000 years.

[5]In designating the stadials and interstadials of the last glaciation, the authors have used the terminology generally adopted for Europe. The names of the corresponding stadials and interstadials in Siberia are given in parantheses.

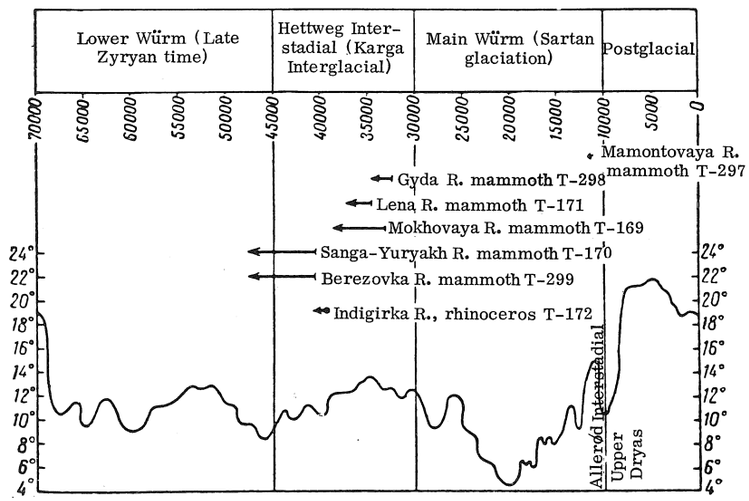

Fig. 1

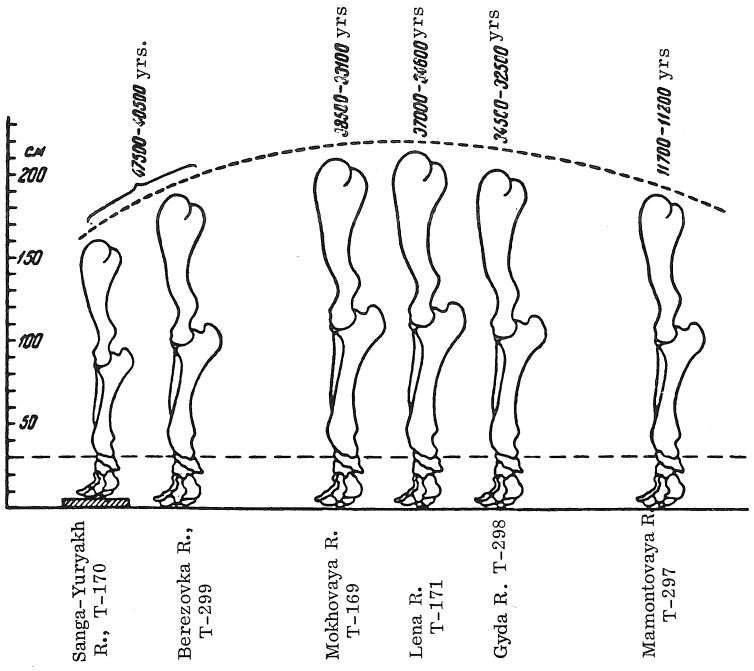

Fig. 2.

Interesting results were also obtained by a study of the relationship between the morphology of the Siberian mammoths, particularly their body size, and the climatic conditions. To show this relationship as clearly as possible, we shall take the sizes of the bones in the anterior extremities of the mammoths investigated and plot them on the same scale in chronological order (Fig. 2). This results in a curve whose general features reproduce Gross's temperature curve; the largest dimensions characterize the mammoths that existed during the period corresponding to the favorable Hettweg Interstadial in Europe, when the vast plains of Siberia were covered by grass and shrub vegetation, providing an abundance of fodder for the numerous mammoth herds. On the other hand, the mammoths which inhabited Siberia during the periods of decreasing temperatures were smaller, since at these times they were evidently unable to find sufficient fodder for themselves.

The reasons for the extinction of the mammoths may well have been connected with various fluctuations of the temperature over a comparatively short interval of time. During the transition from the Riss-Würm Interglacial to the Würm Glaciation, the mammoths may have migrated southward. In the course of the prolonged and favorable Hettweg Interstadial (Karga Interglacial), however, the mammoths again spread far to the north. The rapid deterioration of the climate that began about 25,000 years ago sharply diminished their numbers, so that only a few small remnants of the mammoth herds migrated to the south and there survived the coldest period of the Würm Glaciation. During the time corresponding to the Allerød Interstadial of Europe, small herds of mammoths were again able to migrate northward. Then the third deterioration of the climate, corresponding to the younger Dryas, evidently led to the final extinction of the mammoth species.

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