Part 1 Introduction

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Some pages of history

Remains of ancient animals that once lived in a number of places in the northern hemisphere are from time to time washed out from below the ground along the banks of rivers, lakes, and streams, and on gully slopes. Discoveries of their bones and even complete skeletons are well known from Quaternary deposits in Siberia and North America (Chersky, 1891; Pavlova, 1910; Popov, 1948; Guthrie, 1968, 1982; Sher, 1971; Vereshchagin, 1981; Lazarev, 1982; Agenbroad, 1984, and others). More than 50 almost wholly preserved skeletons of fossil animals have been found in various areas of Siberia. Nevertheless, frozen animal carcasses with well-preserved entrails, including gastrointestinal tracts filled with plant remains, are extremely rare, because the preservation of such remains depends on favorable burial conditions at the site of the animal's death. Some of the animals, such as mammoth (*Mammuthus primigenius*), woolly rhinoceros (*Coelodonta antiquitatis*), cave bear (*Ursus spelaeus*), have become extinct quite recently, and muskoxen (*Ovibos moschatus*) appear to be on the verge of extinction, whereas animals such as bison (*Bison* spp.), yak (*Bos mutus*), and saiga (*Saiga tatarica*) have only suffered from reduced ranges.

For a long time scientists have been aware that finds of herbivorous animals with preserved gastrointestinal contents are very important. Attempts to examine food remains of fossil animals have been made since the middle of the nineteenth century. As early as 1849, Academician F. F. Brandt was the first person to examine plant remains from the oral cavity of the mummified head of a woolly rhinoceros that had been discovered on the bank of the Vilyuy River, near the town of Vilyuysk, Yakutia (Sakha Republic). The plant material was identified as the remains of coniferous species. Shmalgauzen (1968) examined plant remains that were lodged among the teeth of the same rhinoceros, and noted that fragments of stems and leaves of monocotyledonous plants, probably of grasses, were the most common in the food remains

studied. In addition to fragments of monocotyledonous and dicotyledonous plants, he identified twigs of spruce (*Picea*), larch (*Larix*), willow (*Salix*), and *Ephedra*. K. A. Meyer and K. E. Marklin also identified fruits of *Ephedra* sp. and twigs of *Salix* sp. in the food remains of the Vilyuy rhino (Garutt *et al.*, 1970). Thus it appears that the rhinoceros had a rather wide-ranging diet.

The opportunity to examine the composition of plants from a frozen gastrointestinal tract arose for the first time in 1900 when, on the Berezovka River, a right tributary of the Kolyma River, about 320 km northeast of the town of Srednekolymsk, an almost completely preserved frozen mammoth carcass was found (67°10′ N, 155°30′ E: Figure 1.1, site 1). The Russian Academy of Sciences immediately organized an expedition to excavate the mammoth (Herz, 1902). Sukachev (1914) and others studied the food remains of the Berezovka mammoth for several years (see Chapter 14).

The deposits that enclosed a fossilized animal corpse were first studied by Szafer (1946). He identified 14 species of plant remains in strata that contained a woolly rhinoceros corpse discovered in the vicinity of Starunia, western Ukraine. The remains were dominated by dwarf birch (*Betula nana*), willow (*Salix reticulata*), and dryad (*Dryas octopetala*). According to Szafer (1946), this floral composition suggests that a severe arctic climate existed in the discovery area during the lifetime of the Starunia rhinoceros.

Following Sukachev's work, the effort to carry out paleobotanical investigations of megafaunal remains was led by Professor B. A. Tikhomirov. He took part in the excavation of a mammoth found in 1948 in the Shrenk River basin of the northwestern Taymyr Peninsula (75°14′ N, 94°46′ E: Figure 1.1, site 2), and studied the present flora and vegetation in the area of the find (Tikhomirov, 1950a). Conditions of the burial and the geology of the area were studied by Popov (1950, 1959). Palynological analyses of the deposits that enclosed the mammoth skeleton, and of those that existed as built-up terraces in the vicinity of the burial site, were carried out by Zaklinskaya (1954). Fossil mosses associated with the find were examined by Zenkova (1954) and Savich-Lyubitskaya and Abramova (1954).

Pollen analysis of plant remains in the food of the Berezovka mammoth was conducted as late as the late 1950s by Tikhomirov and Kupriyanova (1954) and Kupriyanova (1957). Even after almost 50 years in storage, analysis of the food remains of the animal showed that the pollen and spores were excellently preserved, and hence that this method of analysis showed promise as an avenue of research.

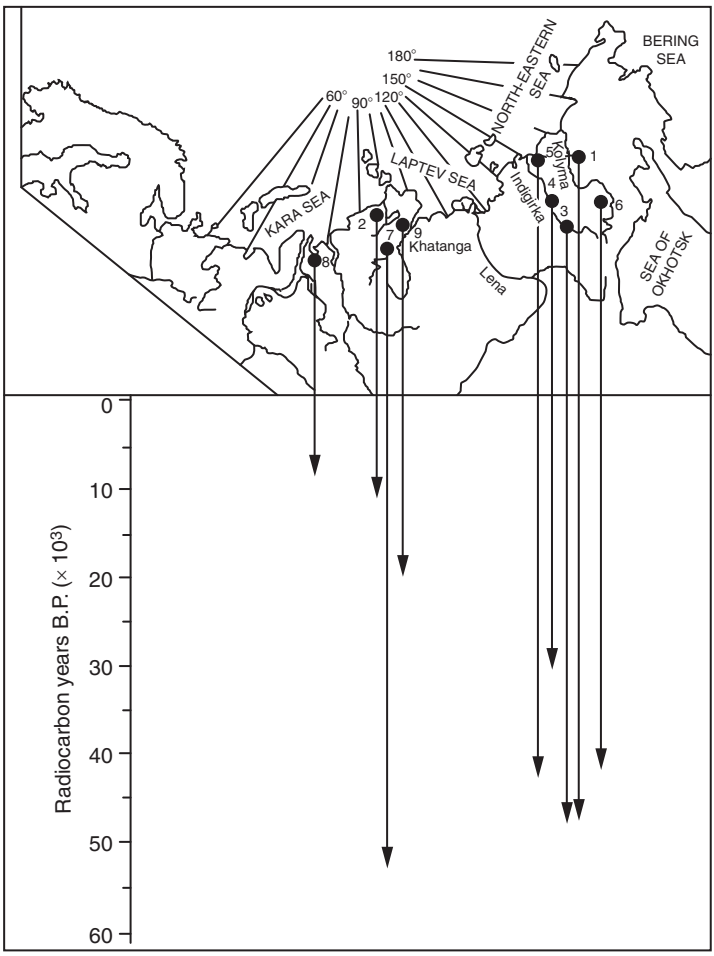

Figure 1.1 Sites of finds of frozen carcasses and skeletons (or their fragments) of animals which perished in different periods of the Pleistocene and Holocene in Siberia. (1) Berezovka mammoth, Berezovka River, lower Kolyma River, 1900; (2) Taymyr mammoth, Mamonta River, Shrenk River, 1948; (3) Selerikan horse, El'gi River, upper Indigirka River, 1968; (4) Mylakhchin bison, middle Indigirka River, 1971; (5) Shandrin mammoth, Shandrin River, lower Indigirka River, 1972; (6) Kirgilyakh mammoth (baby mammoth "Dima"), upper Kolyma River, 1977; (7) Khatanga mammoth, lower Khatanga River, 1977; (8) Yuribei mammoth, Yuribei River, 1979; (9) Jarkov mammoth, Bol'shaya Balakhnya River, 1997.

The application of palynology to paleodiet reconstruction was supported by pollen analysis of food remains preserved between the teeth and within the oral cavity of a woolly rhinoceros discovered on the Kholbui River, Yakutia, in 1877. Analysis was performed by Metel'tseva (Garutt *et al.*, 1970). In spite of the fact that the head of the animal had been kept in a museum for more than 90 years, plant remains as well as pollen and spores that were lodged between the teeth, though rare, were relatively well preserved.

Pollen analysis of a 2 m thick stratum enclosing a mammoth skeleton at the village of Chekurovka, in the lower part of the Lena River valley, illustrated not only the living conditions of the mammoth but also demonstrated the character of later variations that developed in the vegetation, and hence the changes in environmental conditions that characterized the area (Korzhuev and Fedorova, 1962).

Almost 70 years passed between the discovery of the Berezovka mammoth and the 1968 exhumation of a fossil horse that was discovered at a gold mine on Balkhan Creek, a right tributary of the El'gi River, which is a tributary of the Indigirka River (64°40′ N, 147°45′ E: Figure 1.1, site 3). Through the efforts of B. S. Rusanov, P. A. Lazarev, and O. V. Egorov, the find was excavated and delivered to Yakutsk, and then removed to the Saint Petersburg (Leningrad) Zoological Institute. Plant remains from different sections of its gastrointestinal tract were studied at the Komarov Botanical Institute of the USSR (Russian) Academy of Sciences, Saint Petersburg.

The following summer (1969), an expedition was organized to further explore the area of the Balkhan Creek horse discovery. The expedition enlisted the aid of N. V. Lovelius (dendrochronologist, head of the team), Zh. M. Belorusova (geomorphologist), M. V. Sokolova (florist), V. P. Bibikov (geobotanist), V. I. Kozhanchikov (carpologist), and V. N. Adamenko (climatologist). They studied the environmental conditions of the area where the fossil horse was found and its burial conditions. Furthermore, the scientists collected herbarium specimens, seeds, pollen, samples of wood and sediments from strata enclosing the horse, and thus obtained the required material to identify plant remains that comprised the food of the horse. This also allowed them to reconstruct the paleogeographical characteristics of the landscape that existed when the animal was alive.

The results of preliminary examinations confirmed that, for all practical purposes, pollen and spores do not decompose in the gastrointestinal tract (Tikhomirov and Kul'tina [Ukraintseva], 1973). Thus, the pollen–spore analysis data reflect the composition of plant components

that were directly eaten by the animal, as well as those simply growing in the vicinity of the animal when it was alive.

The early 1970s witnessed two extremely valuable finds: a complete mammoth skeleton with well-preserved frozen internal organs was discovered near the Shandrin River in the lower Indigirka River valley (70°30′ N, 151° E: Figure 1.1, site 5), and a relatively well-preserved corpse of a fossil female bison was found in the mid section of the Indigirka River, Mylakhchin District (68°30′ N, 146°40′ E: Figure 1.1, site 4). B. S. Rusanov, P. A. Lazarev, and their colleagues removed both skeletons from permafrost and delivered them to the freezing pit of the Institute of Permafrost at Yakutsk. In January 1973 these two unique finds were transported to Novosibirsk and examined by a group of scientists, including paleontologists, anatomists, microbiologists, parasitologists, botanists, and geologists. Two scientists from the Botanical Institute of the Russian Academy of Sciences – N. V. Lovelius and the author – participated in the study.

A program of botanical studies developed by Professor B. A. Tikhomirov and the author was submitted for consideration by the group. According to the program, the following studies were to be performed: (1) analysis of the remains of vegetative parts of plants preserved in the gastrointestinal tract of the mammoth (stems, leaves, roots, rootstocks and the like); (2) carpological (seed) analysis; (3) pollen analysis of the contents of different parts of the gastrointestinal tract; and (4) radiocarbon analysis of the food remains.

The program envisaged the organization of expeditions to the areas of the two finds, where geologists and botanists would perform joint investigations. For reasons that remain unclear, the expedition never took place. However, in 1974 a group of scientists of the Botanical Institute of the Russian Academy of Sciences did undertake investigations in the area where the Shandrin mammoth had been buried. Examinations of the content of the gastrointestinal tract of the animal were based on studies and collections made during the expedition, and allowed for a reconstruction of the composition and characteristics of the vegetation that grew during the mammoth's lifetime (Solonevich *et al*., 1977; Gorlova, 1982). Furthermore, the investigations served as the basis for the description of the principal climatic characteristics that prevailed when the animal lived; this was the first such study to be performed in that area (see Chapter 8).

Two more fossil animals were found in 1977. In June the first-known wholly preserved corpse of a baby mammoth was discovered in the middle part of the Kirgilyakh Creek, in the upper reaches of the

Kolyma River (62°40′ N, 147°59′ E: Figure 1.1, site 6); it is now universally known by the name "Dima." This unique find was conveyed to Magadan city, and the Presidium of the Russian (USSR) Academy of Sciences at once established a commission under the chairmanship of Academician N. A. Shilo with the aim of examining the mammoth. The members of the Commission were representatives of a number of academic institutes, including the Institute of Microbiology, the Institute of Evolutionary Morphology and Ecology of Animals, and the biology chair of Moscow University. The author was the representative of the Botanical Institute on the Commission. When the Commission completed its work, the group of botanists, led by the author, moved from the area of the Berezovka mammoth burial to the Kirgilyakh Creek area, where they studied the present flora, collected herbarium specimens, and took surface samples for pollen analysis in key types of vegetation cover.

The interest shown in baby mammoth "Dima" outshone another very important paleontological find of 1977, the remains of some parts of the corpse of a mammoth of an early type, as defined by L. I. Alekseeva (oral communication). It was found in the Bol'shaya Lesnaya Rassokha River basin, a right tributary of the Novaya River in the southeastern Taymyr Peninsula (72°20′ N, 108°30′ E: Figure 1.1, site 7). This mammoth is referred to here as the Khatanga mammoth. No gastrointestinal tract material was preserved, but joint investigations undertaken in the area, including detailed palynological study of the deposits enclosing the corpse, permitted reconstruction both of the living conditions of the mammoth and of the major stages in the evolution of habitats in this part of the Taymyr Peninsula over the last 53 000 years (see Chapter 15).

In early September 1979 it became known that a mammoth corpse had been found in the middle part of the Yuribei River on the Gydan Peninsula (70°18′ N, 76°00′ E: Figure 1.1, site 8). The Russian Academy of Sciences at once gathered together a group of specialists, with the objectives of digging it out and conducting an examination of it. The group included a geologist, paleontologists, an anatomist–morphologist, a palynologist, a geocryolithologist (one who studies permafrost), and other specialists, as well as a journalist from the newspaper *Trud*. As early as September the group arrived at the find and started work. In the process of excavation they dug up much of the skeleton, four feet containing soft tissues, separate more or less well-preserved parts of soft tissues, wool and part of the internal organs. A gastrointestinal tract, tightly filled with remains of the plants that had been eaten shortly before death, was complete and well preserved.

At the site of the excavation the scientists took samples from all parts of the gastrointestinal tract in order to perform a variety of botanical analyses, and to secure samples for radiocarbon dating.

Finally, in July 1997, members of the Jarkov family, Dolgan reindeer herders, found the tip of a tusk protruding from the tundra of the Taymyr Peninsula (73°32′ N, 105°49′ E: Figure 1.1, site 9). Upon excavation of the tusk, they found a second one, both still attached to the cranium. As a result of preliminary excavation at this site, about 25% of the skeleton was found, as well as a portion of the skin with hair (approximately 1 m^2) and several kilograms of wool. A Swedish expert in ground-penetrating radar ran a series of profiles over the site, revealing an anomaly interpreted to be the body of the mammoth. In September 1999, several members of a scientific team working at the site excavated a block of permafrost containing the radar anomaly. According to radiocarbon dates derived from the hair of the Jarkov mammoth, the animal perished about 20 380 years BP, during the Sartan Ice Age (late Würm, late Wisconsin).

It can be seen from the brief review above that, starting with the earliest finds of fossil animals in Russia, strong emphasis has been placed not only on examining the food remains they contained, but also on the study of surrounding deposits. Furthermore, since the late 1960s (the time of the fossil horse discovery) multidisciplinary teams of researchers from academic and non-academic institutions have participated in joint investigations. This has allowed a number of problems, both purely academic and applied, to be tackled successfully.

The results of the studies undertaken on the finds described above, and others, were published mainly in Russian, in different years and in various publications. Furthermore, they were produced in such small numbers of copies that they quickly became rarities. I have therefore taken upon myself the difficult task of summarizing and critically commenting on the earlier publications, because this is an opportune time to provide a summary of the data that have been obtained since 1900, i.e. since the time when the Berezovka mammoth was found and studied (Herz, 1902; Chapter 4).

POSTSCRIPT

Woolly mammoth carcasses continue to be found in Siberia, and continue to make the news. In late August 2012, near the Sopkarga polar station on the right bank of the Yenisei River, Taymyr Peninsula, an 11-year-old boy named Evgeniy Salinder found the remains of a mammoth.

It was a partial carcass of a subadult male with separated hind legs and lacking skin from the left part of the body. The abdominal cavity was full of sediments but no internal organs were present. The skull, with a right tusk and a facial skin mask, was attached to the body by a belt of skin. The excavation was carried out between September 24 and 29 by staff of the polar station under the supervision of Dr. Alexey N. Tikhonov from the Zoological Institute, Saint Petersburg. Different samples from the carcass, including sediments, fragments of tissues, and a piece of rib, were taken for radiocarbon dating. The remains of this mammoth, which has been named the Sopkarga mammoth (and nicknamed Zhenya), were delivered in a frozen state to the town of Dudinka, where they are now kept in an ice cellar. From information supplied by A. Tikhonov, the skeleton and samples of deposits will in due course be delivered to Saint Petersburg and Moscow.