The Late Pleistocene *beast solonetz* of Western Siberia: "mineral oases" in mammoth migration paths, foci of the Palaeolithic man's activity

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SUMMARY: The complex archachaeologo-palaeontologo-geological investigations allowed to reveal that the most considerable *in situ* sites of mammoth remains in northern Asia, namely of the Shestakovo and Volchya Griva sites had been the places we called the "*beast solonetz*" (localities where beasts had satisfied their mineral hunger). The mass accumulations of large mammals within the Late Pleistocene beast solonetz bear witness to the extreme palaeoecological conditions and allow considering the beast solonetz to be "mineral oases". The age profiles for the Shestakovo and Volchya Griva mammoths prove the fact that the mineral deficiency and metabolic diseases pri-marily stroke young animals, especially cubs and immature individuals. The late Pleistocene "oases" were confined to the sandy-argillaceous Cretaceous rocks, the deposits of glacier-dammed basins and spillways. The formation of the beast solonetz resulted from the favourable combination of geochemical Ca-Na-Mg landscapes and relief. A close relation was established between the beast solonetz sites, paths of mammoth migrating and travelling of Palaeolithic man groups.

1. Introduction

In Western Siberia two greatest *in situ* localities of the late Pleistocene mammalian remains in Northern Asia have been established: Shestakovo situated in the Kuznetsk Alatau submontane region and Volchya Griva – in the Barabinsk steppe (Fig. 1). Until the present time their genesis has remained uncertain. Hypotheses for the alluvial ac-cumulation, deaths of animals in drinking places and from natural catastrophes, as well as from hunting by the Pa-leolithic men, have not been supported. The peculiarity of both sites lies in the fact that more than 90% of the thou-sands of bones and teeth belong to *Mammuthus primigenius* Blum. In 1997, in studying the Shestakovo materials, the idea of the accumulation of remains within the "beast solonetz" was originally conceived (Leshchinskiy 1998). The "*beast solonetz*" is a term accepted in Russia for a ground surface site containing great amount of certain macro- and microelements. It denotes a zoogeological unit, in distinction to solonetz as a pedological nomination. Animals came to beast solonetz to eat soil and rock, to drink mineralized water from springs, in order to maintain the water-salt balance and make up a deficiency of minerals in their organism (Panichev 1990).

Thus, a new type of a mass burial of big mammaian remains has been reconstructed for Siberia and the whole Russia. The wide distribution of new types of localities has been well proved by the recent investigations in Vol-chya Griva, where the beast solonetz evolved from the soil solonetz (Leshchinskiy 2001).

2. *Beast Solonetz* as "Mineral oases"

The reasons for accumulation of large mammalian remains, predominantly of herbivores, within the beast so-lonetz lie in ecology, especially in the relations of animals with the abiotic environment. In the late Pleistocene the territory of Western Siberia represented the periglacial and extraglacial zones. Here, as the majority of investigators consider, the woodless spaces of tundra, forest-tundra, tundra-steppe

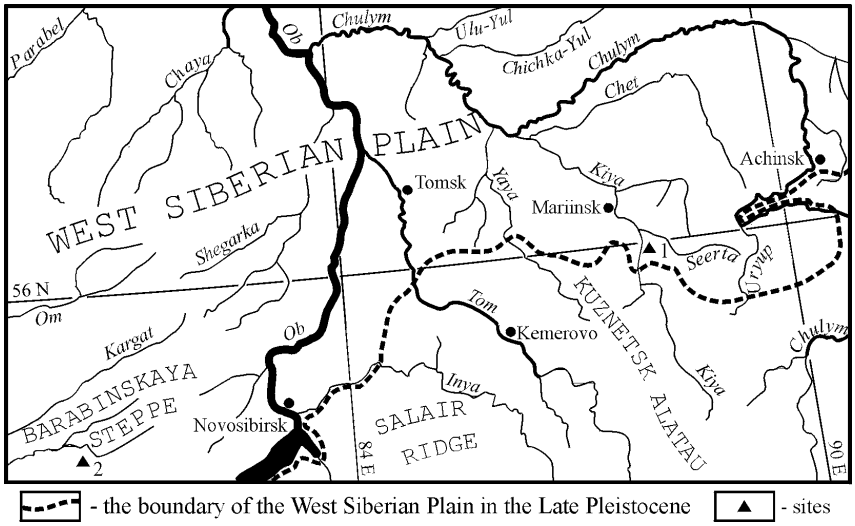

Fig.1 - Location of *beast solonetz* sites: 1 - Shestakovo, 2 - Volchya Griva.

and, less often, steppe were prevailing, complexed with the taiga districts along river valleys. The periodical wide macroclimatic fluctuations were characteristic of that time. The extreme environmental conditions were an additional peculiarity of nearly all periods. It has been established for the most part of the late Pleistocene that tundra- and steppe-land vegetation occurred, as well as the tundra-steppe fauna representatives (mammoth, woolly rhinoceros, bison, horse, saiga, polar fox, lemming and others); pseudomorphisms by desiccation fissures and cryoturbations, as well as aeolian and deluvial processes have been evidenced. Under such conditions, the geochemical landscapes of acid (H) and acid gley (H-Fe) classes most likely predominated. Besides, acid soils (podzolic, peaty-bog, sandy-loam, sandy) were widely distributed.

Nowadays, the soil types mentioned above are well developed through Western Siberia in the tundra zone, taiga-forest non-black earth areas, as well as in the arid steppe zone and, less commonly, in the forest-steppe one. In the modern view, here the large mammals are often affected by endemic diseases [fragility of bones, growth inhibition, the affection of skin, mucous coats, viscera; acobaltosis, anaemia, boric enteritis, endemic goiter, ataxia, Urov disease (Kashin-Beck disease – the endemic osteoarthrosis deformans), B_{12} hypo- and avitaminosis and other disorders]. The metabolic disorders are caused by the deficiency or excess of both macro- and microelements in the soil. In the taiga-forest zone this is, first of all, the deficiency of Ca, Mg, Na, Co (73% of cases), Cu (70%), I (80%), Mo (55%), B (50%), Zn (49%) and the excess of Sr (15%). The soils of the major steppe and forest-steppe pastures and grasslands within the West Siberia plain are now deficient in I (80%), Co (52%), Cu (40%), P and Mg at the back-ground of the excess of B (88%), Zn (76%), Sr (47%) and Mo. The salinized parts of the Kulunda steppe are par-ticularly poor in Cu and Co, 2 to12 times (> 90 %) below normal, with a consequent deficit of these elements in the vegetational fodder. This involves the severe decrease in their level in the animal organism and, as a consequence, metabolic disturbances. The maximum decrease of the Cu level in organism occurs in drought years when the levels of B and Mo in the forage are elevated, thus inhibiting the assimilation of the fodder Cu. The essential deficit in the main macronutrient elements (Ca, Mg, Na and others) affects the

water-and-electrolyte balance of organism at any stage of the individual development, resulting in the rapid cachexia and death. It has been proved experimentally that the micronutrient element deficit, mainly in Cu and Co, leads to the metabolic disturbances, firstly, in young ruminants (e.g., the loss of lambs makes 10 to 50 %). The disturbances manifest themselves as gastroenteritis (the symptoms are as follows: hypotension, diarrhea, dehydration, nutritional dystrophy, etc.) and bronchopneumonia (hypoxia, locomotor ataxia, limb paresis, wool falling, etc.). As a result, the respiratory organs, intestines, liver, heart, kidneys, brain, spinal cord are affected; the disease proceeds for 5-20 days, the death rate ranges from 70 to 75% of the number of the animals getting sick (Kovalskiy 1974, Leshchinskiy 2001).

All foregoing data are presented here to prove our hypothesis for the reasons of mass accumulation of remains in the sites studied. During the late Pleistocene the landscapes impoverished in Ca, Mg, Na, Co, Cu, Zn and other elements necessary for the normal regulation of metabolism in animals were widely distributed. There is no doubt that the herbivorous animals dwelling in such landscapes experienced mineral hunger. As compared with other large mammals, the mammoth had a greater demand for the mineral nutrition of full value. It was the most massive representative of the late Pleistocene land fauna in Northern Eurasia and possessed the greatest body and carcass. The mineral deficiency is closely connected with lithophagy, i.e. using rocks, minerals and mineral water for food. The herbivorous representatives of the mammoth fauna and, especially, mammoths were undoubtedly lithophagous. This is supported by the fact that rock and mineral debris have been always found in the digestive tract and excrements of fossil animals. Thus, in the Kirgilyakh 7-8-month mammoth-calf, the content of the mineral substance (a montmorillonite-hydromica) in the large intestine terminal and in the rectum makes up 90% of the whole content mass (Panichev 1990).

The unstable climate, seasonal feeding and other circumstances caused mammoths to migrate by large distances. In unfavourable geochemical conditions, the landscapes enriched with Ca, Mg, Na, Co and other elements played a crucial role in migrating. In specific conditions, "mineral oases", i.e. beast solonetz, were formed within such landscapes, where, besides the food enriched with macro- and micro-nutrients, the animals could eat rocks. During the periods of the utmost mineral deficit, dozens of mammoths and other herbivores were concentrating in the beast solonetz sites. The mortality of the animals and the conditions for the burial of the remains were sometimes adequate to form the bone-bearing layers.

The most widespread solonetz minerals, alongside zeolites and volcanic glass, are those of the montmorillonite group and opalites. Montmorillonite is the basic mineral substance of the montmorillonite and bentonite clays; its crystalline structure is characterised by the laminated arrangement of anions and cations (mainly, of calcium, magnesium and sodium). Each layered packing terminates in hydroxide ions capable of keeping the water molecules, thus defining the capabilities for the cation exchange and sorption. The herbivorous animals consume clay soils of such kind. This accounts for the fact that the beast solonetz sites were situated near outcrops of crusts of weathering (Panichev 1990). During the Pleistocene in the West Siberian plain, such geochemical landscapes of the Ca-Na-Mg-classes were probably formed near the outcrops of the Mesozoic aleuropelite rock mass, near the deposits of glacier-dammed basins and of runoff hollows.

As it was mentioned above, two Late Pleistocene "mineral oases" with vast mammal remains sites have been discovered, namely Shestakovo (Ca-Mg-Na-solonetz, > 125,000 m^2) and Volchya Griva (Ca-Na-solonetz, > 20,000 m^2). The Shestakovo bone-bearing layers have been dated (^{14}C) to the period from the end of the Kargin warming to the middle of the Sartan cooling (~ 26 to 18 thousand years ago) and in Volchya Griva they correspond to the second half of the Sartan (~ 15 to 10.5 thousand years ago).

2.1 Shestakovo "mineral oasis"

The Shestakovo remains site is located on the high right bank of the Kiya river, the left tributary of the Chulym river (Fig. 1), 500 m downstream from the village of Shestakovo (the Kemerovo region). The steep bank, which is being destroyed by lateral erosion, is composed of Lower Cretaceous coastal rocks (aleurolite, sand, sandstone, gritstone and clay) of the Ilek suite. Upwards, the Upper Pleistocene loess-like loam soils are deposited with disconformity. In the vicinity of the site, there are several tectonic disruptions; along one of them, a huge block ~ 25 km^2 in area has been broken off probably at the Middle/Late Pleistocene boundary. Its south-western portion is an isolated landslide ~0.5 km^2 in area. It is here that the bone-bearing and cultural layers of the Shestakovo site occurs. The sedimentogenesis, accumulation of fossil remains and artifacts were proceeding within the moisty hollow; its slopes were made up by ~ 30 m high outcrops. The hollow owes its formation to the strengthened washout of the Cretaceous rocks along the terrace joint of the landslide (Leshchinskiy 1998). The geochemical investigations of clays and sands of the Ilek suite rocks have demonstrated the high concentration of Ca, Mg, Na and other vitally important elements, this likely arising from the salinity of the Cretaceous basin. Calculations have disclosed that the macronutrient element content of the Lower Cretaceous rocks might have exceeded that of the Pleistocene soils: by Ca – 14, Mg – 4 and Na – 1.8 times. As regards the evaporate accumulation, the concentration might increase several times.

The unique combination of structure and topography have defined the existence of the beast Ca-Mg-Na-solonetz of the lythomorphic-hydromorphic type in the hollow for thousands of years. Thus, in the damper climate, there occurred a washing out of the native rocks and accumulation of deluvial deposits enriched in the scarce elements within the topographic depressions. With the climate aridization, the groundwater became primarily important in supplying the necessary elements (the super-aqueous landscape), and the permafrost was the major geochemical factor. Besides ice, the frozen rocks contained a negative-temperature water that in winter to autumn migrated to the land surface and in spring to summer backwards. The necessary elements were thereby transported from the bedrock to the active layer, and then with cryogenic mixing of the ground they arrived onto the land surface. It is precisely these sites at the bottom of the hollow that attracted the herbivores with their moisture and abundance of feeding stuff. Probably, in the same sites animals consumed the moistened argillaceous rock mass. It should be noted that beasts could consume the native rock at the hollow slopes too.

In Shestakovo the excavating works of 1975 to 1978 and 1992 to 1999 revealed more than 3000 remains belonging to 11 species of large mammals. The mammoths' bones and teeth (~18 individuals) made up no less than 90% of all palaeontological findings. Of special interest was the age profile of the mammoths decimated. Immature animals constituted a very significant rate (~ 44%), among them were: one new-born animal, three calves younger than 2 years, two individuals aged 2 to 6, one individual aged 6 to 14, besides a fragment of an embryo carcass was found. The good preservation of the bones of the immature species and the embryo suggests the presence of "mud baths" inherent in the hydromorphic solonetz soils (Leshchinskiy 1998, Derevianko *et al.* 2000).

2.2 Volchya Griva "mineral oasis"

Volchya Griva (Fig. 1) is a ridge situated in the Barabinsk steppe (near the village of Mamontovoye, Novosibirsk region). The remains site is located in the north-eastern part of the low ridge (10 m high) elongated eastward (8 km in length, up to 1 km in width). The extent of the burial is evidenced by > 5000 remains discovered, of which ~ 98 % are those of mammoths (~ 50 individuals) and the rest belong to horses (≥ 3), bisons (≥ 3) and a wolf (1). The prodigious material has been gathered just for 5 field seasons with the area excavated

averaging no more than 2.5% of the whole perspective space.

At present the Barabinsk plain is a part of the West Siberian province with the sodic salt accumulation. Here the calcic, calcium-sodium and sodium-hydroxylic geochemical landscapes are distributed, and the sodic and chloride-sulphate classes of water migration prevail. The mineralization of soda waters is maximum within the uppermost water-bearing layers confined to the Pleistocene formations, thus proving the active soda formation throughout the whole Quaternary (Shvartsev 1998). In the Late Pleistocene, salinization alternated repeatedly with desalinization during the process of the landscape development in this territory. The trend for the salinization was directly connected to the evaporative concentration of chemical elements migrating upwards from ground waters onto the land surface. Besides, it was possible that salts were delivered from the territory of Central Asia and Kazakhstan together with atmospheric precipitation and dust. In the desalinisation process, the main role was played by tectonic events and humidification of climate.

The geochemical characterisation of the Volchya Griva section points to the fact that the investigated site represented the soda-sulphate solonetz throughout the Sartan cooling. Besides, the pronounced zonality throughout the site section proves the desalinization of the landscape in several levels. Of interest were the results of analyzing coprolite from the bone-bearing layer. The Ca concentration of this fossil was high (80000 g/t), but Zn content was below normal (< 30 g/t). The anomalous content of the elements in the fossil droppings suggested the animal consumption of considerable quantity of clay masses, because in vertebrates Ca constantly participates in the "skeleton" metabolism and Zn prevents the mucosa and skin lesions and osteopathy (Leshchinskiy 2001).

The age profile in the mammoths of Volchya Griva was similar to that revealed in Shestakovo. This proved that the cubs and immature species had been more susceptible to the mineral deficit and the metabolism disturbances than the adult mammoths (The rate of cubs found in Volchya Griva ranged up to 26 % and that of immature animals was ~ 42 %). The same trend is traced in recent herbivorous animals: in the endemic regions the mortality of the young species amounts to as much as 50 %, but the number of ill mature animals approximates no more than 20 % of the live-stock capita of the distinct species population (Kovalskiy 1974). Consequently, at present the majority of the recent mature animals have adapted to the unfavourable conditions. As to the rate of morbidity in the late Pleistocene, it has been much more considerable, judging from the fact that the mass burials of the Volchya Griva or Shestakovo type have no analogues in the modern landscapes of Northern Asia.

3. *Beast Solonetz* Areas as the Foci of the Paleolithic man's activity

Basing on the factual evidence of the Paleolithic encampment in the investigated territory, as well as on the paleogeographic setting in the late Pleistocene, we can state that the early man was in the closest relation to large animals such as mammoth, bison, horse and so on. The repeated findings of bones and teeth of herbivorous mammals at the encampments bear witness of the animals' dominant role in the ancient man's life. The severe conditions of life above all forced the man to be a meat-eater. The meagre plant food couldn't constantly compensate for the energy loss in the extreme conditions of the vital activity. The numerous sites of large mammals remains prove the availability of meat. Analysing the specific composition of the fossil megafauna, one can believe that horse and bison, as well as, to a lesser extent, mammoth, woolly rhinoceros, reindeer, elk and others served as the main meat source. Along with the meat, the man used the animal remains (bones, tusks, teeth, horns, skins, wool, fat, etc.) as fuel and raw material for producing tools, articles of everyday life and art. It has been discovered that not only animals hunted down were utilised, but also corpses found and carcass remains.

There is no doubt that the Late Pleistocene

beast solonetz has been the foci of the early man's activity, as evidenced by the one-act mass accumulations of large mammalian remains. Firstly, cubs, weakened and ill species formed the most part of the animals coming to the beast solonetz, and hunting for them didn't involve making efforts. Secondly, in the beast solonetz there was always offal (animals died from diseases, old age, accidents or attacks of predators), which also attracted the man. Besides, the man was omnivorous and, consequently, like herbivores, he could also suffer from the mineral deficit and be lithophagous.

The activities of the man in the beast solonetz are evidenced by the cultural layers of the Paleolithic encampments superpositioned over the bone-bearing layers at the sites of Volchya Griva and Shestakovo. For example, within the Pleistocene strata at Shestakovo there are 6 cultural layers from which more than 1500 artifacts have been excavated (Derevianko *et al.* 2000). Of particular value for the man were probably the mammoth tusks: in excavating at Shestakovo, the handicrafts with notches, split-outs and tools made of tusks were found.

4. Conclusion

The Pleistocene/Holocene boundary has presented an impenetrable barrier in the evolution of numerous mammalian species of North Asia including *Mammuthus primigenius* Blum. The cardinal change of geochemical landscapes might have led to the disturbance in the ecological connections of biogeocenoses, and this, in its turn, has played the crucial role in the extinction of megafauna. However, the Sartan "mineral oases" established in the south of Western Siberia suggest the occurrence of refugiums in which mammoths might survive during the Holocene. The Paleolithic man has successfully overcome the fatal barrier, for the most part owing to the fact that he was an omnivore. And the changes in the environmental conditions might have been the most important factor of his cultural evolution. It is evident that the close studies on paleofaunal and paleolithic sites, especially in terms of paleoecology, must be of prior importance in studying the Quarternary.

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