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# A NEW FIND OF MAMMOTH TUSK IN LOESS-LIKE SEDIMENTS OF THE ZAKLICZYN BASIN (OUTER WESTERN CARPATHIANS, POLAND)

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**Abstract:** In June 2007, in a valley side of a small stream close to Janowice in the Western Outer Carpathians of Poland, a 1.8 m long mammoth tusk was found within loamy-debris solifluction sediments, *ca.* 1 m thick. These discordantly overlie a 4-m-high strath built up of steeply dipping sandstones of the Krosno beds of the Skole Nappe, being in turn covered by 7.5-m-thick loessial silts and loess-like slopewash sediments. The latter are overlain at the top by another solifluction cover, *ca.* 1.5 m thick. The mammoth tusk belonged to an adult animal, probably 30–60 years old. The succession of malacofaunistic assemblages within loess-like sediments indicates a cold, polar climate, and an environment resembling tundra developed upon moderately moist substratum during the last glacial stage. The lower part of malacological sequence enriched in mesophile species probably refers to the Vistulian (Weichselian) interpleniglacial period. The middle part, indicative of more dry habitats, can be associated with the younger Pleniglacial, whereas the top part should represent the terminal phase of the latter. Sediments bearing the mammoth tusk were probably deposited at the turn of the Vistulian older Pleniglacial and Interpleniglacial time.

**Key words:** loesses, mammoth remains, malacofauna, Upper Pleistocene, Polish Outer Carpathians.

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## INTRODUCTION

In June 2007, in a valley side of a small stream, a right-hand tributary of Lubinka brook flowing into the Dunajec River at Janowice, north of Zakliczyn (medial segment of the Western Outer Carpathian Foothills), a 1.8 m long mammoth tusk was found within loamy-debris solifluction sediments. The section was spotted first by a group of geologists of the GEOKRAK private geological enterprise in Kraków, and M. Cieszkowski and A. Ślączka, and later explored by this group accompanied by W. P. Alexandrowicz, P. Wojtal, J. Zasadni and W. Zuchiewicz. Detailed studies, in turn, were conducted by authors of this paper.

The area is situated in the eastern portion of the Zakliczyn Basin, belonging to the Rożnów Foothills (Starkel, 1972) (Fig. 1). The landscape is a typical foothills one, with relatively small relief, convex-concave slopes and broad, rounded interfluves. Fluvial terraces, predominantly Holocene in age, occupy a relatively wide valley bottom of the Dunajec River (Fig. 2). Detailed description of geomorphic features of the western portion of the Zakliczyn Basin is comprised in a paper by Krysowska-Iwaszkiewicz and Zuchiewicz (1992). In 1991, in an area of Dąbrówka Szczepanowska situated a few kilometres north of Zakliczyn, indeterminable bones of mammoth and – possibly – rhinoceros – were found within the medial-top part of a Vistulian (Weichselian) alluvial fan (Klimek, 1991).

Geologically, the region represents a fragment of the Skole Nappe of the Carpathian fold-and-thrust belt in Poland, predominantly composed of moderately to poorly resistant sandstone and shale-sandstone turbidite complexes. Janowice village is situated between Tarnów and Zakliczyn. Westward of this area, the Skole Nappe is narrowing and disappears from the surface (Wdowiarz, 1951; Koszarski &

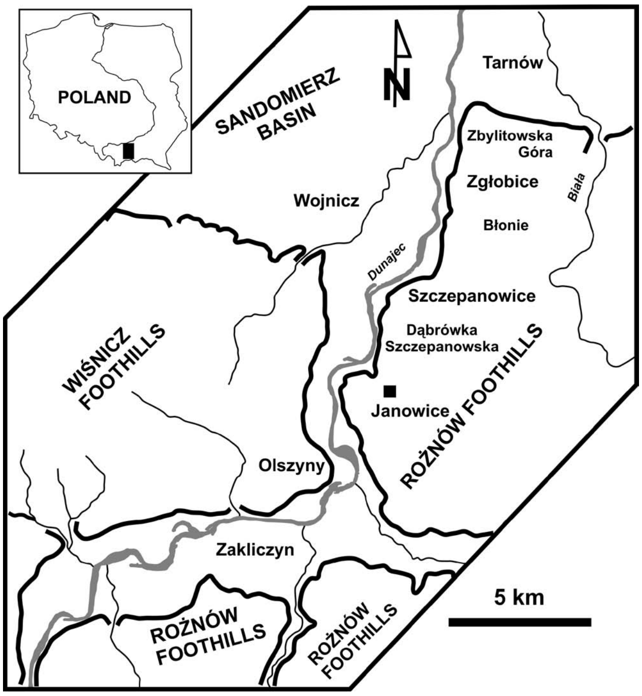


**Fig. 1.** Location sketch of the studied site

Kuciński, 1966). This portion of the Skole Nappe (Książkiewicz, 1977) includes an anticlinorial zone in the north, which is built of the Lower and Upper Cretaceous deposits, and a synclinorial zone in the south, in which Palaeogene deposits are dominated by the Oligocene Menilite and Krosno beds. The investigated site is located in the synclinorial zone, and the sediments bearing the mammoth tusk unconformably overlie the eroded Krosno beds. Only a narrow fragment of the synclinorial zone is exposed on the surface between Tarnów and Zakliczyn, because this portion of the nappe is thrust over by the Silesian Nappe (Wdowiarz, 1951; Koszarski & Kuciński, 1966). South of Janowice, the frontal part of the Silesian Nappe is mainly built of Lower Cretaceous strata.

## SITE DESCRIPTION

The mammoth tusk-bearing solifluction loams discordantly overlie a 4-m-high strath built up of steeply dipping sandstones of the Oligocene Krosno beds. These sandstones include clasts of brown shales derived from the Menilite beds and occasional clasts of the Globigerina marls. The strath is covered with a relatively thin veneer of very poorly rounded and extremely poorly sorted gravels of the small

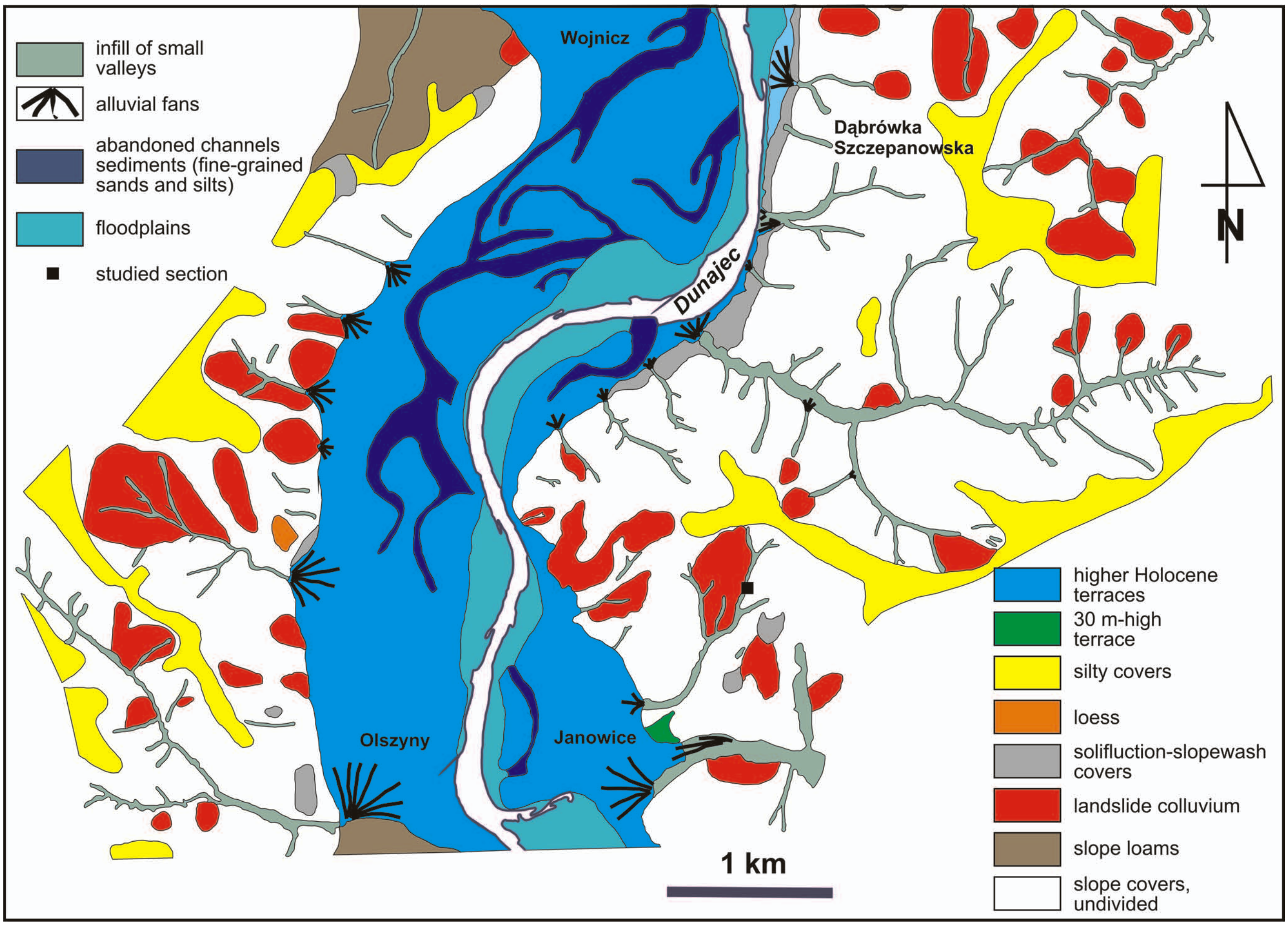


**Fig. 2.** Sketch-map of Quaternary sediments near the Janowice site

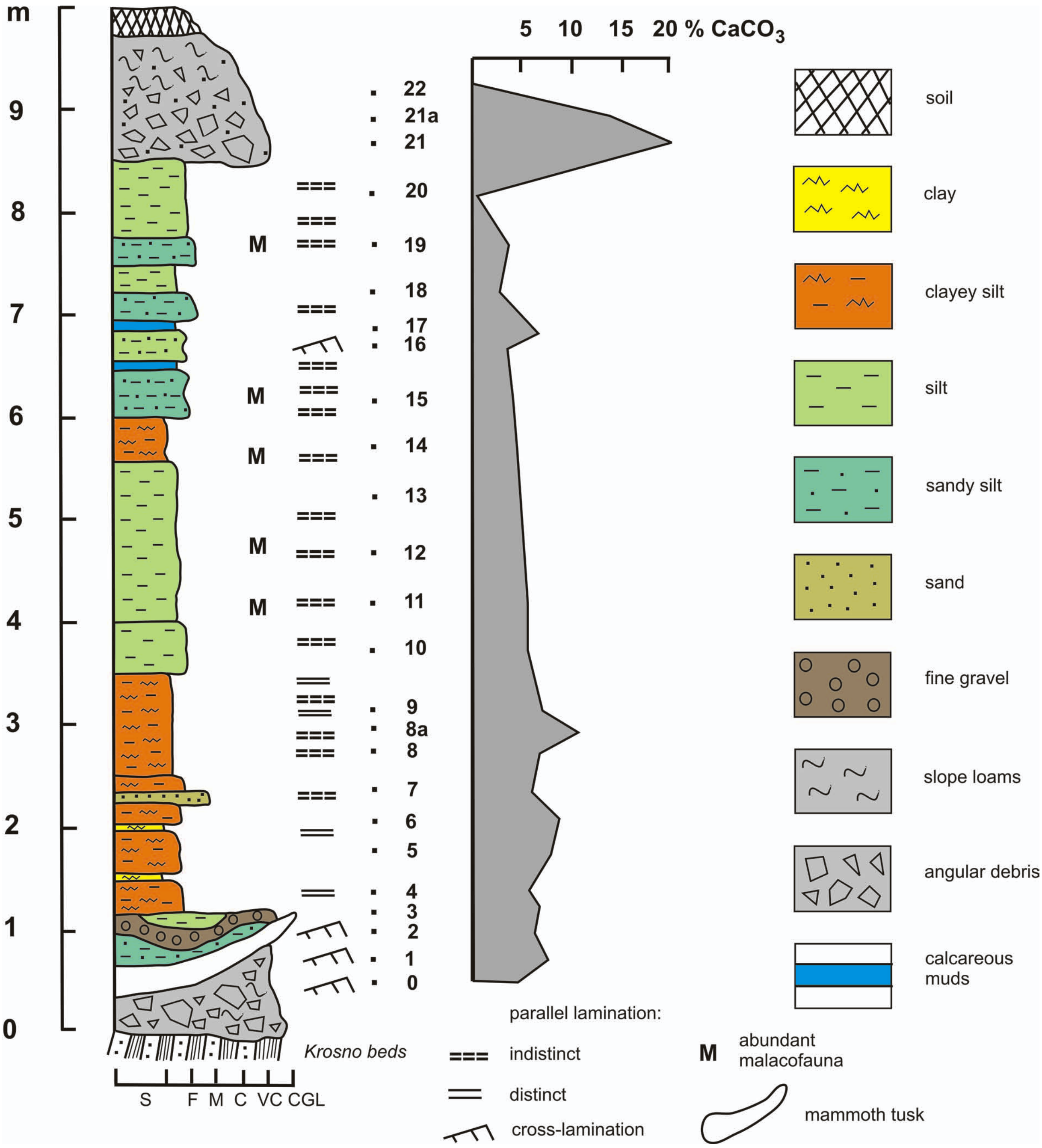


**Fig. 3.** Log of Janowice site showing position of samples, for which grain-size composition and $CaCO_3$ content were examined

stream, upon which a solifluction cover composed of brown and brownish loams with angular debris occurs (Figs 3, 4). This cover is overlain, in turn, by 7.5-m-thick loessial silts and loess-like slopewash sediments, composed of alternating coarse- to medium-grained silts, sandy silts and clayey silts, showing indistinct and – rarely – more distinct lamination parallel to the palaeoslope. The latter sediments are capped at the top by another solifluction cover, *ca*. 1.5 m thick, the lower (*ca*. 1 m thick) part of which is composed of angular debris (5 to 15–20 cm in diameter), the upper part being built of brown loams bearing infrequent angular clasts, 2 to 5 cm in diameter. Both the gravels and the solifluction cover contain local flysch material consisting of pieces of the Krosno sandstones, Menilite shales, and occasional cherts. The entire sequence is covered by recent soil. In the interval occurring 6.5 to 6.9 m above the strath, two laminae composed of whitish carbonate silts occur. Silty sediments exposed between 2.7 m and 8.5 m above the strath comprise numerous mollusc shells (Fig. 3). The calcium carbonate content in the entire section usually changes between 4.2 and 7 %, increasing to 10% close to the above-mentioned carbonate laminae, and 14–20% in the upper solifluction cover (Fig. 3).

As far as grain-size analyses are concerned, the graphic mean diameter Mz in the middle and upper parts of the section is between 5 and 6 (6.5) phi, in the lower part changing between 2 and 6.5 phi (Fig. 5). The graphic standard deviation is usually poor, and in the upper part very poor.


**Fig. 4.** Section at Janowice: **A** – overall view, **B** – position of mammoth tusk within solifluction cover before exploitation, **C** – mammoth tusk after excavation

Graphic skewness values fall in the interval of 0.5–1, showing higher differentiation in the basal and top parts of the section, whereas those of kurtosis are more or less uniform, except the basal part (Fig. 5). Grain-size frequency curves (Fig. 6) are unimodal for the gross part of the section, being dominated by coarse- to medium-grained silts, while the bottom and – particularly – upper solifluction covers show a strongly polymodal pattern. Diagrams SK-1 *vs.* sigma-1 and

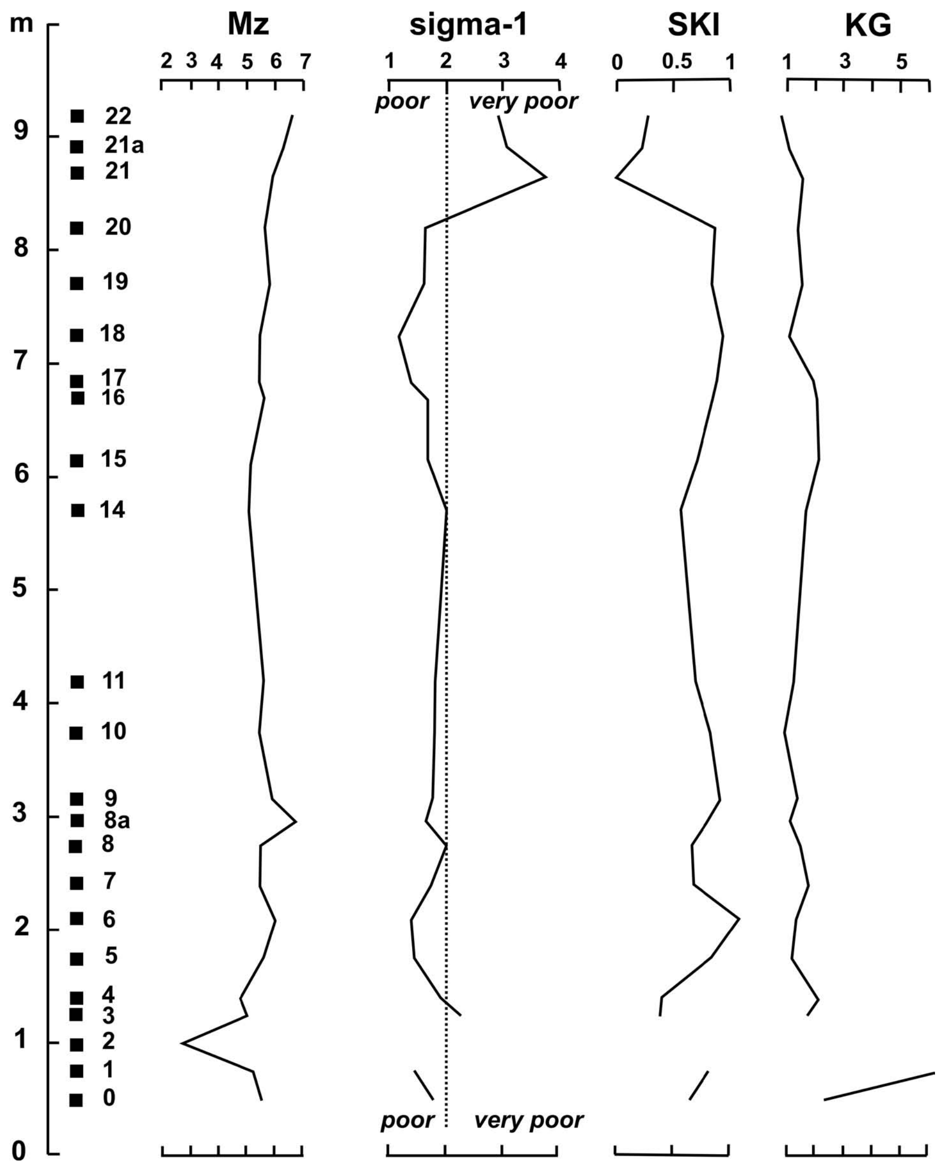


**Fig. 5.** Grain-size characteristics of the Janowice section, showing differentiation of basic Fold and Ward's (1957) parameters: Mz – graphic mean diameter (phi), sigma-1 – graphic standard deviation, SKI – graphic skewness, KG – graphic kurtosis

Mz *vs.* sigma-1 show quasi-linear relationships, except for samples derived from the upper solifluction cover, which clearly stand out of the remaining ones (Fig. 7a,b). The pattern shown in Fig. 7b is typical for aeolian sediments (*cf.* Mycielska-Dowgiałło, 1995), again except samples representing the upper solifluction cover. The Passega's (1964) diagram (Fig. 7c) displays differentiated values of C (first percentile of the cumulative grain-size curve scaled in phi units) at moderately scattered values of graphic mean diameter. Samples derived from the upper solifluction cover do not match the remaining set of data.

## MAMMOTH REMAINS

Mammoth bones were frequently being found in Late Pleistocene sediments of Central and South Poland (Kubiak, 1965; Wojtal, unpublished data). They are usually collected accidentally during exploitation of gravel pits. Remains of these animals are presented, sometimes in large number, also at archaeological open-air sites: Kraków Spadzista Street (B) or Kraków Nowa Huta (Wojtal, 2007). In caves of the Kraków-Częstochowa Upland, only isolated mammoths bones or teeth were collected (Wojtal, 2007). It should be mentioned that remains of woolly mammoth were noted from the Polish segment of the Carpathians in the Pieniny and Tatra Mountains (Kulczycki & Halicki, 1950; Kubiak, 1965), as well as in the Outer Carpathians (Kubiak, 1980; Kubiak *et al.*, 1989). In Obłazowa cave, Pieniny Mts., one of the most famous Palaeolithic site in Europe, apart from a "boomerang" made from mammoth tusk, also other remains of this animal were discovered (Valde-Nowak *et al.*, 1987, 2003).

Mammoth tusks are one of the most characteristic features of this animal. They grew spirally: in some cases quite tightly, in others very openly. The left and right tusks are twisted in opposite directions and occasionally form almost complete circle (Haynes, 1991; Lister & Bahn, 1994). More typical mammoth male tusks measure 2.4–2.7 m and weight about 45 kg. Typical female tusks are about 1.5 – 1.8 m long and weight only 9–11 kg (Lister & Bahn, 1994).

The state of preservation of the found tusk is quite good. Unfortunately, it is preserved as a fragment of only about 180 cm in length when measured along the greatest curve of the tusk. Two parts are missed: that which was attached to the socket in the skull, and the tip of the tusk. The girth of the preserved part is 52 cm and the greatest diameter is 16 cm. It is possible to determine individual age of elephant on the basis of girth and diameter of the tusk (Haynes, 1991; Vereščagin & Tikhonov, 1986). The measurements should be made at the lip line or the alveolar insertion. Unfortunately, the tusk from Zakliczyn has a damaged proximal part. However, on the basis of girth and diameter it could be stated that this tusk certainly belonged to an adult animal, probably between 30 to 60 years old. The tusk's diameter indicates that it belonged to a male.

## MALACOLOGICAL COMPOSITION

The section exposed at Janowice includes fluvial, slope and loess-like deposits, *ca*. 10 m thick, in the lower part of which a mammoth tusk was found. Silty sediments comprised in an interval between 2.7 and 8.5 m above the strath comprise numerous mollusc shells (Fig. 8). From this portion of the section 13 samples were collected, all of them situated above the mammoth tusk (Fig. 8 S). The samples were washed before picking up both completely preserved and fragmentary, but identifiable, shells. Such a material was analysed using standard malacological techniques (*cf.* Ložek, 1964; Alexandrowicz, 1987). Altogether, 1543 specimens belonging to 12 taxa were identified (Table 1). The number of taxa in individual samples varied between 4 and 10 (Table 1, Fig. 8 N). The greatest differentiation in species composition was noted in the interval 3.5–5.5 m (samples Zl-3 – Zl-7), whereas the lowest and upper portions of the section (samples Zl-1, Zl-2 and Zl-8 – Zl-13) were clearly less differentiated. The number of specimens in a sample varied between 4 and 460, attaining the highest figures in samples Zl-3 – Zl-7 (Fig. 8 N).

Species belonging to four ecological groups were identified.

Species of open habitats (group O) include four taxa: *Pupilla muscorum* (L.), *Pupilla muscorum loessica* (Ložek), *Pupilla muscorum densegyrata* (Ložek), and *Vallonia tenuilabris* (Braun). Three above-mentioned forms of the *Pupilla* genus used to be considered separate species for a long time. The first one lives now in Poland and is also fre-

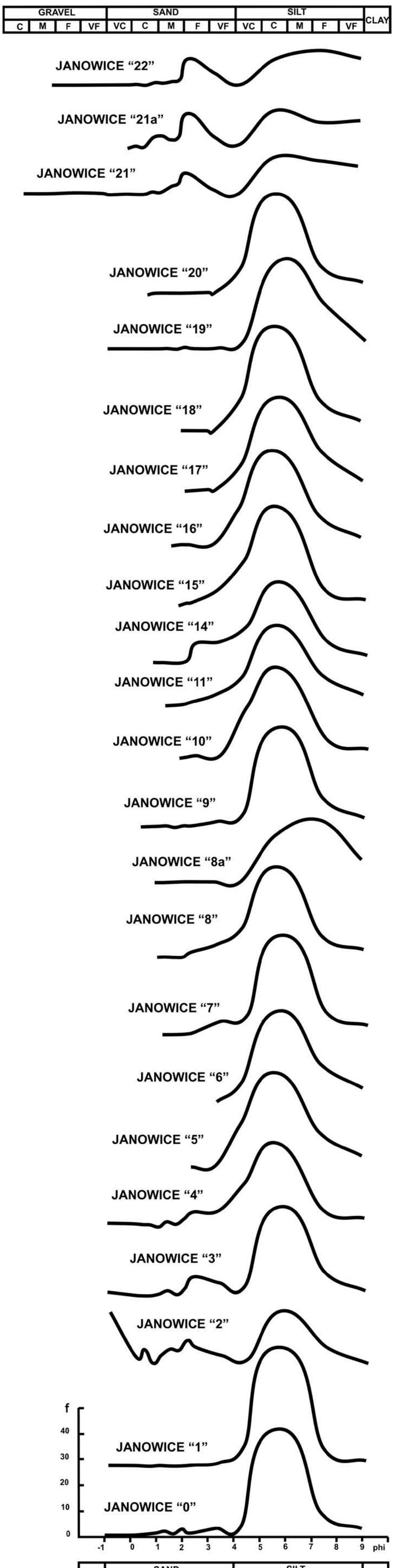


**Fig. 6.** Grain-size frequency curves for individual samples collected from the Janowice site. For sample location – see Figs. 3 and 5

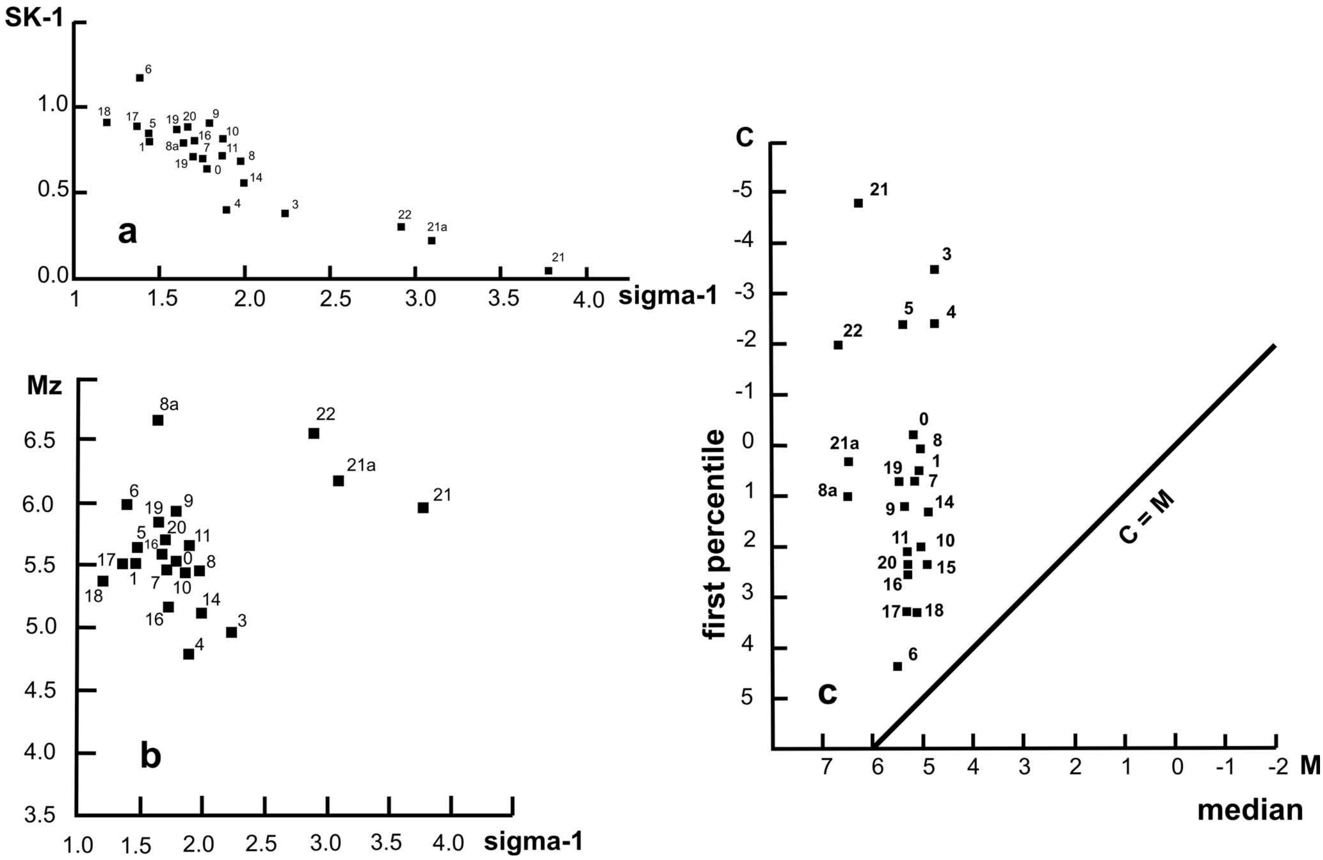


**Fig. 7.** Relations between grain-size parameters in the Janowice section: **a** – graphic skewness *vs.* graphic standard deviation, **b** – graphic mean diameter *vs.* graphic standard deviation, **c** – Passega's (1964) diagram (C – first percentile, M – median)

**Table 1**

Composition of malacofauna assemblages from site Janowice

| EG | Smple / Taxon | Zl-1 | Zl-2 | Zl-3 | Zl-4 | Zl-5 | Zl-6 | Zl-7 | Zl-8 | Zl-9 | Zl-10 | Zl-11 | Zl-12 | Zl-13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| O | *Pupilla muscorum* | | 5 | 19 | 10 | 20 | 32 | 32 | 7 | 2 | 9 | 6 | 2 | 17 |
| O | *Pupilla muscorum densegyrata* | | | 8 | 12 | 35 | 48 | 20 | 8 | 1 | 2 | | | |
| O | *Pupilla muscorum loessica* | | | | 16 | 73 | 95 | 41 | 16 | 3 | | | | |
| O | *Vallonia tenuilabris* | 1 | | 12 | 3 | 21 | 19 | 5 | | | 1 | 1 | 1 | 2 |
| M | *Columella columella* | 2 | | 8 | | 6 | 10 | 2 | 2 | | | | | 3 |
| M | Limacidae (small) | | | | 1 | | 2 | 1 | | | | | 1 | 2 |
| M | *Clausilia dubia* | | | 10 | | 10 | | 1 | | 1 | | | 3 | 4 |
| M | *Trichia hispida* | | 12 | 17 | 30 | 122 | 75 | 39 | 13 | 2 | 8 | 4 | 1 | 2 |
| M | *Succinea oblonga* | 2 | 21 | 41 | 22 | 161 | 96 | 71 | 7 | 2 | 16 | 1 | 3 | 13 |
| H | *Vertigo genesii* | | | | | | | | | | | | | 7 |
| H | *Vertigo parcedentata* | | | | | | 1 | | | | | | 1 | |
| W | *Lymnaea truncatula* | 1 | 8 | 10 | 7 | 12 | 21 | 4 | | | | | | 5 |
| Σ – T | | 4 | 4 | 8 | 8 | 9 | 10 | 10 | 6 | 6 | 5 | 4 | 7 | 9 |
| Σ – S | | 6 | 46 | 125 | 111 | 460 | 399 | 216 | 53 | 11 | 36 | 12 | 11 | 56 |

EG – ecological groups (see Fig. 8 for explanation), Σ – T – number of taxa, Σ – S – number of specimens

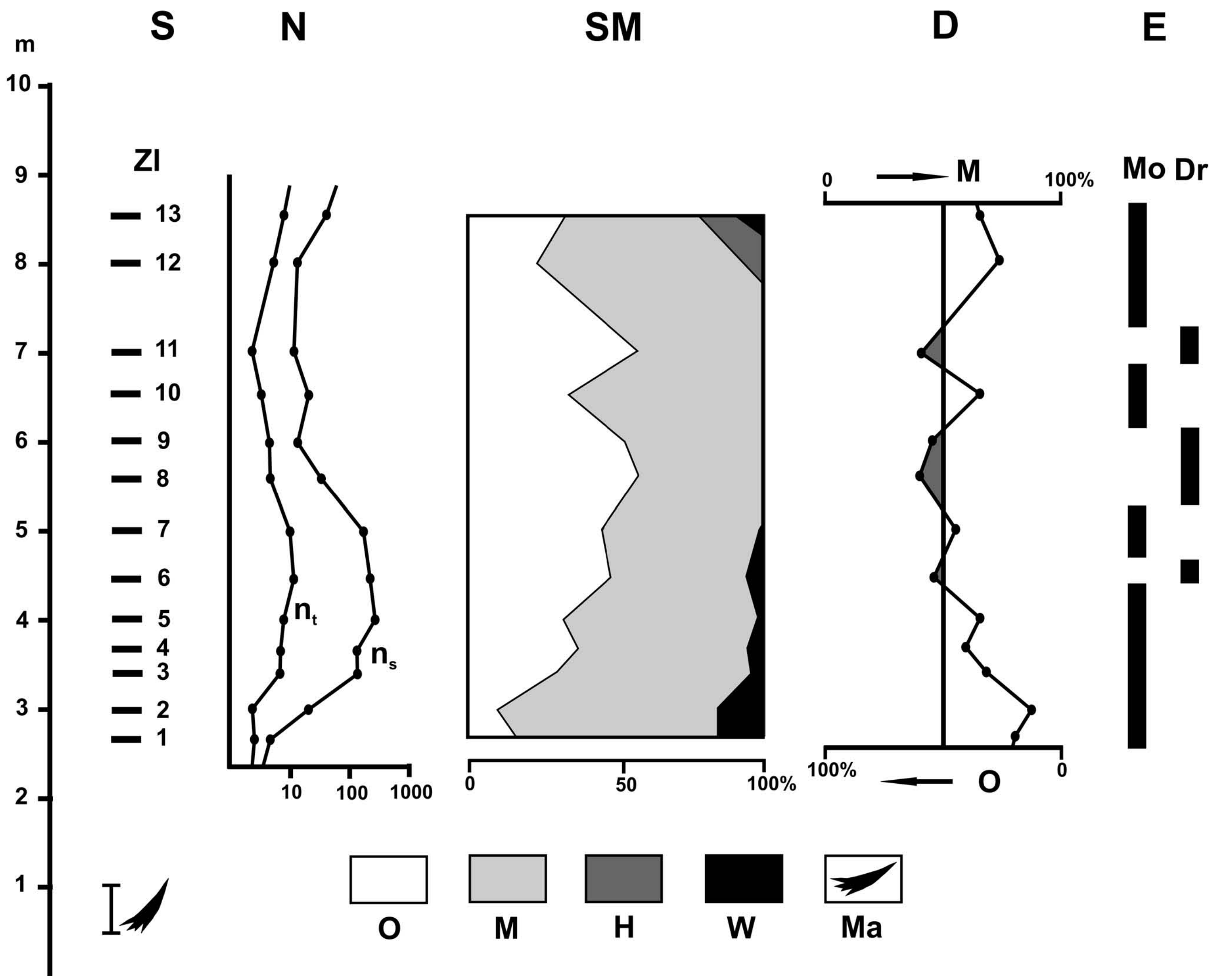


**Fig. 8.** Malacofauna in silty sediments exposed at Janowice. Ecological groups (Ložek, 1964; Alexandrowicz, 1987): O – species of open habitats, M – mesophile species, H – hygrophile species, W – water species; Ma – location of mammoth tusk; S – sampling levels, Zl – sample numbers, N – number of taxa ($n_t$) and specimens ($n_s$), SM – malacological spectrum of individuals (Ložek, 1964; Alexandrowicz, 1987), D – two-component diagram, E – ecological characteristics; Mo – moist habitats, Dr – dry habitats

quently being found in Quaternary sediments. The remaining two became extinct at the end of the Pleistocene. Results of biometric studies (Łopuszyńska, 2002) indicate, however, that these taxa cannot be treated as separate species. Instead, they appear to represent ecoforms, and conchiological differences result from environmental characteristics, mainly climatic conditions. *Vallonia tenuilabris* (Braun) disappeared from Poland at the end of the Pleistocene, but recent populations of this species are known from Siberia. The above taxa are typical for completely open and relatively dry habitats. They are typified by high tolerance to low temperatures and commonly occur in sediments associated with cold climatic phases of the Pleistocene (Alexandrowicz, 1985, 1995) (Table 1).

Mesophile species (group M) include: *Columella Columella* (Mart.), *Clausilia dubia* Drap., *Trichia hispida* (L.) and *Succinea oblonga* Drap. All these forms are known both from recent fauna and numerous sites of Pleistocene and Holocene strata. This group includes as well calcareous plates of slugs *Limacidae*. The above taxa also show high tolerance to low temperatures and tend to settle in slightly shaded and relatively humid habitats. They represent a typical component of assemblages occurring in loess (Alexandrowicz, 1985, 1995) (Table 1).

Snails typical for humid habitats (ecological group H) are represented by two species: *Vertigo genesii* (Gredl.) and *Vertigo parcedentata* (Braun). Both forms typify moist habitats developing in cold climate, particularly in tundra zones. They are extremely rare in the analysed material (single specimens in few samples) (Table 1).

Water species (ecological group W) are represented by *Galba truncatula* (Müll.) only. This snail settles in temporary water reservoirs and shows high thermal tolerance. It occurs mainly in the lowermost part of the analysed section (Table 1).

Ecological characteristics of the molluscan assemblage from Janowice was based on the malacological spectrum of individuals (MSI) and the two-component diagram (Fig. 8

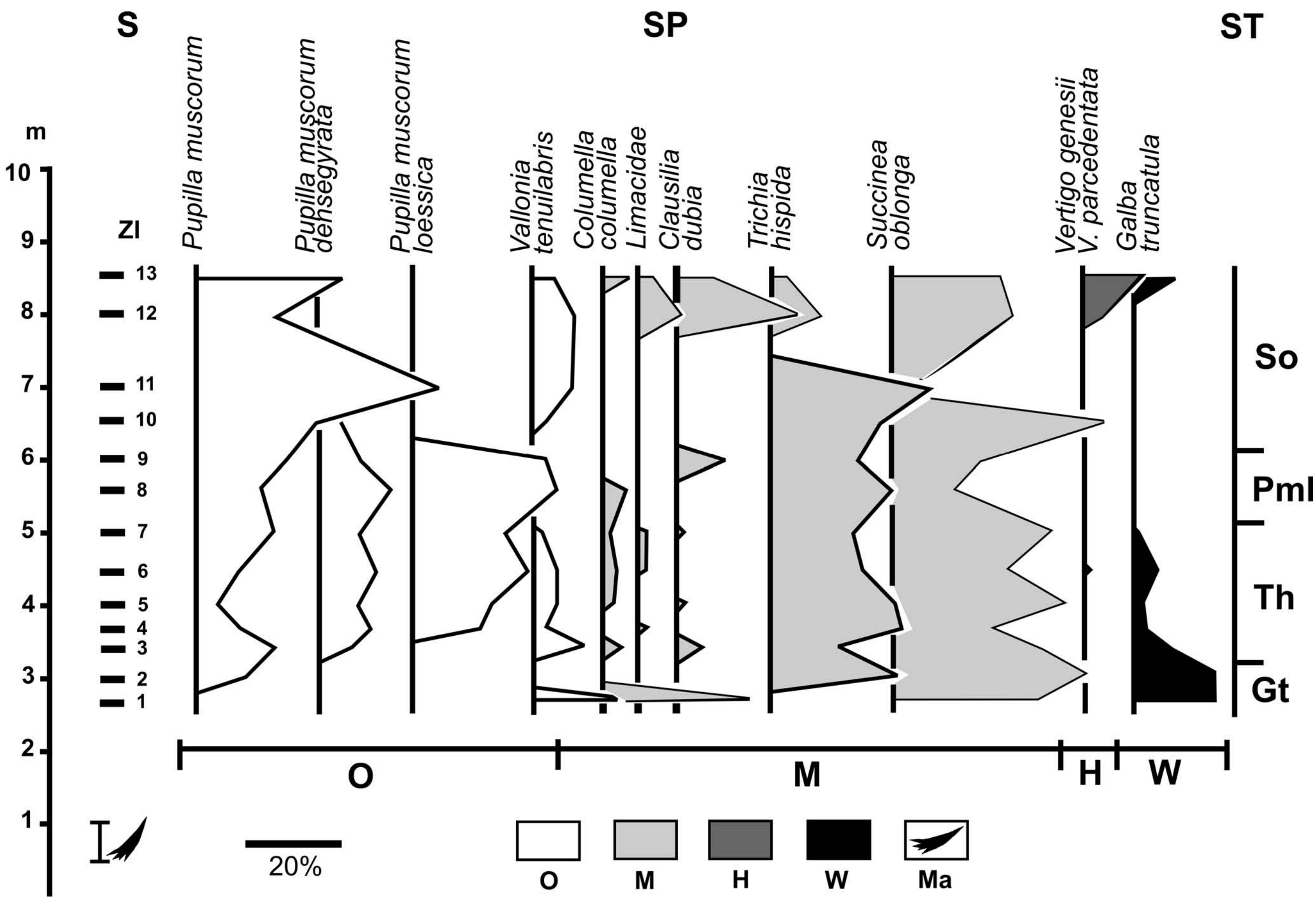


**Fig. 9.** Molluscan fauna from site Janowice: SP – frequency of species, ST – succession of assemblages: Gt – *Galba truncatula*, Th – *Trichia hispida*, Pml – *Pupilla muscorum loessica*, So – *Succinea oblonga*. For other explanation see Fig. 1

SM, D). The entire shell material is dominated by snails of open habitats and mesophile species. The former are most numerous in the middle part of the sequence, their share exceeding 50%. The basal and top intervals, in turn, are characterized by mesophile forms. Water species occur mainly in the lowermost part of the sequence, amounting up to 10% of the assemblage (Fig. 8 SM, D). The section described can be subdivided into three intervals showing different humidity of habitats (Fig. 8 E). The basal and top portions are characterized by domination of more humid habitats, wherein malacofauna is less differentiated and dominated by mesophile species. The middle part of the sequence is typified by higher amount of species preferring dry and open habitats. The molluscan assemblage of this interval is most differentiated (Fig. 8 E).

Three of the twelve species identified in the Janowice section (*Pupilla muscorum* (L.), *Trichia hispida* (L.) and *Succinea oblonga* Drap.) occur in the entire sequence and are usually represented by numerous specimens. Besides these, three other forms are important for interpretation: *Pupilla muscorum loessica* (Ložek), *Pupilla muscorum densegyrata* (Ložek) and *Galba truncatula* (Müll.). These are fairly numerous, but occur only in certain segments of the section. The remaining six taxa are subordinate or accessory.

Four types of fauna can be distinguished in the analysed malacological sequence (Fig. 9):

– assemblage with *Galba truncatula* (Gt) (samples Zl-1 and Zl-2). This fauna typifies open and relatively humid habitats. The occurrence of *Galba truncatula* (Müll.) points to the presence of periodical water reservoirs. High humidity of habitats is also pointed out by the presence of *Columella columella*, and small share of species preferring dry habitats (ecological group O);

– assemblage with *Trichia hispida* (Th) (samples Zl-3 – Zl-7). This malacocoenosis is characterized by domination of mesophile species: *Trichia hispida* (L.) and *Succinea oblonga* Drap., and is typical for moderately humid environments. Proceeding up the section, one can observe increasing drying up of habitats, indicated by increasing share of snails belonging to the genus *Pupilla*, particularly *Pupilla muscorum loessica* (Ložek);

– assemblage with *Pupilla muscorum loessica* (Pml) (samples Zl-8 and Zl-9). It is characterized by a large amount of species of dry and open habitats, particularly the nominal taxon. This malacocoenosis represents a phase of marked drying up of habitats;

– assemblage with *Succinea oblonga* (So) (samples Zl-10 – Zl-13). It is a poor and poorly differentiated association, bearing a high amount of the nominal taxon. More-over, the frequency of species of open habitats clearly diminishes, pointing to increasing humidity.

Malacofauna of the Janowice section includes only species of high thermal tolerance and commonly noted from other sections of loess and loess-like sediments (Alexandrowicz, 1985, 1988, 1995). The succession of faunal assemblages makes it possible to reconstruct environmental changes during sediment deposition. Malacofauna points to a cold, polar climate and tundra environment of moderate humidity of the substratum. The presence of fairly numerous specimens of *Galba truncatula* (Müll.) in the basal interval indicates the presence of periodical water reservoirs. Proceeding up the section, gradual drying up of habitats can be seen, indicated by increasing amount of preferring dry conditions representatives of the genus *Pupilla*, particularly *Pupilla muscorum loessica* (Ložek) and *Pupilla muscorum densegyrata* (Ložek). Another episode of increasing humidity reappears in the top part of the sequence.

The above presented faunal composition and succession of molluscan assemblages are very much alike malacological sequences described from several other sites of silty sediments of the Outer Carpathians (Alexandrowicz, 1988), particularly those from the Rożnów Foothills (Alexandrowicz & Zuchiewicz, 1988, 1990, 1993; Alexandrowicz *et al.*, 1991). The observed minor differences in the composition and structure of molluscan assemblages result from local differentiation of habitats.

## CONCLUSIONS

We conclude that malacofauna-bearing silty sediments at Janowice were formed during the last glacial stage. The lower part of malacological sequence, enriched in mesophile species, probably refers to the Vistulian (Weichselian) Interpleniglacial period. The middle part, in turn, indicative of more dry habitats, can be associated with the younger Pleniglacial, whereas the top part should represent the terminal phase of the latter. Hence, solifluction sediments bearing the mammoth tusk are most probably associated with the turn of the Vistulian (Weichselian) older Pleniglacial and Interpleniglacial time. The discovered mammoth remains, a typical animal of the Pleistocene steppe-tundra, confirm the results of malacological studies. The girth and diameter of the tusk are large, suggesting that this tusk belonged to an adult animal, probably a male of woolly mammoth.

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