Age of some European localities with elephant remains determined by the biometric method

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SUMMARY: Using the biometric dating of lamellar frequency in the last upper molars of the *Archidiskodon-Mammuthus* elephant lineage, the age of the Liventsovka, Sinyaya Balka, Tiraspol' (Russia), Süssenborn, Mosbach (Germany), Ilford, Balderton (Great Britain), Dolni Vestonice, and Předmosti (Czech Republic) localities is determined.

1. Introduction

This work was aimed at absolute age determination by the biometric method using teeth of elephants of the *Archidiskodon-Mammuthus* phyletic lineage from a series of European localities. As indicated earlier (Pevzner & Vangengeim 1994), the lamellar fre-quency in the 10-cm-long interval of the last upper molar is one of the evolutionarily important characteristics of elephants from this lineage. The time-depen-dent changes in this parameter develop according to the areacotangent law, permitting absolute age determina-tion of bone remains and, consequently, of their host localities.

2. Materials and Methods

Since the lamellar frequency is a highly variable parameter (depends on the size and the wearing degree of molars) leading to an erroneous age determination, we consider only localities that yielded tooth series consisting of at least ten teeth (see the table 1). These localities are associated with different genetic types of deposits. The Liventsovka (Rostov region, Russia), Tiraspol' (Moldova), Süssenborn, Mosbach (Germany), Ilford and Balderton (Great Britain) local-ities occur in alluvial sediments; the upper Paleolithic Dolni Vestonice and Předmosti (Czech Republic) sites are in the sedimentary cover deposits; and the Sinyaya Balka locality (Krasnodar region, Tamanskii Peninsula, Russia) is buried in mudflow sediments.

Liventsovka locality: We used the measurement results for 30 teeth of *Archidiskodon gromovi*.

Sinyaya Balka locality: The lamellar frequency values of *Archidiskodon meridionalis tamanensis* are calculated using the plot by Dubrovo (1963, Fig. 1).

Tiraspol' and Süssenborn localities: Dubrovo (1971) reported only on the extreme and mean lamellar frequency values for *M. trogontherii*, missing data necessary for calculating the mean square deviation (δ) and mean square error (*m*). For these localities, the mean square error in age determination (*k*) presented in the table should be considered as most probable only. The are calculated from δ values (marked by asterisks in the table) using δ/M = 11.62%, which is the average value for all other localities.

Mosbach locality (major bone bed): Data on *M. trogontherii* are evaluated using the graph published by Guenther (1968, Fig. 4), who also presented values of LLQ index for 14 M^3 from the depth range of 12.5-18 m. We converted the index to a lamellar frequency in a tooth interval 10 cm long. The parameter obtained is similar to those of 18 teeth from this locality calculated by Lister & Brandon (1991, Tab. 1).

Ilford locality. The extreme and mean values together with the mean square errors are calcu-

Tab.1 - Lamellar frequency in the 10-cm-long interval of the upper last molars (M^3) of *Archidiskodon-Mammuthus* elephants and biometric ages of the studied localities.

Locality	n	lim	$M \pm m$	δ	δ/M%	T	k
Liventsovka(l)	30	3.25-5.5	4.5 ± 0.09	0.48	10.67	2.419	+0.258 -0.223
Sinyaya Balka (2)	45	4.5-6.5	5.5 ± 0.08	0.53	9.64	0.947	+0.066 -0.060
Tiraspol' (3)	19	5.0-8.5	6.1± 0.15	0.65*		0.589	+0.072 -0.063
Süssenborn (3)	130	4.0-8.25	6.35 ± 0.06	0.67*		0.486	+0.022 -0.021
Mosbach (4)	14	5.9-8.3	7.11± 0.21	0.80	11.25	0.276	+0.047 -0.039
(5)	18	5.83-8.74	6.99 ± 0.16	0.66	9.44	0.302	+0.038 -0.034
Ilford (6)	11	7.6-9.6	8.7 ± 0.25	0.83	9.54	0.082	+0.019 -0.015
Dolni Vestonice (7)	26	7.4 -12.2	9.4 ± 0.22	1.12	11.91	0.044	+0.011 -0.009
Balderton (5)	19	7.67-12.17	9.72 ± 0.29	1.25	12.86	0.032	+0.011 -0.009
Předmosti (8)	34	8.1 -12.3	9.89 ±0.18	1.08	10.90	0.027	+0.006 -0.005
(7)	30	7.5-11.9	9.60±0.17	0.93	9.69		
(5)	43	7.61-11.8	9.45 ±0.15	1.01	10.69		

Note: n is number of teeth; lim is the extreme values of lamellar frequency; M is the mean value of lamellar frequency; m denotes the mean square error of M determination: δ is the mean square deviation of M values; T is age in Ma; and k is the mean square error of age determination in Ma. Data used for calculations are from the following sources: (1) measurements of V.E. Garutt; (2) Dubrovo (1963); (3) Dubrovo (1971); (4) Guenther (1968); (5) Lister & Brandon (1991); (6) Lister (1993); (7) Averiyanov *et al.* (1995); (8) Musil (1968). For explanations of figures marked by an asterisk, see the text.

lated for 11 teeth of *Mammuthus primigenius* using the graph of Lister (1993, Fig. 6).

Dolni Vestonice locality: The extreme and mean parameters for 26 teeth of *Mammuthus primigenius* and the mean square errors have been published by Aver'yanov *et al.* (1995), who discussed the measure-ment results of E.V. Urbanas.

Balderton locality: Lister & Brandon (1991) cal-culated the extreme and mean parameters together with δ value for 19 teeth of *M. primigenius* from this locality.

Předmosti locality: In this case, we used the measurement results (Musil 1968, Tab. 43 a, b) for 34 out of 40 teeth of *M. primigenius*, which display a wearing degree of 1-(1-2)-(1-3)-(1-4) and have presumably been recovered from the major cultural bed. In our calculations, we ignored data on strongly worn teeth, which considerably understate the mean lamellar frequency value (*M*). For instance, M for 34 teeth is 9.89, but for 40 teeth, six strongly worn specimens included, this value decreases to 9.53.

Somewhat different data on mammoth teeth from the Předmosti locality were reported by Averřyanov *et al.* (1995) and by Lister & Brandon (1991). The extreme lamellar frequency values are similar in both publications, but lower than that estimated by Musil. Correspondingly, the mean parameter is also lower (Tab. 1). These understated values may indicate that strongly worn teeth were present in the analysed series.

Data on the Liventsovka, Sinyaya Balka, and Předmosti localities were used as reference points for determining the locality positions on the areacotan-gent curve and for scale calibration along the X (time) and Y (morphological evolutionary parameter) axes.

An age of 2.4 Ma, the average between 2.6 Ma (the Gauss-Matuyama boundary) and 2.2 Ma (age of the Psekups locality), was adopted for the Liventsovka locality. The mean parameter (M) for this locality is 4.5. The Sinyaya Balka locality is dated back to 0.95 Ma, which corresponds to the mean age of the Taman faunal assemblage (Vangengeim *et al.* 1991); the respec-tive mean parameter is 5.5. The cultural bed of the Předmosti site yielded the ^{14}C age of 26.5 ka (Svoboda 1990); for this site, the mean parameter is 9.89.

Using the above data, we obtain the following for-mula:

$$T = 1.62\frac{0,141e^{0.623M} + 1}{0.141e^{0.623M} - 1} - 1.6427 \text{ Ma},$$

which is used to calculate ages of localities (T) and the mean square age error (k) (see Tab. 1).

3. Discussion

All the obtained biometric dates should be considered as indicating the maximum possible age, because almost all cited publications lack data on the wearing degree of teeth. When included in statistical analysis, the parameters of strongly worn teeth substantially decrease the mean values of the lamellar frequency, and we obtain an older age.

Our dating results for the Ilford and Balderton local-ities are distinctly inconsistent with those reported recently by English researchers (Brandon & Sumbler 1991, Lister & Brandon 1991, Lister 1993). They refine the former age determinations (Mitchell *et al.* 1973, Clayton 1977, Stuart 1982).

After our request, Lister kindly donated a fragment of a mammoth limb bone from the Balderton Quarry 4e for radiocarbon analysis. The analysis was made by L.D. Sulerzhitskii at the laboratory of the Geological Institute, Russian Academy of Sciences. The obtained date of 29.6 ± 0.6 ka (GIN8743) agrees well with the biometric age (32 +11 / -9 ka) of the locality and excludes the possibility that the Balderton mammoth is older than the middle Würm mammoths from central Europe.

4. Conclusion

The biometric dating of the oldest Liventsovka locality does not essentially change the age accepted at present, since the biometric age is calculated with a large error. The age of the Sinyaya Balka locality was formerly adopted as equal to 0.95 Ma, i.e., to the aver-age value between 1.1 and 0.8 Ma (the time span of the Taman faunal assemblage). Our calculations allow us to reduce the possible time limit of the locality from 1 to 0.9 Ma, leaving the same mean value of the age.

The Tiraspol, Süssenborn, and Mosbach localities similar in composition of the mammal assemblages were formerly considered as close in age; namely, the Tiraspol and Süssenborn sites were assumed to be of the same age and somewhat older than the Mosbach locality. Our investigations infer that the Tiraspol locality is the oldest one, probably about 600 ka old. The Süssenborn site is 100000 years younger, and the Mosbach locality is about 200000 years younger than the latter.

Our dating results for the Ilford and Balderton localities are distinctly inconsistent with those reported recently by English researches. They refine the former age determinations. The biometric age of the Balderton site agrees well wirh the new ^{14}C date obtained for the bone sample from this locality.

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