Geol. Paläont. Westf.	**76**	57-74	4 Fig. 3 Tab.	Münster März 2010

First evidence of southern elephants from Westphalia*

Klaus - Peter Lanser**

Abstract

Finds of elephant remains are described. An evaluation of the partly well preserved molar teeth showed that it was a representative of the southern elephants with predominantly archaic tooth characters. There are similarities with the tooth characters of *Archidiskodon gromovi* GARRUT & ALEXEEVA from the Khapry Sands, Sea of Azov in Russia. In comparison with published data on *Archidiskodon meridionalis* NESTI from the Arno Valley in Italy the present finds indicate an older age. This interpretation is supported by the results of palaeomagnetic studies which indicate a position in either the Olduvai or Reunion Event of the Matuyama Epoch, corresponding to age ranges of 1.77 to 1.95 and 2.14 to 2.19 million years respectively, and hence the Tiglian warm period at the end of the Pliocene. The elephant remains are associated with teeth of hippopotamus *(Hippopotamus* cf. *antiquus*), documenting an earlier record of hippopotamus in central Europe.

Provenance

The bones and teeth come from a filled stream bed, a karst structure in the marine succession of the Lower Coniacian, Erwitte formation (Upper Cretaceous), in the region of the Haarstrang, a range of hills between Dortmund in the west and the Paderborn Plateau in the east, at the transition between the Rheinisch Schiefergebirge (Sauerland) in the south and the Münsterland in the north.

The detailed coordinates of the find locality can be requested from the LWL-Museum für Naturkunde, Paläontologische Bodendenkmalpflege.

Locality and circumstances of the find

Mammalian skeletal remains were found in a working quarry and reported to the LWL-Museum für Naturkunde, Paläontologische Bodendenkmalpflege, who carried out a rescue excavation.

The fossils were found in a 20 m high working face of the quarry, where a filled channel striking at 150° in the surface of the limestone succession had been cut through. In the vicinity of the find point, the channel had a width of ca 2.5 m and tapered steeply to a depth of ca 5 m.

The channel fill consisted of brown-grey silts to fine sands with several layers of pale grey silt. Between the channel and the field surface was a cover of 1.6-1.8 m of recent sediments consisting of brown loess or loess loam, in which from ca 50 cm below the level of ploughing downwards increasing numbers of sharp-edged limestone blocks from the *in situ* Coniacian were incorporated.

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The skeletal remains of the elephants were in places very close together. In particular, the molars were found predominantly in their anatomical association. Numerous elephant skeletons had become embedded very close next to and over each other in a very small area.

This accumulation of animal remains was clearly dependent on the local situation. Because of the jointing of the outcropping Upper Cretaceous rocks, the stream courses of this region locally develop steep and high banks. A valley only a few kilometres east of the find point is 100 m wide, with locally very steep and smooth walls up to 20 m high. At times of storms and heavy precipitation the water flow increases very rapidly.

The finds

All the bones and teeth exhibit a white coloration to varying degree, with various types of rust- and grey-flecking. The bones are penetrated by numerous cracks, consistently deformed and invariably fragmentary. In fresh condition, immediately after removal and while still moist, they had a soft almost creamy consistency. The elephant molars were distinctly better preserved. To date the determinable finds comprise ca 250 elephant molars and larger fragments as well as tusks, bones and bone fragments, together with 15 teeth and tooth fragments of hippopotamus (*Hippopotamus antiquus*), 8 premolars and molars of bovids (*Leptobos* sp.), one premolar of a rhinoceros (*Dicerorhinus* cf. *etruscus*) and a cervid upper jaw molar. In the present paper the elephant molars are documented.

Age distribution of the elephant molars

Inspection of the elephant molars shows that they are mainly second and third molars, of which the latter predominate numerically (Table 1).These statistics do not reflect the natural age composition of an elephant herd. Evidence of juveniles and adolescents based on lower stages of dentition is largely missing. Perhaps there was a differential size selection when the corpses were incorporated in the sediment. The smaller animals – the young elephants and the greater part of the associated fauna – were perhaps deposited elsewhere.

Body size and sexual dimorphism of the elephants

Despite the numerous post-cranial skeletal remains of the elephants, very few statements can be made concerning the body sizes of these animals. The largest available femur lacks the distal articulation. The original total length can be tentatively estimated at ca. 1.47 m. From this, according to GARUTT (1964), the skeleton of this elephant reached a height at the shoulder of over 4 m. According to GARUTT & BAGJUŠEVA (1981), a height of ca. 3.5 m can be inferred for *Archidiskodon gromovi.*

Some of the tusk fragments are somewhat more than 2 m long and show a weak spiral curvature. From the total preserved length, it can be inferred that the diameter decreased only to a small extent. The teeth were therefore invariably squat and compact. Because of the in part strong deformation it is difficult to determine the cross section ratio (ratio of largest to smallest diameter). The maximum diameter, measured in the obviously undeformed parts of the tusk, ranges up to 25 cm. This is in the upper range given by AZZAROLI (1977) for the diameters of tusks of southern elephants from the upper Arno Valley in Italy.

There are distinct and striking differences in the tusk diameters of the elephants from the Haarstrang. Apart from the above-mentioned tusk fragments with diameters of up to 25 cm, there are also distinctly slimmer tusks up to ca. 12 cm in diameter, which also show a weak spiral curvature and hardly any decrease in diameter with length. It is probable that these thinner tusks belonged to female individuals and the sturdier ones to the bulls. Similar marked difference in the size of the tusks was observed by WEITHOFER (1890) in the southern elephant remains from the Arno Valley in Italy.

General characteristics of the molars

The elephant molars are characterized by broad plates, thick enamel and large spaces between the plates. The abrasion figures of the plates do not vary greatly and are mostly very similar. At the onset of chewing, the high points of the plates, the mamillae, form in practically all cases three closely-spaced, equally-sized ovals. This type of coalescence is described as intermediate. Median lamellar, lateral annular coalescence, as is typical of the forest elephant *Palaeoloxodon antiquus* is found as rarely as the median annular, lateral lamellar type of coalescence. A sinus or central notch is almost never present, and when present is only very weakly developed.

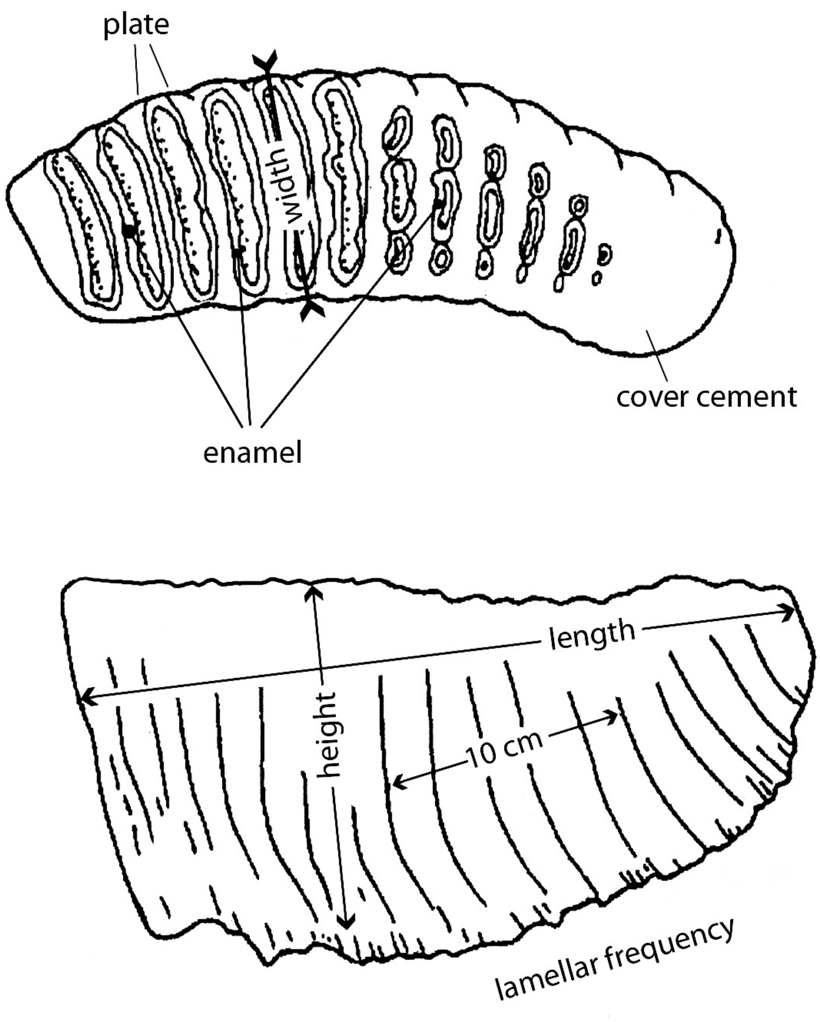

Fig. 1: Diagram of a mammoth molar, in occlusal and lateral views, showing measurements taken.

Dental parameters

The parameters and morphological terms in the following table are explained in POHLIG (1888), SOERGEL (1913), GUENTHER (1968 to 1994) and MUSIL (1968).

The elephant molars studied are really long in comparison with published molar length data for Plio/Pleistocene elephants. This is clearly connected with the body size of these elephants.

A lower jaw third molar, 132 mm wide, shows the highest value for molar width. This is an unusually high value for an elephant molar. However, the next highest values, 125, 118 and 115 mm, are still high in relationship to data from other localities and partly significantly exceed the reported limits of variability.

The high values for the heights of the teeth, in particular those of the third molars of the upper jaw, can be interpreted as a progressive character. The simultaneous occurrence of conservative characters and this progressive character can be interpreted as an adaptation to the special regional ecological conditions that these animals experienced on the edge of the north German plain in the Atlantic climate at the beginning of the ice age. A similar opinion was expressed by FORONOVA & ZUDIN (2001).

The enamel thickness values are again rather unusually high for Plio-/Pleistocene elephants and likewise suggest a low evolutionary developmental stage of these elephant molars.

The number of plates increases from the first to the third molar. In the case of the second molars, there are never more than ten plates. The highest value for the third molars is fifteen plates in the upper jaw in two cases, and fourteen plates in the lower jaw, also in two cases. The lowest number of plates is ten for the third molars of the upper jaw and nine for the third molars of the lower jaw. These are very low values in comparison with available literature data, and signify, together with the high enamel thickness values, a rather low evolutionary stage. A count of eleven plates represents a maximum in the lower part, and a count of fourteen a peak in the higher part of the range for the third molars of the upper and lower jaw. These peaks at eleven and fourteen plates respectively are very striking and clearly originate from sexual dimorphism. According to AZZAROLI (1977), there are one to three plates fewer in female southern elephants than in the bulls.

The lamellar frequency values are likewise very low in comparison with published values. They demonstrate the large distances between the plates of the southern elephants which will soon reduce in size in the course of the rapidly progressing evolution of the eurasian elephants of the mammoth lineage.

mm^3	7								
mm_3	-								
M^1	-								
M_1	-								
			9						
			9						
			9	10					
M^2			9	10					
			9	10					
				10					
				10					
				10					
				10					
			9	10					
			9	10					
			9	10					
M_2		8	9	10					
				10					
				10			13		
				10			13	14	15
				10	11		13	14	15
				10	11		13	14	15
M^3				10	11	12	13	14	15
					11		13		
					11		13		
					11		13		
					11		13		
				10	11		13	14	
			9	10	11	12	13	14	
M_3			9	10	11	12	13	14	

Tab. 1: Plate count for the elephant molars from the Haarstrang area.

In this paper, an attempt is made to explain the stratigraphic position of the elephants from the Haarstrang on the basis of comparisons with finds from localities in Germany, from the lower course of the Rhine in the Netherlands, and from southern Russia and Siberia as well as west and southern Europe.

tooth	n	length	n	width	n	height	n	enamel	n	plates	n	LF
mm^3	1	113,5	1	62	-		1	1,5	1	7	1	8,5
M^1	-	-	3	67, 5; 74; 80	-	-	4	2,7(3,0)3,2	-	-	2	5,5, 6,4
M$_1$	-	-	3	72; 77,5; 81	2	92, 117	3	1,9; 2,7;3,0	-	-	4	5,1 (5,6) 6,2
M^2	6	183(202)226	19	81(91,8)106	3	123(132)147	28	2,7(3,4)4,3	8	9(9,4)10	20	4,1(5,2)6,0
M$_2$	10	183(212)234	37	72(86)102	13	100(115)128	47	2,5(3,3)4,1	13	8(9,5)10	29	4,1(5,0)6,5
M^3	18	205(262)308	33	91(106)120	23	124(142)177	33	2,9(3,6)4,5	25	10(12,3)15	36	4,2(5,1)5,8
M$_3$	18	206(278)343	49	85(103)132	32	110(134)158	55	2,6(3,6)5	19	9(11,8)14	55	3,7(4,6)5,7

Tab. 2. Summary data of length and width, height, enamel thicknesses, plate count and lamellar frequency (LF) for the elephant molars from the Haarstrang area.

Germany and the Netherlands

Nearby and more distant localities with published data on the molars of southern elephants are found in the Netherlands at Dorst-Surae on the lower course of the Rhine (van KOLFSCHOTEN, 1990) and in Germany, where there are finds from Jockgrim in the Pfalz (GRUNER, 1950), the Mosbach Sands near Wiesbaden-Biebrich (GUENTHER, 1968, 1969), the Goldshof Sands near Aalen (ADAM, 1953), Voigtstedt in Thuringia (DIETRICH, 1965), near Offenburg on the Upper Rhine (GUENTHER, 1991) and in the region of the Krefeld Terrace on the Lower Rhine (LANSER, 1983).

In order to clarify the differences between the various elephant populations, figures 1 and 2 were produced. These figures show values, separated into those for the upper and lower dentition, for the width of the third molars in relation to the thickness of the enamel. This procedure has the advantage that the required data can also be obtained from tooth fragments of sufficiently large size. The data from the tooth material under study and from the literature on the localities in the Netherlands and Germany provide a comparatively large dataset. As can be shown further below, the widths of the teeth and the thicknesses of the enamel decrease progressively throughout the course of the evolutionary lineage of the southern elephants, via the steppe elephants to the mammoths of the last Ice Age and right up to the end of their evolution. These two parameters are thus important indicators for the evolutionary stage reached by any given elephant population.

Both the figures show interesting relationships. In the case of the elephant molars from both Dorst-Surae and from Jockgrim, the minimum values for tooth width and enamel thickness of the Haarstrang elephants are either not or only just attained. However, allowance must be made for the fact that, according to GRUNER (1950), the widths of the elephant molars from Jockgrim were measured on the chewing [this should probably be occlusal; Ja!] surfaces. These values can therefore be less than the maximum widths, depending on the extent to which the teeth are worn down. However, the low values for the enamel thickness are also noteworthy. The fauna from Jockgrim was assigned by GRUNER (1950) to the Lower Pleistocene. According to SOERGEL (1925) the Jockgrim fauna lies temporally between the *meridionalis* fauna and the *El. trogontherii* fauna of Mosbach.

According to van KOLFSCHOTEN (1990), the Dorst-Surae fauna comes from the Bavelian, a pre-Cromerian interval between the Menapian and Interglacial 1 of the Cromer Complex. Here again, as in the case of the elephant molars from Jockgrim, the values for tooth widths and enamel thickness are remarkably low and apparently fall outside the range of variation for the southern elephants. If the assignment of the Dorst-Surae fauna to a pre-Cromerian interval were proven, this would imply that this record of steppe elephants was from an early period from which there had previously been no evidence of these elephants. However, it is possible that the elephant molars described from Dorst-Surae actually came from younger strata.

On the other hand, the higher enamel thickness values for the elephants from Voigtstedt and also the greater widths of their molars, in contrast to those of the molars from Dorst-Surae and Jockgrim, are striking. The Voigtstedt fauna was assigned by DIETRICH (1965) to the Cromerian. The lower width values of both the upper jaw molars (M^3) from the Goldshof Sand locality near Aalen (ADAM, 1953) likewise depart significantly from the values for the molars from the Haarstrang locality

There are also distinct differences from the elephant molars from below the Krefeld Terrace west of Krefeld. The smaller enamel thicknesses and tooth widths, in particular, as well as the smaller Length–Lamellar-Quotients, indicate a more advanced evolutionary stage, and a younger age, than the teeth from the Haarstrang.

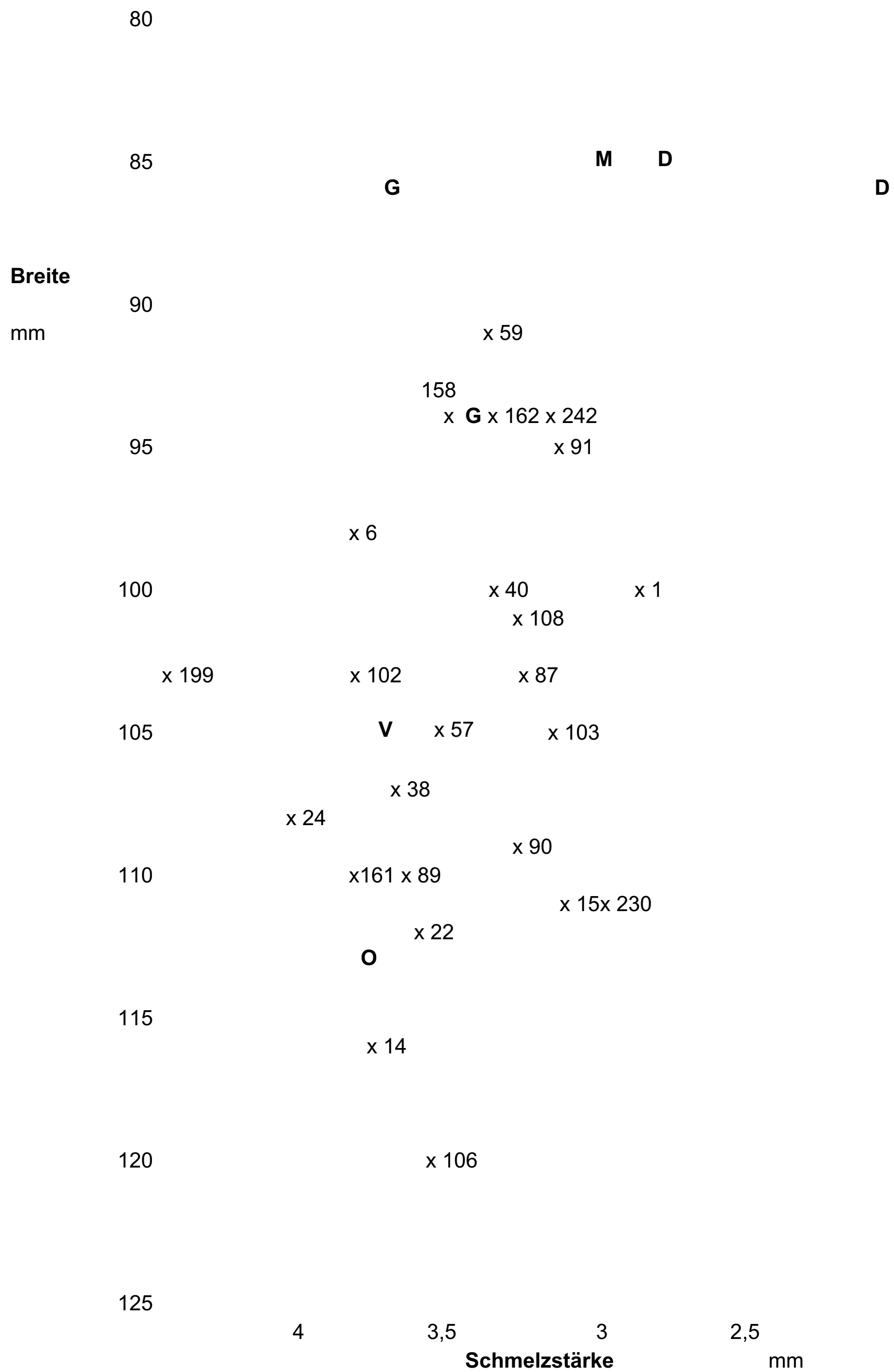

Fig. 2: Tooth widths and enamel thicknesses of third upper jaw molars from the Haarstrang in comparison with those from some German and one Netherlands locality.

D = Dorst-Surae /NL (n. .v KOLFSCHOTEN, 1990)
G = Goldshöfer Sande (n. ADAM, 1953)
J = Jockgrim (n. GRUNER, 1950)
M = Mosbach (n. GUENTHER, 1968, 1969)

N= Niederrhein (n. LANSER, 1983)
O = Oberrhein (n. GUENTHER, 1991)
V = Voigtstedt (n. DIETRICH, 1965)
x = Haarstrang

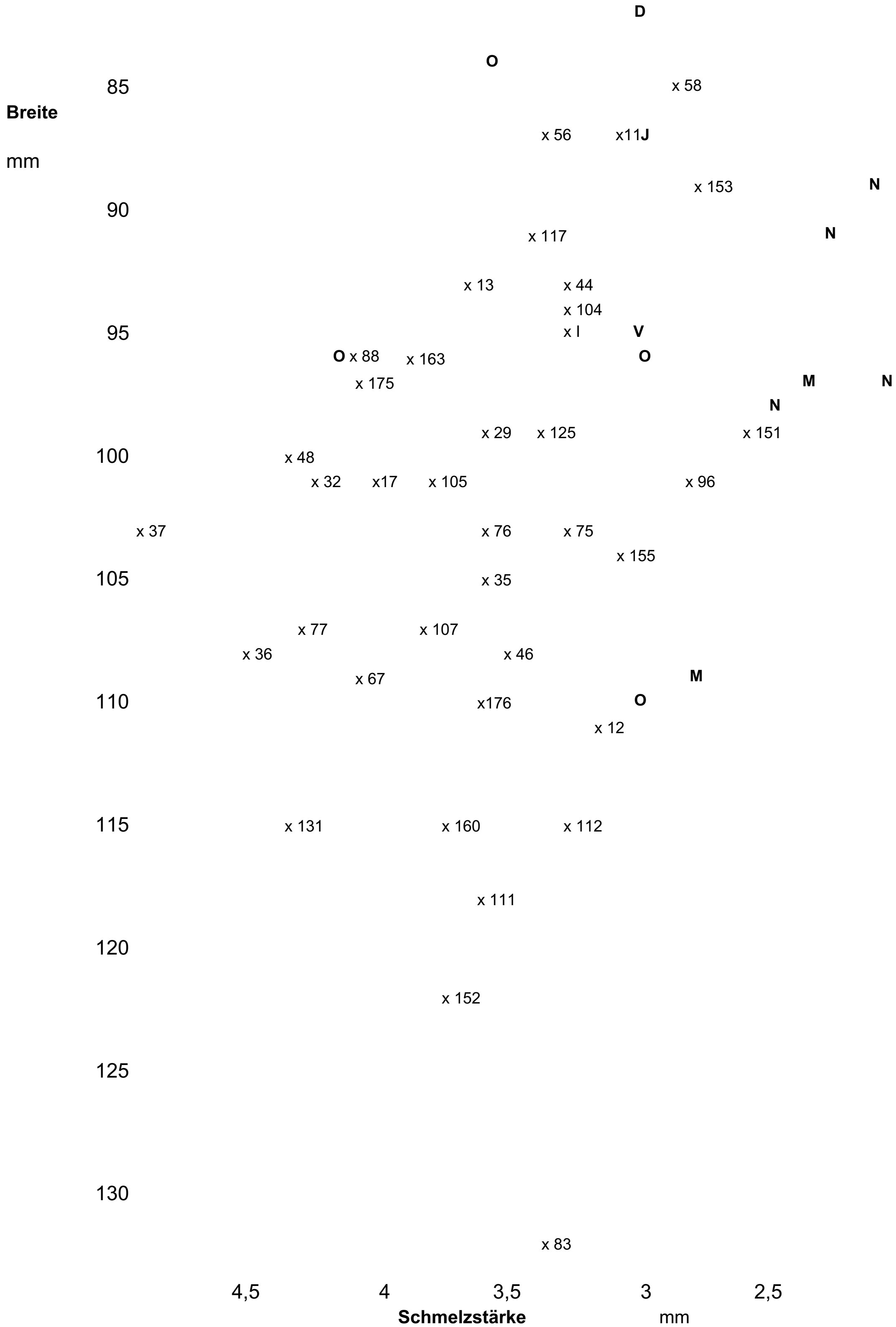

Fig. 3: Tooth widths and enamel thicknesses of the third lower jaw molars from the Haarstrang in comparison with those from some German and one Netherlands locality.

The tooth characters of the southern elephants from Mosbach, published by GUENTHER (1968, 1969), are similar to those of the southern elephants from the Lower Rhine. The Mosbach molars show a greater range of width values than the teeth from the Lower Rhine and their enamel thicknesses do not exceed those of most of the molars from the Haarstrang. Consequently the southern elephants from the Mosbach site appear to be phylogenetically younger than those from the Haarstrang.

There is also a partial agreement with the material from the localities on the Upper Rhine (GUENTHER, 1991), albeit the really small quantity of samples has to be taken into consideration. According to the published data on the elephant molars, parts of the succession are of a similar age to that of the underlying Mosbach Sands (Mosbach 1) or the Goldshof Sands. However, the underlying strata of the Upper Rhine Graben are even older than the lower Mosbach (Mosbach 1), as GUENTHER (1991) was able to show on the basis of a lower jaw molar with a length–lamellar quotient of 27.4. This is a very high value, albeit one also attained by some teeth from the Haarstrang area. According to KNIPPING (2008), pollen studies in the neighbourhood of Mannheim have revealed five warm periods, with the oldest strata belonging to the Tiglian

Consequently, comparison with the corresponding values for the elephant molars from western and southern Germany, as well as from the Dorst-Surae site on the lower course of the Rhine in the Netherlands, provides a provisional coarse framework for the temporal assignment of the elephant finds from the karst structure in the area of the Haarstrang. They can be dated as early Pleistocene, albeit older than the faunas from Mosbach, Jockgrim, Dorst-Surae and the gravels below the Krefeld Terrace on the Lower Rhine.

Western and eastern Europe

Most of the numerous molars of southern elephants from west and east Europe that have been documented by various authors in the past show that the range of variation of the tooth characters of southern elephants is significantly greater than the data from the hitherto comparatively small number of published finds from Germany and the Netherlands might suggest.

The finds of *Archidiskodon gromovi* GARRUT & ALEXEEVA, 1965 come from the Khapry Beds on the north bank of the Sea of Azov and on the lower Don in Russia. SOTNIKOVA et al. (2002) stated that there were connections between the fauna from the Khapry Beds and the faunas from St. Vallier und Costa San Giacoma, in France und Italy respectively. Both these localities belong in the middle Villafranchian and hence in the Upper Pliocene. According to GLIOZZI et al. (1997) they have an age between 2.2 and 2.5 Ma.

Measurements of the molars of *Archidiskodon meridionalis tamanensis* were given by FORONOVA (1986) und DUBROVA (1989). These elephant molars come from the Taman faunal complex which, according to BAJGUŠEVA et al. (2001), characterizes the early Pleistocene of eastern Europe. In addition to *Archidiskodon meridionalis tamanensis*, the fauna also contains *Elasmotherium caucasicum* as well as the last record of *Anancus* ex gr. *avernensis.*

Data on the dimensions of molars of *Archidiskodon meridionalis meridionalis* and its younger subspecies *A. meridionalis vestinus* and *A. m. meridionalis depereti* were documented by FERRETTI (1999). Data on the height of the third molars of *A. m. meridionalis* are taken from DUBROVA (1989).

	n	length	n	width	n	height	n	enamel	n	plates	n	LF
A.* cf. *meridionalis												
Haarstrang												
M^3	18	205(262)308	33	91(106)120	23	124(142)177	33	2,9(3,6)4,5	25	10(12)15	36	4,2(5,1)5,5
M_3	18	206(278)343	49	85(103)132	32	110(134)158	55	2,6(3,6)5	19	9(12)14	50	3,7(4,6)5,7
A. gromovi												
Khapry-Sande												
n. GARRUTT & BAJGUŠEVA, 1981												
M^3	25	203(240)295	37	85(110)120	17	105(134-139)147	36	2,6 - 4,4	26	11(13)15	39	3,3(4,5)5,5
M_3	24	257(266-303)328	38	78(95-103)108	12	108(124)137	12	2,6(3,3)4,8	21	12(13)15	44	3,5(4)5,5
A. m. meridionalis												
Valdarno / Italien												
n. FERRETTI (1999) u. DUBROVA (1989)*												
M^3	-	-	29	83(101)123	-	113 – 150*	33	2,6(3,2)3,9	27	11(14)16	24	4,3(5,4)6,2
M_3	-	-	12	81(91)113	-	114 – 136*	19	2,4(3,0)3,7	19	12(14)16	10	3,9(5,1)5,9
A. merid.* cf. *vestinus												
Pietrafitta / Italien												
n. FERRETTI (1999)												
M^3	-	-	4	84(93)103	-	-	4	2,6(2,9)3,3	3	13(14)16	2	4 - 6,5
M_3	-	-	5	75(85)94	-	-	6	2,7(2,9)3,1	6	12(14)15	2	5 - 5,7
A. m. tamanensis												
Asowsches Meer												
n. DUBROVA (1989) u. FORONOVA (1986)												
M^3	-	252 – 317	12	85(104)115	-	127-185	12	2,2(3,0)4,0	-	12-17	12	4,7(5,8)6,
M_3	-	159 – 328	-	82-122	-	115-120	-	2,5-4	-	12-17	-	4 – 6
A. merid. depereti												
Saint Prest / Frankreich												
COPPENS & BEDEN (1982) zitiert n. FERRETTI (1999)												
M_3	-	-	10	88-105	-	-	10	2,4-3,7	10	15-17	10	4,6 - 6,1
Mammuthus trogontherii												
Süssenborn												
n. . GUENTHER (1969 b) u. FORONOVA (1986)												
M^3	-	246 – 400	47	82(97)116	-	129-212	46	1,9(2,3)3,0	45	15(20)23	48	5,5(7,7)9,1
M_3	-	225 – 383	40	73(94)114	-	127-167	42	2,0(2,3)2,9	36	15(19)23	40	4,4(5,6)7
Mammuthus primigenius												
Předmostí												
n. MUSIL (1968)												
M^3	22	196(237,5)290	-	66 – 104	-	120 – 222	-	1,0 – 2,7	-	18 – 25	-	8,1 – 12
M_3	-	105(249)280	-	56 – 97	96	(127,5)148	-	1,0 – 2,7	17	18 – 24	-	8 - 11

Tab. 3: Length, width and height data, as well as enamel thicknesses, plate counts and lamellar frequencies of the third molars of the upper and lower jaw of elephants from various localities in comparison with data for the elephants from the Haarstrang area.

The finds of *Archidiskodon meridionalis meridionalis* come from various localities of differing ages in the area of the Upper Arno valley (Valdarno) in Tuscany, Italy, which are collectively assigned to the Tasso faunal unit (FERRETTI,1999). GLIOZZI et al. (1997) considered that these finds were somewhat younger than the Olduvai Event of the Matuyama Epoch which, according to GRADSTEIN et al. (2004), can be dated as 1.77 to 1.95 Ma. The finds of *A. meridionalis vestinus* und *A. meridionalis depereti* come from younger successions of late Early Pleistocene and early Middle Pleistocene age (FERRETTI, 1999).

Comparison of the data in the table for dimensions of third elephant molars of the upper and lower jaw dentition is rendered somewhat difficult in that in some cases either no mean values are given or, as in the case of *A. gromovi,* the values are so-called optimal values in the sense of an interval; in other cases, as with *A. m. deppereti*, the data for the upper and lower jaw molars have been combined.

Since there are no mean values available for Süßenborn, it should be noted that there is an inventory of ca. 1000 elephant molars (GUENTHER, 1969 b), with a corresponding wide range of dimensions. Individual extremely high or low values, such as always appear in larger inventories, can provide a false picture in this type of representation.

Tooth length

The lengths of the teeth, in particular those of the third upper jaw molars, show an increase in values from *A. gromovi*, via the Haarstrang elephants, to *A. tamanensis,* up to *Mammuthus trogontherii* from Süßenborn. This means that the molars of *A. gromovi* are shorter than all the others documented herein. The next in length are the teeth from the Haarstrang, followed by the early Ice Age teeth from the Taman Peninsula and finally the Middle Pleistocene steppe elephants from Süßenborn. The increase in length of the molars was clearly connected with the increase in body size of the southern elephants of the latest Pliocene and early Pleistocene, which continued up to the steppe elephants of the middle Ice Age. Later in the Ice Age the tooth lengths decreased again, as MUSIL (1968) was able to demonstrate on the basis of the elephant finds from Předmostí in Moravia (Czech Republic).

Tooth width

Comparison of the mean values for the widths of the third upper and lower jaw molars of *A. gromovi* with those of the molars from the Haarstrang region shows that, for the teeth of the upper jaw, the latter are smaller than those of *A. gromovi*. The mean values for the widths of the third lower jaw teeth from the Haarstrang are identical with the higher part of the range of variability described by GARRUTT & BAJGUŠEVA (1981) as „optimal values“. There are therefore relatively small differences in the widths of the molars of *A. gromovi* and those of the elephants from the Haarstrang. Some of the maximum values of the third lower jaw molars from the Haarstrang region are higher, but this does not affect the mean values.

There is then a reduction in the tooth widths from *A. m. meridionalis* from the Arno valley in Italy to *A. m. vestinus.* In *Mammuthus trogontherii* from Süßenborn there are remarkably low minimum values for the widths of the molars of both the upper and lower jaw. This evidences a general trend for a reduction in width of the molars of the southern elephants. This trend continues in the steppe elephants of the Middle Pleistocene and then in the mammoths of the late last Ice Age (GUENTHER, 1994).

Tooth height

The lowest minimum, mean and maximum values for tooth height are found in *A. gromovi.* These are followed by the heights of the teeth of *Archidiskodon meridionalis meridionalis* from the Arno valley in Italy given by DUBROVA (1989) and then those of the elephants from the Haarstrang. The maximum values for tooth height are found again in the upper jaw teeth of *Archidiskodon meridionalis tamanensis.* These are exceeded by the values for *Mammuthus trogontherii* from Süßenborn, particularly the maximum values.

FORONOVA (1986) documented a find of a left third upper jaw molar of an elephant from the Kuznetsk Basin in west Siberia which she assigned to *Archidiskodon* cf. *meridionalis.* At a width of 105 mm, it showed a crown height of 177 mm. The average length of a plate was 19 mm and the thickness of the tooth enamel 3.2 mm. The stratigraphic age was given as probably late Pliocene.

Enamel thickness

In the thickness of the enamel, the third molars of the elephants from the Haarstrang region differ from those detailed in Table 2. Only the maximum enamel thickness values of the third upper jaw molars of *A. gromovi* are, according to GARRUTT & BAJGUŠEVA (1981), somewhat higher than those of the elephants from the Haarstrang. A mean value was not given. Really high enamel thickness values are also shown by the lower dentition stages of the elephant molars from the Haarstrang region (Table 1)

According to GUENTHER (1969 b) and FORONOVA (1986) there is a reduction in the thickness of the enamel of elephants in the course of their evolution. This development is clearly evidenced in the decrease in enamel thicknesses from *Archidiskodon gromovi* to *Archidiskodon meridionalis* and its younger subspecies, up to *Mammuthus trogontherii.* The endpoint of this development is reached in the mammoths of the last Ice Age.

Plate count

Statements on the numbers of enamel plates in upper Tertiary and Pleistocene elephant molars are to be found in several publications. The variability in the numbers of enamel plates changes progressively in the direction of increasingly higher plate counts in the course of evolution, from the early southern elephants up to the mammoths of the last Ice Age. In the final stage of this development the third upper jaw molars of *Mammuthus primigenius* partly show a plate count of over 30 plates.

Data on the plate counts of molars of elephant populations of various ages are to be found in LISTER & SHER (2001). Comparison of the plate counts in their fig. 3 (A) with the corresponding values for the third elephant molars from the Haarstrang region shows that the latter fall in the lower part of the figure, above the localities listed as Red Crag +. In the eight elephant molars of the upper and lower jaw dentition from various localities in Great Britain, Italy and Romania listed together under the description Red Crag +, the plate count given by LISTER & SHER (2001) lies between nine and eleven, with a maximum of ten plates. The plate count for the third molars of the upper and lower jaw dentition of the elephants from the Khapry Sands given by GARRUTT & BAJGUŠEVA (1981) lies between 11 and 15 plates, in contrast to the smaller plate counts in LISTER & SHER (2001).

In the third molars of the elephants from the Haarstrang region, the smallest plate count is 10 plates for the upper jaw molars and nine plates for the lower jaw molars, i.e. less than the lowest plate counts of 11 and 12 plates for the upper and lower jaw molars respectively given by GARRUTT & BAJGUŠEVA (1981) for the elephants from the Khapry Sands. The highest plate count of 15 plates for the upper jaw molars is identical for both localities but is only 14 plates for the lower jaw molars from the Haarstrang region.

The mean values of 11 and 12 plates respectively for the third molars of the lower and upper jaw from the Haarstrang are less than the means for the molars from the Khapri Sands, which are 13 plates in both the upper and lower jaw dentition. In particular, these really low plate counts show the low evolutionary stage attained by the elephants from the Haarstrang.

The plate counts for both *Archidiskodon meridionalis meridionalis* from the Arno valley in Italy, and *Archidiskodon gromovi*, lie in the minimum part of the range for this parameter. In each case, the mean and maximum values are one plate more. In *A. merid. tamanensis* and *A. merid. depereti* the maximum values for the plate counts for the third molars of the upper and lower jaw dentition increase to 17 plates. There are distinct differences from the higher plate counts for the steppe elephants of Süßenborn and the mammoths of Předmostí.

Lamellar Frequency

The mean value for the lamellar frequency for the third upper jaw molars of *A. gromovi* is 4.5 according to GARRUTT & BAJGUŠEVA (1981). The corresponding value for the teeth from the Haarstrang is 5.1. For the lower jaw molars the mean values are 4 and 4.7 respectively. These values for the elephant teeth from the region of the Haarstrang are always distinctly smaller than the mean lamellar frequency for *Archidiskodon meridionalis meridionalis* from the Arno valley, which in turn is exceeded by the minimum and maximum values for the younger subspecies. There is an even greater difference, particularly in the very high maximum values, from the lamellar frequency of the steppe elephants from Süßenborn. The high point of this development is reached in the mammoths of the last Ice Age as a consequence of the increasing insertion of enamel lamellae in progressively shortening molars.

Palaeomagnetic dating

In order to obtain a possible palaeomagnetic dating, twenty-eight sediment samples were collected. Their evaluation was undertaken by M. Urbat of the Geological Institute of the University of Cologne. All of the samples showed normal polarity.

In view of the fact that the molars from the region of the Haarstrang provided evidence of elephants with characters indicative of a relatively low evolutionary stage, both the Recent Brunhes Epoch and the Jaramillo Event of the Matuyama Epoch can be excluded from consideration as possible periods. The sediments of the Haarstrang elephant locality may well belong to the Olduvai Event (Chron C2n) of the Matuyama Epoch, which, according to GRADSTEIN et al. (2004) corresponds to an age of 1.77 – 1.95 million years.

If the samples were older than 1.95 miliion years, they would show reverse polarity, if not a short older phase of normal polarity (Reunion), corresponding to an age of 2.14 to 2.19 million years.

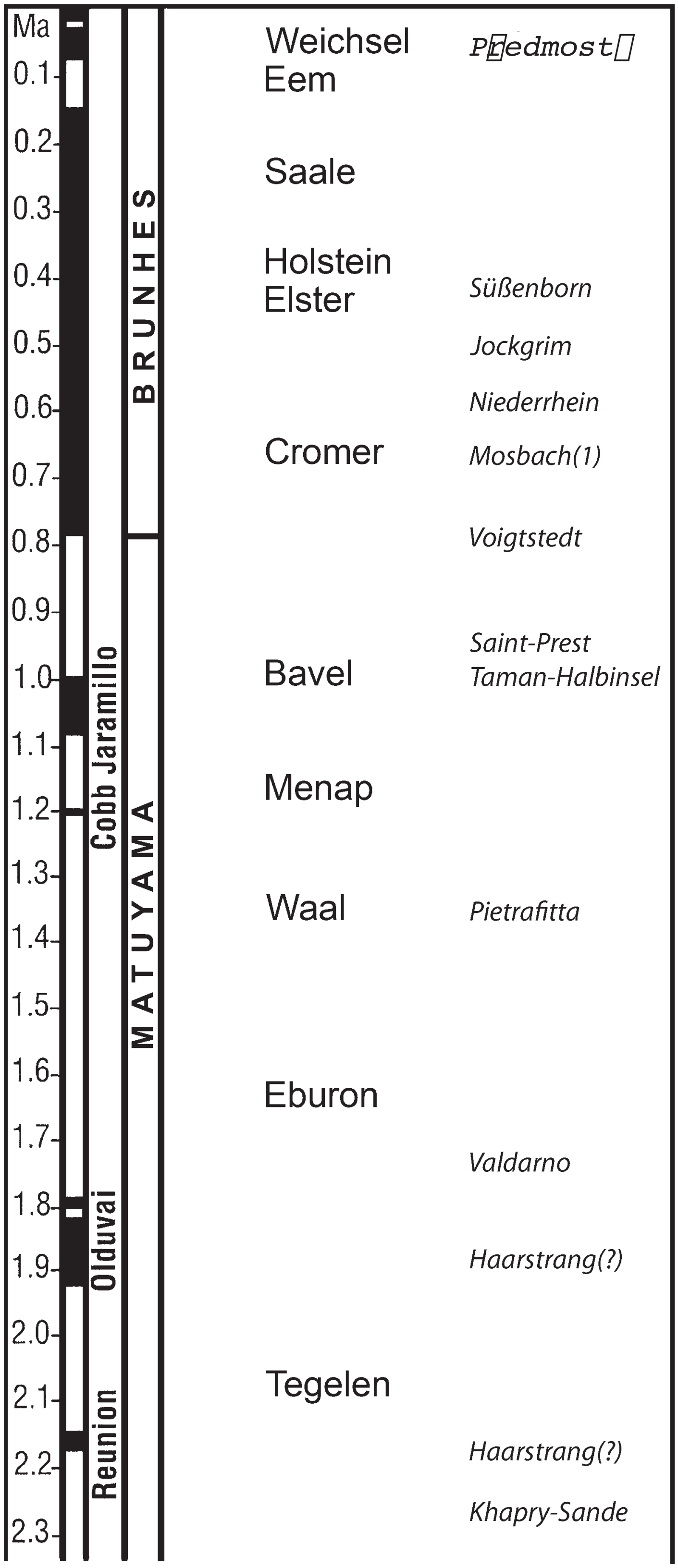

Fig. 4: Time table (after GRADSTEIN et al., 2004) and the stratigraphical position of the mentioned Elephas faunas.

Conclusions

On the basis of their tooth characters, the elephants from the karst structure in the Haarstrang are located temporally between the finds from the Khapry Sands, Sea of Azov in Russia (*Archidiskodon gromovi* GARRUT & ALEXEEVA) and those from the upper Arno valley in Italy (*Archidiskodon meridionalis meridionalis* NESTI). This is supported by the results of the palaeomagnetic investigations which indicate either the Olduvai or Reunion Event of the Matuyama Epoch, corresponding to age ranges of 1.77 to 1.95 and 2.14 to 2.19 million years respectively.

The occurrence of hippopotamus is an important environmental indication in that the presence of these large herbivores presupposes a humid, warm temperate climate. The climatic evidence from the hippopotamus population, the evolutionary stage reached by the elephant molars and the results of the palaeomagnetic investigations indicate the Tiglian warm period at the end of the Pliocene for the fossil locality in the region of the Haarstrang east of Dortmund.

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