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Two skeletons of *Mammuthus trogontherii* from the Sea of Azov Region

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ABSTRACT

In 1964 and 1999, respectively in the northern Sea of Azov Region in the Kagal'nik sand pit, two almost complete skeletons of *Mammuthus trogontherii* were found. The finds were dated to the early Middle Pleistocene freshwater deposits. Their individual ages were defined as 40 and 47 years. The proportion differences in size and some morphological characteristics suggest that they were probably of different gender. The elephants' features coincide with those of representatives of the species from Süssenborn and Tiraspol, which were typical for the early stage of the Tiraspol faunal complex (=Cromerian) in Eastern Europe.

1. Introduction

The findings of two skeletons of *Mammuthus trogontherii* (Pohlig, 1885) in the northern Sea of Azov Region are important for understanding the biological features of development and gender differences of Middle Pleistocene steppe elephants. They were found in different years, but in the same Kagal'nik sand pit (47°05′N 39°20′E), which exposes the Platovo/Semibalki terrace deposits of the left bank of the Don Valley, northeast of the mouth of the Kagal'nik River. It is situated 7 km southwest of Azov town (Rostov Region, Russia), 2 km west of Kagal'nik village. The skeletons were deposited in dark brown loams with carbonate concretions and sparse shells of freshwater molluscs. The fossiliferous layer overlapped a 9 m thick stratum of light grey fine-grained sands, containing lenses of clayey sand with freshwater mollusc shells and bones of small mammals (Baygusheva and Garutt, 1987; Tesakov et al., 2007).

The first skeleton (Az I) was excavated during the severe winter of 1964 by workers of the Azov local Museum and the Rostov regional museum of local history (Baygusheva and Garutt, 1987). Due to difficult working conditions, some bones were damaged. In total, there were more than 40 definable bones, including the slightly deformed skull. Preservation and restoration were conducted by Garutt at the Zoological Institute RAS (St. Petersburg). Since 1982, the mounted skeleton has been exhibited at the Azov Museum-Reserve.

In 1999, almost a complete skeleton of *M. trogontherii* (Az II) was found in anatomical position. It was excavated by the employees of the Azov museum-reserve and archeologists of the Rostov State University. A total of 148 definable bones and 26 small fragments of one individual were discovered (Bajgusheva, 2001). The preservation and restoration of fossil remains was conducted by the employees of the Azov museum-reserve Rychagov and Timonina. Since 2009, the bones of the skeleton have been also exhibited in the Azov museum-reserve.

The evolutionary level of *M. trogontherii* dental system, the position in the section, the data on molluscs and small mammals from underlying beds date the finds to the early Middle Pleistocene. The rodent association, including the primitive *Lagurus transiens*, *Stenocranius gregaloides* and *Microtus nivaloides*, relates this mammoth to the early stage of the Tiraspol faunal complex, MQR6-5 zone in the local biostratigraphical scale (Tesakov et al., 2007).

2. Material and methods

Skeleton Az I of the 1964 excavations (coll. AMZ, № CP-21081) is represented by slightly deformed skull, lower jaw with teeth M2/m2-M3/m3, four cervical, one thoracic, one lumbar, three sacral vertebrae, fragments of ribs, right humerus, left ulna, both lunate, triangular, small multitangulum, capitate, hamate bones, and left large multitangulum carpal bones, right metacarpal IV, three phalanges of hand, fragments of the right femur, right patella, left tibia and fibula, astragali, right calcaneus, left centrotarsal bone, left metatarsal II and two phalanges of the foot (Fig. 1). Skeleton AZ II of the 1999 excavations (coll. AMZ, KP-28689) includes the fragmentary skull with the damaged cerebral part, lower jaw, teeth M3/m3, left hyoid bone, 10 thoracic, 5 lumbar, 5 sacral, 3 caudal vertebrae, 33 ribs, manubrium of sternum, 2 scapulae, pelvis, humeri, ulnae, radii, femurs, tibiae, right fibula, 10 wrist, 8 tarsal bones, 8 posterior

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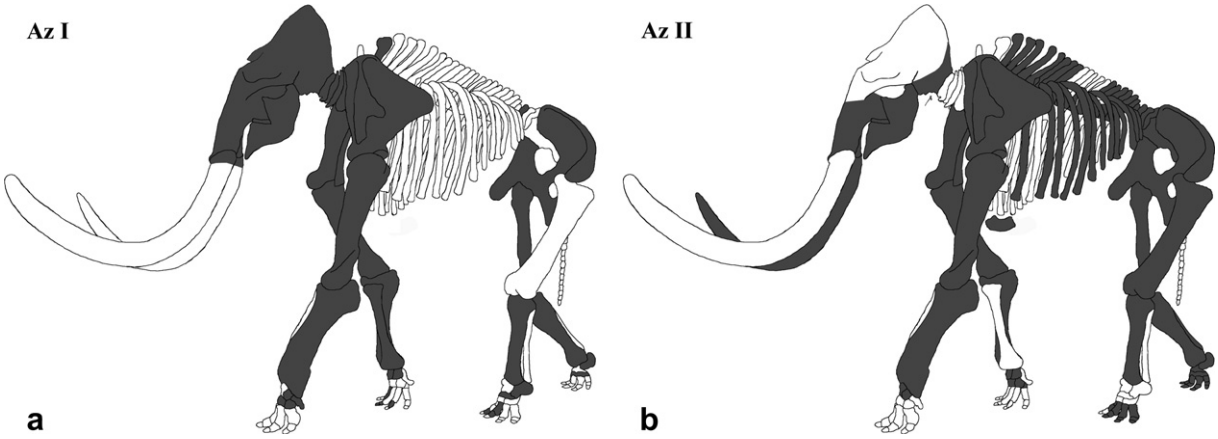

Fig. 1. Schematic representation of bones of skeletons of *Mammuthus trogontherii* from Kagal'nik sand pit (Sea of Azov Region, early Middle Pleistocene): a – skeleton Az I of 1964 excavations; b – skeleton Az II of 1964 excavations.

metapodiums, 8 sesamoid bones and 19 phalanges (Bajgusheva, 2001; Bajgusheva and Titov, 2010). The material is from the collection of Azov museum-reserve (AMZ).

The degree of bone fossilization is weak. The bone surfaces are light-cream color with grey dendrites, and white on the fractures. The cancellous tissue is light gray. The tusks on the break are white with the traces of dendrites and ferrugination. Tooth enamel is blue-gray (Baygusheva and Timonina, 2001).

Measurements and characteristics of the tooth system followed Dubrovo's methods (Dubrovo, 1960); see Maglio (1973) and Garutt and Foronova (1976). Parameters of postcranial bones were taken according to the standard method of Driesch (1976) with additions by Garutt (1954), Lister (1996), and Mol et al. (1999). Individual age was defined by the averaged data of teeth generations (according to Garutt, 1977; Lister and Stuart, 2010), and the regularity of epiphysis fusing of postcranial bones of the recent elephants *Loxodonta africana* and *Elephas asiaticus* (according to Lister, 1999).

3. Description

3.1. Skeleton of the 1964 excavation (Az I)

There are some slight damages on the frontal surface and upper nasal aperture edge of the skull. The skull has traces of deformation, as a result of which its cerebral part is overturned backwards (Fig. 2). The occiput surface has feebly marked bumps. The top of

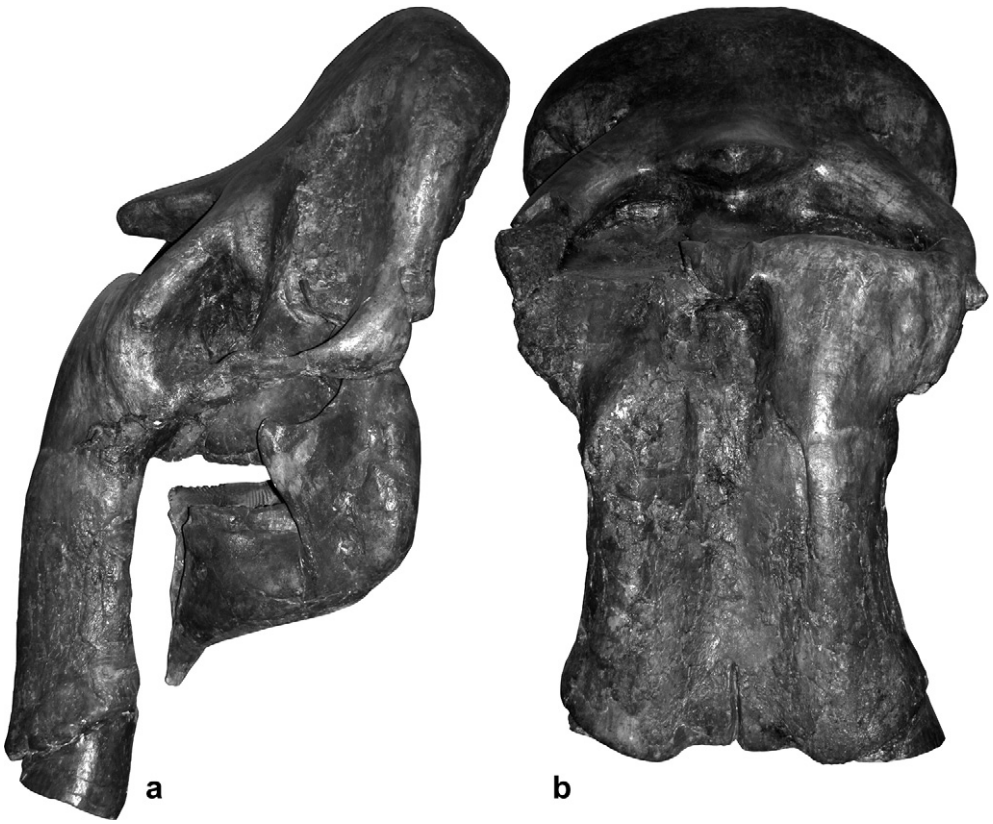

Fig. 2. The skull with lower jaw of *Mammuthus trogontherii* Az I (AMZ KP 21081/5) from Kagal'nik sand pit (Sea of Azov Region, early Middle Pleistocene): a – left lateral view; b – front view.

the skull is semi-circular without a saddle-shaped depression. The forehead surface is concave in the longitudinal direction and slightly convex in the transversal one. Nasal foramen is low, wide with pointed, slightly lowered down lateral edges. Its lower edge is located at the level of the eye orbits middle. The premaxillae are slightly narrowed from the sides in the middle part, so that they have an X-shape when viewed from the front. The skull is shortened in the anterio-posterior direction (Table 1). Fragments of tusks are preserved only in the alveoli of premaxillae. They have a well-defined spiral convolution. In the cross section they are oval and have a diameter of 215 × 174 mm (Baygusheva and Garutt, 1987; Garutt and Nikolskaya, 1988).

Horizontal mandible ramus is relatively deep. Dimensions of its height at the level of anterior part of alveoli (271 mm) are slightly larger than the length from the front teeth edge till the beginning of ascending branch (Table 2). Mental process of medium size is directed forward and downward. The vertical rami were damaged partly. They form approximately a right-angle with the horizontal ones.

In the skull and lower jaw, there are strongly erased M2/m2 (6.5 plates and posterior talon (=platelet) are preserved in the upper teeth, and 7 plates and talonid (=platelet) in the lower), and slightly worn M3/m3 (touched upon by erasing a talon and 6 plates in the upper teeth, and talonid and 5 plates in the lower ones) (Table 3). The incipient figure of plates wearing out is of meridionaloid type. There are two lamellae and a talon on the anterior root in all upper and lower teeth.

The atlas is elongated greatly in the transverse direction due to wings development (alae atlantis). Bodies of cervical vertebrae are noticeably shortened.

Due to the original restoration and the absence of some bones, it was impossible to restore the degree of epiphyses fusion on all bones. The femoral head on the right femur was unfused, most probably. The proximal epiphyses of right humerus and left tibia are fused with preservation of an open epiphyseal suture. Other epiphyses were presumably completely fused.

3.2. Skeleton of the 1999 excavation (Az II)

The premaxillae at the level of tusks beginning are slightly expanded. The angle of the tusks alveoli divergence is 50°. The premaxillae are slightly latero-medially narrowed in the middle part. The depression between alveoli is narrow and significantly expands aborally. The foramen magnum is oval with a long horizontal axis. The tusks are large; they extend from the alveoli down and sideways. The diameter of the right tusk at the alveolar level is 199 × 155 mm. The maximum tusk diameter is 185 mm in its middle.

The stylohyoideum has an almost complete left hyoid bone, except for the tip of the inferior ramus (Fig. 3). The longest inferior and superior rami are more than 173 mm. At the ends of posterior and superior rami cartilages were present during the life of an elephant. Inferior ramus significantly arched in the anterior-posterior direction. It branches off from the posterior-superior rami with the angle of 90°. The angle between the inferior and posterior rami is 65° (according to the measurements of Shoshani et al., 2007). For the stilohyoideum of Az II, there is a relatively small angle between the posterior and superior rami – 122°. The posterior and superior rami are oval in section. Anterior-posterior diameter of the superior ramus (its epiphysis broadened part) – 23.2, and its width is 12 mm. Its measurements in the neck are 17.3 × 9.4 mm. The posterior ramus height is 17.8, while its width is 10.6 mm in epiphysis part and 8 mm in the neck. Length ratio of the ratio of length of superior (36 mm) and posterior rami (45.4 mm) is

Table 1
Measurements of the skull of *Mammuthus trogontherii* from Middle Pleistocene deposits of Kagal'nik locality (Sea of Azov Region, delta of the Don River). A collection of the Azov museum-reserve, №№ AMZ KP-21081 (Az I, 1964 excavation), AMZ KP-28689 (Az II, 1999 excavation). ca – reconstructed measurements. * – Measurements were making during the excavations.

Skull Measurements (mm)	AMZ KP-21081/5 (Az I)	AMZ KP-28689 (Az II)*
Cranial length: distance between the front edges of orbits to condyles	695	–
Cranial height from top of cranium to grinding teeth	ca 1100	–
Length from top of cranium to the tip of premaxilla	ca 1900	–
Length from top of cranium to the lower edge of premaxilla	965	–
Length from condyles to the tip of premaxilla	1440	1150
Height of calvarium: from top of cranium to lower border of external auditory meatus	ca 700	–
Sagital height of the occipital: from the top of cranium to condyles including	ca 670	–
Occipital width	1056	–
Cranial width at the zygomatic process of temporal bones	1050	ca 830
Length of malar arch	ca 580	450
Distance between the inner edges of the alveoli tusks	375	–
Anterio-posterior diameter of the premaxilla above the tusk alveolus	226	–
Posterior rostral width (taken between the infra-orbital foramina)	640	ca 540
Rostral width in the middle part	570	–
Anterior rostral width	731	ca 660
Width of nasal fossa	ca 700	–
Width of foramen magnum	100	120
Height of foramen magnum	72	–
Width of occipital condyles	225	ca 151
Width of the left occipital condyle	85	91
Height of the left occipital condyle	117	110
Width of the right occipital condyle	–	90
Height of the right occipital condyle	–	116
Minimal palatal width between the anterior inner sides of grinding teeth	118	122
Length of premaxilla	962	–

Table 2
Measurements of the lower jaw of *Mammuthus trogontherii* from Kagal'nik sand pit (early Middle Pleistocene), collection of Azov museum.

Lower jaw measurements (mm)	AMZ KP-21081/5a (Az I)	AMZ KP-28689/6 (Az II)
Maximal length of mandible from the rostrum to an articular process	ca 880	ca 770
Maximum width between the outermost points of the horizontal rami	271	181
Length of symphysis	ca 207	ca 164
Length from the top of mental process to the front edge of the alveoli	380	270
Width of mental process at the base	ca 45	ca 35
Height of the horizontal ramus at the beginning of ascending branch	187	162
Maximal width of the horizontal ramus	200	200
Distance between inner part of horizontal rami at the level of posterior edges of chewing surfaces	320	180
Distance between inner part of anterior part of chewing surfaces	162	174
Length from the top of mental process to the front edge of the alveoli	105	–
Length from the front edge of the teeth to the beginning of ascending branch	260	ca 187
Length from the anterior edge of ascending branch to level of articular process	174	–

0.79. Cross section of the inferior ramus is semi-circular. The angle of deflection of inferior ramus from the axis formed by the posterior-superior rami is 21°. There are two bends in inferior ramus when viewed anteriorly. A shelf area at the place of three rami convergence is not observed.

There is a fragment of the posterior part of left thyrohyoid, semi-circular in cross section. Its end also used to be equipped with a cartilage. In the caudal part its width is 33.2 mm, and transverse diameter is 17 mm.

The ascending branch of lower jaw was significantly damaged during the excavation (Fig. 4). Mental process is small, its length about 19 cm, it is directed forward and downward. On both branches before the m3 there are vestiges from socket of m2.

Upper teeth M3 are of 2 wear stage (Fig. 5, Table 3). A talon and 9 plates are touched by wearing. Length of the occlusal surface is 183 mm on the left and 186.6 mm on the right M3. On the second and third plates there are weakly expressed median sinuses. The angle of teeth wearing is 60°, the angle of the occlusal surface relatively to the base of the crown – 45°. There is some lifetime pathological deformation of crowns. On the lingual surface of teeth anterior part there are 5 additional enamel columns on the right tooth, and 2 on the left one. Incipient wear figures on the occlusal surface of trinomial plate are of "meridionaloid type". They consist of three ovals, the middle of which is shorter and more rounded.

Lower teeth are of the second wear stage – 10 plates are touched by erasing. The crowns are large, wide and relatively low. The teeth are strongly curved. Interplate intervals after the third lamellar are sizeable.

The right rib of the anterior part of thorax with traces of lifetime fracture is of interest. The fracture occurred at about a half of the rib length. There is a significant overgrowth of bone tissue at the fracture place with the formation of a false joint.

The scapula is high and wide (Table 4). The spine high with a large hamiform process (processus hamatus), which forms the angle of 110° with it. The akromion is bent forward, hanging over the front surface of the scapula. Neck of scapula is relatively thin. Greatly thickened fused epiphysis on the medial border has three branches, which pass on the spine, cranial and caudal edges of the scapula.

The humerus with slightly curved axis noticeably narrowed in the middle of the bone. The ratio of the diaphysis width to the bone length is 11.72. Tall and broad deltoid tuberosity is protruded cranially significantly. The proximal bone end is massive. The head (caput humeri) is oval and convex. The distal bone part is flattened and massive. The front upper edge of the distal trochlea is rounded. The width of the medial trochlea is 2/3 of the lateral one. The coronoid fossa is deep. Lateral and medial epicondyles are bent backwards and form a deep olecranon fossa.

The ulna is slightly curved in the anterior–posterior direction. The ulnar olecranon is flattened and splays backwards. Its supraglenoid part exceeds the parameter in the articulation. The hamiform process (proccessus anconeus) is short, broad, slightly overhangs the semilunar notch. The semilunar notch (incisura semilunaris) is low and broad; its articular surface slightly comes to the sides of the hamiform process. The diaphysis in the middle of the bone is subtriangular in cross section.

The radius is thin with a curved diaphysis. The proximal end is slightly expanded. The ratio of its width to the smallest diaphysis width is 38.4. The distal end is expanded considerably; the diaphysis width at the epiphyseal suture slightly exceeds the joint width.

The pelvic bones (pelvis) are completely preserved in articulation with the sacrum and caudal vertebrae. The iliac bones are relatively long (Table 5). The iliac crest is convex. The surface of the wings is rough, concave on both sides. At the place of pubic bones' symphysis there is a well developed pubic tubercle. Oval obturator foramens are located obliquely in relation to each other. The ischial bones are narrow. The pelvic aperture is oval with a large horizontal diameter. Two halves of the pelvis were separated and connected with a cartilage.

The ratio of main pelvic canal width and the minimum ilium width above the acetabulum (measures 3 and 5, Table 5) is 2.7 sin and 2.66 dex in Az II skeleton, and the length ratio from the lowest point on the scar for the sacrum till to the closest point on the midline of the lower edge of the pelvic canal to the minimum width of the ilium (measures 2 and 5, Table 5) is 3.35 sin and 3.30 dex. The maximum transverse diameter and diagonal height of pelvic aperture were measured on the complete pelvis in situ during the excavations (Fig. 6). According to the data of Lister (1996), they unambiguously testify that the skeleton belonged to a female individual.

The femur is with a slightly curved medially distal end of the diaphysis. The bone is not massive, the ratio of the diaphysis width to its length is 12.5 (Table 6). The upper bone end is with an underdeveloped greater trochanter, which is located at the level of the base of femur head articular surface. The hemispherical head is removed medially from the bone axis and is located on a wide and

Table 3
Measurements of teeth M3/m3 *Mammuthus trogontherii* from Middle Pleistocene deposits of Kagal'nik locality (Sea of Azov Region, delta of the Don River). A collection of the Azov museum-reserve, №№ AMZ KP-21081 (Az I, 1964 excavation), AMZ KP-28689 (Az II, 1999 excavation). * – lamellar frequency in the middle of the crown/basal lamellar frequency.

Measurements	M3				m3		
	Az I		Az II		Az I		Az II
	sin	dex	sin	dex	sin	dex	sin
Length	372.0	354.0	385.0	380.0	418.0	–	330.0
Width	105.0	104.0	120.0	120.5	91.0	91.0	110.0
Height	189.0	191.0	206.0	210.0	168.0	–	141.0
Plate formula	t20p	t181p	t21p	t21p	t21p	–	t19p
Enamel thickness	2.3	2.4	2.91	2.95	2.2	2.4	3.53
Lamellar frequency	5.5	5.5	5.5	5.5	5.25/4.75*	5.9	5.25/4.75*
Length of single plate	19.0	19.0	16.04	16.0	19	19	18.74
Hipsodonty index	1.80	1.84	1.71	1.74	1.85	–	1.23

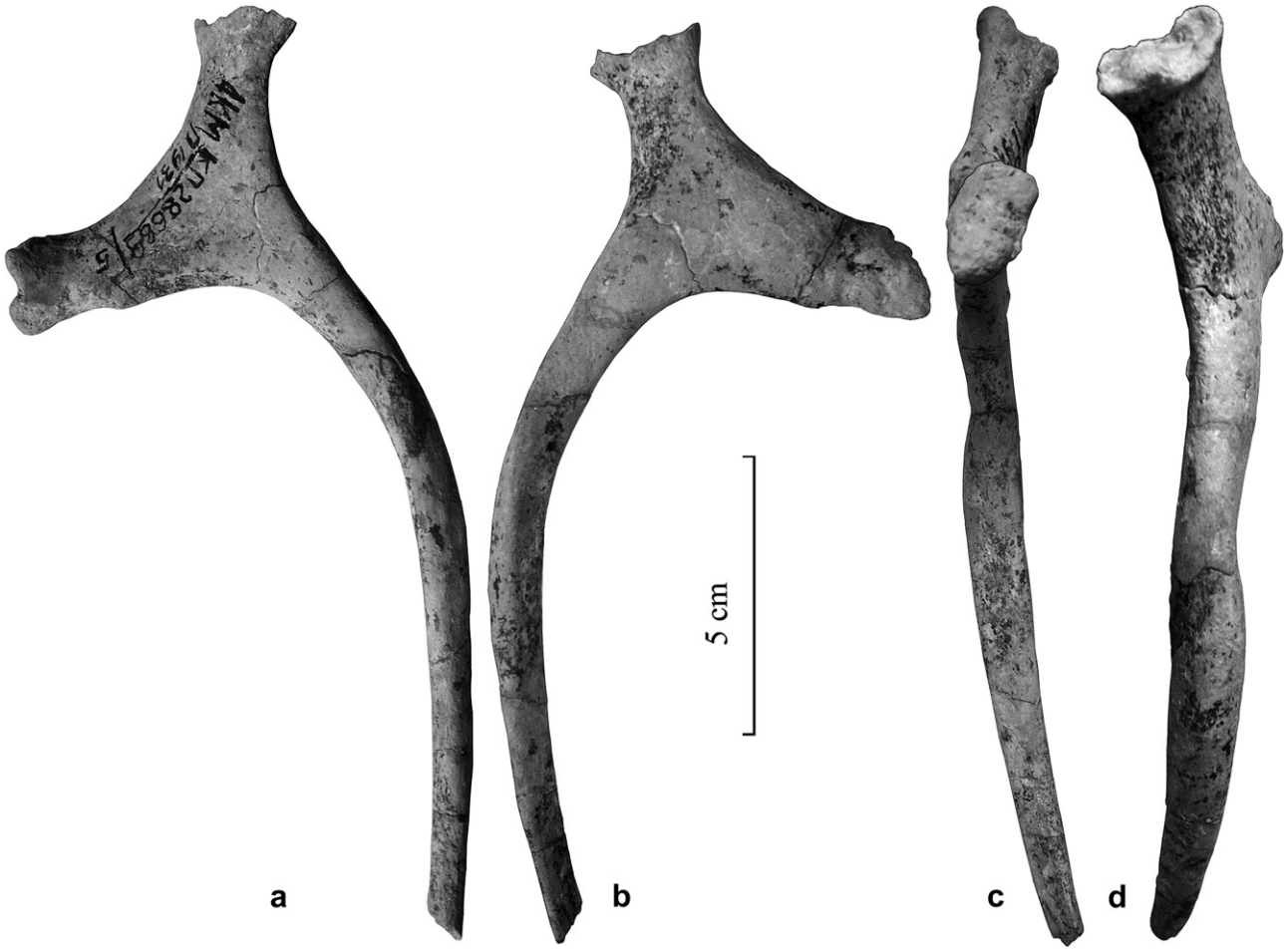

Fig. 3. Left stylohyoid bone (AMZ KP 28689/5) of *Mammuthus trogontherii* Az II from Kagal'nik sand pit (Sea of Azov Region, early Middle Pleistocene): a – medial view; b – lateral view; c – aboral view; d – rostral view.

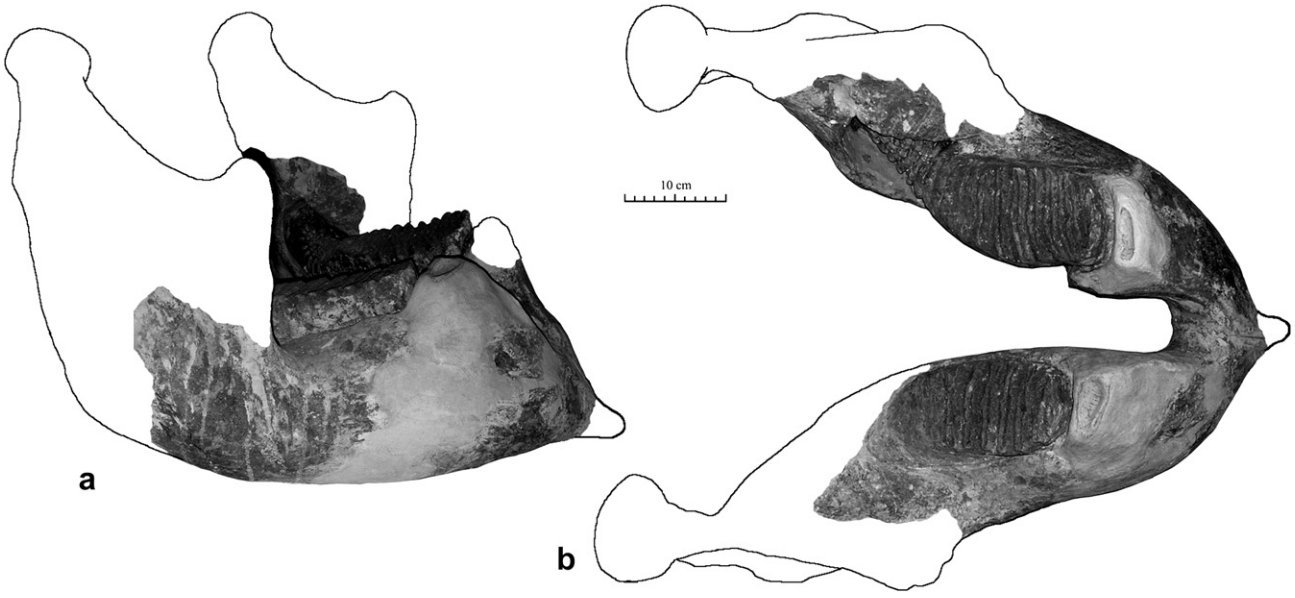

Fig. 4. The lower jaw of *Mammuthus trogontherii* Az II (AMZ KP 28689/6) from Kagal'nik sand pit (Sea of Azov Region, early Middle Pleistocene): a – right lateral view; b – occlusal view.

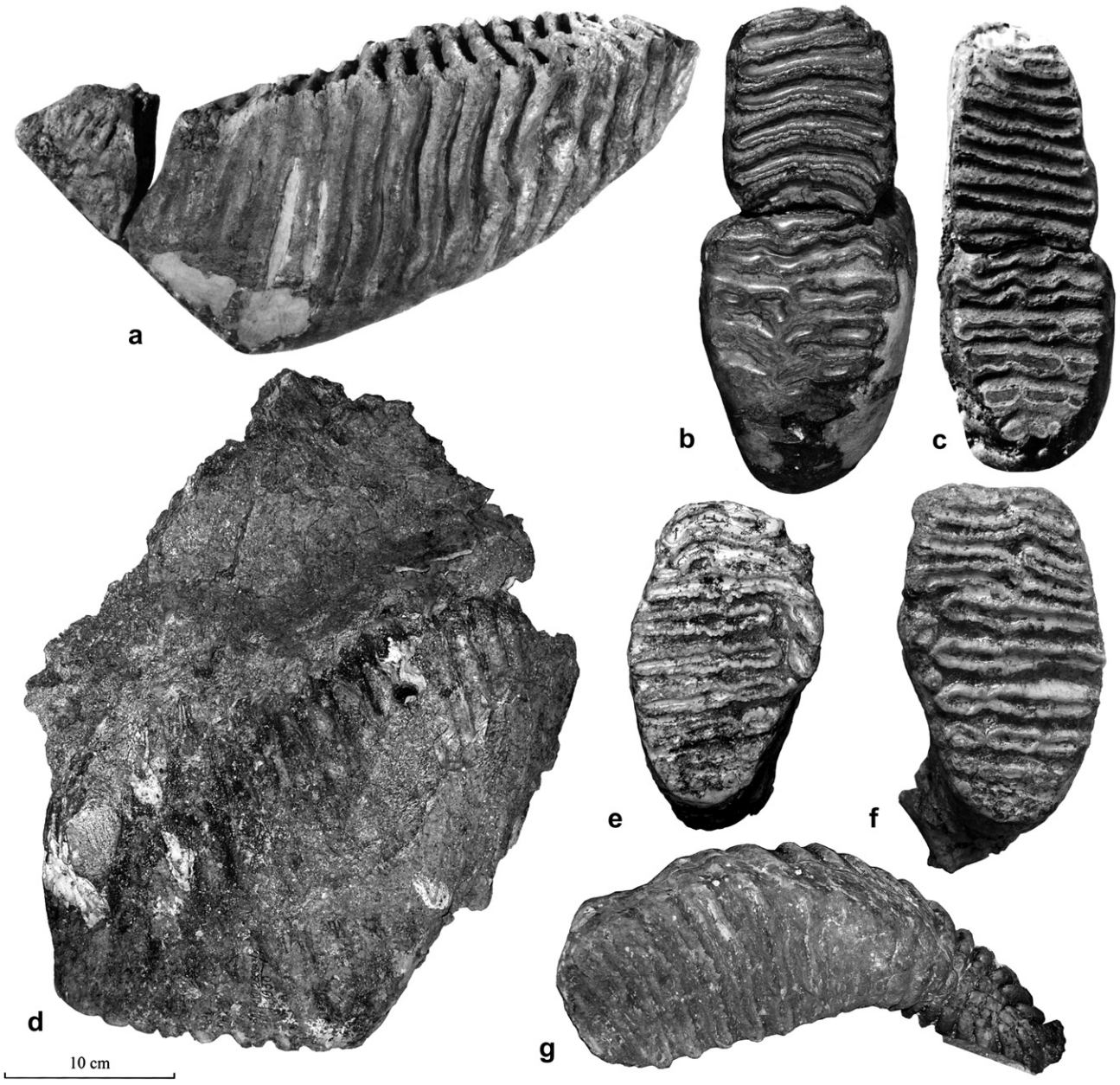

Fig. 5. Teeth of *Mammuthus trogontherii* from Kagal'nik sand pit (Sea of Azov Region, early Middle Pleistocene): a – left upper M3 and M2 of Az I (AMZ KP 21081/4) in lateral view; b – occlusal surface of right upper M2 and M3 of Az I; c – occlusal surface of right lower M2 and M3 of Az I; d – left M3 of Az II (AMZ KP 28689/4) in lateral view; e – occlusal surface of left M3 of Az II; f – occlusal surface of right M3 of Az II (AMZ KP 28689/3); g – left lower M3 of Az II (AMZ KP 28689/6) in occlusal view (the posterior part of the teeth is in the mandible).

short neck. The supraglenoid epicondyles are slightly wider than the distal articulation. The lateral condyle is subrounded with the splayed outer part. The medial condyle is suboval. The lateral trochlea edge for the patella is lowered.

The patella is oval. The ratio of its width to the length is 88.0 and 86.6 (for right and left, respectively). The corresponding ratios of maximum transversal diameter to the maximum width are 72.6 and 74.8.

The tibia bone is with a curved diaphysis. The medial side of the bone is straight, but lateral is concave. The tibial tuberositas is small. The crest (crista tibiae) is weakly developed. The ratio of the diaphysis width to the greatest bone length is 15.0 and 15.2 (left and right, respectively). Articular surface of the medial condyle of the distal joint is wider and oviform, with a longer transverse axis. The oval lateral condyle is more elongated longitudinally. The ridge that separates the surface of the condyles (eminentia intercondyloidea) is high. On the medial side of the distal end, the articular surface for the fibula is visible.

The vertebral bodies' epiphysis and spinous processes apophysis of vertebras are unfused. The degree of rib heads fusion is various: the majority of them are unfused, but some of them preserved the open epiphyseal sutures. A massive proximal epiphysis got fused on the scapulas, preserving an open epiphyseal suture. The iliac bones epiphysis of the pelvis, as well as pubic bone and ischium are joined by a cartilage. On the long limb bones the distal epiphysis of humerus and femur are completely fused, as well as proximal epiphysis of radial bones. The head and trochanter of the femur are combined into a single epiphysis. All the tibial epiphysis and the

Table 4
Measurements of forelimb bones of *Mammuthus trogontherii* from Middle Pleistocene deposits of Kagal'nik locality (Sea of Azov Region, delta of the Don River).

Measurements, mm	Az I	Az II sin; dex
Scapula		
Maximal length	–	1070.0; 1010.0
Distance from a crown of the front corner to the middle of articular socket	–	1045.0; 1040.0
Distance from a back corner to the middle of articular socket	–	620.0; 635.0
Width of a head together with a tuber, maximal	–	295.0; 320.0
Width of a neck of scapula	–	277.0; 270.0
Length of articular socket	–	245.0; 241.0
Width of articular socket	–	150.0; 140.0
Length of scapula crest	–	850.0; 840.0
Humerus		
Maximal length from the top of the humeral head to lateral edge of distal trochlea	1290.0	1160.0; –
Maximal transversal diameter of a head	240.0	262.0; 265.0
Width of proximal end	–	270.0; 275.0
Transversal diameter of proximal end	–	–; 375.0
Maximal thickness of distal end (at the level of epiphyseal suture)	347.0	330.0; –
Width of distal trochlea	292.0	274.0; –
Maximal thickness of medial trochlea	265.0	192.0; 205.0
Transversal diameter of diaphysis minimal	(198)	155.0; 160.0
Maximal thickness of lateral trochlea	205.0	165.0; –
Height of a trochlea	–	140.0; 140.0
Height of lateral epicondyle	–	400.0; –
Width of diaphysis minimal	–	136.0; 135.0
Ulna		
Maximal length	1250.0	1020.0; –
Length from the first edge of semilunar incisure to distal end	(950)	990.0; –
Width of articular surface for a humerus trochlea	(298)	270.0; 274.0
Width of distal end	–	210.0; –
Transversal diameter of distal end	–	190.0; –
Width of diaphysis minimal	108.0	115.0; 116.0
Transversal diameter of diaphysis	177.0	122.0; 120.0
Length of an ulnar processus	–	263.0; 260.0
Width of an ulnar processus	–	125.0; 118.0
Length of a semilunar notch	–	210.0; 210.0
Width of an inner articular surface of proximal end	–	120.0; 119.0
Width of an outer articular surface of proximal end	–	70.0; 80.0
Radius		
Maximal length	–	–; 930.0
Width of proximal end	–	148.0; 142.0
Transversal diameter of proximal end	–	–; 111.2
Width of distal end (at the level of epiphyseal suture)	–	148.0; 163.0
Transversal diameter of distal end	–	128.0; 127.6
Width of diaphysis minimal	–	56.0; 55.0
Width of distal articulation	–	130.0; 132.0
Transversal diameter of distal articulation	–	151.0; 149.2

proximal epiphysis of fibulas are fused, preserving a closed epiphysis suture. Open epiphysis sutures were observed in the attachment of diaphysis of distal fibular and right radial epiphyses, as well as the femoral head. The distal epiphysis of the left radius was found isolated.

The carpus structure in both skeletons of Kagal'nik is serial, as for southern meridionaloid elephants (Bajgusheva, 2001). The ratio of os lunatum width to the width of os magnum is 78.3 for Az I and 89.8 for Az II, and the ratio of the difference between the width of these bones to the os lunatum width – 21.7 and 10.21, respectively (Table 7). Such ratios are not characteristic for aserial carpus specified for *M. trogontherii* and *Mammuthus primigenius* (Dubrovo and Jakubowski, 1988).

There are number tarsal bones of the right side (Table 8), and several metacarpal bones of both feet (Table 9).

Table 5
Measurements of pelvis bones of female *Mammuthus trogontherii* from Middle Pleistocene deposits of Kagal'nik location (Sea of Azov Region, delta of the Don River). A collection of the Azov museum-reserve, № AMZ KP-28689 (Az II, 1999 of excavation).

Pelvis measurements (mm)	AMZ KP-28689	
	sin	dex
Maximal horizontal width of pelvic girdle	1820.0	–
Diagonal height of pelvic aperture from pubic symphysis to lowest point on the sacral attachment	723.0	–
Maximal horizontal width of pelvic aperture	583.0	–
Height of pelvic aperture from sacrum to share bones	660.0	–
Minimal width of ilium shaft	216.0	219.0
Distance between ischial tuberosities	490.0	–
Length of ilium, maximal	900.0	1000.0
Width of ilium wing from tuber coxae to nearest point of pelvic aperture	610.0	610.0
Longitudinal diameter of acetabulum	207.0	208.0
Length of pubic simphysis	560.0	–
Thickness of the upper part of share bone	120.0	–
Length of an oval aperture	245.0	250.0
Width of an oval aperture	120.0	130.0

3.3. Individual age determination

Based on data of the degree of bone epiphyses fusion, and taking into consideration the insufficient data, the individual age of *M. trogontherii* Az I is in the range of 30–50 years. According to the stage of teeth wearing, this sample refers to the XXI-XXII groups of African elephants by Laws (1966), Jachmann (1988), and Kangwana (1996). It corresponds to 37 ± 2 "African Equivalent years". Allowing for the specification for determining of age by the teeth (Lister and Stuart, 2010) for trogontherine elephants, the age can be defined as 40 years. This is close to the data for the age determination of 40–45 years old (Baygusheva and Garutt, 1987), made on the basis of the dental system development and the character of bone epiphyses fusion, which modern African and Indian elephants have (Lister, 1999; Kosintsev et al., 2004).

The second mammoth, Az II, was older. The character of epiphyses fusion indicates an age within the range of 30–50 years according to modern elephants' data (Lister, 1999). According to the degree of teeth wearing this individual belongs to XXIII–XXIV group (Kangwana, 1996) and its age is determined as 44 ± 2 years. Taking into account the correction of Lister and Stuart (2010), the age of the specimen can be defined as 47 years.

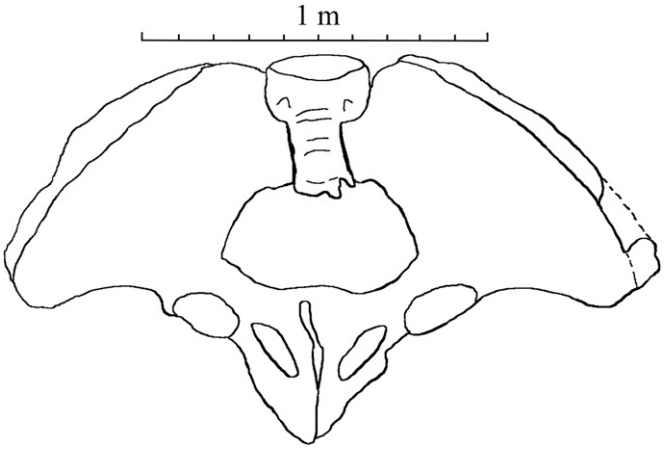

Fig. 6. The outline of *Mammuthus trogontherii* Az II pelvis from Kagal'nik sand pit (Sea of Azov Region, early Middle Pleistocene) during the 1999 excavations.

Table 6
Measurements of hind limbs bones of *Mammuthus trogontherii* Middle Pleistocene deposits of Kagal'nik location (Sea of Azov Region, delta of the Don River).

Measurements, mm	Az I	Az II sin; dex
Femur		
Maximal length from the top of a head to lateral end	-	1400.0; 1380.0
Medial length	-	1360.0; 1360.0
Transversal diameter of a head maximal	230.0	191.8; 195.0
Width of a neck minimal	-	174.0; 172.0
Width of distal end (at the level of epiphyseal suture)	-	280.0; 282.0
Width of diaphysis in the middle, minimal	(230)	175.0; 172.0
Transversal diameter of a diaphysis, minimal	-	110.0; 110.0
Width of articular surfaces for a patella	143.0	140.0; 140.0
Maximal width between external edges of articulare condyles	284.0	250.0; 253.8
Tibia		
Maximal length	890.0	800.0; 810.0
Width of proximal end, maximal	285.0	251.2; 267.0
Transversal diameter of proximal end	187.0	195.0; 190.0
Width of distal end, maximal	255.0	220.0; 196.2
Transversal diameter of distal end	172.0	160.0; 160.0
Width of a diaphysis, minimal	127.0	120.0; 123.0
Transversal diameter of a diaphysis, minimal	-	107.0; 101.0
Width of facet for astragalus	-	156.0; 153.0
Fibula		
Maximal length	ca 868	-; 750.0
Width of proximal end, maximal	81.0	-
Transversal diameter of proximal end	51.0	-
Width of distal end, maximal	151.0	-; 100.0
Transversal diameter of distal end	120.0	-; 65.0
Patella		
Maximal length	-	159.4; 155.0
Maximal width		138.0; 136.8
Transversal diameter, maximal		103.2; 99.4

Table 7
Measurements of wrist bones of *Mammuthus trogontherii* from Middle Pleistocene deposits of Kagal'nik locality (Sea of Azov Region, delta of the Don River).

Measurements, mm	Az I	Az II sin; dex
Navicular bone (os radiale)		
Maximal height	–	148.0; 155.0
Maximal width		135.3; 135.0
Width of proximal articular surface		74.8; 75.8
Width of distal articular surface for carpale I, II		108.6; 108.0
Width of distal articular surface for intermedium		–; 53.8
Lunate bone (os intermedium)		
Height of medial edge maximal	102.0	82.0; 81.0
Height of lateral edge maximal	97.0	62.0; 60.0
Width of proximal end	–	150.0; 154.0
Width of distal end for carpale III	166.0	140.5; 139.0
Transverse diameter maximal	162.0	150.7; 151.0
Triangular bone (os ulnare)		
Maximal height	–	–; 92.0
Width of proximal end		–; 128.0
Maximal transverse diameter		–; 181.8
Width of facet for carpale IV + V		–; 124.0
Pisiform bone (os pisiforme)		
Maximal height	–	–; 176.4
Width of facet for ulnare		–; 72.6
Transverse diameter in the middle of a bone		–; 74.6
Multitangulum major (os carpale I)		
Maximal height	–	–; 87.0
Width of facet for carpale II		–; 50.0
Width of facet for metacarpale I		–; 80.0
Multitangulum minor (os carpale II)		
Maximal height	–	57.4
Width of a forward surface		86.0
Transverse diameter maximal		93.6
Capitate bone (os carpale III)		
Height	136.0	–; 94.2
Width in front of the upper end	130.0	–; 124.8
Width of distal end	–	–; 100.8
Width behind of proximal end	128.0	–; 119.0
Transversal diameter of proximal end	–	–; 133.2
Transversal diameter maximal	158.0	–; 155
Hamate bone (os carpale IV + V)		
Medial height		–; 97.6
Width of distal end in front		122.2
Medial transversal diameter	–	123.0

3.4. Skeleton size

The shoulder height of the mounted Az I skeleton was 4.5 m by the definition of Garutt (1964), while the growth of the mammoth reached 4.8–4.9 m (Baygusheva and Garutt, 1987). On the base of calculated relations of limb bones length and skeleton height of some trogontherine (from Odessa, West Runton, Steinheim, Edersleben) and southern elephants (from Nogaisk and Georgievsk), as well as of the large mammoth *M. primigenius* "*fraasi*" (from Stuttgart), the following data were obtained: the length of the scapula in average is 27.7% of the skeleton shoulder height, humerus – 32.4%, ulna – 26.7%, radius – 24.9%, femur – 37.6%, tibia – 22.1%, and fibula – 20.95%. These data are similar with the relations given by Dubrovo (1975) for woolly mammoths, but do not coincide with those of Shpanskiy et al. (2008). Consequently, data on the skeleton shoulder height of *M. trogontherii* from Kagal'nik sand pit were obtained. For the Az I height was 4158 mm, and for Az II – 3719 mm.

3.5. Sex determination

The male gender of sample Az I is not in doubt. This is indicated by its large size, massive tusks and a well-pronounced relief of postcranial skeleton bones (Baygusheva and Garutt, 1987). Unfortunately, the adverse conditions during its excavations together with low fossilization did not allow preservation of its pelvis and the necessary measurements.

Characteristics of skeleton Az II do not definitely determine its sex. The relatively thick tusks argue for the male gender. Their diameter is insignificantly smaller to those of the Az I, considered male. Later fusion of postcranial skeleton bones epiphyses also suggests male gender. Only the distal epiphyses of humerus and femur, and proximal one of radius are completely fused. Other epiphyses of limb bones are not fully fused, and they preserve open epiphyseal sutures. It is known that recent elephant's females are characterized with the earlier fusion of long bone epiphyses at about 25 years old, whereas males have this process completed only at about 40 years (Lister and Stuart, 2010).

However, there are some data incompatible with referring the skeleton to the male gender. First are the pelvis characteristics. The pelvic aperture on the fine-preserved pelvis of Az II is relatively wide (the horizontal diameter is bigger than the vertical). According to the pelvis indexes proposed by Lister (1996), this part of the skeleton most likely belonged to a female. The ratio of the main pelvic canal width and the minimum width of the ilium above the acetabulum is slightly greater than that of males. The second index, the ratio of the length from the lowest point on the scar of the sacrum to the closest point on the midline of the lower edge of the pelvic canal to the minimum width of the ilium, is typical for females. In addition, the two halves of the pelvis were connected by cartilage. Comparative characteristics of the two skeletons from Kagal'nik sand pit also indicate the affiliation of the second skeleton to the female gender. The second skeleton is noticeably smaller, and its bones are slender. The degree of slenderness, defined by the ratio of diaphysis width to the bone length is for humerus Az I – 15.3, and for Az II – 11.7, for ulna – 11.4 and 11.3, tibia – 14.3 and 14.1, respectively. The first sample submental process is larger than

Table 8
Measurements of right tarsal bones *Mammuthus trogontherii* from Middle Pleistocene deposits of Kagal'nik location (Sea of Azov Region, delta of the Don River) from the collection of the Azov museum-reserve, № AMZ KP-28689 (Az II, 1999 excavation).

Measurements, mm	dex
Astragalus (os astragalus)	
Maximal medial height	160.0
Maximal width	186.2
Transversal diameter, maximal	110.0
Width of articulation facet for tibia	147.0
Transversal diameter of articulation facet for tibia	135.0
Width of facet for a calcaneal bone	158.0
Transversal diameter of facet for a calcaneal bone	108.0
Width of facet for naviculare	162.4
Transversal diameter of facet for naviculare	85.0
Calcaneum (os calcaneus)	
Maximal height	246.0
Width of facet for astragalus	171.2
Transversal diameter of a tuber	167.0
Width of facet for tarsale IV + V	103.0
Transversal diameter of facet for tarsale IV + V	71.0
Central tarsus bone (os naviculare)	
Width of facet for astragalus, maximal	135.0
Transversal diameter of facet for astragalus	89.2
Width of distal end	154.2
Transversal diameter of distal end	101.4
Height of a bone at a front edge	50.2
Medial cuneiforme bone (os tarsale I)	
Height at a front edge	83.0
Width of a distal edge, maximal	50.0
Transversal diameter of distal edge	40.0
Intermediate cuneiforme bone (os tarsale II)	
Height at a front edge, maximal	41.4
Width at the greatest	59.0
Transversal diameter, maximal	100.6
Lateral cuneiforme bone (os tarsale III)	
Height at a front edge, maximal	41.6
Width at the greatest	82.2
Transversal diameter, maximal	120.0
Cuboideum bone (os tarsale IV + V)	
Height at a front edge, maximal	49.4
Width at the greatest	128.2
Transversal diameter, maximal	139.0

the second one, despite the fact that Az II is older than Az I by about 7 years. According to the pooled data, Az II was most likely female. The existing discrepancies can be explained by insufficient knowledge of these large elephants' features and peculiarities of their habitat.

Table 9
Measurements of metatarsal bones *Mammuthus trogontherii* from Middle Pleistocene deposits of Kagal'nik location Sea of Azov Region, delta of the Don River). A collection of the Azov museum-reserve, № AMZ KP-28689 (Az II, 1999 excavation).

Measurements, mm	Mt I		Mt II		Mt III		Mt IV		Mt V	
	dex	sin	dex	sin	dex	sin	dex	sin	dex	sin
Length	77.4	149.4	167.0	171.0	158.0	160.0	105.2	106.2		
Width at proximal end	40.0	58.8	85.5	84.6	79.4	83.0	62.0	57.4		
Transversal diameter at proximal end	(45)	80.2	98.2	85.0	89.0	(87)	77.2	72.6		
Width of distal end	38.0	66.2	78.2	78.2	78.0	74.0	80.4	74.8		
Transversal diameter of distal end	52.0	79.0	84.8	87.2	94.4	90.8	88.0	84.6		

4. Comparison

According to teeth characteristics, elephants from Kagal'nik sand pit fall within the variability range of *M. trogontherii* from Süssenborn and Tiraspol. The length of the crown is at the upper limits of the teeth from Süssenborn and close to the average parameters from Tiraspol (Dubrovo, 1975), as well as to the tooth from West Runton (Great Britain; Lister and Stuart, 2010), and Nolhac (France; Mol and Lacombat, 2009; Figs. 7 and 8). The lamellar frequency of upper teeth of elephants from the Sea of Azov region fall into the extreme lower variability limits of mammoths from these localities.

These finds are ones of the largest among representatives of the species. They are similar in size with the same from East Runton (Great Britain; Lister and Stuart, 2010), Khadzibeysk estuary (Odessa, Ukraine; Yatsko, 1948), Steinheim (Germany; Lister and Stuart, 2010), smaller than the specimen from Pyatiryzhsk (Western Siberia, Kazakhstan; Shpanskiy et al., 2008). They are somewhat larger than the elephant from Edersleben (Germany; Lister and Stuart, 2010) and Novogeorgievsk (Stavropol; Zakrevska, 1935).

On the graph of ratio of limb bones lengths (Fig. 9) there are some differences in forelegs proportions in several specimens. This probably can be explained by individual characteristics, as well as by differences in the methods of measurements. On the graph of bones slenderness ratio, there is a significant difference of characteristics of the elephant from Chembakchino (Lower Irtysh). It is also attributed by some authors to the steppe mammoth (Kosintsev et al., 2004). However, such distinctions may indicate different taxonomic affiliation.

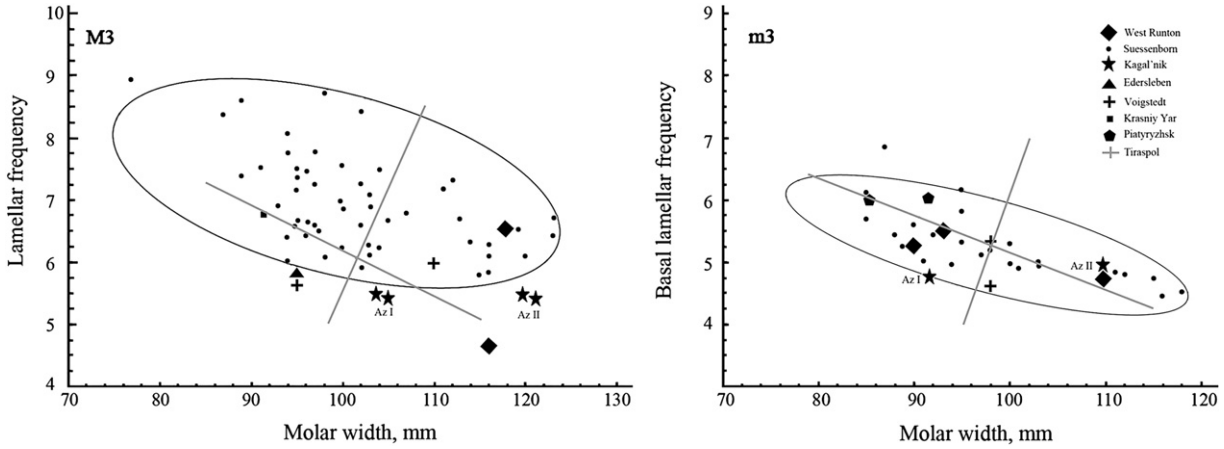

Fig. 7. Lamellar frequency of upper M3 and lower m3 of some *Mammuthus trogontherii* plotted against molar width. Data of teeth parameters from Süssenborn according to Lister and Stuart (2010, Fig. 26), and from Tiraspol according to Dubrovo (1975).

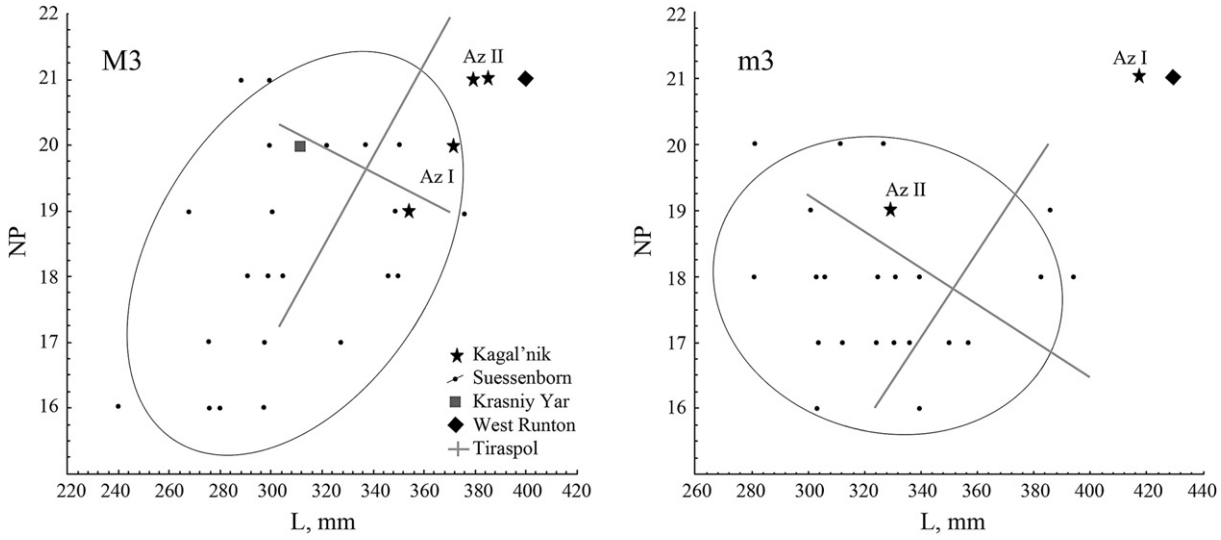

Fig. 8. Number of plates (NP) of upper M3 and lower m3 of some *Mammuthus trogontherii* plotted against crown length (L). Data of teeth parameters from Süssenborn according to Guenther (1969), and from Tiraspol according to Dubrovo (1975) with changes.

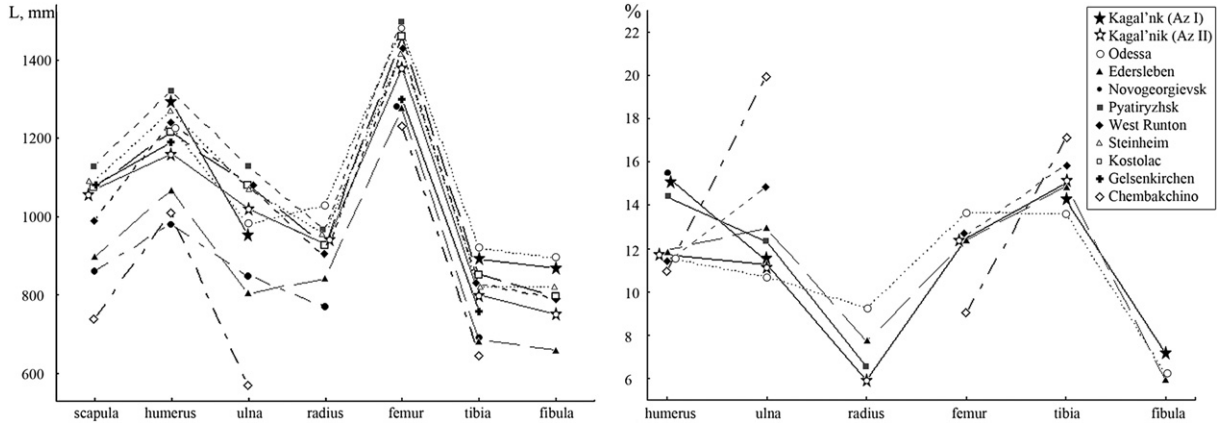

Fig. 9. The ratio of limb bones length (left), and limb bones' slenderness (right) of throgontherine mammoth.

5. Conclusions

The findings of two almost complete skeletons of *M. trogontherii* in one locality in the Sea of Azov region is rather a unique occurrence. Both skeletons belonged to adult animals with a difference of individual age of approximately 7 years. The larger skeleton, according to its characteristics, was male. The second smaller one was older. According to the pooled data, most likely it was a female. Parameters of these specimens testify to their similarity with other members of the species from early Middle Pleistocene of Europe, for example, from Süssenborn and Tiraspol. The ordinary of these animals' remains in Eastern Europe indicates that they were common for Tiraspol faunal complex (=Cromerian) in that territory. Due to insignificant dimensional differences and similarities of the dentition of *M. trogontherii* from Western and Eastern Europe, Western Siberia, the living conditions of these animals over a wide area were similar.

The rather large size and features of the habitat most likely were the cause of some differences in their skeletons' development, compared to modern elephants and woolly mammoths. The same factors probably caused a slightly different development of sex differences. The rarity of finds of trogontherii elephants' skeletons, as well as samples from Kagal'nik sand pit, does not allow these questions to be resolved completely for the moment.

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