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Kastykhtakh mammoth from Taimyr (Russia)

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ABSTRACT

Taimyr Peninsula is a unique region of Northern Russia, with spectacular outstanding finds of complete mammoth skeletons and carcasses. In 2008, a skeleton of a small female mammoth was found in the Upper Karga deposits of Kastykhtakh River valley. The animal lived during the Middle Valdai megainterstage (Weichselian, Denekamp Interstadial) about 32070–30565 BP. The skeleton contains 104 bones. The individual shows several peculiar features, including skeletal malformations, such as the fissure in the atlas' neural arch, several fractures of ribs having been broken independently, sigmoid contact between lower molars m2 and m3, and a notable displacement of m2 relative to the axis of the mandible.

1. Introduction

Although discoveries of mammoth remains are common in Eurasia, skeletons are still rare. The samples from Taimyr occupy a special place among them. The research history of mammoths from the Taimyr Peninsula, situated on the north of Siberia, is associated with the beginning of scientific exploration of the region. The first find of a *Mammuthus primigenius* skeleton was made by Alexander Middendorf in 1843 on the Upper Taimyr River, during the famous Siberian expedition of the Russian Academy of Sciences. Since the second half of the 19th century, skeletons and carcasses of woolly mammoths which lived during different periods of the Pleistocene were discovered in the permafrost of the Taimyr Peninsula (Mol et al., 2003, 2006). Some of them are well investigated.

Here, in 1908, an incomplete skeleton of a large adult male was discovered in the Mokhovaya River basin, which was called subsequently the Kutomanov mammoth (Averianov, 1994). This skeleton is about 35,000 years old according to ^{14}C dating. In the description, which was made many years after the discovery, it was revealed that the biological age of the Kutomanov individual is 50–60 years (based at the teeth M3 wearing, defined by analogy with the modern Asian elephant). However, its age, determined by the epiphysis's fusion at large long bones, was much younger. The reason of such a discrepancy could be explained by faster tooth wear caused by a special composition of feed and/or by dust laden with mineral particles. The shoulder height of the mammoth skeleton was determined at about 290 cm (Averianov, 1994). According to the radiocarbon date (35800 ± 2700 years, after Heintz and Garutt, 1964) the Kutomanov mammoth lived in the Karga interglacial period.

Another important find was made in Taimyr in 1948 in the valley of an unnamed river, which later was called "the Mammoth River" (the Upper Taimyr River basin). A nearly complete skeleton with the remains of soft tissues belonged to an adult 45–50-year old male. It has almost completely fused epiphyses of long bones (Garutt and Dubinin, 1951). Geological age of the finds determined by the radiocarbon method was 11,450 ± 250 years (Heintz and Garutt, 1964), corresponding with Late Sartanian age (=Late Glacial Boiling-Allerod interstadial). During the mounting of the Taimyr mammoth skeleton in the Zoological Institute of the USSR (Leningrad, Russia), Garutt used new principles developed from the analysis of previous reconstructions. The proportions of its feet were used as an illustration of the mammoth size dependence from the climatic conditions (Heintz and Garutt, 1964; Garutt, 1964; Heintz and Garutt, 1965, Fig. 2). Thus, the work with this sample represents a new stage in the study of mammoth and skeletons' mounting, summarizing many years work of several paleontologists. Moreover, by the proposal of Garutt, the Taimyr mammoth was officially accepted as a neotype of *M. primigenius* (Blumenbach, 1799) instead of the holotype, which was accepted as lost at that time (Garutt et al., 1990; Garutt, 2001). The youngest findings of *M. primigenius* from Taimyr date are 9670 ± 60 BP and 9920 ± 60 BP (Sulerzhitskiy and Romanenko, 1997; Mol et al., 2003).

This paper presents the results of a first study of the new find of an almost complete mammoth skeleton from the Taimyr Peninsula. It was found by Viktor Bakush in autumn 2008 under the steep right bank of the Kastykhtakh River (a tributary of the

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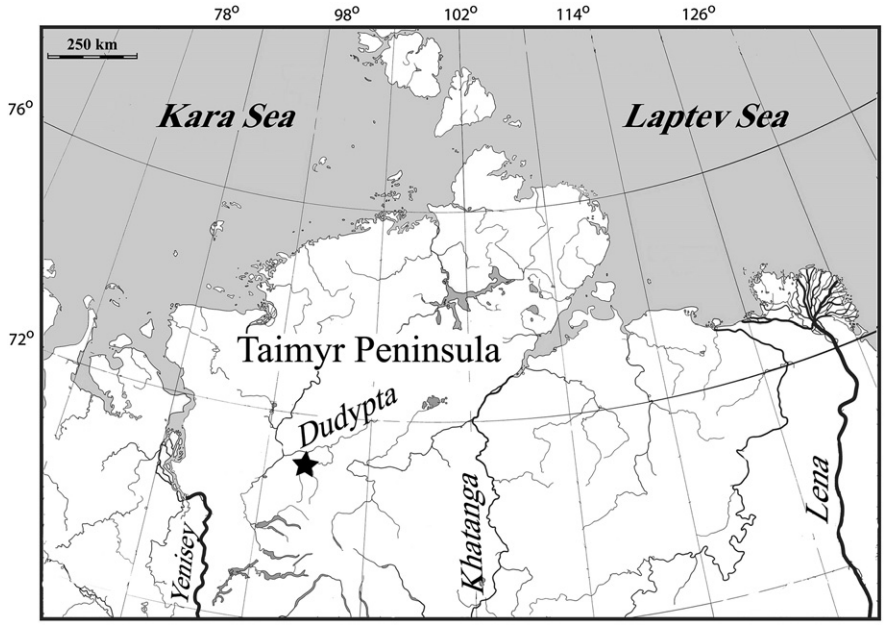

Fig. 1. Kastykhtakh mammoth locality, Taimyr Peninsula of Northern Russia (asterisk).

Dudypta River), at 2.5 km upstream from its mouth (Fig. 1). In this area the bank escarpment is about 7 m height. The upper part of the cross-section consists of peat deposits about 2 m thickness. Its lower part is covered by landslides but, in places, yellowish-grey fine-grained sand layers appear at the surface and a horizontal boundary of two sedimentary units is observed (V. Bakush, personal communication, 2008). The skeleton occurs almost in anatomical order at the foot of the outcrop. The skull and limb bones were located 0.7 m away from its vertebral column. Such a distribution of bones is indicative of a recent defrosting of the skeleton from the permafrost. The cavities of the skull and other bones were filled with silt which supplied by the lower sedimentary unit.

2. Materials and methods

The sample is kept in the "Ice Age" Museum collection, Moscow, Russia (collection number F-2466/1-104). The skeleton consists of a considerable part of the elements, including one tusk (Fig. 2). Bones are dark-grey, and have good natural preservation. In each jaw at the moment of animal death, teeth of the two last generations are present. The axial skeleton is represented by 7 cervical, 19 thoracic, 5 lumbar, 1 sacral (fragment), and 2 caudal vertebrae of the vertebral column, incomplete sacrum, both scapulas, complete pelvis, and almost all ribs including 19 right and 20 left ones except the distal parts of 7 posterior left ribs. All long limb bones are present, but the right tibia, left humerus, and fibulae are fragmentary. Distal parts of

Fig. 2. Preserved parts of female *Mammuthus primigenius* from Kastykhtakh River (Taimyr Peninsula, Russia). Missing elements are marked in grey.

Table 1
Measurements of the skull of *Mammuthus primigenius* from Kastykhtakh River locality (Late Pleistocene), collection of Ice Age museum.

Skull measurements (mm)	F-2644/1
Anterior rostral width	267.0
Distance between the inner edges of the alveoli tusks	120.0
Antero-posterior diameter of the premaxilla above the tusk alveolus	90.0
Antero-posterior diameter of premaxilla at the level of the mid-rostrum	86.0
Antero-posterior diameter of the premaxilla at the level of the chewing surfaces of teeth	107.5
Rostral width, minimal	105.5
Posterior rostral width (taken between the infra-orbital foramina)	237.0
Internal width of the palate taken at the anterior grinding teeth	91.0
Internal width of the palate taken at the posterior grinding teeth	123.0
Height of processus zygomaticus, minimal	25.0
Zygomatic width, maximal	(500)
Width of nasal fossa	(320)
Maximal supra-orbital width	432.3
The width of the occipital socket	88.6
Width of foramen magnum	63.0
Height of foramen magnum	52.0
Width of occipital condyles	184.5
Width of the left occipital condyle	66.0
Height of the left occipital condyle	78.0
Width of the right occipital condyle	69.8
Height of the right occipital condyle	77.0
Maximal width of choanae	66.9
The length of the palate from the front edge of the chewing surfaces of teeth to choanae	195.0
Minimal palatal width between the interalveolar cristae	28.1
The length of the orbitotemporal fossa	197.5
Height of the orbit	(76.5)
Length of premaxilla	380.0
Length of the fossa incisiva	422.5

anterior and posterior extremities are incomplete and represented by 2 astragali, 8 metapodia, and 2 phalanxes.

The measurements of limb bones were made by the standard method of Driesch (1976) with addition by Garutt (1954), Lister (1996), and Mol et al. (1999). Descriptions and measurements of teeth follow Dubrovo (1960), Maglio (1973), and Garutt and Foronova (1976). Individual age was determined by the averaged data of teeth generations (according to Garutt, 1977), and the regularity of epiphysis adhering to the bones of recent elephants *Loxodonta africana* and *Elephas asiaticus* (Lister, 1999; Kosintsev et al., 2004). Radiocarbon dating was made in the Laboratory of Biogeocoenology and Historical Ecology of A.N. Severtsov Institute of Ecology and Evolution (IEMAE RAS).

3. Description and comparison

3.1. Description

The skull has a semicircular top and a small saddle-shaped depression. On each side of the fossa nuchales, there are slightly convex occipital tubercles. Supraorbital processes are small. Premaxillary bones are slightly widened with a small narrowing in the middle part (Table 1).

The extant right tusk is quite thin, and has a diameter at the base 57.8×69.0 mm. Total length of the tusk by the greater curvature is 1150 mm, and by the small one, 1010 mm. It is weakly helically folded outwards and forward. There are two wearing sections on it. The largest (303×38.3 mm) is located on the front surface of the distal part of the tusk, its proximal edge located at a distance of 362 mm from the tip of the tusk. A small one located on the dorsal side of the end of the tusk has dimensions of 100×36 mm.

Table 2
Measurements of the lower jaw of *Mammuthus primigenius* from Kastykhtakh River locality (Late Pleistocene), collection of Ice Age museum.

Lower jaw measurements (mm)	F-2644/2
Maximal length of mandible from the rostrum to an articular process	380.0
Maximum width between the outermost points of the horizontal rami	425.0
Maximum width between the outermost points of the articular processes	417.0
Length of symphysis	90.6
Height of symphysis	63.0
Anterior-posterior length of the ascending branch	208.0
Height of the horizontal ramus at m3	118.0
Maximal width of the horizontal ramus	117.0
Width of the articular condyle	74.0
Antero-posterior diameter of the articular condyle	51.5

The lower jaw is short and high, with well defined jaw angle (Table 2). The submental process is weakly pronounced, with 3 small tubercles.

At death, two teeth functioned in each jaw of the animal. There were considerably erased M2 and m2, which have intensively resorptioned roots, but approximately half of plates are worn on

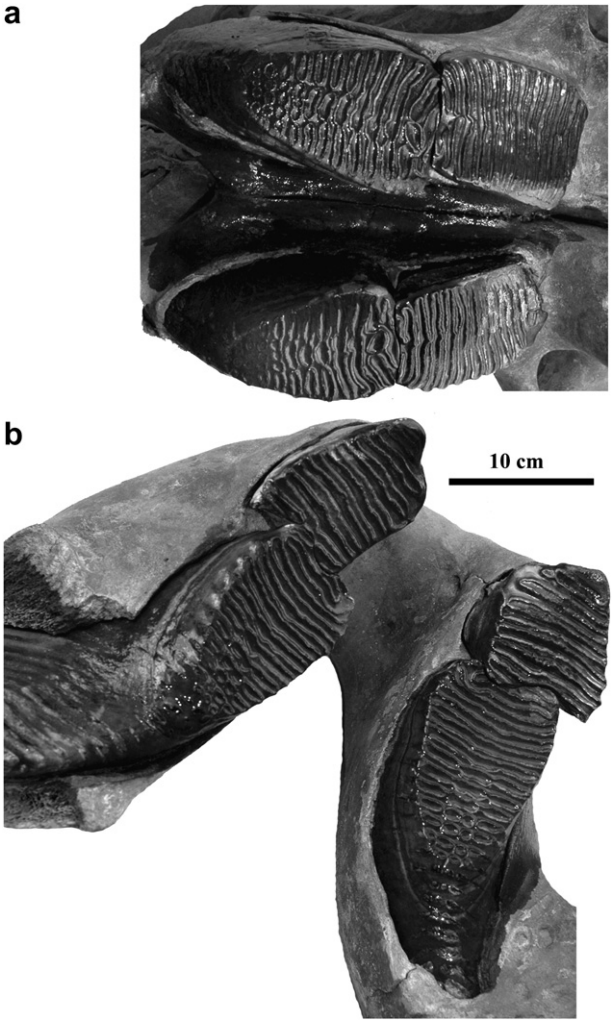

Fig. 3. *Mammuthus primigenius* from Kastykhtakh River (Taimyr Peninsula, Russia; Upper Pleistocene), collection of Ice Age museum: (a) upper jaw fragment with left and right M2-M3 F-2644/1, occlusal view; (b) lower law with left and right m2-m3 F-2644/2, occlusal view.

Table 3
Teeth measurements of *Mammuthus primigenius* from Kastykhtakh River locality (Late Pleistocene), F-26644/1, collection of Ice Age museum. * – in mandible; t – talon/talonid; ~ obliterated plates; – data in brackets are approximate.

Teeth measurements (mm)	M^2 sin	M^2 dex	M^3 sin	M^3 dex	M_2 sin	M_2 dex	M_3 sin	M_3 dex
Tooth formula	~11~^{t}	~11~^{t}	>t16*	t24t	~7~	~8~	^{t}~21t	^{t}~20t*
Length of a crown	>89	>88.5	–*	243.8	(88.5)	(76.25)	225	–*
Width of plates	70.0	73.0	75.7	74.1	61.8	59.3	69	68.2
Height	–	–	–*	154.6	–	–	126.0	–
Lamellar frequency	13.0	13.25	11.25	11.75	10.0	9.5	12.62	12.0
Length of single plate	7,8	7.75	8.97	8.62	9.5	10.4	8.42	8.34
Enamel thickness	1.27	1.24	1.34	1.39	1.47	1.42	1.40	1.51
Wear stage	6	6	3	3	6	6	3	3

M3 and m3 (Fig. 3, Table 3). The complete replacement of the second molar by the third one in recent elephants happens at the age of 40–45 years (Garutt, 1977). Hence the individual age of the mammoth from Kastykhtakh, by teeth characteristics, is estimated at 35–40 years.

The degree of rib head fusion varies: 10 heads are unfused, and on the other ones the epiphyseal sutures remained open. Proximal epiphyses on the scapulas are fused, with an open epiphyseal suture. Epiphyses iliac bones of the pelvis, as well as pubic and the ischium, are not fully fused, with preservation of predominantly open epiphyseal sutures. In the long limb bones, distal humeral and femoral epiphyses and proximal epiphyses of radial, ulnar and tibia are completely fused. Open epiphyseal sutures are marked in the field of joining of the proximal joints to the diaphysis of the humerus, as well as the distal epiphysis of the tibia. The femoral head, distal epiphyses of radius and ulna bones are unfused. In the vertebrae, the fusion of the epiphyses is complete only at the cervical vertebrae, with recent fusing in the thoracic ones (with preservation of epiphyseal suture), and in some cases in the lumbar. Individual age of the mammoth from Kastykhtakh according these data corresponds to 38–45 years (Lister, 1999). Thus, the individual's ages, as defined by the dental system state and stage of epiphysis fusion, in general are similar. Some discrepancy may be due to sexual and individual characteristics.

The ratio of the width of the main pelvic canal, and the minimum width of the ilium above the acetabulum (measures 3 and 5, Table 11) is 3.06 for the mammoth from Kastykhtakh, and the ratio of the length from the lowest point on the scar for the sacrum, 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 11) is 2.77. According to Lister (1996) they unambiguously testify that the skeleton belonged to a female individual. Female sexual attribution is also indicated by the rather thin and weakly curved tusks, the weak symphysis's submental processes, and the absence of the tuber and rugosity of muscle attachment on the first cervical vertebra (Garutt, 1992; Averianov, 1996).

The height of the skeleton at shoulder for the Kastykhtakh mammoth was calculated on whole long limb bones using the

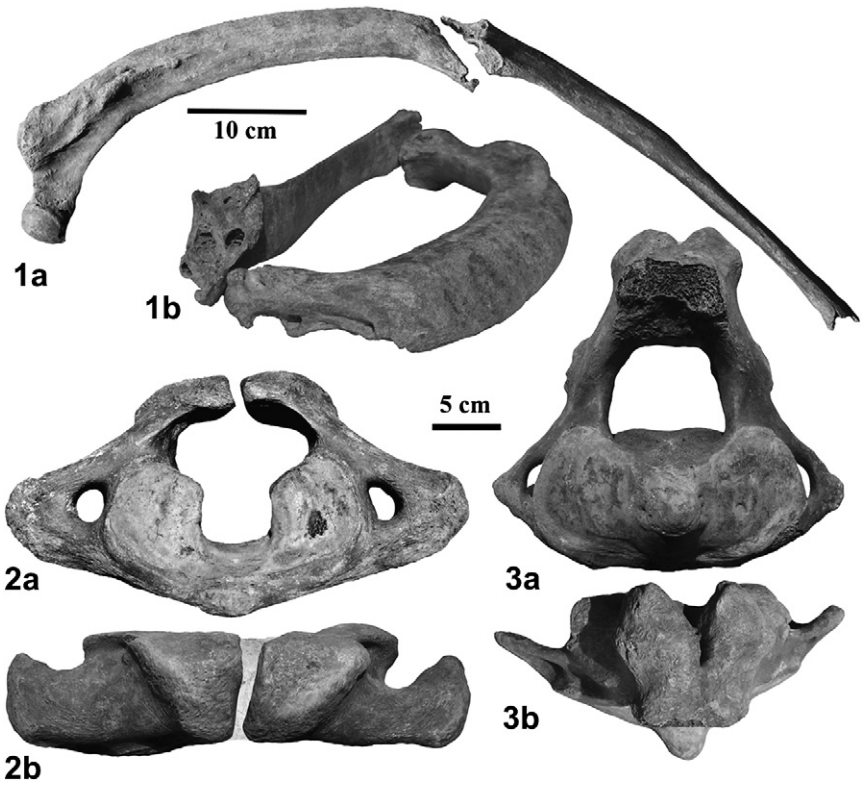

Fig. 4. *Mammuthus primigenius* from Kastykhtakh River (Taimyr Peninsula, Russia; Upper Pleistocene), collection of Ice Age museum, individual features: 1. Right rib F-2644/41 with false joint in the place of intravital fracture (a) general view, (b) the place of connection of the false joint; 2. First cervical vertebra (atlas) F-2644/3 (a) posterior view, (b) dorsal view; 3. Second cervical vertebra (epistropheus) F-2644/4 (a) anterior view, (b) dorsal view.

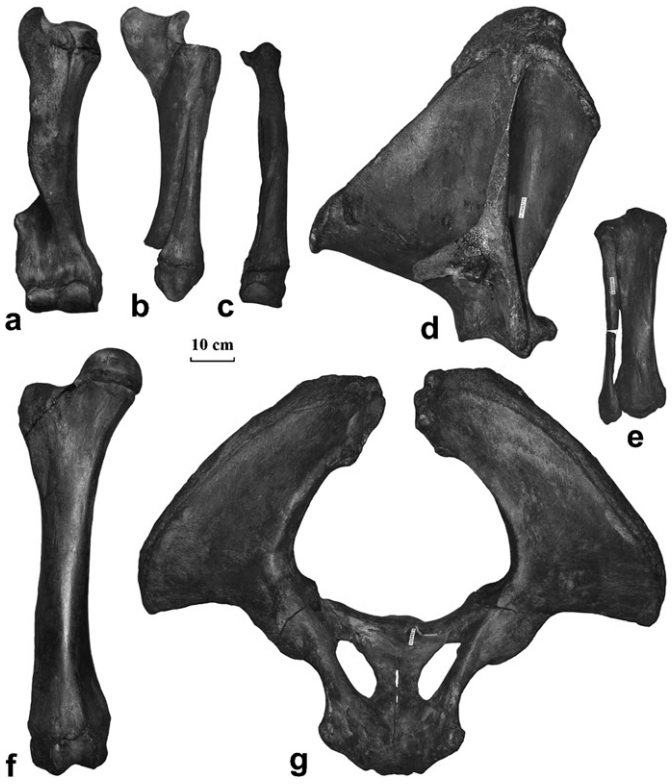

Fig. 5. *Mammuthus primigenius* from Kastykhtakh River (Taimyr Peninsula, Russia; Upper Pleistocene), collection of Ice Age museum, postcranial skeleton bones: (a) right humerus F-2466/78, anterior view; (b) bones of left forearm F-2466/79-80, medial view; (c) right radius F-2466/79, anterior view; (d) right scapula F-2466/77, lateral view; (e) bones of left crus F-2466/89-90, posterior view; (f) right femur F-2466/86, anterior view; (g) pelvis, posterior view.

coefficient suggested by Garutt (1964). For the humerus it is 32.2% of the height of the skeleton, and for the tibia –21.4%. In both cases the skeleton's height is 2.24 m.

3.2. Individual features

The mammoth female skeleton from Taimyr has several individual features:

Table 4
Measurements of scapulas of *Mammuthus primigenius* from Kastykhtakh River locality (Late Pleistocene), collection of Ice Age museum.

Scapula measurements (mm)	F-2644/77 dex	F-2644/81 sin
Maximal length	660.0	671.0
Distance from a top of the front corner to the middle of articular socket	637.0	632.0
Distance from a crown of a front corner to the middle of articular socket	403.0	(400)
The distance from the rear corner to the middle of the articular cavity	495.0	500.0
Width of a head together with a tuber, maximal	222.0	218.0
Width of a scapula's cervix	187.0	184.5
Transverse diameter of a scapula's cervix	70.0	58.5
Length of articular socket	164.0	168.0
Width of articular socket	93.0	90.5
Length of scapula crest	(512)	(525)
Height of a hamate process	(184)	191.0
The width of a scapula's ridge in front	47.0	43.5
Maximum height of a scapula (between anterior and posterior corners)	614.0	–

Table 5
Measurements of humeri of *Mammuthus primigenius* from Kastykhtakh River locality (Late Pleistocene), collection of Ice Age museum.

Humerus measurements (mm)	F-2644/78 dex	F-2644/82 sin
Maximal length	731.0	(748)
Length from the top of the humeral head to lateral edge of distal trochlea	717.0	–
Maximal transversal diameter of a head	170.0	178.0
Minimal diameter of a head	(128)	120.0
Width of proximal end	203.0	192.0
Transversal diameter of proximal end	199	213.0
Maximal thickness of distal end (at the level of epiphyseal suture)	(183)	(188.5)
Width of distal trochlea	178.5	170.0
Maximal thickness of medial trochlea	140.0	124.0
Transversal diameter of a trochlea's constriction	87.0	88.0
Maximal thickness of lateral trochlea	108.0	111.0
Height of a trochlea, medial	93.0	93.0
Height of a trochlea's constriction	64.0	56.0
Height of lateral epicondyle	79.0	72.0
Width of diaphysis, minimal	85.0	75.0
Transversal diameter of diaphysis, minimal	76.0	96.0
Width of proximal end (at the level of epiphyseal suture)	189.0	190.0
Width of distal end above the articulation, maximal	209.0	–

1. On the lower jaw is a well marked abnormality of the teeth position, which consists in the significant labial shift of second molars m2 relative to the axis of m3. The labial edge of m3 is on the level of the longitudinal axis of m2. The posterior side of the second molar and the anterior portion of the third one form an S-shaped (sigmoid) contact.
2. There is spina bifida in the neural arch of the atlas which is expressed as a fissure at the top.
3. In the anterior thorax, along its left side two adjacent ribs bear traces of intravital fractures, with formation of a clavus in one case, and of a false joint in the second one (Fig. 4-a). In the thorax back, two right adjacent ribs also display solid fractures with the formation of calluses. The lifetime fractures happened in both body sides in the middle and distal parts of ribs. It is

Table 6
Measurements of ulnae of *Mammuthus primigenius* from Kastykhtakh River locality (Late Pleistocene), collection of Ice Age museum.

Ulna measurements (mm)	F-2644/80 dex	F-2644/84 sin
Maximal length	–	(618)
Length from the top of the cubital tubera to epiphyseal suture of distal end	551.0	–
Length from the anterior edge of semilunar incisure to epiphyseal suture of distal end	463.5	–
Length of diaphysis (between epiphyseal sutures)	433.5	–
Width of articular surface for a humerus trochlea	177.0	177.5
Width of distal end	–	136.0
Transversal diameter of distal end	–	135.0
Width of distal articulation	–	102.0
Transversal diameter of distal articulation	–	75.5
Width of diaphysis minimal	83.5	90.0
Transversal diameter of diaphysis	66.0	73.0
Length of an ulnar processus	163.0	161.0
Width of an ulnar processus	138.5	139.4
Length of a semilunar notch	108.0	101.0
Width of an inner articular surface of proximal end	–	90.0
Width of an outer articular surface of proximal end	–	30.5
Width of distal end of joint ulna and radius above the articulation	–	210.0
Articulation width of distal end of joint ulna and radius	–	179.0

Table 7
Measurements of radiuses of *Mammuthus primigenius* from Kastykhtakh River locality (Late Pleistocene), collection of Ice Age museum.

Radius measurements (mm)	F-2644/83 dex	F-2644/79 sin
Maximal length	–	565.0
Width of proximal end	96.0	96.5
Transversal diameter of proximal end	64.5	61.0
Width of distal end (at the level of epiphyseal suture)	91.6	93.0
Transversal diameter of distal end	101.5	115
Width of diaphysis, minimal	40.5	51.5
Transversal diameter of diaphysis, maximal	40.0	35.5
Width of distal articulation	86.5	84.5
Transversal diameter of distal articulation	106.5	102.0

possible the animal suffered such a trauma as a result of falling down or some impact. Judging by the state of the rib bone tissue, the fractures did not happen simultaneously but at different stages of adulthood. The bones have no obvious syndromes of diseases except multiple rib fractures, and the bone tissue is flat and solid. There is no noticeable tenuity of cancellous tissue at bone fractures.

3.3. Comparison

The form and the structure of postcranial bones are similar with other *Mammuthus*. The parameters of bones (Fig. 5, Tables 4–17) from Kastykhtakh fall within the variability of later mammoths of the Late Glacial Boiling-Allerod warming of Berelekh, adult females from Sevsk and Lugovskoy, and within the upper limits of small latest mammoths from Wrangel Island. The described find is smaller than animals from younger sites – Bereleh, Eliseevichi, Yuribey, Kostenki XI, Shestakovo, and from similar geological age localities – Lyakhovsky, Berezovka, Khomsk, Kamskoe Ust'e, Kozlovo, Rottweil, from Kutomanov's and Taimyr's mammoths (Averianov et al., 1995; Ziegler, 2001; Maschenko et al., 2006; Mashchenko et al., 2006; Petrova, 2009).

A comparison with sizes of not numerous skeletons of *M. primigenius* females (Garutt, 1964; Ziegler, 2001; Maschenko et al., 2006; Lister and Stuart, 2010) showed that the specimen from Kastykhtakh is smaller than ones from l'Aa (France; Late Pleistocene), Rottweil (Gemany; Würm), and Oyosh (Siberia, Novosibirsk; Late Pleistocene). It is similar to the skeleton of a more ancient mammoth female from Sanga-Jurjach (Yakutia; Hengelo interstadial) (Table 18).

Table 8
Measurements of wrist trapezoideum *(os carpale secundum)* bones of *Mammuthus primigenius* from Kastykhtakh River locality (Late Pleistocene), collection of Ice Age museum.

Trapezoideum measurements (mm)	F-2644/101 sin
Height anterior surface medialy	65.2
Height anterior surface laterally	52.0
The width of the proximal end	94.3
Transversal diameter, maximal	93.0
Maximal antero-posterior diameter of the proximal articular surface	89.0
Maximal transverse diameter of proximal articular facet anteriorly	86.0
Maximal antero-posterior diameter	105.7
Transverse diameter of the distal articular facet for the MC II	93.6
Antero-posterior diameter of the distal articular facet for the MC II	91.0
The height of the front surface, lateral	50.0
The height of the anterior surface, medial	66.2

Table 9
Measurements of wrist *pisiforme (os carpale accessorium)* bones of *Mammuthus primigenius* from Kastykhtakh River locality (Late Pleistocene), collection of Ice Age museum.

Os pisiforme measurements (mm)	F-2644/100 sin
Maximal height	101.0
Maximal transverse diameter of proximal articulation facet	31.8
Maximal antero-posterior diameter of proximal articulation facet	50.0
Transverse diameter proximal, maximal	35.0
Antero-posterior diameter proximal, maximal	58.0
Minimal antero-posterior diameter midshaft	45.3
Minimal transverse diameter midshaft	33.5
Width of the facet for ulnare	46.5

Table 10
Measurements of wrist magnum bone *(capitatum, os carpale III)* bones of *Mammuthus primigenius* from Kastykhtakh River locality (Late Pleistocene), collection of Ice Age museum.

Magnum measurements (mm)	F-2644/100 sin
Maximal height	81.2
Width of the distal end	62.2
Antero-posterior diameter, maximal	105.0
Greatest diagonal diameter at proximal articulation facet	108.0
Smallest diagonal diameter at proximal articulation facet	85.2
Transverse diameter	63.4
Antero-posterior diameter of distal articulation facet, maximal	79.8

4. Results and discussion

Radiocarbon dating of the Kastykhtakh sample, defined by fragments of tubular bones, is 26,830 ± 430 years (IEMAE-1409). Calibration of this date, taking into account changes in the concentration of radioactive carbon in the atmosphere (programme OxCal 4.1; calibration curve IntCal09), shows that the mammoth death occurred in the interval from 32,070 to 30,565 years ago (Kirillova et al., 2011). The period of the mammoth existence related to the terminal stage of the Middle Valdai megainterstadial (Weichselian, Denekamp Interstadial) – Briansk interval (Dunaevskiy warming).

At the end of Middle Valdai megainterstadial – during the Denekamp interstadial (=Bryansk) the mammoths' distribution covered practically the whole of Europe, including the Iberian Peninsula, British Isles, northern Europe and Scandinavia. It indicates the significant degradation of the glacier cover and the existence of

Table 11
Measurements of pelvis bones of female *Mammuthus primigenius* from Kastykhtakh River locality (Late Pleistocene), collection of Ice Age museum.

Pelvis measurements (mm)	dex	F-2644/85	sin
Maximal horizontal width of pelvic girdle		1160.0	
Diagonal height of pelvic aperture from pubic symphysis to lowest point on the sacral attachment		399.0	
Maximal horizontal width of pelvic aperture		442.0	
Height of pelvic aperture from sacrum to share bones		321.0	
Minimal width of ilium shaft	145.7		142.5
Distance between ischial tuberosities		283.5	
Length of ilium, maximal	746.0		747.0
Width of ilium wing from tuber coxae to nearest point of pelvic aperture	399.5		384.0
Longitudinal diameter of acetabulum	136.0		142.0
Transverse diameter of acetabulum	140.0		135.0
Length of pubic simphysis		347.0	
Thickness of the upper part of share bone		–	
Length of an oval aperture	132.0		133.0
Width of an oval aperture	72.0		75.0

Table 12
Measurements of femurs of *Mammuthus primigenius* from Kastykhtakh River locality (Late Pleistocene), collection of Ice Age museum.

Femur measurements (mm)	F-2644/86 dex	F-2644/88 sin
Maximal length from the top of a head to lateral end	880.0	–
Medial length	812.0	–
Length from distal trochlea to the epiphyseal suture of a head	802.0	810.0
Transversal diameter of a femoral head	132.0	–
Diameter of a femoral head, maximal	132.0	–
Width of a femoral neck, minimal	116.0	(106.5)
Transversal diameter of a femoral neck, minimal	111.0	106.0
Width of distal end (at the level of epiphyseal suture)	178.0	184.0
Width of diaphysis in the middle, minimal	108.0	110.0
Transversal diameter of a diaphysis, minimal	70.0	74.0
Width of articular surface for a patella	94.0	82.5
Maximal width between external edges of articular condyles	160.0	161.0
Medial transversal diameter of distal end	202.0	209.0
Lateral transversal diameter of distal end	162.0	160.0
Width of medial distal articular condyle	82.0	83.5
Width of lateral distal articular condyle	71.5	60.0

spacious ice-free areas (Markova et al., 2010). This testifies to considerable favorable living conditions for mammoths.

The relatively small size of the described sample actually is not unusual for a Late Pleistocene mammoth of Northern Eurasia. Several authors considered that a significant size decrease of these animals occurred after the maximum Late Valdai (=Late Weichselian) glaciation (Mashchenko, 2004; Leshchinskiy, 2009). The height of a male skeleton of the same geological age from Taimyr Peninsula (Kutomanov mammoth) is about 290 cm (Averianov, 1994). So, the small size of the female mammoth from the Kastykhtakh River may be a result of sexual dimorphism.

The complex of individual characteristics of Kastykhtakh individual is of interest. All of them are rare in mammoth.

1. The displacement of teeth relatively to the alveolar line is observed in elephants and mammoths mostly at the change of the last two generations. They most often occur as a result of the delayed change of teeth, or a higher rate of formation of m3 compared with that of the previous tooth's wearing (Garutt, 1977; Maschenko and Shpansky, 2005). A similar case of dental abnormality is known in *M. primigenius* from Otterstadt, Germany (Lister and Bahn, 2007) and from Yakutia, Russia (collection of Ice Age museum, No F-2293). In the specimen from Germany, there is significant displacement of the last teeth generation relative to the longitudinal axis of lower jaw. But they do not form a sigmoid contact, and the last molars lean to the lateral posterior part of the previous ones. Lister and Bahn (2007) interpreted this case as the replacement of six molars by supernumerary teeth.

Table 13
Measurements of tibiae of *Mammuthus primigenius* from Kastykhtakh River locality (Late Pleistocene), collection of Ice Age museum.

Tibia measurements (mm)	F-2644/87 dex	F-2644/89 sin
Maximal length	501.0	500.0
Width of proximal end, maximal	174.0	182.5
Transversal diameter of proximal end	149.0	148.0
Width of distal end, maximal	139.0	141.5
Transversal diameter of distal end	117.5	117.5
Width of a diaphysis, minimal	78.5	78.0
Transversal diameter of a diaphysis, minimal	70.0	69.5
Width of facet for astragalus	96.0	101.0

Table 14
Measurements of fibulae of *Mammuthus primigenius* from Kastykhtakh River locality (Late Pleistocene), collection of Ice Age museum.

Fibula measurements (mm)	F-2644/91 dex	F-2644/90 sin
Maximal length	483.0	491.0
Width of proximal end, maximal	46.0	47.0
Transversal diameter of proximal end	33.8	34.5
Width of distal end, maximal	51.5	53.0
Transversal diameter of distal end	60.0	60.5
Width of a diaphysis in the midst	31.0	28.0
Transversal diameter of a diaphysis in the midst	27.0	32.5

Table 15
Measurements of tarsus astragali bones of *Mammuthus primigenius* from Kastykhtakh River locality (Late Pleistocene), collection of Ice Age museum.

Astragalus measurements (mm)	F-2644/92 dex	F-2644/93 sin
Maximal medial height	67.8	66.3
Maximal height (life position)	73.5	74.0
Maximal width	120.0	120.0
Transversal diameter, maximal	107.5	110.0
Width of articulation facet for tibia	89.2	89.0
Transversal diameter of articulation facet for tibia	83.0	82.5
Transversal diameter of maximal distal articulation facets (with calcaneus)	107.0	102.5
Antero-posterior diameter of maximal distal articulation facets (with calcaneus)	77.3	73.4
Width of articulation facets for naviculare	68.0	63.8
Transversal diameter of articulation facet for naviculare	71.7	70.3

Table 16
Measurements of metapodials of *Mammuthus primigenius* from Kastykhtakh River locality (Late Pleistocene), collection of Ice Age museum.

Metapodials measurements (mm)	F-2644/94 dex	F-2644/95 sin	F-2644/96 dex	F-2644/97 sin	F-2644/98 dex
	MC III	MC II	MC II	MC III	MT V
Length	152.0	136.3	137.0	154.2	83.0
Width at proximal end	58.5	59.5	54.0	58.5	42.5
Transversal diameter at proximal end	85.5	78.8	82.3	85.0	59.7
Width of distal end	64.0	60.8	61.8	59.8	46.2
Transversal diameter of distal end	69.0	66.3	66.7	67.0	48.0
Width of a diaphysis in the midst, minimal	49.0	51.2	47.2	47.3	32.8
Transversal diameter of a diaphysis in the midst, minimal	47.5	48.0	44.0	49.0	36.5

Table 17
Measurements of phalanxes of *Mammuthus primigenius* from Kastykhtakh River locality (Late Pleistocene), collection of Ice Age museum.

Phalanx measurements (mm)	Ph I, F-2644/102	Ph II, F-2644/103
Length	72.7	41.0
Width of proximal end	51.1	33.5
Transversal diameter at proximal end	49.2	31.1
Width of distal end	47.0	38.8
Transversal diameter of distal end	39.4	21.8
Width of a diaphysis, minimal	37.6	–
Transversal diameter of a diaphysis, minimal	36.5	–

Table 18
The comparison of the length of limb bones (mm) and shoulder heights (cm) of some skeletons of *Mammuthus primigenius* females.

Locality	Age	Scapula	Humerus	Ulna	Radius	Femur	Tibia	Fibula	Shoulder height (cm)	Reference
Oyosh (Siberia, Russia)	Late Pleistocene	635	730	–	592	945	–	535	215 (240)[a]	Maschenko et al., 2006; Lister and Stuart, 2010
l'Aa (France)	Late Pleistocene	710	840	–	670	1100	640	–	301	Lister and Stuart, 2010
Rottweil (Germany)	Würm	650	805	695	–	495	540	521	250	Ziegler, 2001
Kastykhtakh (Siberia, Russia)	Denekamp Interstadial	660	731	618	565	880	501	483	224	coll. Ice Age museum
Sanga-Jurjach (Yakutia, Russia)	Hengelo Interstadial	–	725	563	–	915	–	–	226	Lister and Stuart, 2010

[a] Own calculations.

2. The presence of non-union neural arc of the first cervical vertebra is marked for the first time in mammoth, although the same feature is well known for people. The frequency of spina bifida posterior in groups of recent men can reach 20%, and it is considered as a congenital character (Dyachenko, 1954). Although human features cannot be assumed for mammoths directly, but similar features could be present. Research in this direction has not been conducted yet.

The presence of perforations and hollows on the spinous processes of the thoracic and lumbar vertebrae of *M. primigenius* noted in the findings from Russia (Sevsk, Yudinovo, Shestakovo and Gary; Maschenko et al., 2006; Leshchinskiy, 2009), Poland (Kraków Spadzista Street; Wojtal, 2001; Krzemińska, 2008), Czech Republic (Dolní Věstonice and Milovice; Krzemińska, 2008), and Great Britain (Linford and Condover; Brothwell, 2008; Lister, 2009). So, the character expressed in the female from Taimyr is an extreme variation of a normal mammoth feature. Some researchers explain these cases as ontological changes or a result of poor diet (Krzemińska, 2008; Leshchinskiy, 2009). Similar deviations were noted in some vertebrae from Sevsk which were members of a family group. Such features may be interpreted as genetically determined (Maschenko et al., 2006). The presence of this peculiarity in several familial elephant calves from Sevsk, as well as in some specimens from Krakow and Linford, supports the view of heritability of the feature in family groups.

3. Life-time rib fractures are an interesting phenomenon in elephants and known not only in woolly mammoths, but also in the meridionalis and trogontherine elephants. The forming of a false joint in one case of the rib fractures in the Taimyr sample indicates the absence of immobility in the damaged area. Similar cases are observed in a sample of *M. primigenius* specimen from the private collection of F. Hellman (Moscow), in the skeleton of a female *Mammuthus trogontherii* from the Kagalnik sand pit (Azov, Lower Don, Russia) stored in the collection of the Azov museum-reserve (right rib from the anterior part of thorax, coll. AKM 28689/33), and in the female skeleton of *M.* cf. *trogontherii chosaricus* from late Middle Pleistocene locality Cherny Yar (Lower Volga, Russia; right rib from the middle part of thorax, collection of Astrakhan' museum-reserve).

A combination of these deviations can be explained by possible disbalance in the organism, and by unfavorable habitat conditions or life circumstances. The latter factors can be attributed as the consequences of pregnancies. However, other evident signs of metabolic disturbances resulting from disorders of calcium metabolism, on the elements of the skeleton are not expressed. In this connection, the features of the Kastykhtakh mammoth's skeleton were not associated with mineral starvation or geochemical stress. These phenomena, according to some authors (Leshchinskiy, 2009; Leshcinskiy et al., 2010), were characteristic for some mammoths during and after the last maximum Valdai (=Weichselian) glaciation in the form of abnormalities in the structure of bones and teeth. According to statistics, approximately 4% of mammoths' finds bear the traces of diseases, and in most cases, different disruptions of the process of tooth replacement (Lister and Bahn, 2007).

However, taking into consideration the periodical occurrence of such "abnormalities" in Late Pleistocene mammoths of different geological ages and from different regions, these malformations are not unique. At the present stage of investigation, few of the features in the skeleton of Kastykhtakh female can be interpreted as a unique combination. However, the absence of serial material from this locality does not permit a reliable conclusion about the degree of influence of factors of heredity, unfavorable environmental impacts or weakness in the development of the skeleton of this individual. Further findings and the studying of the specimen (histological, roentgenological and other analysis) will provide some clearness concerning the peculiarities of this mammoth's ontogeny and biology.

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