Slovak Geol. Mag., 12, 1 (2006), 57 – 62

Revision of a mastodon find from the Neogene at Kuzmice near Topoľčany (Slovakia)

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Abstract: The study deals with the review of a mastodon find in Kuzmice (Slovakia). Schmidt determined the find as *Tetralophodon grandincisivus* and because of its well-preserved tusks and preserved remains of the skull it became a find of European importance. The age of the sediment was dated to the Late Pontian (Miocene). However, the revision of the material under study has shown that it is not possible to include the find in this genus. The find has clear characteristics, which are diagnostic for *Mammut borsoni* Hays, 1834. Taking into account the fact and viewing new finds of mastodons from the locality, the age of the sedimentary complex is dated to the Late Pliocene (MN 16-17).

Key words: Pliocene, Slovakia, Kuzmice, Proboscidea, *Tetralophodon grandincisivus*, *Mammut borsoni*

Introduction

A mastodon find at Kuzmice (Slovakia) was determined by Schmidt (1963) as *Tetralophodon grandincisivus* Schlesinger, 1917. The age of the sediment was dated to the Late Pontian (Miocene). Schlesinger's (1917) taxon *"Mastodon" grandincisivus* – allocated by Tobien (1978) to the elephantoid-genus *Stegotetrabelodon* – is classified as an amebelodontid indet. by Tassy (1985). This bunodont species spread from Maragha in Persia to the Central Europe (Osborn, 1936) where it is known at 5 localities (Austria – Mannersdorf near Angern, Paasdorf near Mistelbach; Hungary – Pestszentlörinz, Nesztmély and Slovakia – Topoľčany); (Schmidt, 1963). All localities from the Central Europe are dated to the Pontian (Miocene); (Schmidt, 1963). The discovery in Kuzmice was the sixth locality and it was the first find of this species with so well-preserved tusks and preserved remains of the skull (Schmidt, 1963). Because of this reason it became a find of European importance.

The revision of this specimen PZv – 23 enables to assign it to the species *Mammut borsoni* Hays, 1834. This species belongs to zygodont trilophodont dibelodont longirostrine mastodons. Schlesinger (1922) derived this species from the Miocene species *"Mastodon tapiroides"* (= *Zygolophodon turicensis* Schinz, 1833) through the intermediate form *M. tapiroides (americanus)* divided into *M. borsoni*, *M. americanus* forma *praetypica* and *M. americanus* forma *typica*. They lived during the Upper Pliocene together with *M. borsoni.* At the end of that time they migrated to North America. The American mastodon had developed from European ancestors and migrated across the Bering pass to North America (Schlesinger, 1922). Lehman (1950) assumed that the American mastodon might evolved from zygodont mastodons existing on the American continent on the Miocene – Pliocene boundary. This might concern the genera *Serridentinus* or *Pliomastodon* (Lehman, 1950). Also Tobien (1976) assumed that *Mastodon americanus* Osborn, 1936 evolved from populations of zygodont mastodons parallely to Eurasian populations of *M. borsoni.* Molars of these mastodons are so similar that Tobien (1976) ranges them to one genus – *Mammut.* This opinion may be accepted. Differences between the "species" *M. borsoni* and *M. americanus* forma *praetypica* cannot be regarded as species differences (Holec, 1985). It was already mentioned by Venjukov (1902) who found the characters differing two forms to one specimen. Schlesinger (1917) described the forms together from several localities of the former Austria-Hungary. Pavlová (1894) denoted the progressive form as *ohioticus* and the conservative form as *borsoni.*

During the evolution from *Zygolophodon turicensis* to *Mammut borsoni* their lower tusks got reduced. *Zygolophodon turicensis* has normally developed lower tusks but those of *Mammut borsoni* are markedly reduced, rudimentary (Holec, 1985). Although it is proved that mastodons, especially *Zygolophodon turicensis*, were forest animals, we must admit that with respect to the vast area that they lived in, they could not be restricted to one biotope. Mainly terminal types of mastodons *Anancus arvernensis*, *Mammut borsoni* and its relative from the American continent – *Mammut americanus* might also lived in steppe-forest, partly in arid environment (in contrast to *Deinotherium*) because they lasted up to the Pleistocene, and *M. americanus* even to the Holocene (Holec, 1985).

The remains of the species *Mammut borsoni* are know from many European and Asian localities (Holec, 1985). In Slovakia, the species is known from Hajnáčka (Fejfar, 1961, 1964; Holec in Sabol (ed.), 2005), Strekov, (Schmidt AND Halouzka, 1970; Holec, 1996), Spišské Podhradie (Holec, 1992), Nová Vieska (Holec, 1996), Moravský Ján (Holec, 1986), Veľké Bielice (Holec, 1979), and Ceroviny (Holec et al., 2002).

The object of this work is a redetermination of the find and to disprove its dating to the Miocene. Schmidt (1963) has not described some structures in details. Therefore I considered necessary to make a revision and to describe this undescribed structures of the find.

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Slovak Geol. Mag., 12, 1 (2006), 57 – 62

Dental nomenclature was used according to Shoshany and Tassy (1996). Measurements were taken according to Göhlich (1998; modified) and Berta (1988; modified).

Geological settings

The fossil material described in this paper comes from a locality in the western Slovakia. It lies in the Nitra Upland in the district Topolčany. The Nitra Upland comprises the most extensive, northernmost offshoot of the Danube Lowland and it belongs to areally extensive regions. It extends by its southern part into the Danube Basin, its middle and northern parts are wedging in a form of wide bay among the Považský Inovec Mts., Tríbeč Mts. and Strážovské vrchy Mts. It is separated from the Horná Nitra Depression by Uherec brana gate. The upland is bound to the Považský Inovec Mts. and Tríbeč Mts. by striking faults. The northern and northeastern boundary to the Strážovské vrchy Mts. has an erosion-denudation character and as the only locally it has fault character with striking wedging into the mountains. The Nitra Upland is predominantly composed of Neogene deposits prevailingly covered by Quaternary deposits (Pristaš et al., 2000).

The locality is situated approximately 500 m, on the south-east from the road going from Kuzmice to Jacovce, on the field "Hájik". The locality is 289 meters above the sea level. The mastodon remains were found in overturned position in a sand pit (Schmidt, 1963). The find was situated in a stratum of grey-yellow, rustily spotted sand approximately 5 meters below where alternated sands of different granularity show a cross stratification (Schmidt, 1963). The organic remains are rare. The sedimentation took place in freshwater environment (Schmidt, 1963). As for the map and the profile of the locality, see Schmidt (1963, Fig. 1 and 2). As for the age of the locality, see discussion.

Methods

The material is housed in the Tribeč Museum. Photographs were made by camera Sony 101. Measurements were taken by tape measure and calliper rule. Abbreviations used in figures are as follows: I2 sin. – the left tusk, tad – trace of *alveola dentale*, fM2 – fang of M2 sin, M3 sin – left upper molar, m – maxilla, fo – *foramen opticum*, f – frontal, l – lacrimal, sqt – *squama temporalis.*

Systematic part

Class:	Mammalia LINNAEUS, 1758
Group:	Proboscidea ILLIGER, 1811
Suborder:	Elephantiformes TASSY, 1988
Superfamily:	Elephantoidea GRAY, 1821
Family:	Mastodontidae HAY, 1922
Genus:	Mammut BLUMENBACH, 1799
Species:	*Mammut borsoni* HAYS, 1834

Synonyms:

1834 *Mammut borsoni* (Hays p. 334)
1963 *Tetralophodon grandincisivus* (Schmidt p. 169–174)
1985 *Tetralophodon grandincisivus* (Holec p. 32)
2000 *Tetralophodon grandincisivus* (Pristaš et al. p. 116)

Holotyp: M3 described by Hays, 1834, page 334.

Diagnosis: Species of *Mammut borsoni* is zygodont brevirostrinous trilophodont dibelodont mastodon. The tusks are long, relatively direct. Total length of the tooth M3 is usually 150 – 167 mm and maximum width of M3 is about 96 mm. Dentin thickness is about 5 mm.

Locality: Kuzmice (Slovakia)

Stratigraphic range: Pliocene, Mammal zone MN 16 - 17

Material: The remains of the skull of *Mammut borsoni* are significantly damaged and shapes of bones are not clear. The left side is relatively preserved, remained in fragments. The find is deposited as PZv-23 with the registration number 218/62 in Tribeč Museum in Topoľčany (Slovakia).

Description

The structures of the skull or bones, which are missing in Schmidt (1963), are described in this part. It states also the new description of the teeth and the measurements of skull, teeth and tasks.

Skull

The total length of the find is 3350 mm. The maximum breadth of the find is 600 mm and maximum height is 410 mm above the molar. The length of the skeleton part is 1155 mm.

Maxilla: The left maxilla is preserved with M3 sin. and the fang of M2 sin. The surface of the bone is smooth. A part of maxillar *processus zygomaticus* sin. is preserved on the left part, standing out on the place of M3 sin. in ventral view. It juts out in postero-lateral direction. Its dorsal margin is a part of the ventral edge of the orbit. The distance between alveolus M3 sin. and the dorsal margin of *processus zygomaticus* sin. is 190 mm.

Two low depressions are preserved in the frontal part behind the line of the beginning of the tusks. The depressions have an oval concave shape, prolonged in antero-posterior direction. The surface is smooth. The left one is well preserved (Fig. 1a). It measures 230 mm in antero-posterior direction and 88 mm in medio-lateral direction. I consider them to be the traces of alveoli remaining from dropped older teeth, which were pushed away by permanent teeth. Therefore this area is shallow and significantly pushed at the anterior end. Its posterior part is bordered by the *pars molaris* of permanent teeth. Because of the pushing of teeth the inner part of the palatine shows naturally apparent deformation starting from the lingual margin of the area – as if it was a plastic tearing in the direction of the line of pushing. That caused the creating of structures, the orientation of which is similar to tectonic cuts. They are more noticeable on the posterior part close to the margin of the area. They rotate askew in acute angle towards the line of movement, to the lateral part. The structures end up in medial direction and the slope descends.

The preserved *processus palatinus* dext. et sin. is divided by *sutura palatina mediana*. It measures 490 mm in antero-posterior direction.

Frontal: A part of frontal is preserved in the left side. There is the dorsal margin of the left orbit, which is only partly preserved (Fig. 1b). It forms the dorsal edge of the interior smooth concave area, which continues in medial

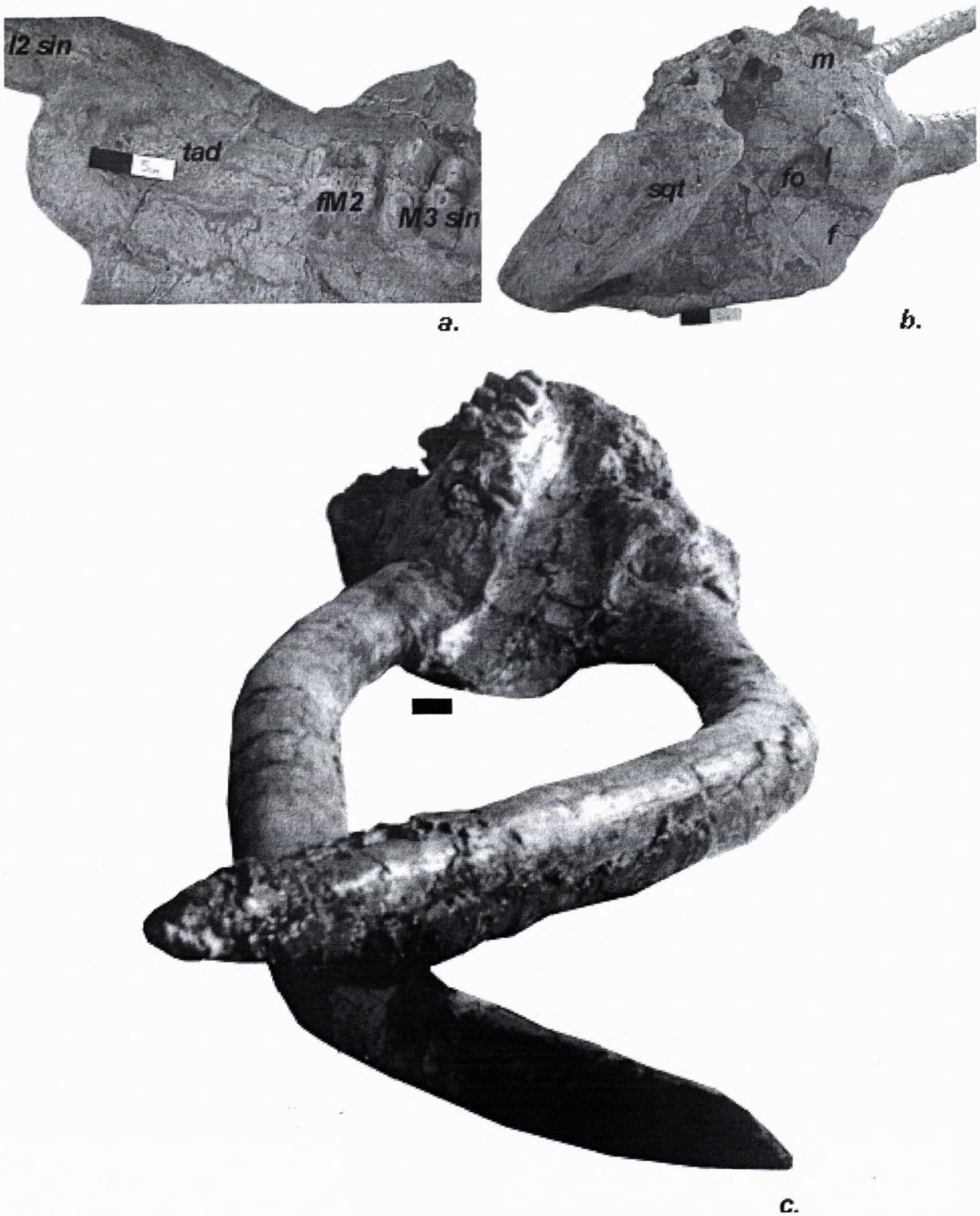

Fig. 1. *Mammut borsoni* Hays, 1834: a – dorsal view on the left trace of alveola dentale. (Photo by M. Žáčik); b – posterior part with dorsal interior part of orbit. (Photo by M. Žáčik); c – frontal view (Tribeč Museum archives); 1 unit equals to 5 cm.

direction. The preserved part of the concave area measures 200 mm in antero-posterior direction. *Processus zygomaticus* of frontal is not clear and has never been linked with *os zygomaticum*. *Foramen opticum* is situated inside of this central area. The bordering part of the bone between *foramen opticum* and *fossa sacci lacrimalis* is broken. *Foramen opticum* has an ellipsoid shape for this reason. It measures 86 mm in dorso-ventral direction and 125 mm antero-posterior direction. Outside of the orbit, the frontal is not so complete and the rest of the bone is lost. Probably *squama frontalis* is partly preserved under the remains of the skull.

Slovak Geol. Mag., 12, 1 (2006), 57 – 62

Lacrimal: A part of lacrimal is preserved in the left side and forms the antero-medial margin of the orbit (Fig. 1b). The surface of the bone is smooth and the border with frontal is not clear.

Temporal: A part of temporal is preserved in posterior part of the left side (Fig. 1b). The bone is plane, gently convex of shape. The ventral part is lost, but the bone was probably longer than it is wide. The surface of the bone is smooth. *Processus zygomaticus* of temporal is preserved in its anterior part and juts out in antero-ventral direction.

Teeth

M2 sin.: The only fang of the tooth remained (Fig. 2). It is distinctly bare on lingual side. It consists of three fangs. Two fangs are well preserved however the third one is damaged. The fangs preserved at the lingual side measure 83 mm in length. The height of the bare part on the first one is 55.5 mm; the second one measures 59 mm in length and the third one measures 26 mm. The alveolus is seriously damaged on the buccal side, however the view from above renders visible the contours of all three damaged fangs on this side. The area of the fang measures 90 mm in breadth. The whole area is damaged but according to the number of three fangs from not preserved ridges, it is evident that the tooth had three yokes. The mark is called trilophodontism (as for this mark, see Falconer, 1857).

Fig. 2. *Mammut borsoni* Hays, 1834: naked fang of M^2 sin. (Photo by M. Žáčik); 1 unit equals to 1 cm.

M3 sin.: In general well preserved, the last ridge a bit damaged in the distal part. The tooth has four ridges (Fig. 3). Crosswise the half-ridges show one line. Therefore the cones and ridges are arranged in a direct vertical line versus antero-posterior line of the crown.

There are sharp vales between the ridges; they are not covered in profile. The vales are bit broader on the lingual side. The tooth does not tend to lay cement. The ridges are sharp, it is caused by anterior-posterior compression; transforming of central cones to sharp pretrite and postrite ridges is developed. The crown colour is light, greyish-blue. The tooth is apparently abraded. The abrasion fades out towards the distal end. The buccal half-ridges are higher than lingual ones, while it is vice versa in last one. The lingual walls of the ridges show higher inclination than the buccal ones, which are quite steep. The measurements of M3 sin. correspond to the range of *M. borsoni* (Tab. 1).

Tab. 1. Size of the tooth M^3 a sin. [mm]

Lenght max.	Width max.	Dentin thickness
158	104	5

number of the ridge	1	2	3	4
width of the ridge	104	93	90	71
crown height on the lingual side	43	45	52	42
crown height on the buccal side	49	54	56	33

Proloph (the first ridge) shows visible abrasion. The lingual half-ridge is damaged in the area of median sulcus. The ridge surface is immensely abraded. Naked dentin is on the main tips. Paracone has a form of a crater on the buccal side. There is a cleft in the area of the first vale on the tooth. The first lingual half ridge is subtly shifted. It was turned slightly counter clockwise in the view from inside. However, it is caused by preservation process. Protocone is significantly abraded. Metaloph (the second ridge) is abraded, especially the lingual part with naked dentin. Hypocone is a crater in the shape. There is a cleft on the lingual side of the second vale. Talon: triloph (the third ridge) is not much abraded, the dentin is covered. The fourth ridge is damaged in the distal part. Mostly, the lingual half ridge is damaged. Its posterior as well as the upper part of tip is missing.

The surface of the tooth is covered with small tuberosities. They are polished with the tongue on the lingual side so the surface of this part is more or less smooth. The mesial part of the tooth is preserved and well bounded. The cingulum protruded in this part. Its highest point of the area of median sulcus, reaching the height of 25 mm. Cingulum also in the shape of tuberosities runs through the buccal side and loops the first half-ridge up to the height of 18 mm. It passes through the exoflexus then it suddenly disappears.

Dentes incisivi: The tusks are long (Tab. 2.), relatively direct. The span between the tusks is approximately 330 mm at the beginning of alveoli. The tusks are crossed in the distance of 340 mm from the end of tips of I2 sin. and I2 dext. (Fig. 1c). The crossing is only secondary and is caused by post mortal and fossilization process. I2 sin. is slightly sagged down in the distance of 750 mm from alveolus (in the position as it was discovered). That curving also resulted in not much apparent medio-lateral fissures extending on almost entire breadth of the tusk within the distance from 640 to 1080 mm. The entire tusk is unnaturally anchored in the alveolus. It is slightly shifted towards the interior part so the tusk I2 sin. is directed below I2 dext. (due to overturned position nowadays). During the life of animal, there was not the crossing. I2 dext. is approximately in correct position from anatomical aspect.

Tab. 2. Size of tusks [mm].

The size of I^2 dext. [mm]	length in the exterior part	2240
	length in the interior part	2140
	length from the upper side	2220
The size of I^2 sin. [mm]	length in the exterior part	2320
	length in the interior part	2180
	length from the upper side	It is not possible to measure because of crossing

Discussion

The restudy of the material PZv – 23 enables to assign it to the species *M. borsoni.* It is not possible to regard the preserved molar M3 sin. as bunodont type. It has typical zygodont morphology. Schmidt (1963) stated that the preserved molar had likely five and half ridges, while the first and the second ridge was not preserved. However, the almost entire tooth remained and the mesial end shows normal ending. It has four ridges. It is possible that Schmidt (1963) considered the fang of M2 sin. to be the remaining part of the first and second ridge.

According to presented results this is a zygodont mastodon *Mammut borsoni* Hays, 1834. The find of mastodon from Kuzmice is redetermined for these marks:

1. Zygodont tooth M3 sin., crosswise the half-ridges show one line, there are sharp vales between the four ridges and they are not covered in profile. It is typical mark for this species (Fejfar, 1964) and it is a key determination characteristic because it is not possible to find it in bunodont types. It is typical for zygodont types (Fejfar, 1964; Holec, 1985).

2. The lingual walls of the ridges show higher inclination than the buccal ones, which are quite steep. This typical mark is described for zygodont mastodons (Tobien, 1975).

3. Metric of M3 sin. corresponds to *M. borsoni* (Tab. 1) (Osborn, 1936; in comparison with material in Holec, 1985).

4. Trilophodontism is a typical mark for zygodont mastodons (Falconer, 1857), which never reached the tetralophodontic level of bunodont types (Tobien, 1973).

5. The tusks are long (Tab. 2), relatively direct, that is a typical mark for genus *Mammut* (Tobien, 1975).

For the remarks it is not possible to regard this find as taxon *grandincisivus* Schlesinger, 1917. The find has not progressive characters.

Schmidt (1963) quoted there are sediments from Upper Pontian (Upper Miocene) in the subsoil of covering formations from Quaternary period in the excavation as well as in the broader area. The revision and examination of new finds of teeth disprove dating as Miocene. Pristaš et al. (2000) has classified the sediments as Volkovce Formation (Pliocene – Dacian). The species *Mammut borsoni* Hays, 1834 indicates mammal zone MN 16-17 (Pliocene, Dacian-Romanian); (Holec, et al., 2002). Another finds of not published mastodons also come from this locality: namely the tusks and teeth of the species *Mammut borsoni* Hays, 1834 – m3 sin. (PZv-22) and *Anancus arvernensis* Croizet et Jobert, 1828 – m3 dext. (PZv-36), m3 sin. (PZv-36b, PZv-18b). Similarly alternation of half ridges on M3 of Kuzmice findings in *Anancus arvernensis* proves up to Pliocene. If we see the evolution line starting from *Gomphotherium* genus, *Tetralophodon* up to *Anancus* genus we may find out that the alternation of half-ridge moves from milk teeth to permanent teeth. A slight shift of half-ridges on D4 and M1 is seen in typical form of *Tetralophodon longirostris* from Early Pannonian. The alternation of half-ridges on D4, M1, and M2 is regular; the same is variable on M3 in interim form of *T. longirostris* and *A. arvernensis* from Middle and Late Pannonian. Eventually the alternation of half-ridges on M3 is also fully developed in typical form of *A. arvernensis* from the end of Pliocene (Holec, 1985); the alternation on M3 is distinct in Kuzmice finds. The other progressive characteristics, for instance the tendency to lay cementum that is developed on some teeth (mainly m3 sin. PZv-18b) also proves the age of Pliocene (this progressive mark is characteristic for Late Pliocene - as for progressive marks, see Holec, 1985). The trend of laying cement is not clearly developed in many teeth of *A. arvernensis* from the locality but in other finds that is already developed. It proves a certain diversity of population and different manifestation of progressive characteristics (intraspecies variability).

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References

Berta, A., 1988: Quaternary evolution and biogeography of the large south American Canidae (Mammalia, Carnivora). University of California Publication, Geological Sciences, Vol. 132, Berkeley, 150

Falconer, H., 1857: On the species of mastodon and elephant occurring in the fossil stage in Great Britain. Part I. Mastodon. Quarterly Journal of the Geological Society of London, 13, p. 60-307

Fejfar, O., 1964: The Lower Villafranchian Vertebrates from Hajnáčka near Fiľakovo in Southern Slovakia. Rozpr. Ústř. Úst. Geol., Nakl. ČSAV, 30, Praha, 115.

Fejfar, O., 1961: Die plio-pleistozänan Wirbelttierfaunen von Hajnáčka und Ivanovce (Slowakei), ČSR. I. Die Fundumstände und Stratigraphie. Neues Jahrb. Geol. Paläontol. Abh. 11 (3), Stuttgart, 257-273.

Göhlich, U. B., 1998: Elephantoidea (Proboscidea, Mammalia) aus dem Mittel- und Untermiozän der Oberen Süßwassermolasse Süddeutschlands: Odontologie und Osteologie. Münchner Geowissenschaftliche Abhandlungen, (A) 36, Munich, 255, ISBN 3-931516-44-X.

Hays, J., 1834: Descriptions of the specimens of interior maxillary bones of mastodons in the Cabinet of the American Philosophical Society, with remarks on the genus Tetracaulodon (Godman), etc. Trans. Amer. Phil. Soc., N.S., IV, Philadelphia, 317-339.

Holec, P., 1979: The Vertebrates of Neogene and basal Quaternary of the West Carpatians: Finds of Hipparion and Mastodon. (in Slov.), Manuscript – Faculty of Natural Sciences, Comenias University, Department of Geology and Paleontology, Bratislava, 135.

Holec, P., 1985: Finds of Mastodon (Proboscidea, Mammalia) Relics in Neogene and Quaternary. Sediments of Slovakia (ČSSR). Západ. Karpaty, Sér. Paleont., 10, 13-53.

Holec, P., 1986: Reste von Mastodonten (Mammalia, Proboscidea) aus dem Neogen des Wiener Beckens bei Moravský Ján (Slowakei). Acta geologica et geographica Universitatis Comenianae, 41, Bratislava, 135-144.

Holec, P., 1992: The casts of teeth of mastodon Mammut borsoni (Hays, 1834) in drevenícky travertine at the Spišské Podhradie. (in Slov.), Mineralia slovaca, 24, 467-469.

Holec, P., 1996: A Plio-Pleistocene large mammal fauna from Strekov and Nová Vieska, south Slovakia. Acta zool. cracov., 39, 1, Kraków, 219-222.

Holec, P., 2005: Proboscideans. In Sabol, M. (ed.): The Villanyian site of Hajnáčka I. Paleontological research 1996-2000, Gemer-Malohont Museum in Rimavská Sobota, Bratislava, 124-130.

Holec, P., Kováč, M., Sliva, Ľ., Vojtko & R. Joniak, P., 2002: The find of Mastodon Mammut borsoni (Hays, 1834) at Ceroviny: Lithological conditions and stratigraphy. (in Slov), Mineralia Slovaca, 34, 353-358. (In Slovak).

Lehmann, U., 1950: Über Mastodontenreste in der Bayerischen Staatsammlung in München.Paläontographica, (A), 99, Stuttgart, 121-228.

Osborn, H. F., 1936: Proboscidea: A monography of the discovery, evolution, migration and extinction of the Mastodonts and Elephants of the World. The American Museum Press, Abb. 1-680, New York, 802.

Pavlova, M., 1894: Les mastodontes de la Russie et leur rapports avec les mastodontes des autres pays. Mém. Acad. Imp. Sci. Pétersbourgh (8), I. 3, Pétersbourgh, 9–43.

Pristaš, J., Elečko, M., Maglay, J., Fordinál, K., Šimon, L., Gross, P., Polák, M., Havrila, M., Ivanička, J., Határ, J., Vozár, J., Tkáčová, H., Tkáč, J., Liščák, P., Jánová, V., Švasta, J., Remšík, A., Žáková & E., Töröková, I., 2000: Explanatory notes to geological map of the Danube lowland – Nitrianska pahorkatina upland 1:50 000. The National geological society of Dionýz Štúr, Bratislava, 250, ISBN 80-88974-26-7.

Shoshany, P. & Tassy, P., 1996: The Proboscidea. Evolution and palaeoecology of elephants and their relatives, New York (Oxford Universinty), 472, ISBN 0 19 854652 1.

Schlesinger, G., 1917: Die Mastodonten der k. k. Naturhistorisches Hofmuseums 1, Wien, 230.

Schlesinger, G., 1922: Die Mastodonten der Budapester Sammlungen. Geologica Hungarica, 2, 1, Budapest, 284.

Schmidt, Z., 1963: The finds of mastodon Tetralophodon grandincisivus Schlesinger, 1917 in the Pliocene (Pontian) at Kuzmice locality by Topoľčany. Geological papers, N 27. Bratislava, 169-174. (In Slovak).

Schmidt, Z. & Halouzka, R., 1970: The new fauna of vertebrates in the Villafranchien at Strekov – the Hron Upland (the Danube lowland). Geological papers, N 51, Bratislava, 173-183. (In Slovak).

Tassy, P., 1985: La place des mastodontes miocénes de l'Ancien Monde dans la phylogénie des Proboscideas (Mammalia). – Unpublished Thése Doctorat és Sciences, Université Pierre et Marie Curie. Paris. 861.

Tobien, H., 1973: On the evolution of mastodonts (Proboscidea, Mammalia) Part 1: The bunodont trilophodont Groups. Notizbl. hess. L. – Amt Bodenforsch., 101, 17 Abb., Wiesbaden, 202-276.

Tobien, H., 1975: The structure of the mastodont molar (Proboscidea, Mammalia)Part 2: The zygodont and zygobunodont patterns. Mainzer geowiss. Mitt., 4, 32 Abh., Mainz, 195-233.

Tobien, H, 1976: Zur paläontologischen Geschichte der Mastodonten (Proboscidea, Mammalia). Mainzer geowiss. Mitt. 5, Mainz, 143–225.

Tobien, H., 1978: On the evolution of the mastodons (Proboscidea, Mammalia) Part 2: The bunodont tetralophodont Groups. Geol. Jb. Hessen, 106, Wiesbaden, 159-208.

Venjukov, P., 1902: Die Säugetierfauna der Sandschichten von Balta in Gouvernement Podolien. Mat. Geol. Russl., XXI, St. Pétersbourg.