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Article

Large mammals (Proboscidea, Perissodactyla) from the late Miocene Burel Basin in West Bulgaria

Madelaine Böhme, Panagiotis Kampouridis, Georgi N. Markov, Latinka Hristova, and Nikolai Spassov

With 6 figures

Abstract: The Neogene Burel Basin in the Western Srednogorje region of the Balkans provides rare fossil large mammals, which have importance for mammalian evolution and faunal chronology at the Miocene-Pliocene transition of the Balkan Peninsula. Here we report on new, and review published, proboscideans and perissodactyls from the Kaisiinitsa and Tranerska formations. We identify the following taxa: *Anancus* ? *lehmanni*, '*Mammut*' sp., *Deinotherium proavum*, *Dihoplus* sp., *Tapirus arvernensis*, and *Hipparion crassum*. Our biochronologic interpretation is consistent with a late Turolian (MN13) age of both formations and in support of a correlation to the Pontian stage. However, we admit that numerical dating of the Burel section is needed by future research using magnetostratigraphy and geochronology.

Key words: Taxonomy, Mammalia, Bulgaria, Neogene, Miocene.

1. Introduction

Fossil vertebrate faunas from the Balkan Peninsula have greatly promoted our knowledge about the Neogene mammalian evolution, in which the late Miocene plays a significant role. Rich assemblages predominantly from 'Pikermian time' (middle Turolian, MN12) have been described from Attica (Gaudry 1862; Abel 1922; Roussiakis et al. 2019), Euboea (Woodward 1901; Theodorou et al. 2003), Thessalia (Koufos 2006), the Axios/Vardar valley (Schlosser 1924; Arambourg & Piveteau 1929; Koufos 2013; Spassov et al. 2018), from the Chalkidiki Peninsula (Koufos & Kostopoulos 2016), and the Mesta and Sandanski Basins (Spassov 2002; Spassov et al. 2006; Geraads et al. 2011; Spassov et al. 2019). The age of the typical Pikermian fauna has been constrained by magnetostratigraphy to between 7.44 and 7.26 Ma (Böhme et al. 2017; Böhme et al. 2018), which correlates to the latest Tortonian or the earliest Meotian in the regional Eastern Paratethys scale (Palcu et al. 2018). However, much chronologic and taxonomic uncertainties exist with younger Miocene to early Pliocene faunas from this region. Such faunas are known in Bulgaria from the Sofia Basin and several smaller nearby basins in western Bulgaria (e.g., Bakalov & Nikolov 1962; Kojumdgieva et al. 1984). One of these proximate basins is the intramontane Burel Basin (also known as the Beli Breg or Gaber Basin), situated in the Western Srednogorje region of the Balkans about 50 km northwest of Sofia (Fig. 1).

In this contribution we aim to describe the proboscideans and the perissodactyl ungulates from the Burel Basin, assessable in the collections of the National Museum for Natural History Sofia (Bulgaria) and the Palaeontological Collection of Tübingen University (Germany). We furthermore critically discuss the published large mammal data and interpret our results in

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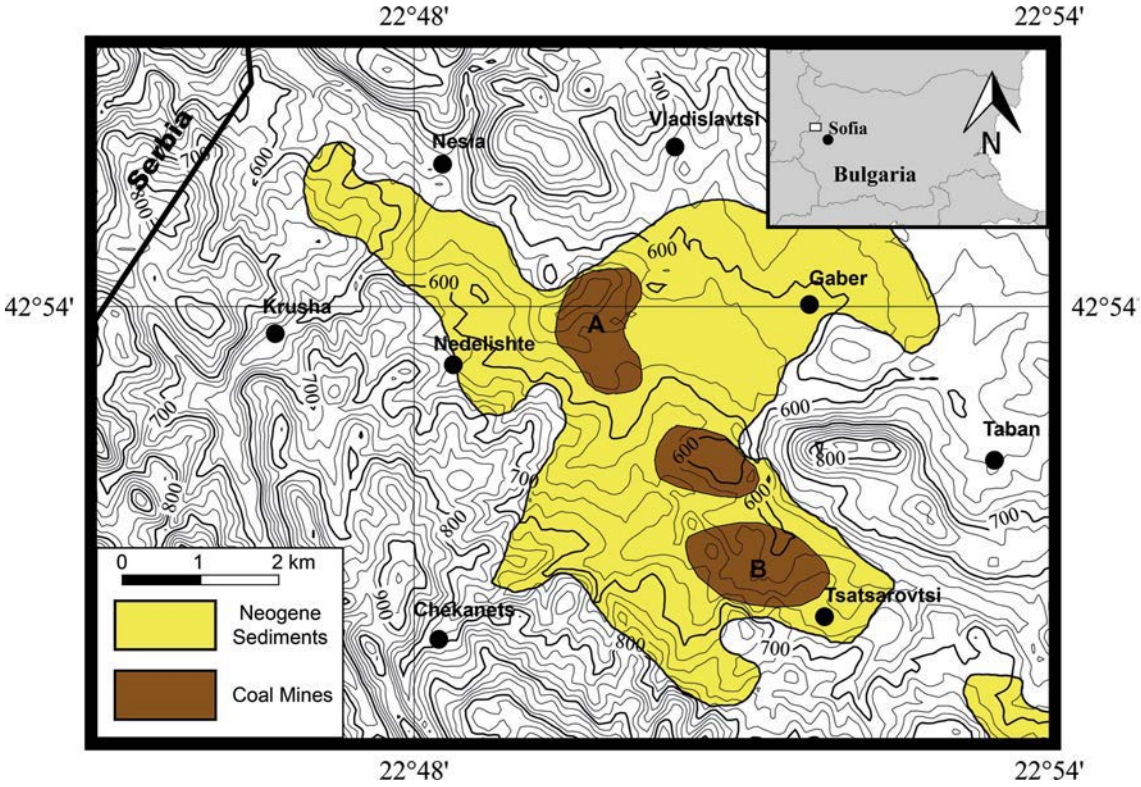

Fig. 1. Distribution of Neogene sediments (yellow) in the Burel Basin (western Bulgaria) according to Zagorchev et al. (1995). The brown area marks places of former and present mining activities. **A** – Nedelishte coal mine; **B** – Tsatsarovtsi coal mine. The map was created using Generic Mapping Tools (Wessel et al. 2013).

terms of biochronology, as a further step to elucidate mammalian evolution and faunal chronology at the Miocene-Pliocene transition of the Balkan Peninsula.

2. Geological setting

The geology of the Burel Basin has been described by Konjarov (1932) and Yovchev (1960). The basin has an NW–SE directed extension of about 9 km. Around the village of Gaber, the Burel Basin is 6.5 km wide, in NE–SW direction (Fig. 1). Folded Mesozoic carbonates, sandstones and volcanites provide a topographic range of about 300 m, filled with over 100 m of Neogene sediments. These sediments occur along the Gaber river, from the village of Nesla in NW at the Serbian border to the village of Tsatsarovtsi in the SE (Fig. 1).

The Neogene distribution is tectonically divided (Gochev et al. 1970; Zagorchev et al. 1995) in a south-eastern part, mined by the Beli Breg Mining Company in the former open-cast mine Bolshevik (called Beli Breg or Tsatsarovtsi mine by Ivanov et al. 2007 and Bozukov et al. 2011) and a north-western part, mined (after 1990) in the Nedelishte open-cast mine (Fig. 1). Sediments in both parts of the basin are tectonically disturbed by extension and their bedding range from sub-horizontal (Fig. 2A) to 8° northern direction in the Nedelishte mine, whereas in the southern part of the basin the sediments exhibit a dip of strata, ranging between 11° northern to 7° southern directions (Konjarov 1932).

A lithostratigraphic subdivision into three concordant formations was introduced by Vatsev & Zdravkov (2004). The basal Nedelishte Formation, composed of conglomerates and yellowish-grey fine-clastics, is mainly known from boreholes. The productive Kaisiinitsa Formation is about 50–70 m thick and contains two to three brown-coal seams of variable thickness. The lower, most productive, seam is usually 10–20 m thick with decreasing tendency towards

Fig. 2. The brown-coal mine Nedelishte in the Burel Basin. **A** – Overview over the sedimentary succession taken in September 2020. **B** – Mammalian ribs and gastropods in the coal-seam of the Kaisiinitsa Fm. **C** – Rhythmical bedding in the uppermost meter of lacustrine marls of the Kaisiinitsa Fm. **D** – Limonitic concretion from lacustrine marls of the Kaisiinitsa Fm. **E** – Disarticulated fish skeleton (Barbinae indet.) from lacustrine marls of the Kaisiinitsa Fm.

north (Konjarov 1932, fig. 39), whereas the upper seam in the northern Nedelishte mine reaches less than three meters (Figs. 2A, 3). These coals are lignitic and include a high component of fusite and xylite (Zdravkov & Kortenski 2004), the latter is formed by strongly compressed tree trunks. Beside rare mammalian fossils (Fig. 2B), the coal contains badly preserved freshwater and terrestrial molluscs (Konjarov 1932), identified by us as *Planorbis* and Helicidae indet.

The lower seam is overlaid by 33 m (Nedelishte mine) to 45 m (Tsatsarovtsi mine, Bozukov et al. 2011, fig. 2) of bright lacustrine marls and diatomites, rhythmically intercalated by various thin organic-rich layers (Fig. 2C). Marls in the Nedelishte mine can contain decimetre-sized limonitic concretions (Fig. 2D), indicating phases of deeper lake conditions. Laminated marls and diatomites preserve ostracods, rare fish fossils (Fig. 2E) and a rich macro- and micro-flora (Bozukov et al. 2011; Ivanov et al. 2007; Mai & Palamarev 1997; Ognjanova-Rumenova & Yaneva 2000; Palamarev 1972; Palamarev & Kitanov 1988).

The Tranerska Formation overlay the top coal seam with a sharp lithologic transition to greenish and bluish clays. These clays are massive to thickly bedded and contain according to Vatsev & Zdravkov (2004) subordinate amounts of sands and conglomerates. Fluvial channels with cross-stratification and fine-gravels we identified at the very top of the Tranerska Formation. Within the greenish sandy clay, we found few badly preserved terrestrial gastropods and the rhino tooth described herein (GPIT/MA/13386). In the north-

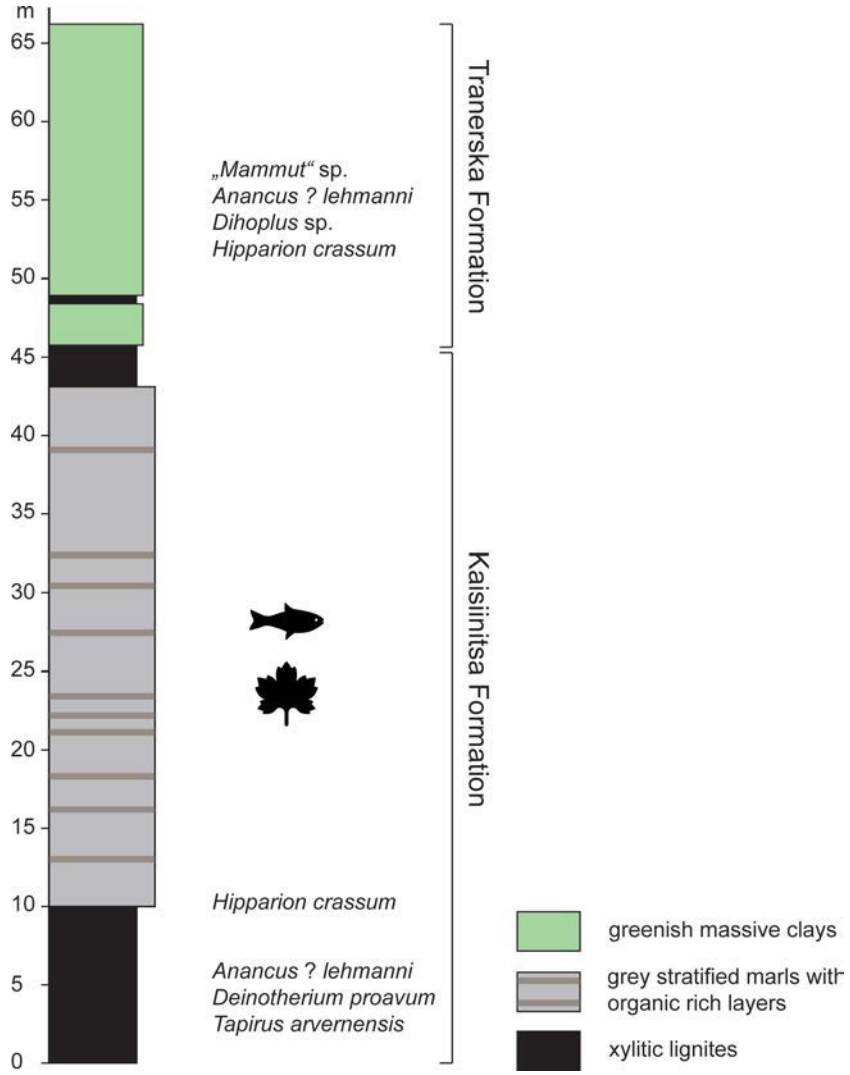

Fig. 3. Sedimentary profile of the brown-coal mine Nedelishte (southern part) with stratigraphic distribution of its fossils.

ern sub-basin the lower part of the alluvial Tranerska Formation contain a coal-seam of 0.5 m thickness, which is intercalated by a white marl bed, indicating a short-term and local return of palustrine and lacustrine conditions. Pollen are practically not preserved in the clayey Tranerska Formation (Ivanov et al. 2007).

3. Fauna

Fossil mammals are very rare in the Burel Basin. Konjarov (1932, pl. 61) figured a tooth, referred to ‘*Mastodon*’ *arvernensis*, and mentioned a proboscidean mandible, both from the lower seam of the Tsatsarovtsi mine. From the same stratum, mine workers have collected the *Tapirus* mandible and the proboscidean tooth described by Maisch (2014) as *Tetralophodon longirostris*. Mining surveyors excavated in the Nedelishte mine a *Hipparion* skeleton in 2018 from the transition of the lower seam to the lacustrine marls. In addition, they collected a partial deinothere tooth from the lower seam and a cervid antler as a stray find, which, according to its yellowish colour and abraded preservation, may potentially be derived from sandy facies from the top of Tranerska Formation. The only fossil that definitely comes from the Tranerska Formation is the deciduous rhino tooth (GPIT/MA/13386)

found in 2012. The whereabout of the fossil mammals mentioned, but only partially described, by Bakalov & Nikolov (1962), Nikolov (1962, 1985, 1989), and Kojumdgieva et al. (1984) are unknown and can therefore only commented here for briefly described and figured hipparions (Bakalov & Nikolov 1962) and proboscideans (Nikolov 1962).

Kojumdgieva et al. (1984; see also Nikolov 1985; Nikolov 1989) subdivided stratigraphically and biochronologically the fauna of Tsatsarovtsi mine (= Gaber, Bolshevik mine) into a lower level of the main coal seam (now Kaisiinitsa Formation) with *Tetralophodon longirostris* (together with *Gomphotherium angustidens*, *Aceratherium incisivum* and *Microstonyx major*) and an upper level (upper eight to ten meters) with *A. arvernensis* (together with *Zygolophodon borsoni*, *Dicerorhinus schleichermacheri* and *Hipparion mediterraneum*), most probably related to the Tranerska Formation. However, most of these taxonomic assignments (some of which indicate too old biochronologic age) are reconsidered by us in this publication.

4. Stratigraphy

Based on the find of '*Mastodon*' *arvernensis*, Konjarov (1932) correlated the Cenozoic sediments of the Burel basin to the Pontian, and Kojumdgieva et al. (1984) interpreted their lower mammalian level as corresponding to the lower Pontian (Novorossian, respectively Odessian) and the upper level to the middle Pontian (Portaferian). This interpretation was supported by the diatom composition from the lacustrine levels of the Kaisiinitsa Formation by Ognjanova-Rumenova & Yaneva (2000), who found close resemblance to the diatom flora of the middle Pontian Novi Iskar Formation of the Sofia Basin (Ognjanova-Rumenova et al. 2008). A slightly younger age, Pontian to Dacian, was initially concluded by Palamarev & Kitanov (1988) based on palaeo-floristic composition of the Kaisiinitsa Formation, whereas later Palamarev & Ivanov (1998) refused a Dacian correlation (retained by Bozukov et al. 2011). Both, the Novorossian (respectively Odessian) and the Portaferian regional sub-stages of the Pontian in the Dacian and Black Sea Basins have been recently well-dated by bio-magnetostratigraphy to between 6.1–5.6 Ma (Krijgsman et al. 2010; Lazarev et al. 2020). Recently, Ivanov et al. (2021) speculate about a significantly older age of the Kaisiinitsa Formation based on cyclostratigraphic considerations and a postulated mammalian biochronology of MN12 by Maisch (2014).

5. Material and methods

The studied materials include two proboscidean teeth stored in the National Museum for Natural History Sofia (NMNHS, FM 2010 and FM 3548) and a tapirid mandible (FM 3547), all from the Kaisiinitsa Formation of the Tsatsarovtsi mine and a rhinocerotid lower deciduous d3 tooth from the Tranerska Formation in the northern part of the Nedelishte mine, stored in the Palaeontological Collection of Tübingen University (GPIT/MA/13386).

6. Systematic palaeontology

Order Proboscidea Illiger, 1811
Family Mammutidae Hay, 1922
"*Mammut*" sp.

Nikolov (1985) listed *Zygolophodon borsoni* from the upper part of the Bolshevik (= Tsatsarovtsi) mine (Tranerska Fm). The material is unpublished and its present whereabouts are unknown. Considering the locality's age, the mammutid in question could be "*Mammut*" *obliquelophus* and not "*M.*" *borsoni* (on the generic affiliation of these two taxa, belonging neither to *Zygolophodon* nor the American genus *Mammut* see Markov 2008).

Family Gomphotheriidae Hay, 1922
Genus *Anancus* Aymard, 1855
Anancus sp. (*Anancus* ? *lehmanni*)

Non-mammutid material from the Bolshevik mine has been referred to various taxa in the literature, but all finds seem to represent a single anancine species (Markov 2004); the proper name for the Turolian form predating *A. arvernensis* in Europe should be *Anancus lehmanni* (Gaziry, 1997) (see discussion in Markov 2008; Markov et al. 2014; Konidaris & Roussiakis 2019).

Konjarov (1932, pl. 61) figured a left m3 of "*Mastodon arvernensis*" but provided no metrical data. The tooth has six lophids and a distal talonid (Fig. 4B, C).

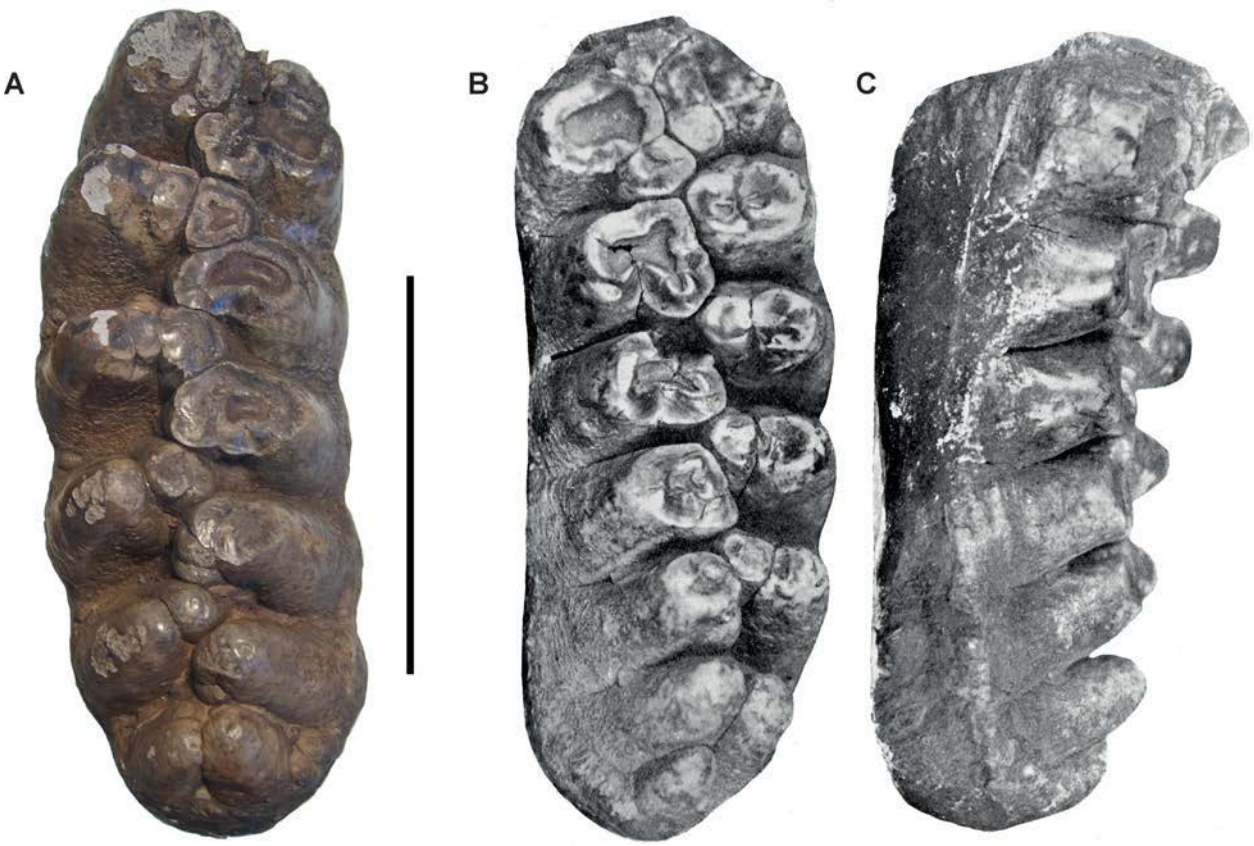

Fig. 4. *Anancus* sp. (*A.* ? *lehmanni)* from the Kaisiinitsa Fm of Tsatsarovtsi mine. **A** – Right m3 (FM 3548) in occlusal view (scale bar 10 cm). **B, C** – Left m3 in occlusal (B) and buccal (C) views, both reproduced from Konjarov (1932: pl. 61) and not to scale.

A left M3 published by Bakalov & Nikolov (1962, pl. 63, fig. 1) as *Tetralophodon longirostris* was referred to *Anancus* by Markov (2004) due to the cross-contacts between the pretrite and the posttrite semilophs. Further material has been described by Nikolov (1962): right M3 (Nikolov 1962, pl. 7), currently at the NMNHS (coll. no. FM2001), lacking the most mesial posttrite semiloph which is present on the original photo; right M2 (or M1) (Nikolov 1962, pl. 8, fig. 1), currently at NMNHS (coll. no. FM2010, second and third pretrite semilophs partially restored with plaster of Paris on the lingual side), both as *Tetralophodon longirostris*; left incomplete m3 (Nikolov 1962, pl. 11, as *Anancus arvernensis*), and a posterior fragment of a left m3 (Nikolov 1962, pl. 6, fig. 1, as *Trilophodon angustidens*). The upper teeth described as *T. longirostris* were referred to *Anancus* sp. by Markov (2004) due to the cross-contacts between the semilophs; the posterior fragment, while not positively identifiable in itself, can hardly be referred to *G. angustidens* and most probably belongs to the same anancine species as the rest of the finds. That find might be the reason Kostopoulos et al. (2001) report *Choerolophodon* from the locality; while virtually every find described as "*Trilophodon angustidens*" in the older Bulgarian literature indeed represents *Ch. pentelici*, the fragment from Bolshevik mine seems to be an exception.

Another fragmentary molar was described by Maisch (2014, fig. 2), as *Tetralophodon longirostris*. Again, cross-contacts in the interlophids support attribution to *Anancus*.

Two more finds from this locality are stored at the NMNHS. One, FM 2011, is a posterior fragment of a left M3 preserving the last two lophs and a posterior cingulum partially damaged on the posttrite side. The other, FM 3548, is a very well-preserved right m3 (Fig. 4A). The tooth has six lophids and a very weak posterior cingulum. The enamel is thick and unfold-

ed, the anancoidy is well pronounced. Occlusion on the first four lophids, dentine exposed on the first three pretrite semilophids. The measurements are as follows (in mm): length: 240; width: 87/99/100/99/90/66; height: >75 (on 3po); enamel thickness: 6–8.

No finds support the presence of *Tetralophodon longirostris*, *Gomphotherium angustidens* or *Choerolophodon pentelici* in the Burel Basin, contrary to previous reports. All gomphotheriid specimens can be referred to *Anancus*, possibly the Turolian species *A. lehmanni*. Another proboscidean species, *Deinotherium proavum* (= *D. gigantissimum*) is represented by a molar fragment (buccolingual width 98 mm) in a private collection, from the lower seam of the Kaisiinitsa Formation.

Order Perissodactyla Owen, 1848
Family Tapiridae Burnett, 1830
Genus *Tapirus* Brisson, 1762
Tapirus avernensis Croizet & Jobert, 1828

Maisch (2014) published from the Burel coal-bearing deposits of the Beli Breg (= Tsatsarovtsi) mine an incomplete right mandibular corpus and symphyseal region with well-preserved second to fourth premolars of tapir, under the name *Tapirus arvernensis* Croizet & Jobert (the original is now in the collection of the NMNHS under the FM 3547). Having in mind the Messinian (late Turolian) age of this remain and since this species is usually considered to be typically Ruscinian (Guérin & Eisenmann 1982), it makes sense to discuss the find once again in comparison with the species *T. balkanicus* (Spassov & Ginsburg 1999), described from the late Turolian localities Hrabarsko and Balsha (Sofia Basin, Bulgaria). The right lower teeth of FM 3547 fit the size of *T. arvernensis* teeth. In contrast, the left mandibular teeth of *T. balkanicus* from Balsha are visibly smaller (or in some cases barely reach the minimum) than the significant number of known *T. arvernensis* teeth (Guérin & Eisenmann 1994; Sala et al. 1990). At the same time, the strong molarisation of the upper and lower premolars of *T. balkanicus* is a hallmark of this taxon. The premolars of the Burel *Tapirus* do not show a strong molarization. Their hypolophids are significantly larger than the metalophid. This is the case on the p4, the only tooth which can be compared directly with the p4 from Balsha. Its metalophid is relatively shorter than the hypolophid, the metaconid and the entoconid are better expressed, the tooth is shorter and larger in proportions and more brachydont, the lingual and buccal walls are less well formed. All these features indicate differences with the stronger molarized (adapted to hard savannah vegetation – see below) dentition of *T. balkanicus* and demonstrate the appurtenance to *T. arvernensis*.

The hypodigm of the small *Tapirus balkanicus* is limited to the maxillary teeth from Hrabarsko (holotype of the species) and the mandibular ones from Balsha (Spassov & Ginsburg, 1999), from which arouse some mistrust about the status of the species. In a further revision Made & Stefanovic (2006) did not accept this taxon and referred, after metric criteria, the Balsha find to *T. pannonicus* and the Hrabarsko one to *Tapirus arvernensis*. Hulbert et al. (2009) also note the dimensional similarity of *T. balkanicus* with *T. pannonicus*. They also mention that a larger sample is needed to confirm the difference between the type of *T. balkanicus* and the small tapir *T. jeanpiveteaui* with no well-defined age (MN11–MN15, Spassov & Ginsburg 1999). A number of objections could be noted in relation to these taxonomical considerations: There is no doubt that a large sample can show significant variability, and some of the highlighted traits of species difference may be within the individual variability. But the upper teeth from Hrabarsko have a number of specific differences (as the developed cingulum and the features of strong molarisation) to both *T. arvernensis* and *T. jeanpiveteaui*, which reflect the mode of life and diet in the more arid conditions of the late Turolian. The locality of Balsha is hardly much older than Hrabarsko, both are from the late Turolian (Messinian). Even the Hrabarsko find is possibly slightly older than the Balsha one, after the stratigraphical scheme of Kamenov & Kojumdjieva 1983. The length of the teeth of the tapir from Habarsko are smaller than the average in *T. arvernensis*, but the proportions are different (Hrabarsko teeth have a relatively big linguobuccal width, reflecting the pronounced molarization in this species). The difference in size between Balsha and Hrabarsko is similar to individual/sex differences in other tapirs (see fig. 15 in Hulbert et al. 2009 on the big size variability in the small tapir *T. polkensis*). The existence of one and the same species *T. pannonicus* from the late Vallesian till the late Turolian seems rather unlikely. We could suppose, on the recent stage of knowledge, that a phylum of small tapirs, *Tapirus* (*Tapiriscus*) existed in Europe from the Vallesian till the late Turolian with two (or possibly three, together with T. *jeanpiveteaui*?) successive species, adapted (the body size including) to harder vegetation and intensive mobility in the more arid and opened landscapes.

Fig. 5. *Dihoplus* sp. from the Tranerska Fm of Nedelishte mine. Third lower deciduous premolar (d3) (GPIT/MA/13386) in occlusal view. Scale bar: 3 cm.

The discovery of a tapir tooth (Hadjidimovo, MN11, Spassov & Ginsburg 1999) and a postcranial remain (Strumyani, MN12, Geraads et al. 2011) with small size in the Turolian savannah conditions of Bulgaria supports this conclusion.

It is obvious that some typically Pliocene ungulates appeared in Southeastern Europe as early as the end of the Miocene (see Spassov 2002 for *H. crassum*) and this is also the case with *T. arvernensis*. It is theoretically possible that *T. balkanicus* and *T. arvernensis* coexisted for a short time during the Messinian or that the latter species appeared in the late Messinian, shortly after the disappearance of *T. balkanicus*, which seems more plausible for us.

Family Rhinocerotidae Gray, 1821
Tribe Dicerorhinini Ringström, 1924
Genus *Dihoplus* Brandt, 1878
Dihoplus sp.

Description: A single third lower deciduous tooth (GPIT/MA/13386, Fig. 5) from the Tranerska Formation (Burel Basin) was collected from the Nedelishte Mine (West Bulgaria). The distal part of the tooth is broken, with the hypolophid being cut in half mesiodistally. The ectolophid is broken in the middle, missing the distal part of the protoconid. The enamel of the tooth is very thin, as expected in a deciduous tooth. The root of the tooth is almost completely lost, with only some small remnants existing in the mesial part of the tooth. The crown is quite short, also common in deciduous teeth. The paralophid is well-developed and double. The mesial lobe is small and slightly lingually projecting, due to the mesiodistal wear with the d2 it is not completely preserved. The distal lobe of the paralophid is much longer and wider than the mesial one and is lingually projecting. From its lingual tip a thin enamel fold bends distolingually. The double paralophid does not fuse and no closed paralophid groove is formed. The metaconid is wide, long, and slightly distally projecting. The morphology of the talonid cannot be observed, due to the damage in that part. The metalophid is not yet fused with the metaconid, indicating a relative early wear stage.

Comparison: Geraads & Spassov (2009) studied rhino material from numerous localities of Bulgaria and reported the presence of five rhino genera in the late Miocene of Bulgaria. An assignment of GPIT/MA/13386 to the genus *Brachypotherium* can be ex-

cluded based on the smaller size of the d3 from the Burel Basin. Other aceratherines (*Acerorhinus* and *Chilotherium*) can be ruled out based on the much larger size of the d3 (Athanassiou et al. 2014). Therefore, the GPIT/MA/13386 can only be associated with a horned rhino.

Giaourtsakis (2009) discussed some diagnostic characters for the separation of the late Miocene species *Dihoplus pikermiensis* and *Ceratotherium neumayri*, based on the d3. Specifically, he mentioned that concerning the paralophid in *C. neumayri* the mesial lobe is larger, and a closed paralophid groove is formed when worn. The distal lobe is shorter in *C. neumayri*, whereas in *D. pikermiensis* it is longer, and its lingual tip bends distolingually. The comparison to *D. pikermiensis* (AMPG-PA3690/91; Alifieri 2019, fig. 12) and *C. neumayri* (Giaourtsakis 2009, pl. 4, figs. 7–10), shows that the d3 from the Tranerska Formation (GPIT/MA/13386) is much more similar to *D. pikermiensis* from Pikermi, because of the above-mentioned distinctive features.

The comparison within the genus *Dihoplus* is much more delicate. The dental morphology of the genus in general is quite uniform. The extreme scarcity of described deciduous teeth of *Dihoplus* spp. in the literature makes the identification even more difficult. As already mentioned, Giaourtsakis (2009) described some morphological features of *D. pikermiensis* and Alifieri (2019) described and figured one juvenile mandible of the same species. To the best of our knowledge, no detailed description, or figures of the d3 of *Dihoplus schleiermacheri* or *Dihoplus megarhinus* exist in the literature. Guérin (1980) only mentioned that the d3 of *D. megarhinus* has wide V-shaped valleys, a feature that cannot be used for the identification of the species. However, Dawkins (1865) and Guérin (1980) provided measurements for some deciduous lower toothrows of *D. megarhinus*. Based on its dimensions (L > 41 mm and Wm = 22 mm), it seems that the d3 from the Tranerska Formation falls metrically between *D. pikermiensis* and the larger *D. megarhinus*, specifically the mesial width seems to be the best indicator distinguishing *C. neumayri* from *Dihoplus* spp. (Fig. 6). Because the variability of the deciduous teeth size of *Dihoplus* spp. cannot be assessed an attribution to *Dihoplus* sp. seems most plausible.

D. pikermiensis is the best-known and most frequent of the two during the Turolian of the Eastern Mediterranean (Giaourtsakis 2003). *D. megarhinus* is typical for the Pliocene of Europe (Ballatore et al. 2017; Pandolfi 2013). Only recently has it been suggested

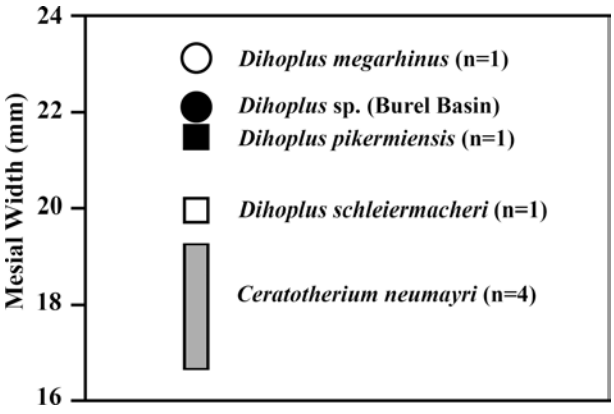

Fig. 6. Univariate plot of the mesial width of the d3 of *Dihoplus* sp. (GPIT/MA/13386; Burel Basin), *Dihoplus megarhinus* (Dawkins, 1865), *Dihoplus pikermiensis* (Alifieri, 2019), *Dihoplus schleiermacheri* (Guérin, 1980) and *Ceratotherium neumayri* (Giaourtsakis, 2009).

that the latter species was also present during the late Miocene in Hungary (Pandolfi et al. 2015; Pandolfi et al. 2016) and Italy (Pandolfi & Rook 2017). In the past, it has been suggested that *D. megarhinus* might be the descendant of *D. pikermiensis* (Giaourtsakis 2009; Guérin 1980; Heissig 1996; Heissig 1999), therefore the material from the Burel Basin could represent an intermediate state between *D. pikermiensis* and *D. megarhinus*. However, a comprehensive study with more material is needed to support this hypothesis.

Family Equidae Gray, 1821
Tribe Hipparionini Quinn, 1955
Genus *Hipparion* Christol, 1832
Hipparion crassum Gervais, 1859

Bakalov & Nikolov (1962) described briefly finds of the hipparionine horses from Burel basin (Tranerska Fm of Bolshevik = Tsatarovtsi mine), which they attributed to the species *Hipparion mediterraneum*. Unfortunately, this material, stored at Sofia University, is not accessible for investigation at the moment. Forsten (2002) discussed the finds from coal mines in the Sofia Basin (mandibular teeth from Kotina, Malorad, Hairedin) and Burel Basin and noted that they all have plicated and crenulated enamel and she referred them as belonging to *H. crassum* Group. Pictures of skeletal remains of a hipparionine horse, collected

by the mining surveyor Nedyalko Nedyalkov from the Kaisiinitsa Fm shows two upper molars, the morphology of which resembles the one of the *H. crassum* Group (after Forsten 2002): richly plicated enamel, "… the protocones and hypocones are short relative to tooth occlusal length …". On the pictures could be observed also metapodials with quite robust proportions. Therefore, the private finds support the conclusion of Forsten (2002) about the presence of a hipparionine species belonging to the *H. crassum* Group in the Burel Basin.

7. Conclusions

The available fossil specimens from the Burel Basin reveal a consistent large mammal fauna in both the Kaisiinitsa and Tranerska Formations. The following taxa have been identified: *Anancus* ? *lehmanni*, '*Mammut*' sp., *Deinotherium proavum*, *Dihoplus* sp., *Tapirus arvernensis*, and *Hipparion crassum*. The latter two species are classically regarded as typical for the Pliocene (Ruscinian) and show in the Kaisiinitsa Formation probably one of their earliest occurrences. If the Burel section is late Miocene in age, it should be clearly at the very end of this period. Biochronologically speaking, it should be referred to the late Turolian MN13. All documented perissodactyl taxa are not present during the middle Turolian ('Pikermian', MN12). A numeric age of the Kaisiinitsa Formation between 7.3 and 6.9 Ma (early Messinian, post-'Pikermian'), as proposed by Ivanov et al. (2021), is unwarranted, also from a palaeoclimatic point of view. The early Messinian is climatically rather dry in Bulgaria and elsewhere in the Balkan Peninsula. This contrasts with the humid climate reconstructed for the swampy-to-lacustrine Kaisiinitsa Formation (Ivanov et al. 2021). Members of the browsing Tapiridae, which lived in mesic habitats, are lacking from the Balkan region (as from western Eurasia) during the early Messinian (early Meotian) and no coal deposit (except the Rafina coal in Attica, Böhme et al. 2017) is dated to this period (Steenbrink et al. 2006). Coeval sediments from the Sandanski Basin (Kalimantsi Fm, SW Bulgaria) are indicative of relatively dry conditions and the basin received substantial influx of reddish dust from the Sahara Desert between 7.4 and 6.8 Ma (Böhme et al. 2018), meanwhile showing a totally different middle Turolian mammalian association (Spassov et al. 2019). Instead, comparatively more humid conditions are inferred for the late Messinian (Koufos & Vasileiadou 2015). Therefore, the mammal fauna and the overall climatic trends point to an age of the Burel Basin infill younger than 6.9 Ma, possibly around 6 Ma, as it was argued by Kojumdgieva et al. (1984). Numerical dating of the Burel section is needed, which should be provided by future research in a combination of magnetostratigraphy with geochronology of ash layers.

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Addresses of the authors:

Madelaine Böhme, Department of Geosciences, Eberhard-Karls-Universität Tübingen & Senckenberg Centre for Human Evolution and Palaeoenvironment, Tübingen, Germany;
e-mail: m.boehme@ifg.uni-tuebingen.de

Panagiotis Kampouridis, Department of Geosciences, Eberhard-Karls-Universität Tübingen, Tübingen, Germany.

Georgi N. Markov, National Museum of Natural History, Bulgarian Academy of Sciences, Sofia, Bulgaria.

Latinka Hristova, National Museum of Natural History, Bulgarian Academy of Sciences, Sofia, Bulgaria.

Nikolai Spassov, National Museum of Natural History, Bulgarian Academy of Sciences, Sofia, Bulgaria.