Late Neogene stratigraphy, biochronology, faunal diversity and environments of South-West Bulgaria (Struma River Valley)

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ABSTRACT

The stratigraphy of the Neogene deposits along the Middle Struma River (SW Bulgaria) is revised. Five genetic lithocomplexes are recognized, replacing the numerous lithostratigraphic formations currently used. The basic concept is that the upper Miocene alluvial-proluvial deposits along the Middle Struma River Valley are a product of "braided rivers" transporting important volumes of loose rocks, characterized by rapid and irregular accumulation. This accumulation occurred in conditions of increasing aridification. Uprising of the Rila and Pirin Mountains occurred later. Unlike northern Greece, where Vallesian landscapes were relatively open, humid habitats and forest vegetation seem to be well represented in the late Vallesian of the middle Struma region, but herbaceous and shrub communities already had a significant role. The Mesta River might have flowed into the Middle Struma, south of today's Petrich tectonic basin. The Turolian landscape can be reconstructed thanks to the rich Turolian mammalian faunas from the numerous (about 40) localities along the Middle

Struma. Dominant taxa are *Palaeoreas lindermayeri*, *Hipparion* (*H. brachypus*, *H.* gr. *mediterraneum-moldavicum*, and *H.* cf. *macedonicum*), *Gazella*, *Tragoportax*, giraffes. Their likely ecological requirements show that the "Pikermian biome" (*sensu* Solounias *et al.* 1999) was dominated by open woodlands resembling park type forest (rather than by shrubby vegetation). By the end of the middle and the beginning of the late Turolian, time of accumulation of Piperitsa Genetic Lithocomplex, characterized by reddish terrigenous-sandy deposits, open landscapes probably prevailed, with spots of sclerophyllous woodlands. This is probably the time of the first occurrence of the genus *Anancus* in the middle Struma, Bulgaria, and Europe.

KEY WORDS
Paleoenvironment,
stratigraphy,
biochronology,
late Neogene,
Bulgaria,
fossil mammals,
Vallesian,
Turolian,
Rhinocerotidae,
Orycteropus.

RÉSUMÉ

Stratigraphie, biochronologie, diversité faunique et environnements du Néogène supérieur du Sud-Ouest de la Bulgarie (vallée de la Struma).

La stratigraphie des dépôts néogènes le long de la moyenne vallée de la Struma (SW Bulgarie) est révisée. Nous reconnaissons cinq lithocomplexes génétiques, remplaçant les nombreuses formations lithostratigraphiques utilisées jusqu'alors. L'idée de base est que les dépôts du Miocène supérieur alluvial et proluvial le long de la moyenne vallée de la Struma ont été constitués par un réseau de rivières transportant d'importants volumes de sédiments, déposés de manière rapide mais irrégulière, dans un contexte d'aridification croissante, antérieurement au soulèvement des massifs de Rila et de Pirin. À la différence de la Grèce du Nord, où le Vallésien était relativement ouvert, les habitats humides et une végétation forestière semblent bien représentés dans le Vallésien final de la moyenne Struma, mais les herbes et petits arbustes jouaient déjà un rôle significatif. Il se peut que la Mesta ait été tributaire de la moyenne Struma, leur confluent se situant au sud de l'actuel bassin tectonique de Petrich. Les riches faunes turoliennes des quelque 40 localités de la moyenne Struma permettent de reconstituer les paysages turoliens. Les taxons dominants sont *Palaeoreas lindermayeri*, *Hipparion* (*H. brachypus*, *H.* gr. *mediterraneum-moldavicum* et *H.* cf. *macedonicum*), *Gazella*, *Tragoportax* et les girafes. Leurs exigences écologiques probables montrent que le « biome pikermien » (*sensu* Solounias *et al.* 1999) était dominé, plutôt que par une brousse arbustive, par une forêt claire ressemblant à une forêt de type parc. Dans la deuxième moitié du Turolien, au cours du dépôt du lithocomplexe de Piperitsa, caractérisé par des sables terrigènes rougeâtres, les milieux ouverts dominaient probablement, accompagnés de zones de forêts claires sclérophylles. C'est probablement à cette époque qu'apparaît le genre *Anancus*, dans la moyenne Struma ainsi qu'en Europe.

MOTS CLÉS
Paléoenvironnement,
stratigraphie,
biochronologie,
Néogène supérieur,
Bulgarie,
mammifères fossiles,
Vallésien,
Turolien,
Rhinocerotidae,
Orycteropus.

INTRODUCTION

About 40 localities of late Miocene (late Vallesian to middle Turolian) mammal faunas have been recorded by us in the Neogene deposits of the Bulgarian part of the Struma River Valley (= Strimon River in Greece; Fig. 1). Few of them are currently under exploitation, but many of them are extremely rich and promising for paleontological and stratigraphic investigations, as well as for the comprehension of the faunal and landscape evolution in the late Neogene of SE Europe. Furthermore, previous discoveries of

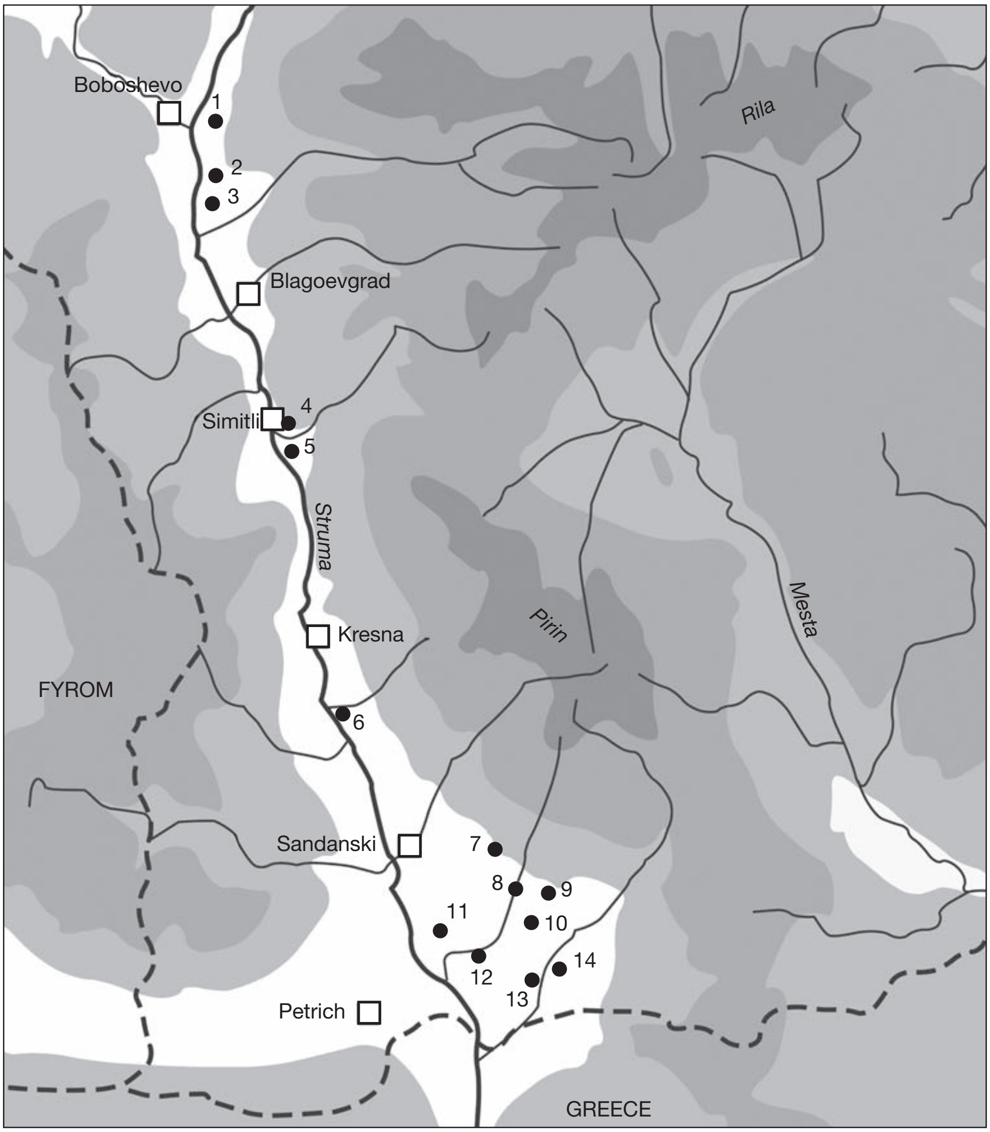

FIG. 1. — Topographic map of south-western Bulgaria with main cities and fossiliferous sites: **1**, Slatino-1 and 2; **2**, Mursalevo; **3**, Kocherinovo-1 and 2; **4**, Oranovo; **5**, Poleto; **6**, Strumyani-1 and 2; **7**, Gorna Sushitsa; **8**, Melnik; **9**, Liubovishte; **10**, Zlatolist; **11**, Levunovo; **12**, Kromidovo; **13**, Katuntsi; **14**, Kalimantsi localities.

late Vallesian and Turolian hominoids in northern Greece (about 90 km south of the Bulgarian late Miocene sites) and Turkey, in similar depositional contexts, stimulates the search for late Miocene hominoids in the rich and promising localities of south-western Bulgaria.

In previous works, the Neogene deposits of the Struma River Valley were dismembered in 27 lithostratigraphic units (formations or members; Tenchov 1993). This former lithostratigraphic subdivision of the Neogene deposits in the Struma River Valley was established on a basis valid for marine or brackish sediments, which accumulate very slowly in steady basin. However, our recent investigations have proved that the upper Miocene deposits in this area are completely of terrigenous-continental (alluvial or alluvial-proluvial) type. Their accumulation is related to active and inconstant river activity, especially of so-called braided rivers (*sensu* Leopold *et al.* 1995). This type of continental deposits is characterized by: rapid and very irregular accumulation, frequent lack of granulometric and rock gradient, cross- or drift-bedding, and very frequent lateral and vertical change of rock varieties within one and the same locality. The formerly defined lithostratigraphic units have no clear and precise superpositional relationships nor constant lithological and other features. These major shortcomings necessitate a revision of the former lithostratigraphic models and their replacement by suitable lithological subdivisions. The regional Neogene stratigraphic subdivision of the Middle Struma in SW Bulgaria proposed in this article is based on the definition of five genetic lithocomplexes (Tzankov *et al.* 2005). The estimated time of their accumulation is based on their mammalian faunas. The lithological and structural particularities of the rocks included in these lithocomplexes can also be interpreted as indicators of the late Miocene climate and environment of the region.

GEOLOGY, STRATIGRAPHY AND BIOCHRONOLOGY OF NEOGENE DEPOSITS

The Oranovo Genetic Lithocomplex

The Oranovo Genetic Lithocomplex is characterized by upper Miocene sandy clay coal-bearing deposits. The lower part of the deposits is composed of dark grey conglomerates with clayey-sandy cement. It is overlain by an alternation of grey-green sandstones, argillites and grey-brown fine bedded clays. The genetic lithocomplex, up to 200 m thick, is developed in the Simitli tectonic basin with type area in the vicinity of Oranovo, Arnautska Mahala, Krupnik and Poleto villages. Its lower boundary is erosional on the Pre-Neogene metamorphic rocks. The upper boundary is also erosional (with angular unconformity near Pankova Mahala) with the lower parts of the Slatino Genetic Lithocomplex. The lithological features give evidence of restless, quite chaotic, irregular fluvial rock transport. These features represent indirect evidence that deposition occurred in relatively humid climatic conditions and distinct seasonality. The age of the deposits corresponds most probably to the late Vallesian, given the terrestrial mammalian fauna.

Localities, faunas and age

Oranovo Quarry. A lower incisor of *Chilotherium* was found in the coal-rich levels of the quarry at a depth of about 200 m. We refer it to *Chilotherium* cf. *sarmaticum* Korotkevich, 1970.

Description of the material and taxonomic discussion: the crown of the Oranovo incisor (i2) is slightly sickle-like curved (Fig. 2C). The tooth is flattened, with a regular width, without significant broadening of the base. It has, even in the basal part, a triangular cross-section, with three clear surfaces. The lingual (dorsal) surface is the broadest one, and it lacks enamel, as in other *Chilotherium* species (Ringström 1924). This surface is slightly concave, abruptly becoming narrower towards the apex. It is separated from the slightly convex labio-mesial (ventro-medial) surface by a dorso-medial edge much sharpened by wear, but with a distinct prominence at its base. A third, disto-labial (ventro-lateral), surface is flat or even slightly concave, and delimited by two clear edges from the other surfaces. It is of almost regular width towards the base. This morphology is characteristic for the tusks of *Chilotherium*, in contrast to *Aceratherium* and *Acerorhinus*, and is related to their cutting (sickle-like) function. Upper incisors being lost, the wear of the occlusal surface results only from the contact with the upper lip which presses the food against the tusks and then cuts it by a head movement (Ringström 1924). The third surface is not so sharply delimited and becomes broader towards the base in the tusks of large species, such as *C. persiae* (collection of the Muséum national d'Histoire naturelle, Paris, MNHN) and *C. kowalewskii* (collection of the Paleontological Institute, Moscow, PIN) (see also Ringström 1924, in *C. gracile* and *C. wimani*). In those species the crown base is subtriangular

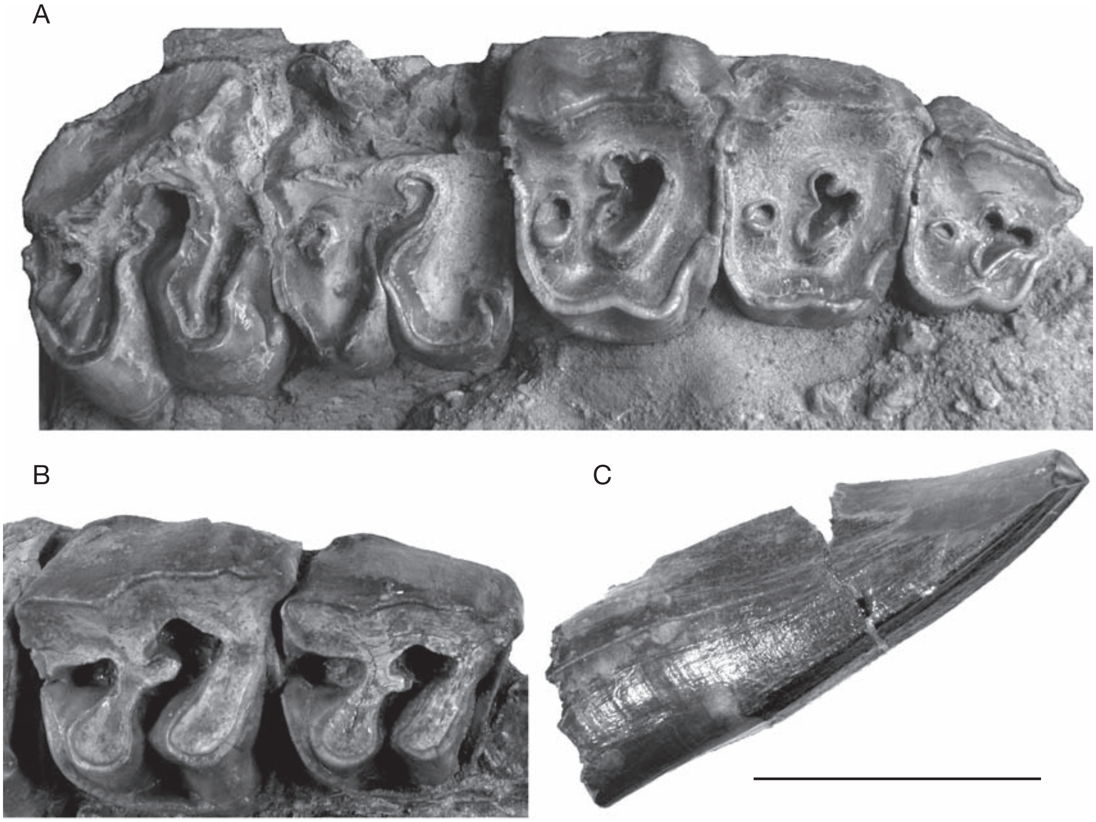

FIG. 2. — **A**, cf. *Dihoplus schleiermacheri*, upper tooth row, Slatino-2; **B**, *Aceratherium* (s.l.) sp., P2-P3, Slatino-1; **C**, *Chilotherium* cf. *sarmaticum*, lower right i2, Oranovo. Scale bar: 5 cm.

to oval in cross-section. The Oranovo incisor has the following dimensions: max. basal width of the wear surface ≈ 39 mm, crown length = 78 (restored ≈ 86 mm), max. root diameter = 35 mm, width of disto-labial surface ≈12 mm. The male tusks of *C. persiae* from Maragha (MNHN) are clearly larger than the Oranovo specimen (max. basal crown diameter: males = 56, 54, 51, 50, 49, 49; females = 30, 29; max. crown length: males = 152, 131, 103; female = 64; max. root diameter: male = 42.5; female = 27). However, the dimensions (especially the width) of the Oranovo tusk are larger than the Iranian specimens that we consider as females. The morphology of the Oranovo incisor is typical for a male: with large crown base, robust root and abrupt narrowing towards the apex. The Oranovo incisor is virtually identical in shape and size with *C.* cf. *sarmaticum* described from Reghiu, Romania (NS pers. obs. in the collection of the Institute of Speleology "E. Racovită", Bucharest), a locality that was assigned to the beginning of MN 11 (Ştiuca 2003). However, the faunal list of Reghiu includes several species that remind more of a MN 10 fauna, such as *Hipparion* ex gr. *sarmaticum*, *Galerix* ex gr. *sarmaticum* and cf. *Paenelimnoecus* sp.

Biochronological interpretation: a rich material of *Chilotherium sarmaticum* was first described from Berislav, Ukraine (Korotkevich 1970). Although not discussed in the synonymy lists of the chilotheres published by Heissig (1975, 1999), this species is smaller than the currently accepted taxa from the Asia Minor-East Europe region, such as *C. schlosseri* and *C. kowalewskii*. Berislav has been referred to the late Vallesian (MN 10) (Korotkevich 1988; De

Bruijn *et al.* 1992). Oranovo could have a similar age and could mark, together with Staniantsi in the Godech region of south-western Bulgaria, where a fragment of a similar incisor was found, and possibly Pentalophos-1 (Greece), the western limit of the range of *Chilotherium*. In Greece, this group is known only by a primitive form from the Vallesian of Pentalophos-1, *Aceratherium kiliasi* Geraads & Koufos, 1990, which was included in *Chilotherium* s.s. by Heissig (1996) and Fortelius *et al.* (2003). The detailed phylogenetic analysis of these tusked rhinos still needs to be worked out, because diagnoses are still badly missing, but in any case no specimen from Pentalophos matches the Oranovo incisor. Detailed comparisons of the latter with the smaller forms from Samos may shed more light on its affinities.

Poleto. Green-grey coal-bearing laminated slates crop out on the northern margin of Poleto Village. The teeth described by Spassov & Koufos (2002) as *Dinocrocuta gigantea* (Percrocutidae) probably come from these deposits. This species is known until the Turolian in China (Werdelin 1996; Deng 2004) but in Europe, it is restricted to the Vallesian of the south-eastern part of the continent: Pentalophos-1 in Greece (Koufos 1995), Varnitsa in Moldova (Lungu 1978) as well as from an unknown locality near Nessebar (Bulgaria). This supports a Vallesian age for Poleto as well. It seems that the progressive extinction of *Dinocrocuta* begins in this part of Europe, where it could be related to the progressive Turolian aridification. Such environmental conditions could have been more suitable for a probably better socially organized competitor, *Adcrocuta* (Koufos 1995; Spassov & Koufos 2002). *Dinocrocuta* persisted also in the Turolian of Western and Central Europe with at least another species (Werdelin 1996; Morlo 1997).

THE SLATINO GENETIC LITHOCOMPLEX

The name of the Slatino Genetic Lithocomplex comes from the village of Slatino. It is characterized by upper Miocene alluvial-proluvial carbonate-free terrigenous deposits. It consists mostly of sands but also of sandy-clays and aleurolite-clays. The lithocomplex section is composed by unsustained beds, interlayers and lenses of clays with gravels (as a dominant component) and sandy or aleurolite-sandy clays with clay concretions. The rocks are mostly grey but also blue, green or yellow, without any indicator of aridity. The type area, with characteristic sections, is located between the villages of Slatino, Badino and Usoika. This genetic lithocomplex includes Dzherman and Pokrovishka formations (in the area between Dupnitsa and Blagoevgrad), Simitli and Chernichevo formations (in the area between Simitli and Krupnik) and Delchevo Formation (south of Kresna). The lower boundary of the complex is very sharp on the medley basement of Pre-Cambrian metamorphic rocks, the Paleogene sediments or the deposits of the Oranovo Genetic Lithocomplex (north of Simitli). The upper boundary of Slatino Lithocomplex with the overlying grey or blue-grey calyces of the Gradishte Bench Mark Group of strata is transitional.

The lithological characteristics of the Slatino Genetic Lithocomplex present indirect evidence that its deposits were formed from water streams with irregular flow, hydroenergy and direction in a relatively humid climate with marked seasonality.

The mammalian faunas indicate a late Vallesian age, but they must be more recent than the Oranovo ones, because they are stratigraphically higher.

Deposits probably contemporaneous with the Oranovo-Slatino Genetic Lithocomplexes crop out on the right bank of the Struma River between the Slivnitsa and Drakata villages, with scarce faunal remains near Kamenitsa.

Localities, faunas and age

Two Miocene rhinoceros from the region of Slatino were found in the collections of the Boboshevo museum. Their clayey matrix indicates that the fossils probably come from two different localities: Slatino-1 and Slatino-2.

Slatino-1. Description and comparison: the find is a maxillary fragment with DP1 and P2-P3 and roots of P4 (Fig. 2B) (DP1 length × max. width = 21 × 18 mm; P2 = 39 × 43.5; P3 = 43.5 × 50). We refer it to *Aceratherium* (s.l.) sp. P2-P4 are moderately worn. The milk premolar is strongly worn, small, and triangular (mesially pointed). P2-P4 are relatively elongated (P2 is sub-quadratic in shape). The ectolophs are preserved in P2-P3. Their labial walls are inclined lingually and with relatively smooth surfaces. The paracone fold is weak, especially on P2. The posterior part of the ectoloph is relatively thick. The metalophs of P2-P3 are rather short, with a rounded hypocone, and the protolophs are oblique. The crochet of all two permanent premolars is short. The median valley is closed lingually by the antecrochet, which forms a high connection between protoloph and metaloph. It is separated from the protocone, on the lingual surface of the protoloph, by a vertical furrow, which increases in depth from P2 to P4. On P2, the posterior valley is not totally closed and the postfossette is elongated. P2 and P3 have very strong mesial and lingual cingula, especially high around the hypocone. The lingual outline is straight, whereas the Turolian specimens of the Struma Valley have a broken outline.

Identification of fragmentary dental remains of rhinoceroses is not easy. The flat labial wall makes them unlike those of *Dicerorhinus* s.l., and they differ from *Ceratotherium* by the broad antecrochet. These teeth have some resemblance with those of "*Dicerorhinus*" *belvederensis* Wang, 1929, included in *Hoploaceratherium* by Heissig (1999). On the whole, they are indeed more like those of *Aceratherium* s.l., a waste-basket genus with a very sparse record after the Vallesian.

Slatino-2. The find represents a skull fragment with well worn right P2-M2, but the molar ectolophs are missing (Fig. 2A). We refer it to cf. *Dihoplus schleiermacheri* (Kaup, 1832). The matrix is a grey-green gravellite clay concretion most probably washed by running waters. Such kind of clays, typical for the Slatino Lithocomplex crop out in several places around Slatino village (e.g., East of the village where they are more than 15 m thick).

Description and comparison: P2-P4 length = 108 mm; P2 length × max. width = 32 × 40; P3 = ≈ 37 × ≈ 48; P3 = 41 × ≈ 54). The premolars are broad. The labial wall of P2 is convex. The metacone and especially the paracone ribs are strong on P3-P4. The lingual cingulum is weak on the premolars, and totally absent on the molars. The median valley is closed lingually on the premolars with a high and broad wall between the protoloph and the metaloph. The crochet is present but small on all teeth and a small crista is formed only on the premolars. The postfossettes are closed on all teeth. On the molars, the protoloph is lingually pinched, so that the protocone is distinct, with anterior and posterior furrows, and a broad antecrochet. By these features, these teeth show similarities with "*Dicerorhinus*" *pikermiensis* and *Dihoplus schleiermacheri*, two species that are dentally similar. However, the Slatino-2 maxilla shares with the type of the latter species (Hessisches Landesmuseum, Darmstadt, HLMD-Din1932) a very anterior position of the bottom of the nasal opening (a primitive feature), which does not extend caudally beyond the level of the anterior part of P2. It is always significantly more posterior in "*D.*" *pikermiensis*. Accordingly, we provisionally assign the Slatino-2 maxilla to *Dihoplus schleiermacheri* (Kaup, 1832).

Biochronological discussion: *Dihoplus schleiermacheri*, defined at Eppelsheim, has sometimes been reported from Turolian sites, but this is doubtlessly due to its tooth similarities with "*D.*" *pikermiensis*. All Turolian skulls (several are known from Pikermi) are distinct from the Eppelsheim type of *D. schleiermacheri* and this species is, at present, characteristic of the Vallesian of Western Europe (Guérin 1980). Bakalov & Nikolov (1962) reported it from Bulgaria upon inadequate remains, and this erroneous identification was repeated by Nikolov (1985). Recently it has also been reported from the Turolian of European Turkey at Yulafli (Kaya & Heissig 2001), but the site is in fact clearly Vallesian (Geraads *et al.* 2005).

Therefore, although final identifications are always difficult with fragmentary rhino remains, we take both finds from Slatino (Slatino-1 and 2) as strongly suggestive of Vallesian faunas in the area.

Levunovo. A fossil found in a core near Levunovo village was identified by Nikolov (1985) as *Micromeryx flourensianus* Lartet, 1851 and referred by him to the middle Miocene (Sarmatian). *Micromeryx* is known until the early Turolian (Gentry *et al.* 1999) and is of little help to determine the age of Levunovo, all the more as the fossil is not from an outcrop and is not presently available for revision. However, the stratigraphic data suggest that the Slatino Lithocomplex might crop out in this area.

GRADISHTE BENCH MARK GROUP OF STRATA

This stratigraphic unit is present by a bundle of mostly grey-green to olive green, rarely yellow-brown clays with various thickness, up to 10-15 m (rarely more). The lower boundary is transitional with the rocks of the Slatino Genetic Lithocomplex. The upper boundary is also transitional with the lower parts of the Strumyani Genetic Lithocomplex. The Gradishte Bench Mark Group of strata crops out as big spots or short bands in the area of Dzherman (south of Dupnitsa), from Mursalevo through Elenov Vrah peak as far as the Gradishteto peak (the type area of this genetic lithocomplex), in the area of Blagoevgrad and Sandanski, and of the villages of Novo Delchevo, Spatovo, Hotovo, Harsovo, Kalimantsi and Katuntsi. This unit consists of lacustrine-marshy or fluvial deposits formed by braided rivers. The lithological data indicate relatively stable conditions of accumulation and not very intensive hydrodynamic processes in a climate not less humid than that of the Slatino Genetic Lithocomplex deposits, but perhaps with less expressed seasonality. The mammalian fauna indicates a Turolian age.

Localities, faunas and age

Mammal localities: Mursalevo (MN 11?); Kocherinovo-1; Kocherinovo-2; Sandanski (MN 11?); Kalimantsi-1.

The main localities are as follows:

Kocherinovo-1. In the first half of the 1970s a fossil mammal fauna was discovered by I. Nikolov between the villages of Mursalevo and Kocherinovo in the region of Kamarata (or Gradishte – hence the name of the Gradishte Lithocomplex). His unpublished notes list: *Indarctos* sp., Proboscidea indet., *Hipparion mediterraneum*, *Dicerorhinus* sp., *Microstonyx major*, *Helladotherium* sp., *Gazella* sp. (see also Nikolov 1985). The location of the locality was lost after Nikolov's death. The fossils (stored mostly in the collections of the Palaeontological Museum of the Faculty of Geology and Geography of the State University of Sofia) are still undescribed and not available. Some bones from this locality, kept in the Natural Museum of Natural History, Sofia (NMNH) (hipparion and a female of *Tragoportax* sp.) show that the matrix is the typical green clay of the Gradishte Bench Mark Group of strata. One of the most interesting finds from the locality (still unpublished and apparently lost after Nikolov's death) is an almost complete skull of *Orycteropus*, lacking the rostrum and most of the teeth.

Description, comparison and biochronological significance: some photos of the skull are preserved (Fig. 3). They show that the temporal lines are true crests, stronger than in *O. gaudryi*. The caudal portions of these lines almost meet, thus virtually forming a sagittal crest (a primitive feature as in the archaic forms of the phylum). From the photos, the M3 is small, short mesio-distally and broad, with an almost round outline. Its posterior lobe is quite small, and separated from the mesial one by inconspicuous lingual and buccal grooves (Fig. 3D). The tooth dimensions are unknown, but manuscript notes of I. Nikolov suggest that M3 had a width of 7.5 and a length of 7.3 mm. The M3 is quite distinct from the 8-shaped M3 of *O. gaudryi* from the Balkano-Iranian middle Turolian, and more like the M3s with a reduced second lobe of earlier forms such as *O. pottieri* of Greece and Turkey, *O. mauritanicus* from Algeria, and especially *O. browni* Colbert, 1933 from the Siwaliks (Colbert 1933; Pickford 1978; Bonis *et al.* 1994), a skull of which was tentatively dated recently at 7.9 Ma, which corresponds to the early Turolian (Barry *et al.* 2002).

Kocherinovo-2. This locality was discovered in 2001 by Spassov and Geraads, during our field investigations on the Neogene of Middle Struma. It is located immediately north of the Gradishte Hill in the level of the uppermost green sandy clays of the Gradishte Bench Mark Group of strata. It does not match Nikolov's description of Kocherinovo-1; thus, it is probably a different locality.

Excavations were carried out in 2002. The preliminary faunal list (det. Spassov, Geraads, Markov & Hristova) includes:

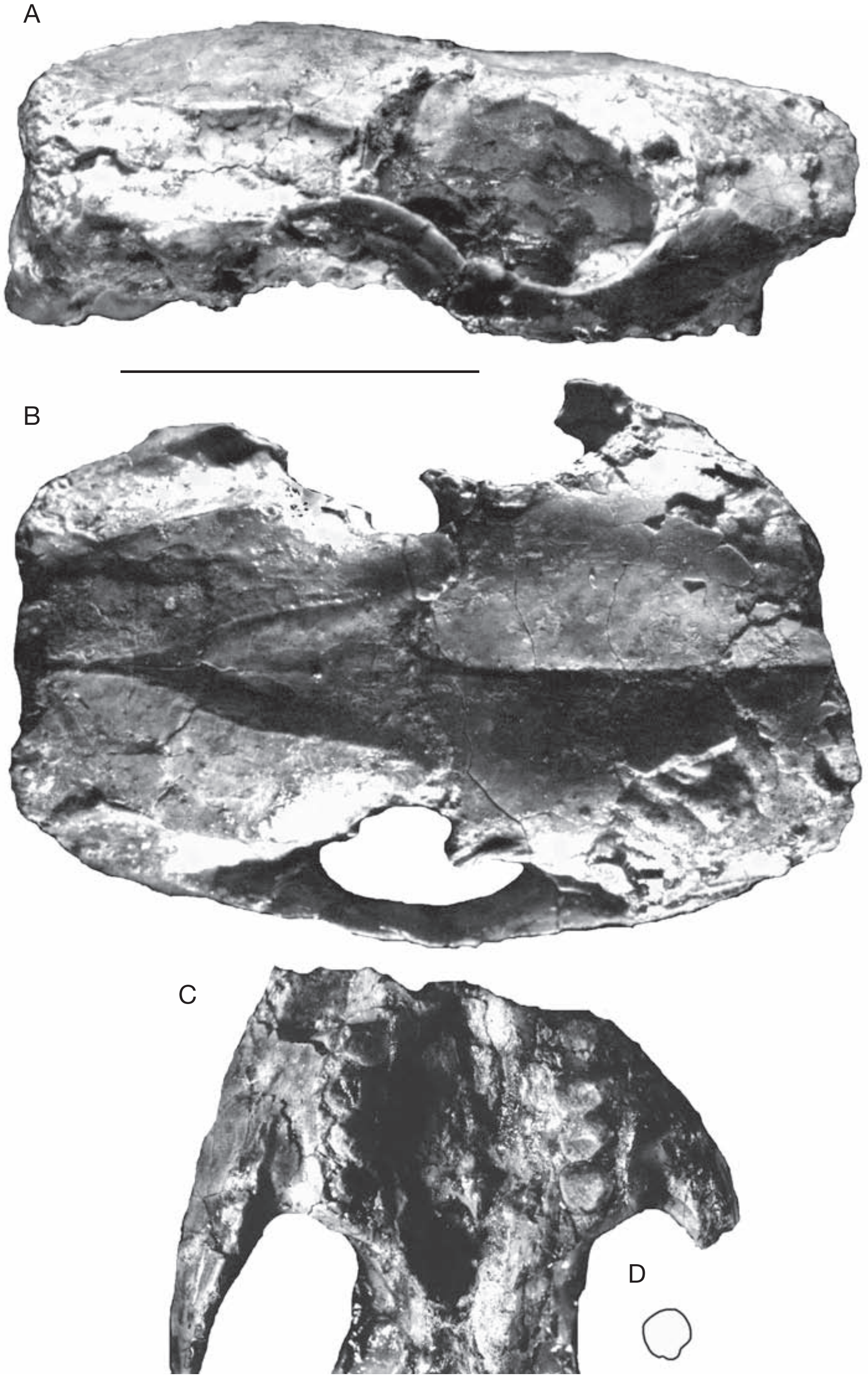

FIG. 3. — *Orycteropus* cf. *browni*, skull: **A**, lateral view; **B**, dorsal view; **C**, ventral view; **D**, outline of left M3. Kocherinovo-1 (reproduction of unpublished photos by I. Nikolov). Scale bar: *c*. 5 cm.

Choerolophodon pentelici ssp., *Hipparion* sp. (medium-sized form), *Hipparion* gr. *macedonicum*, *Microstonyx major*, Giraffidae indet. (small form), *Gazella* sp., *Palaeoreas lindermayeri* (small-horned morph), Bovidae indet. (*Miotragocerus* (*Pikermicerus*) *gaudryi*?).

The fauna could belong to (early?) MN 11. The dp3 of *Choerolophodon pentelici* corresponds to the evolutionary stage of specimen KTD 66 from Kemiklitepe-D, Turkey (MN 11) (see Tassy 1994). The very small hipparion from Kocherinovo-2 (*H.* gr. *macedonicum*) is not known from the MN 12 faunas of Bulgaria. Lithostratigraphically, the deposits correspond to levels lower than those of the localities Strumyani-1 and 2 (see below), also provisionally ascribed to MN 11.

Kalimantsi-1 (KAL-1). The fossiliferous area of the Kalimantsi village is the richest in the basin of the Middle Struma and the best known of the Bulgarian late Miocene vertebrate localities. In fact the name Kalimantsi refers to a large area (≈ 6 km^2) of late Miocene fossiliferous deposits with more than 10 known fossiliferous spots. The first data on the fossil mammals are from the 1930s (Drenovski 1932). This fauna is best known from the classic monograph of Bakalov & Nikolov (1962). The biochronology of the localities rested mostly, until recently, on the latest paper of Nikolov (1985) based on the data collected till the 1980s from the classic localities of the Kalimantsi area, such as Kalimantsi-1 (the old excavations at the river bank), Kalimantsi-2 (Peshternik), Kalimantsi-3 (Prehvarloka) and Kalimantsi-4 (Beliovski pat). The excavations in the late 1970s and the 1980s conducted by D. Kovachev led to the discovery of a rich fossil material as well as of new Kalimantsi (KAL) localities such as KAL-Pehtsata, KAL-Bukovets, KAL-Bardovski pat, KAL-Atso, etc.

Until recently (Kojumdgieva *et al.* 1982), the lower fossiliferous level of the Kalimantsi area (KAL-1) was thought to be of Vallesian age; this opinion was based upon old mammal identifications (Bakalov & Nikolov 1962; Nikolov 1972, 1985). New revisions (Geraads *et al.* 2001 on chalicotheres; Geraads *et al.* in prep. on rhinoceroses; Markov 2004 on deinotheres; Forstén *in litt.* on the doubtful old determination of *Hipparion* cf. *theobaldi* by Nikolov) as well as new field survey led us to revise the former biochronological concepts. We conclude that all Kalimantsi localities (distributed over deposits more than 100 m thick) are of Turolian age and that there is no evidence of any Vallesian fauna in the Kalimantsi area. KAL-1, which seems to belong to the uppermost part of the green clays of the Gradishte Lithocomplex, yielded a fauna that is probably of early Turolian age (see below). The other Kalimantsi localities (referred to the Strumyani Lithocomplex) are probably of middle Turolian age (see below: localities of the Strumyani Genetic Lithocomplex).

Preliminary identifications of the fauna collected during our new excavations in Kalimantsi-1, the river bank near the old farm yard (2002-2003) are: Proboscidea indet., *Hipparion* gr. *macedonicum*, *Hipparion* cf. *brachypus*, *Bohlinia* sp., *Helladotherium duvernoyi*, *Gazella* sp., *Tragoportax* sp. (see Spassov & Geraads 2004 for the taxonomy of this genus), *Prostrepsiceros* cf. *houtumschindleri*, *Mesopithecus* sp. (the fossils are deposited in the Paleontological Museum of Assenovgrad, a branch of the NMNH). The *Mesopithecus* material is insufficient for a final conclusion about the affinities of the Kalimantsi-1 sample, which lie either with the earlier *M. delsoni* or with the later and smaller *M. pentelicus*, but we can mention that partial male and female remains (coll. D. Kovachev) consist of relatively robust individuals.

STRUMYANI GENETIC LITHOCOMPLEX

This stratigraphic unit consists of alluvial-proluvial terrigenous deposits, composed mostly of sands or sandy-clays and aleurolite-clays. Unsustained beds, interlayers and lenses represented mostly by sands, but also by gravel sands or aleurolite-sandy calyces, several hundred meters thick (in some regions probably less), compose the complex section. The main lithological characters of the unit are: 1) presence of carbonate substance in the rock cement and lenses of carbonate and carbonate-sandy calyces; 2) absence of clay concretions; and 3) appearance (in the upper parts of the lithocomplex sections) and gradual (upwards) increase of the aridity marks (yellow-orange, orange, reddish to dark red coloration of some beds or bed bundles). The rocks are mostly white-grey, grey, yellow-grey or yellow. The lower boundary of the stratigraphic unit is transitional upon the rocks of Gradishte Bench Mark Group of strata. The upper boundary presents a rapid transition to the basement of the Piperitsa Genetic Lithocomplex. The Strumyani Genetic Lithocomplex includes what are often called Sandanski and Kalimantsi formations (except the Ilindentsi member of the latter). It crops out in a wide belt on the left bank of the Struma (with some small outcrops on the right bank) between Dzherman and Blagoevgrad; in the Simitli tectonic basin; between Kresna, Sandanski and Melnik and to the south in the larger part of Petrich tectonic basin. Its type area is between Strumiani, Ploski and Kresna villages. Our revisions show that in the area between the villages of Brezhani, Mechkul, Senokos and Stara Kresna (on the left Struma bank in the Kresna Gorge) this lithocomplex (and the upper Neogene deposits as a whole) is absent (*contra* the data in the sheet Razlog of the 1:100,000 Geological Map of Bulgaria, in which the Kalimantsi Formation is mapped in this area). Only intensively weathered to disintegrated Paleozoic granitoides crop out in this area.

The Strumyani Lithocomplex was probably deposited during the time span that corresponds to the late early Turolian and to the middle Turolian (perhaps before the end of the middle Turolian).

Localities, faunas and age

The known localities are: Brejani (MN 11?-12), Gorna Gradeshnitsa (MN 11-12), Gorna Sushitsa (MN 11-12), Strumiani-1 and 2 (possibly the second half of the MN 11), Ploski (MN 11-12), Djigurovo (MN 11?), Novo Delchevo (MN 11?-12), Liubovishte (MN 12), Vinogradi (MN 11-12), Marino Pole (MN 11-12), Kromidovo-1 (MN 12?), Kromidovo-2 (MN 12), Zlatolist (= Dolna Sushitsa) (MN 11-12), Chereshnitsa (MN 11-12) and the Kalimantsi localities of the MN 12 zone (that is, except Kalimantsi-1, MN 11, see above: Gradishte Bench Mark Group of strata). The localities with better-known or richer faunas are reviewed below.

Gorna Sushitsa (MN 11-12). The revised faunal list summarized from the papers of Bakalov & Nikolov (1962), Nikolov (1985), Geraads *et al.* (2001), Spassov (2002), and Koufos *et al.* (2003) includes the following taxa: *Ancylotherium pentelicum*, *Chalicotherium goldfussi*, *Hipparion* sp. (*Hipparion* "*theobaldi*"?), *Hipparion* aff. *mediterraneum*, *Tragoportax* sp., *Palaeoreas lindermayeri*, *Mesopithecus pentelicus*. The identification of "*Hipparion* cf. *theobaldi*" by Nikolov (1985) is ambiguous and needs revision (Forstén *in litt.*). It is quite possible that the fossils originate from more than one fossiliferous spot near the village of Gorna Sushitsa. Recent surveys in this area by two of us (NS and DG) in 2004-2005 resulted in the discovery of nine different fossiliferous spots in both sides of the ravine near the village; some of them differ significantly in altitude, implying at least some age differences. Remains of a large giraffid, of a small hipparion, as well as of a rhino (cf. *Dicerorhinus*) and of a chalicothere were found in the lowermost part of the newly discovered spots.

Strumyani-1 (later part of MN 11?) (= Ilindentsi-1 in Spassov 2002). The locality was discovered in 2001. The preliminary faunal list (det. D. Geraads, N. Spassov, L. Hristova) includes: Proboscidea indet., *Ancylotherium pentelicum*, *Hipparion* sp. I, small form (*H. macedonicum-H. matthewi*), *Hipparion* sp. II-robust form (*H. primigenium-H. brachypus*), Rhinocerotidae (*Ceratotherium*?), Giraffidae indet. (rather large), *Gazella* sp., *Tragoportax* sp.?, *Palaeoreas lindermayeri* (small-horned morph), *Sporadotragus* sp.

The locality is stratigraphically just above the green sandy clays of the upper level of the Gradishte Bench Mark Group of strata. Thus, it might be contemporaneous or slightly younger than the Kocherinovo localities (see above).

Strumyani-2 (later part of MN 11?) (= Ilindentsi-2 in Spassov 2002). We discovered the locality and conducted excavations in 2003 (Fig. 4). The preliminary faunal list (det. D. Geraads, N. Spassov, L. Hristova) includes: *Hystrix* sp., Mustelidae indet., Proboscidea indet., *Hipparion* sp. I (*H. moldavicum*?), *Hipparion* sp. II robust-form (*H.* cf. *brachypus*), *Hip-*

FIG. 4. — The Turolian locality of Strumyani-2, in 2003.

parion sp. III (*H.* cf. *dietrichi*), *Ceratotherium* sp.?, cf. *Dicerorhinus* sp., *Microstonyx major*, Giraffidae I (size of *Helladotherium*/*Samotherium*), Giraffidae II (small form), *Dorcatherium* sp., *Gazella* sp., *Tragoportax* aff. *rugosifrons*. From their stratigraphic position both Strumyani localities could be very close, just above the green clays of the upper level of the Gradishte Lithocomplex.

Kromidovo-2 (MN 12). The fauna discovered in the region includes: *Bohlinia attica*, *Hipparion* cf. *mediterraneum*?, *Hipparion* cf. *matthewi*?, *Adcrocuta eximia*, *Mesopithecus pentelicus* (after Nikolov 1985 with our own corrections and a revision of *Mesopithecus* by Koufos *et al.* 2003).

Kalimantsi-2 (KAL-2) (Peshternik ravine) (early MN 12?). The exact location of the old excavations is not known with precision. Most probably the fauna was discovered in the brownish or grey-brown to grey-green sandy clays around the ravine (perhaps its right bank near the village). The fauna contains: *Simocyon primigenius*, *Thalassictis robusta*?, *Plioviverrops orbignyi*?, *Adcrocuta eximia*, *Paramachairodus* cf. *orientalis*, *Ancylotherium pentelicum*, *Hipparion mediterraneum*, *Hipparion* cf. *brachypus*, *Microstonyx major*, *Tragoportax* cf. *amalthea*, *Mesopithecus pentelicus* (after Bakalov 1934; Nikolov 1985 with revisions by Geraads *et al.* 2001; Spassov 2002; Koufos *et al.* 2003, and our own additions). It is not quite sure that the *Mesopithecus* remains were associated with the rest of the fauna: the stratigraphy in the area of the lowermost Kalimantsi localities is complex. KAL-1 and KAL-2 (the latter is at a higher altitude) may be of roughly the same age. On the other hand, the *Mesopithecus* from KAL-2 is similar to samples from the MN 12 zone, not with those from MN 11, the zone into which we include KAL-1. Ginsburg (1999) referred the *Simocyon* remains from the locality to the species known from the MN 12 localities of Pikermi and Concud.

Kalimantsi-4 (Beliovski pat) (MN 12). The fauna contains: *Plioviverrops orbignyi*?, Rhinocerotinae indet., *Hipparion* aff. *brachypus*, *Hipparion* gr. *mediterraneum-moldavicum*, Bovidae indet. sp. 1 and 2, *Helladotherium duvernoyi*, *Mesopithecus pentelicus*.

This list is from the catalogue of I. Nikolov (1985), including our own taxonomic or nomenclatural revisions and additions. *Hipparion crassum* Gervais, 1859 noted by Nikolov (1985) is a Ruscinian species and its penetration in Europe earlier than the second half or end of MN 13 is very doubtful, but there is no evidence of a fauna younger than the middle Turolian in Kalimantsi. Already, Forstén (2002) doubted the presence of this species in this locality.

Kalimantsi-Pehtsata (MN 12). The locality was discovered by D. Kovachev. The following taxa were identified: *Mesopithecus pentelicus*, *Indarctos bakalovi*, aff. *Hyaenictitherium* sp., *Helladotherium duvernoyi*, *Bohlinia attica*, *Gazella* sp., *Kalimantsia bulgarica* (Kovachev 1988; Geraads *et al.* 2001; Geraads *et al.* in press).

PIPERITSA GENETIC LITHOCOMPLEX

This lithocomplex is composed of irregular alternated deposits as follows: 1) thick (around 350 m) unsorted interdigitated red, violate-red, reddish and brown-reddish medium-clastic conglomerates and breccia conglomerates with reddish sandy, carbonate-sandy and carbonate-clay-sandy matrix; 2) red or reddish gravelites, sandstones and rare green or reddish-green clay. The lower boundary presents a rapid transition from the Strumyani Lithocomplex. The upper boundary is erosional and covered by lower Pleistocene pebbles. This lithocomplex includes the previously recognised Katuntsi Formation, some of the uppermost parts of the Kalimantsi Formation in the Pirinska Bistritsa basin and probably also the Ilinden Member of the Kalimantsi Formation (in the area of Ilindentsi south of Kresna). In its type area, in the south-eastern part of the Petrich tectonic basin, the outcrops of this stratigraphic unit are limited by the villages of Gorno Spanchevo, Katuntsi and Piperitsa. Similar deposits occur as well in the Strumitsa tectonic basin and between Strumitsa and Valandovo in the eastern part of the Republic of Macedonia, with a Turolian fauna in the Valandovo area. The upward increase of red or reddish colour intensity in the section of the Piperitsa Genetic Lithocomplex indicates a gradual and long process of aridification. The formation of this stratigraphic unit may correspond to the end of MN 12 and MN 13 mammalian zones.

Localities, faunas and age

The scarce traces of mammal fauna that most probably originates from this Piperitsa Lithocomplex mostly include two single finds of *Anancus* "*arvernensis*". According to Bakalov & Nikolov (1962) and Nikolov (1985) one of the fossils was found near Kresna and the other in the region of Melnik, but the exact localities are not known. A mandible fragment of Rhinocerotinae (labelled "Kulata"; see Bakalov & Nikolov 1962) could also derive from the Piperitsa Lithocomplex, because it retains traces of its brick-reddish clay matrix. Most probably this find is from the region to the east of Kulata (at the Greek border), where the deposits of the Piperitsa Lithocomplex crop out on the left bank of Petrovska River. The age of the *Anancus* finds is not very clear. They may originate from the reddish to fawn-reddish sands and gravelites with reddish clay that crop out near Melnik (or more precisely near Rojen). These deposits are of latest Miocene rather than Pliocene age, because no sharp boundary is seen between them and the immediately underlying yellow to yellow-grey upper Miocene deposits, which are similar in composition, whereas a sharp boundary could be expected between the dry late Miocene (Messinian) environment and the humid woody early Pliocene (Ruscinian) one. If the *Anancus* remains mentioned above are not from the Piperitsa deposits they could originate from the uppermost levels of the Strumyani complex.

This early occurrence of *Anancus* in Bulgaria should be compared with some other European finds. *Anancus arvernensis* Croizet & Jobert, 1828 is typical for the Pliocene of Europe and it is especially widespread in the Ruscinian as well as in the early Villafranchian. However, this species possibly appears in Europe as early as the end of the Turolian, while the genus *Anancus* is present in South and Central Europe before this time. The recent determinations suggest that its earliest finds on the continent (in Bulgaria as well) are as early as middle or late MN 12 according to Metz-Muller (2000). According to this author, *A. arvernensis* might be present in three MN 12? and MN 13

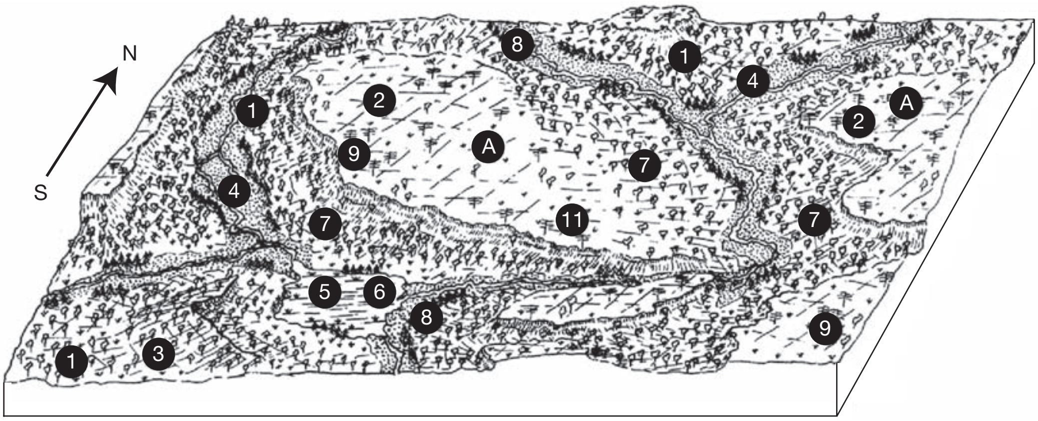

FIG. 5. — Reconstruction of the late Vallesian environment in south-western Bulgaria: **1**, lowland, flat land and hilly flat land relief (forming pediment bottom); **2**, plateau and inselbergs; **3**, monoclinal volcanic ridge; **4**, principal breaded river channel band with the active river bed; **5**, lake; **6**, swamp with swamp vegetation; **7**, broad-leaved forests to open woodlands; **8**, hygromesophyllic (incl. wetland) forest and woodlands; **9**, mixed/coniferous forests; **11**, open woodland; **A**, fragments of the early Miocene denudation-accumulation plain (orthoplain).

localities of Spain, but the species determination is ambiguous. A probably different species, more primitive by its tooth features and perhaps with strong affinities to the Asian Turolian *A. perimensis* occurs at Hohenwart (Austria, MN 12-13?) and in Dorn-Dürkheim 1 (Germany), where the presence of a primitive *Anancus* in the Gomphotheriid sample described by Gaziry (1997: pls 1-4) is unquestionable. It is assumed that Dorn-Dürkheim 1 is a MN 11 locality mostly after the micromammals but also after the whole fauna (Franzen & Storch 1999; Kaiser *et al.* 2003). However, the geology and the macromammals (including the *Anancus*) suggest a complex taphonomy and biochronological problems. The presence of *Anancus* in a European fauna of late Vallesian to early Turolian character is unusual given our present knowledge of the history of the genus (Metz-Muller 2000; Markov 2004a). If confirmed, the MN 11 occurrence (Dorn-Dürkheim 1) could result from a temporary and unsuccessful first wave of immigration from the East to Europe in the early Turolian, followed by more successful waves in the second half of the Turolian. Alternatively, and perhaps more likely, some of the faunal elements from different levels may have been mixed in the German locality. This possibility is supported by the known cases of inclusion of middle Pleistocene *Mammuthus* teeth (from Dorn-Dürkheim 3) in the late Miocene levels (Franzen *et al.* 2000).

Many Bulgarian localities with *Anancus* sp. are of middle-late Turolian age (MN 12-13) (Metz-Muller 2000, although not all localities listed by her are really of this age; Spassov 2002; Markov 2004b; Tzankov *et al.* 2005). The molars from these localities show primitive features, different from those of *A. arvernensis* (Markov 2004a). The species might have arisen in the Asian part of the the Balkano-Iranian late Miocene zoogeographic province, under conditions of gradually increasing aridification during the Turolian, and later may have migrated to Europe in the late middle to late Turolian.

SUCCESSIONS OF THE LATE MIOCENE ENVIRONMENTS

LATE VALLESIAN (FIG. 5)

In our concept, the late Miocene deposits in the region accumulated relatively rapidly by the activity of braided rivers transporting important volumes of loose rocks. This accumulation occurred in conditions of gradual landscape peneplenisation

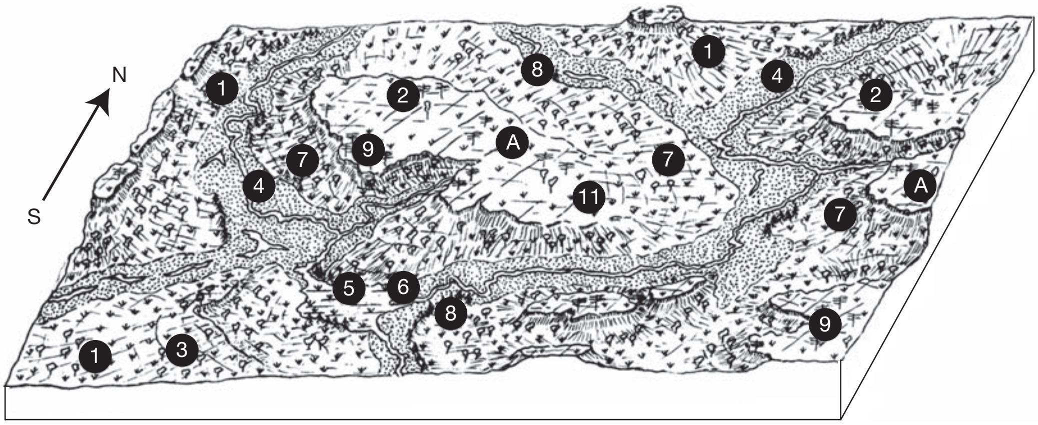

FIG. 6. — Reconstruction of the environment at the beginning of the Turolian in south-western Bulgaria. Legend as for Figure 5.

and increasing aridification. Uprising of the Rila and Pirin Mountains occurred later (Tzankov *et al.* 2005). One of the most important arguments for the post-early Pleistocene rapid uplift of Rila and Pirin Mountain ranges is the recent uplifted fragments of the early Pleistocene continental deposits and of their basement (which includes upper Neogene deposits) on both sides of the Struma River south of Dupnitsa. These fragments are delimited by post-early Pleistocene high angular and low-angular listric normal faults. The movements on the fault planes have cut up a large number of listric prisms, arranged in successive steps uplifted towards mountain slopes. They include relics of lower Pleistocene and upper Neogene deposits, so that some parts of the Neogene cover in the region are elevated up to more than 900 m above sea level (Tzankov *et al.* 2005).

It is usually admitted that the European Vallesian is characterized by a humid climate with widespread forest vegetation (Reumer 1995). At the same time, beginning with the middle Vallesian, increasing aridification on the continent led to faunal changes, more significant in Western Europe and less expressed and more gradual in the less woody Eastern Europe (Fortelius *et al.* 1996).

The geological and paleontological features of the Oranovo and Slatino Genetic Lithocomplexes suggest some ideas about the late Vallesian environments in the Middle Struma.

Paleofloristic data from north-western Bulgaria indicate that at about this time thermophilous forests prevailed in this area, where *Quercus*, *Castanea*, *Ulmus* and *Carya* dominated, while herbaceous and shrub communities gradually started to play an important role (Stuchlik *et al.* 1999). Rich paleofloristic data also derive from cores in the Sandanski region of the Middle Struma (Ivanov 2001, 2003). The floral remains are from the coal and charring clay levels (≈ 120-460 m depth), which probably correspond to the levels of the Oranovo Lithocomplex, because no other lithocomplex yields coal deposits, and because the ecological requirements of the mentioned flora are quite distinct from those indicated by the Turolian faunas. The plant remains from the Sandanski region indicate the dominance of flooded marshy forest paleocoenoses mainly with Taxodiaceae. *Quercus*, *Castanea*, *Ulmus*, *Pterocarya* and *Carya* played an important role in forming mesophytic forests in which *Betula*, *Carpinus*, *Fagus*, etc., also occurred. Mixed forest communities with *Pinus*, *Tsuga*, *Abies*, *Picea*, *Cedrus*, *Betula*, etc., were probably developed at higher altitudes (for example on the plateau remains that probably existed in the area of the recent Rila and Pirin mountains; Fig. 5). Herbs are also abundant showing the presence of vast open patches (Ivanov 2003). The fact that the cores with plant remains are from the Oranovo clays of the region of the former middle Miocene Kojukh volcano caldera (Stoyanov

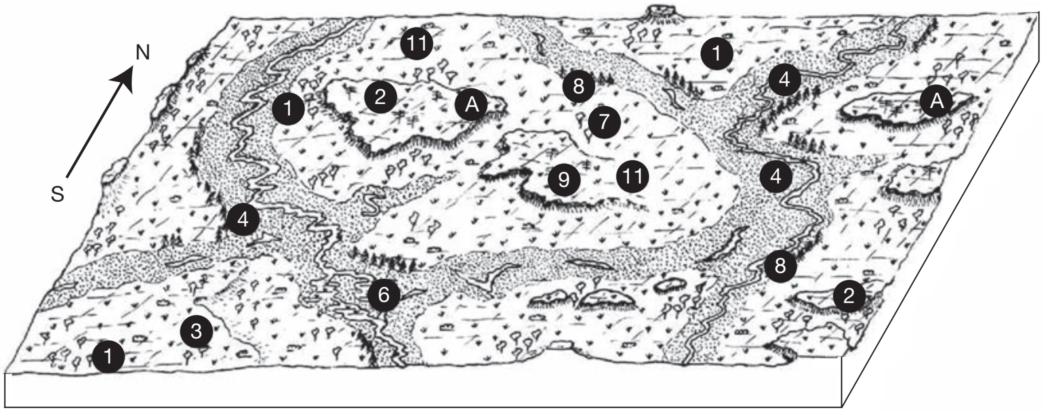

FIG. 7. — Reconstruction of the late early and middle Turolian environment in south-western Bulgaria. Legend as for Figure 5.

& Tzankov 2000) may explain the dominance of flooded Taxodiaceae forests in the area: they grew in the swampy remains of a lake. This lake existed during the middle Miocene and possibly the early late Miocene (Nedialkov *et al.* 1986) in the area of the former caldera, as we have established.

The faunal data from Ravin de la Pluie in northern Greece, about 100 km south of the Middle Struma, support the opinion that the Greek late Vallesian environment is somewhat different from the Bulgarian one, and that it is dominated by open spaces (Bonis *et al.* 1992a). The presence of *Tetralophodon* and of the giraffids *Palaeogiraffa major* (Bonis & Bouvrain 2003) and *Bohlinia* in the taphocoenosis of Ravin de la Pluie indicate the presence of open woodlands there.

Thus, our lithological, faunal as well as botanical data lead us to believe that the environment in the area of the recent Middle Struma River basin, north of northern Greece, was a mosaic landscape of woods and grasslands (including wetland herbaceous vegetation), crossed by braided rivers. The forest vegetation (probably the typical biotope of *Dinocrocuta gigantea*, Spassov & Koufos 2002) was well represented, but areas of open landscapes existed as well, as shown by the grazer *Chilotherium*.

The Miocene lake (Nedialkov *et al.* 1986) formed in the caldera of the Kozhukh paleo-volcano (Stoyanov & Tzankov 2000) was shrinking and fragmenting, as suggested by the occurrence of mammal finds of possible Vallesian age from mostly fluvial deposits near Levunovo, which is inside the caldera.

EARLY TUROLIAN (FIG. 6)

The faunas from the localities included in the Gradishte Lithocomplex are of Turolian age, possibly early Turolian, but there is no evidence yet of an older age. The regular occurrence in the taphocenoses of giraffids, hipparions and bovids, typical for the so-called "Pikermian biome" (Solounias *et al.* 1999) indicates the dominance of mosaic and semi-open landscapes having the physiognomy of open woodland or park type forest (Spassov 2002). In the river-surrounding valleys the woody taxa inherited from the Vallesian (*Quercus*, *Pterocarya*, *Carya*, *Ulmus*) prevailed, and persisted until the middle Turolian. The accumulation of the Gradishte Lithocomplex sandy clays indicates a more quiet activity of the braided rivers, which could have resulted in periodical formation of temporary marshlands. The former lake in the paleo-volcano caldera (Stoyanov & Tzankov 2000) had almost disappeared and was mostly replaced by fragmented swamps, except a small remnant probably preserved near the village of Hursovo: compact dark-green clays of the Gradishte Lithocomplex crop out in this area under the sandy deposits of the Strumyani Lithocomplex. Their accumulation indicates that

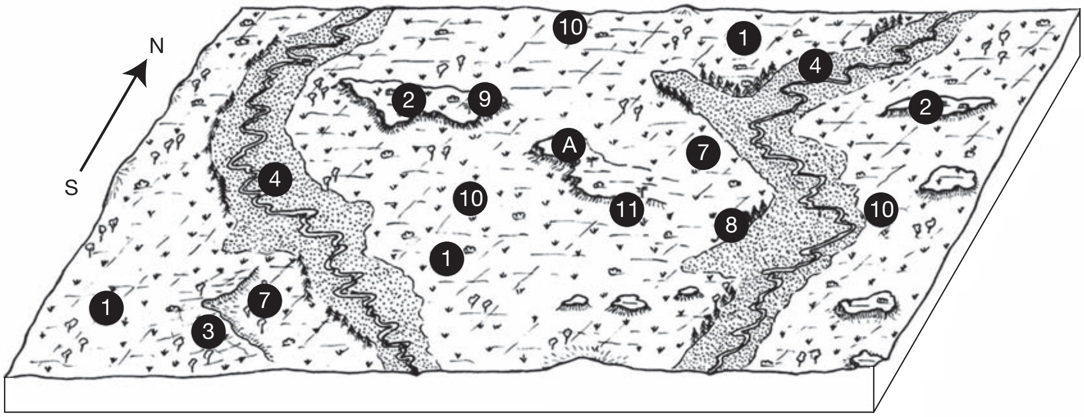

FIG. 8. — Reconstruction of the late Turolian environment in south-western Bulgaria. Legend as for Figure 5, and **10**, bushes.

the beginning of the Turolian was only slightly, if at all, less humid than the late Vallesian, with a more homogeneous arboreal cover contrasting with the mosaic landscape of the Vallesian.

LATE EARLY TUROLIAN-MIDDLE TUROLIAN (FIG. 7)

Most of the localities date from this period, and they are the richest in species and remains. The formation of this genetic lithocomplex indicates a significant activity of the braided rivers in conditions of gradual aridification and expressed seasonality. Rare reddish horizons in the Strumyani deposits provide additional indications about this aridification. This is the time of the climax of the so-called "Pikermian biome" *sensu* Solounias *et al.* (1999) on the territory of the Greco-Irano-Afghan (*sensu* Bonis *et al.* 1992b) (i.e. the Balkano-Iranian) faunal paleo-province and the time of maximal dispersal of a fauna similar in appearance to that of the recent African savannah (Spassov 2002). The occurrence of many mammalian fossil localities in fluviatile context within the caldera of the Kojuh paleo-volcano (such as Kromidovo-1, Kromidovo-2, Vinogradi and Marino Pole) indicates the complete drying up of the previous lake in this area, although fragmented swamps still persist on a large part of its territory. At that time, the paleo-Mesta River may not have flown into the Aegean sea, but into the paleo-Struma in the area of Kalimantsi.

LATE MIDDLE AND LATE TUROLIAN (FIG. 8)

The reddish terrigenous sandy layers indicate a considerable aridification leading gradually to the so-called Messinian crisis. According to several opinions, such reddish deposits (red beds) accumulate in hot arid climate with clear seasonal changes (Psilovikos *et al.* 1985). The thick hard limestone cementation typical for this lithocomplex (for example near Ilindentsi) was probably formed under such a climate, which led to the extension of open areas and shrinking of marshes.

Red horizons have been observed also in the lower layers of the Strumyani Lithocomplex. This is an indication of a periodical gradual aridification that started possibly as early as the second half of the early Turolian. Such horizons can be seen around Strumyani as well as in the fossiliferous alternate sands and clays at the lower boundary of the complex north-east of Djigurovo. However, dominance of the dark red and reddish deposits is typical of the Piperitsa Lithocomplex only and its fauna can be ascribed to the second half of the Turolian.

THE LATE MIOCENE ENVIRONMENTS IN SW BULGARIA: A SUITABLE HABITAT FOR LATE MIOCENE HOMINOIDS?

The latest hominid discoveries in Africa in the late Miocene (about 6-7 Ma) (Senut *et al.* 2001; Leakey *et al.* 2001; Brunet *et al.* 2002) indicate that the divergence of the hominoid phylum leading to the hominids must be searched in the late Miocene at the time about 10-8 Ma. It has become clear that the southern Balkans and Asia Minor represent an important centrum in the process of speciation that led to the separation of the Asian and African branches and to the *Homo* lineage. Four different hominoid taxa inhabited this region in the Vallesian and Turolian. Besides the relatively well known late Vallesian *Ouranopithecus* (Koufos & Bonis 2004) (found in three localities in northern Greece, close to the Bulgarian sites of the Middle Struma) and the other Vallesian form from Anatolia, *Ankarapithecus* (Alpagut *et al.* 1996), two other forms probably survived into the Turolian. The long-debated *Graecopithecus* is probably a valid taxon, different from *Ouranopithecus* (Koufos & Bonis 2004). Published identifications of the associated fauna suggest a Turolian age. A new Turolian hominoid taxon, still undescribed and unnamed, was recently found in Turkey (Sevim *et al.* 2001). These new data suggest that the African hominids are not a product of an autochthonous evolution. Most probably they originate from Turolian migrants from the Balkans or Asia Minor (Begun *et al.* 2003), which were preadapted to the conditions of relatively sclerophyllous forest vegetation. This would support the idea of Solounias *et al.* (1999) that the origin of the modern African fauna of the sclerophyllous savannahs can be found in the "Pikermian biome" of the so-called Balkano-Iranian (Greco-Iranian) (Bonis *et al.* 1979, 1992b; Spassov 2002; Geraads *et al.* 2003) or subparatethyan (Bernor 1983) zoogeographic province. The aridification at the end of the middle Turolian could be the main cause of the hominoid extinction from the Balkano-Anatolian region and their survival under less severe conditions in Africa. From the fossil faunas and floras, open forests represent the dominant landscapes of the late Miocene of South-East Europe (Spassov 2002). The characteristics of the fauna from the *Ouranopithecus* localities indicate that its environment must have been open woodland – a very different habitat from the dense forests inhabited by recent apes. The large molars with thick enamel of *Ouranopithecus* must be related to abrasive food in conditions drier than those of the modern rain forest apes. The recent teeth micro-wear analysis of *Ouranopithecus* has demonstrated also that in contrast to the recent apes his diet was mostly composed of herbaceous plants (Merceron *et al.* 2004). This food could be consumed not only in open landscapes but also in open forests and open woodlands, with seasonal diet changes. The *Ouranopithecus* tooth morphology was adapted to the local food resources (probably including also, as a small component, leaves and fruits). The typical hominoid habitats were most probably destroyed during the Turolian environmental changes related to the aridification. The available environmental data give ground to think that conditions for survival of the late Miocene hominoids existed longer in the north – in the region of Middle Struma and Mesta rivers in South Bulgaria.

CONCLUSIONS

The revision of the lithostratigraphic formations of the Middle Struma Neogene deposits, as well as of the included mammalian fauna, lead us to recognize five Neogene genetic lithocomplexes for the area, ranging from the late Vallesian till the middle and possibly the early late Turolian. New evidence favours the conception that the alluvial-proluvial Neogene deposits probably accumulated in the context of braided rivers flows and landscape peneplenisation under generally increasing aridification. About 40 localities of late Miocene mammal faunas have been reported in these Neogene deposits. Because of their richness in mammalian remains, they are promising for new faunal discoveries and investigations. The lithological, stratigraphic, faunal and floral data and revisions provide the basis for environmental reconstruction of the successive Neogene landscapes, improving our understanding of the nature and evolution of the European part of the Balkano-Iranian late Neogene bioprovince.

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