

# *Paenelimnoecus* sp. (Lipotyphla, Mammalia) from the Late Miocene Deposits of the Turiec Basin (Slovakia) and its Paleoenvironment

by

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## Zusammenfassung

Ein Insectivorenrest bestimmt in die Gattung *Paenelimnoecus* ist aus den oberemiozänen lakustrischen Sedimenten des Turiec Becken festgestellt. Die morphologischen und metrischen Merkmale des gefundenen Zahn (m2 sin.) gestatteten das zu keiner neogene Art des Europas einreihen.

Die paläoökologischen Angaben, festgestellt auf der Grundlage der häufigen Flora- und Evertebratenfunde, indizieren ein Waldhabitat (in welchem *Paenelimnoecus* gelebt hat) an dem Gestade eines limnischen See.

**Schlüsselwörter:** Miozän, Mammalia, Lipotyphla, Ostracoda, Palökologie

## Summary

An insectivore fragment attributed to the genus *Paenelimnoecus* is identified from the Late Miocene lacustrine deposits of the Turiec Basin. The morphological and metrical characteristics of the found tooth (m2 sin.) do not allow its attribution to any of the Middle Miocene till Pliocene European species. Palaeoecological data based on numerous floras and invertebrate remains indicate that *Paenelimnoecus* was living in a forest biotope, neighbouring the marshy littoral part of a freshwater lake.

**Key words:** Miocene, Mammalia, Soricomorpha, Ostracoda, palaeoecology

## 1. Introduction

The Turiec Basin represents an isolated intra-mountain depression in the Slovak territory. The thickness of the Neogene deposits reach up to 1,250 m (ZBOŘIL et al., 1985; GA PARÍK et al., 1995). The study of the mollusc and ostracod communities of the Turiec Basin shows the presence of species related to the Paratethys region. From the morphological point of view the comparison between the Turiec Basin and the European Miocene species is difficult because of the endemic fauna. Only a few ostracod species of 85 described are compared to the Quaternary and Recent Holarctic ones (POKORNÝ, 1954, 1960; RAKÚS, 1958; ONDREJČKOVÁ, 1974; PÍPIK, 2001). The fossils as a whole (plants, fish otoliths, bivalves, gastropods, ostracods, sponges) allow to precise the biological and physical properties of this ancient lake (PÍPIK, 2001).

On the basis of all stratigraphical and taxonomical studies, the main sedimentary period of the Turiec Basin would be the Middle to Late Miocene. The rhyolite from the borehole GHS-1 picked in depth 550.00 – 551.50 m is correlated with the volcanic complex of the Kremnica Mts. (southern border of the Turiec Basin). This volcanic complex is dated to the period  $12.4 \pm 2.2$  to  $10.7 \pm 0.3$  Ma (KONEČNÝ et al., 1983; GA PARÍK et al., 1995). PÍPIK (2001) demonstrates that all five ostracod assemblages are contemporaneous and occur above a rhyolite layer of the borehole GHS-1. Thus, the Late Miocene appears to be the main evolutionary period of all ostracod assemblages in the Turiec Basin.

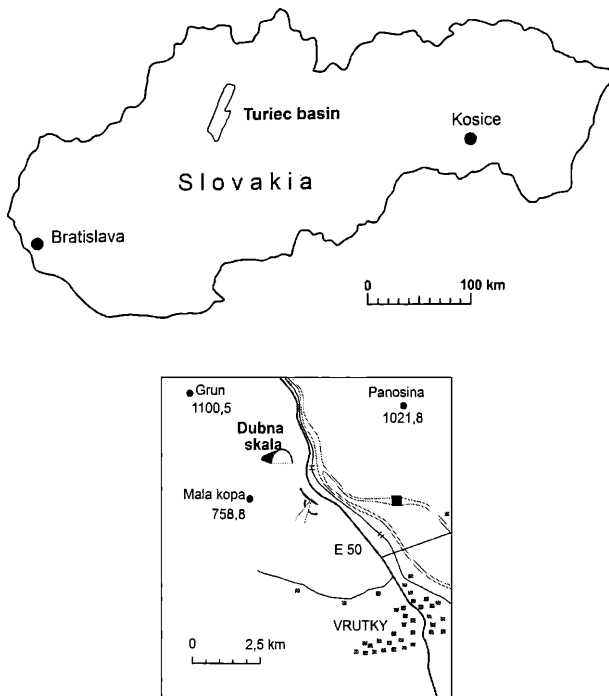
Mammals represent a good stratigraphical tool, but until now, have not been found in the deposits of the Turiec Basin. In the paper, the first record of a mammal (*Paenelimnoecus* sp.) is described from the Dubná skala site, situated in the northern part of the Turiec Basin.

## 2. Dubná skala Cross-section

The locality is situated on the left bank of the Váh River near the road E50, and 8km to NNW from the town Martin, and the geographical coordinates of the site are  $49^{\circ} 07' N$  and  $18^{\circ} 53' E$  (fig. 1).

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**Figure 1:** Geographic position of the Turiec Basin in Slovakia and geographic sketch of the Dubná skala cross-section.

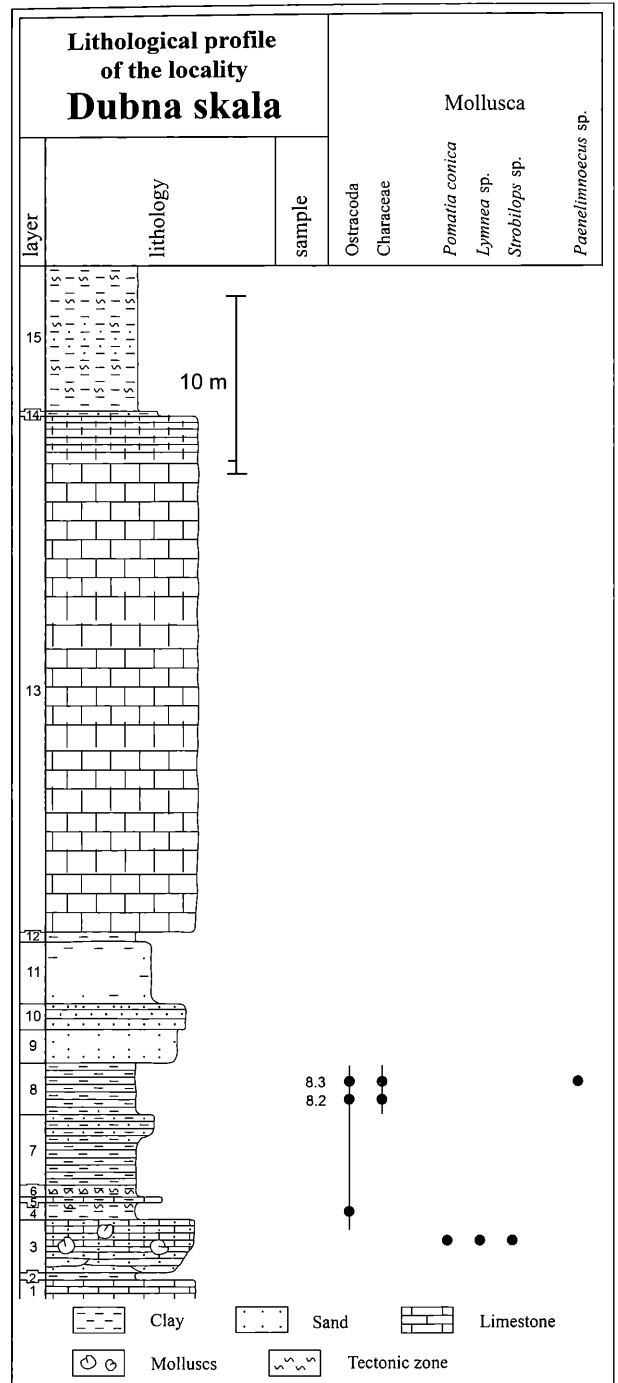
The locality consists of two cross-sections. The first is an ancient abandoned quarry with vertical walls and has a particularly difficult access. The cross-section exposes massive bedded and laminated limestone slightly dipping to the basin centre.

The second cross-section is situated in a foot of the quarry. It was opened in 1998 on occasion of tunnel construction (highway D1, under construction), which will connect the towns Žilina and Košice.

More accessible than the former, it allows to distinguish from below till the top of clay, sand, gravel and limestone layers with measured structural elements  $93/55^\circ$  up to  $93/75^\circ$

#### Lithological description of the cross-section (fig. 2)

1. brown limestone (more than 1.0 m);
2. brown and grey clay (0.5 m);
3. brown sandstone (1.3 m) with gastropods and lignite remains at the base passing gradually into a sandy limestone (1.5 m); the preserved molluscs belong to the taxa *Strobulops* sp., *Lymnea* sp., and *Pomatia conica* (KLEIN) (determination RAKÚS, pers. comm.);
4. light grey clay; some rare ostracods juveniles (4.0 m);
5. pink and purple mudstone (0.3 m);
6. light grey clay at bottom, dark in the top, tectonized (0.6 m);
7. brown sandy mudstone (4.0 m);
8. grey clay passing to clay of rust colour at top; ostracods and Characeae (3.0 m);
9. fine-grained gravel with sand at the base (2.0 m);
10. graded bedding conglomerate passing into sandstone with quartz grains (1.5 m);
11. brown and grey sand, slightly argillaceous passing to



**Figure 2:** Geological profile of the Dubná skala locality.

12. laminated grey and brown clay (0.5 m);
13. laminated and massive limestone of travertine structure (30.0m);
14. sandy, grey and brown clay (0.5 m);
15. laminated and tectonized dark grey clay passing into a sandy clay in the middle of the layer; pyrite (more than 8.0 m).

Conglomerates form the first cross-section and limestone containing the fossil leaves. SITAŘ (pers. comm.) identified *Glyprostrobilus europaeus* and *Typha latissima*. The fossil findings of both species are known from all parts of the

Turiec Basin (PIPIK, 2001). HÓK et al. (1998) attribute these deposits to the Pravno Member of the Turiec Formation and supposes their Pannonian age, zone H in the sense of RÖGL et al. (1993). The Dubná skala limestone would be an analogue of the Pannonian freshwater limestone from both the Vienna and Danube Basins. A lacustrine sedimentary environment is presumed for the clastic deposits, which originated in Permian rocks. They were not transported over large distance (HÓK et al., 1998).

So far, the second cross-section had not been studied. Some rare and non-identified ostracod valves were observed in the layers 4 and 8, which could belong to genera *?Candonopsis* and *?Cyclocypris*. RAKÚS (pers. comm.) recognised the gastropods *Pomatia conica*, *Strobilops* sp. (both terrestrial snails) and freshwater *Lymnea* sp. The layer 8 contains Characeae with teratological characters (SOULIÉ-MARSCHÉ, pers. comm.), which have not been found elsewhere.

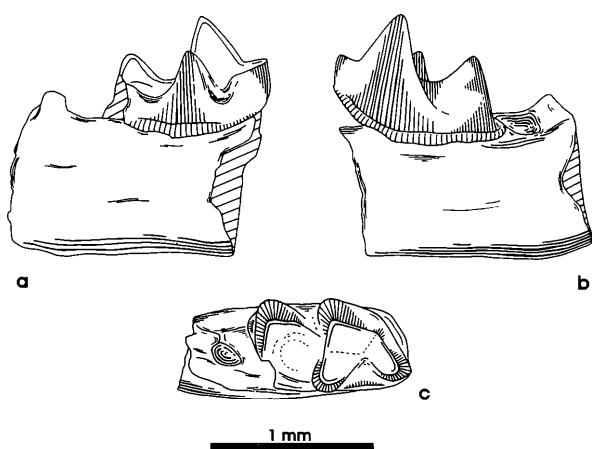
### 3. Systematic Paleontology

Classis Mammalia LINNAEUS, 1758  
 Grandorder Lipotyphla HAECKEL, 1866  
 Order Soricomorpha GREGORY, 1910  
 Superfamily Soricoidea FISCHER DE WALDHEIM, 1817  
 Family Soricidae FISCHER DE WALDHEIM, 1817  
 ?Subfamily Soricinae FISCHER DE WALDHEIM, 1817

Genus *Paenelimnoecus* BAUDELLOT, 1972

*Paenelimnoecus* sp.

fig. 3



**Figure 3:** *Paenelimnoecus* sp., fragment of the left mandible with m2, Dubná skala, layer 8.3.; a) lingual view; b) buccal view; c) occlusal view.

**Material:** A fragment of the left mandible with m2 (No. MS8, deposited in the Department of Geology and Paleontology, Faculty of Science, Comenius University in Bratislava, layer 8.3).

**Description:** The weakly worn light-brown crown with grey tips of buccal cusps is damaged on the both lingual and distal side. The anterior part of the crown on the buccal side is uplifted, probably for the extended posterior part of m1. The blunt paraconid is relatively low, with the distinct paralophid and one crest on the lingual side. The protoconid, the largest of all cusps, is connected with the lower metaconid by the distinct cristid. The trigonid basin is small, rounded, and deep, opens on the lingual side. The hypoconid is similar to the protoconid, but much lower and with a weakly concave posterior part. The oblique crest extends towards the central part of the protoconid-metaconid posterior wall base. The hypolophid runs towards the small entostylid (lost during the research). The entoconid is absent. There is only present a ledge between the both metaconid and entostylid, what can be interpreted as a remainder of the entocristid(?). The talonid basin is wide, relatively deep, opening on the lingual side. The re-entrant valley is short, but deep, opening distinctly above the cingulid on the buccal side. The buccal cingulid is strong, whereas the damaged lingual one is distinctly weaker.

**Relationship to other *Paenelimnoecus* species:** So far, six species of *Paenelimnoecus* are known from the Early Miocene till the Late Pliocene of the Old World Northern Hemisphere – *P. micromorphus* (DOBEN-FLORIN, 1964) (MN 3 – 4), *P. crouzeli* BAUDELLOT, 1972 (MN 6 – 7/8), *P. repenningi* (BACHMAYER & WILSON, 1970) (MN 9(aff.) – 10), *P. obtusus* STORCH, 1995 (MN 13), *P. pannonicus* (KORMOS, 1934) (MN 11(cf.), MN 14 – 16), and *P. chinensis* JIN & KAWAMURA, 1997 (Late Pliocene). However, the systematic position of the genus is not wholly clear as yet. From 1972, when BAUDELLOT it erroneously included in the subfamily Limnoecinae REPENNING, 1967 (REUMER, 1984; ZIEGLER, 2003), the genus was allocated to various systematical groups – from Allosoricini FEJFAR, 1966 (REUMER, 1984) through Allosoricinae FEJFAR, 1966 (JIN & KAWAMURA, 1997; MCKENNA & BELL, 1997; REUMER, 1992; RZEBIK-KOWALSKA, 1998) and Soricinae incertae sedis (STORCH, 1995; ZIEGLER, 1999) to Crocidosoricinae REUMER, 1987 and/or Soricinae FISCHER VON WALDHEIM, 1817 (ZIEGLER, 1999, 2003). The earliest representative of the genus (*P. micromorphus*) causes the whole dispute. This species was tentatively allocated to the Crocidosoricinae (ZIEGLER, 1999), whereas other five ones of the genus *Paenelimnoecus* are allocated to the Soricinae (ZIEGLER, 2003). Because the classification of various species of one genus to the different subfamilies is incorrect from the viewpoint of the phylogenetic taxonomy, ZIEGLER (2003) suggests to interpret the morphology of *P. micromorphus* as an incipient soricine and whole genus to place in the Soricinae. On the other hand, the excluding of *micromorphus* from the genus *Paenelimnoecus* and its allocation to a new crocidosoricine genus (as the ancestor of *P. crouzeli* with *Crocidura*-like condyle and V-shaped wear facet of p4) can be also next solution of this problem, although ZIEGLER (2003) assumes that the generic assignment of *micromorphus* to *Paenelimnoecus* is correct. Apart from the type locality Wintershof-West (ZIEGLER, 2003), the *P. micromorphus* is also known from Erkets-

Taxon / Locality (age)	L				TRW				TAW			
	n	min.	mean	max.	n	min.	mean	max.	n	min.	mean	max.
<b><i>P. micromorphus</i></b>												
Erkertshofen 2 (MN 4b)	1	—	0.96	—	1	—	0.48	—	—	—	—	—
Petersbuch 2 (MN 4b)	5	0.93	1.01	1.05	5	0.51	0.56	0.64	—	—	—	—
<b><i>P. crouzeli</i></b>												
Sansan (MN 6)	3	1.00	1.05	1.12	3	0.68	0.71	0.72	—	—	—	—
Utrecht collection	1	—	1.13	—	—	—	—	—	—	—	—	—
Petersbuch 6 (MN 7+8)	3	1.09	1.13	1.16	3	0.66	0.70	0.74	3	0.65	0.69	0.73
Petersbuch 10 (MN 7+8)	2	1.07	1.13	1.18	2	0.61	0.64	0.66	2	0.61	0.66	0.71
Petersbuch 18 (MN 7+8)	3	1.05	1.08	1.10	3	0.71	0.73	0.76	3	0.66	0.67	0.68
Petersbuch 31 (MN 7+8)	7	1.06	1.11	1.14	8	0.61	0.66	0.71	8	0.60	0.63	0.66
Eskihisar (MN 8)	1	—	1.18	—	1	—	0.76	—	—	—	—	—
<b><i>P. repenningi</i></b>												
Kohfidisch (MN 10)	?	1.10	—	1.30		0.70	—	0.80	—	—	—	—
type specimen	1	—	1.20	—	1	—	0.70	—	—	—	—	—
<b><i>P. obtusus</i></b>												
Ertemte (MN 13)	7	0.96	1.04	1.08	7	0.60	0.63	0.66	7	0.58	0.62	0.64
<b><i>P. pannonicus</i></b>												
Osztramos 9 (MN 15b)	3	0.99	1.04	1.08	3	0.59	0.63	0.66	3	0.61	0.63	0.65
Csarnóta 2 (MN 15b)	55	0.98	1.10	1.18	55	0.55	0.64	0.72	56	0.54	0.63	0.72
Osztramos 7 (MN 16b)	4	0.85	0.98	1.04	4	0.52	0.60	0.68	4	0.51	0.58	0.64
<b><i>Paenelimnoecus</i> sp.</b>												
Dubná skala (Late Neogene)	1	—	1.01	—	1	—	0.57	—	1	—	0.55	—

**Table 1:** The comparison of m2 measurements (mm) of various species of the genus *Paenelimnoecus* from some European and Asian sites (BACHMAYER & WILSON, 1970; ENGESSER, 1980; REUMER, 1984; ZIEGLER, 1989, 2003). Abbreviations: L – length of the tooth, TRW – width of the trigonid, TAW – width of the talonid.

hofen 2 and Petersbuch 2 in Germany (ZIEGLER, 1989). Later *P. crouzeli* is recorded in Sansan (BAUDELLOT, 1972), La Grive (DE BRUIJN et al., 1992), and Petersbuch (ZIEGLER, 2003). REUMER (1984) assigned to this species also material from Eskihisar (MN 8) from Turkey, originally determined by ENGESSER (1980) as *Paenelimnoecus* sp. only. Next two species (*P. repenningi* and *P. pannonicus*) have been found in Western and Central Europe – *P. repenningi* is known from Austria (BACHMAYER & WILSON, 1970) and probably also from Spain (HOEK OSTENDE, pers. comm.), and *P. pannonicus* is mentioned from Hungary (REUMER, 1984) and probably from Austria (ZIEGLER, 1999) and Poland (REUMER, 1984, 1992) as well. In Asia, the genus is represented by *P. obtusus* from Ertemte in Inner Mongolia (STORCH, 1995) and *P. chinensis* from Yinan in China (JIN & KAWAMURA, 1997).

The genus is typical the absence of the entoconid. However, the some morphological differences among single species can be found in the development of the lower incisor (in *P. crouzeli* it does not reach m1, in *P. pannonicus* and *P. obtusus* it extends to below the protoconid of m1, and in *P. chinensis* its weak serrated lower incisor extends more posteriorly), in the morphology of back teeth (stronger cingulid in lower molars of *P. pannonicus*, P4 with a projecting parastyle and rectangular lower molars in *P. obtusus*, and completely lacking entoconid and entoc-

ristid in m1-2 of *P. chinensis*), in the position of the mental foramen (in *P. crouzeli* below the protoconid of m1, in *P. pannonicus* below the re-entrant valley or the hypoconid, in *P. repenningi* and *P. obtusus* more posteriorly, and in *P. chinensis* below the middle of m1), in the shape of the condyle (*Crociodura*-like in *P. micromorphus* and soricine-like in other species, not fully separated condyle facets in *P. crouzeli*, narrower interarticulation of the condyle area in *P. repenningi* and *P. chinensis*, and more clearly separated condyle facets in *P. pannonicus*), and in the position of the infraorbital and lacrimal foramen (in *P. chinensis* situated more anteriorly) (REUMER, 1984; ZIEGLER, 2003). In addition, the primitive *P. repenningi* with some advanced features (ZIEGLER, 1999) seems to be closer to *P. crouzeli* in morphology than to *P. pannonicus* (REUMER, 1984).

The teeth measurements of all species are very similar (Tab. 1), when only *P. repenningi* has slightly bigger teeth on an average in comparison with *P. crouzeli* (ZIEGLER, 2003), teeth measurements of whose are not significantly different from those of *P. pannonicus* (REUMER, 1984).

Because m2 is not a diagnostic tooth for the exact species determination and no comparative material has been seen, the insectivore fragment of the left mandible with m2 from Dubná skala is determined only as *Paenelimnoecus* sp. from this point of view. However, the reference to *P. repenningi* or *P. pannonicus* is not excluded. On

the other hand, this finding could also represent a new species of *Paenelimnoecus* from the Late Neogene of Central Europe.

#### 4. Palaeoecological interpretation

A statistical approach distinguished five different contemporaneous ostracod assemblages, which are result from the ecological difference of the Turiec Basin (PIPIK, 2001). The northern part of the basin, where the fragment of *Paenelimnoecus* was found, is characterised by an assemblage of *Candona robusta jiriceki*. The four other ostracod assemblages are situated in the central and southern parts. The assemblage of *Candona robusta jiriceki* is composed by new species of *Candona*, *Euxinocythere*, *Ilyocypris*, and *Cypria*. Seven taxa were attributed to the known species:

*Darwinula stevensoni* (BRADY & ROBERTSON, 1870)  
*Vestalenula pagliolii* (PINTO & KOTZIAN, 1961)  
*Candona clivosa* FUHRMANN, 1991  
*Candonopsis arida* SIEBER, 1905  
*Pseudocandona compressa* (KOCH, 1838)  
*Fabaeformiscandona balatonica* (DADAY, 1894)  
*Cavernocypris subterranea* (WOLF, 1920)

*Darwinula stevensoni* existing from the Oligocene till the Recent prefers ponds, lakes and slow streams. It occurs at depth of 0 to 12 m on muddy and sandy substrates; generally freshwater, it tolerates an increase of salinity up to 15 ‰; thermoeuryplastic (MEISCH, 2000).

*Vestalenula pagliolii* is a recent species living in riverine pools and lakes of Brasil. Its fossil populations are described from the Miocene, Pliocene and Pleistocene limnic and estuarine formations of Turkey and Slovakia. It is also known from the Pleistocene of Germany and the Holocene of Sudan (Africa) (FREELS, 1980; PIETRZENIUK, 1991; GRIFFITHS & BUTLIN, 1994; PIPIK, 2001; MARTENS et al., 1997; ROSSETTI & MARTENS, 1998).

*Candona clivosa* is a fossil species known from lacustrine limnic, limno-fluvial and limno-brackish formations of the Early Miocene and Early Pliocene of Turkey. It is described also from the stagnant littoral waters of the Middle Pleistocene warm climate period (FREELS, 1980; FUHRMANN, 1991).

*Candonopsis arida* is a fossil species known from the Middle Miocene deposits of Germany and Late Miocene of the Turiec Basin. In Germany, it was observed in the freshwater paleo-lakes of warm climate (MALZ & MOAYEDPOUR, 1973; JANZ, 1992, 1997).

*Pseudocandona compressa* is a recent Holarctic species recorded from the waters with maximum salt content of 8 ‰. It lives in a permanent and temporary environment; mesothermophilic. It prefers a littoral zone to the depth of 8 m (MEISCH, 2000). Its first appearance is dated to the Tortonian of the Swiss molasse (CARBONNEL et al., 1985).

*Fabaeformiscandona balatonica* is a recent Palaeartic, possibly Holarctic freshwater species, also known from

the Middle Miocene of Germany. It prefers temporary pools and swampy, very shallow zone of lakes that dry up seasonally; probably mesothermophilic. It inhabits also in woodland ditches and in canals with dense vegetation (JANZ, 1997; MEISCH, 2000).

*Cavernocypris subterranea* is a Palaeartic stygophilic species known mainly from the mountain region of the West and Central Europe. An inhabitant of surface and underground waters, it occurs in springs, the littoral zone of mountain lakes, interstitial milieu, caves; stenothermal, it lives in cold water within a temperature of 6-12°C. It prefers slowly flowing, well-oxygenated waters. It is known from the Middle Miocene (MARMONIER et al., 1989; VAN FRAUSUM & WOUTERS, 1990; JANZ, 1997; MEISCH, 2000). The sediments of the northern part of the Turiec Basin are also rich on freshwater plants - *Potamogeton martinianus*, *Nelumbium protospeciosum*, *Typha latissima*, *Phragmites oeningensis*, and Characeae which grew in stagnant or slowly flowing milieu (SITÁR, 1966, 1969). Flowing waters could be deduced also from the presence of *Ilyocypris*, *Darwinula stevensoni*, *Cavernocypris subterranea*, limestone with pisolithic structure and strontium isotopic composition (<sup>87</sup>Sr/<sup>86</sup>Sr ratios) (ANDRUSOV, 1954; PIPIK, 2001; BRIOT et al., 2002). The lignite layers and roots of trees support a hypothesis about marshy littoral conditions in the northern part of Turiec Basin.

A permanent water milieu could pass into temporary aquatic milieu (*Fabaeformiscandona balatonica*, *Pseudocandona compressa*, *Cypria*, *Ilyocypris*) with oxbows (*Nelumbium protospeciosum*) (SITÁR, 1966; PIPIK, 2001). A coastal moist and temperate forest grew in proximity of the lake which is documented by numerous fossil leaves *Quercus pseudocastanea*, *Q. grandidentata*, *Alnus rotunda*, *Populus balsamoides*, *Ulmus plurinervis*, *Glyptostrobus europaeus*, *Platanus aceroides*, *Betula prisca*, *Parotia fagifolia*, *Carpinus grandis*, *Fagus dingeri*, *Castanea atavia*, *Zelkova zelkovaefolia*, *Acer tricuspdatum* and by terrestrial snails *Carychium*, *Pomatia*, *Strobilops*, *Succinea*, *Vertigo*, *Gonyodiscus* sp., *Helix* cf. *occlusa*, Clausiliidae and Limacidae (POKORNÝ 1954; ONDREJČKOVÁ, 1974; RAKÚS, pers. comm.).

A hilly inland was covered by *Pterocarya denticulata*, *Zelkova zelkovaefolia*, *Fagus haidingeri*, *Carya serraefolia* (SITÁR, 1966, 1969), where caves could exist (*Cavernocypris subterranea*). The flora was compared with the Sarmatian – Pannonian floras of Central Europe (NĚMEJC, 1957, 1967; SITÁR, 1966, 1969, 1982).

#### 5. Conclusion

The mandible fragment with m2 of soricid (*Paenelimnoecus* sp.) is the first record of mammal in the Late Miocene lacustrine sediments of the Turiec Basin (Slovakia). However, a determination to the species level of this insectivore is impossible because important morphological characters (e. g. lower incisor or mental foramen) are absent. The numerous flora and fauna remnants document that *Paenelimnoecus* could occur near littoral, marshy zone

of freshwater lake with slowly flowing waters, although its occurrence in the woody hilly inland can be also not excluded. In this case, its remains could be dropped into the water by owls, which play an important role in the taphonomy of micromammals.

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