11. RECONSTRUCTION AND EVOLUTION OF THE HAJNÁČKA I PALEOENVIRONMENT

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Abstract. The Hajnáčka I is one of the European paleontological localities dated to the Early Villanyian, MN 16a biozone (Late Pliocene). From its discovery in 19[th] century, many scientists have dealt by the research of this site. The new systematic research started in the second half of 90s of the last century 35 years after the last FEJFAR´s site investigation. The new data, obtained during this new systematic research of the site, allow to specify the reconstruction and evolution of Hajnáčka paleoenvironment.

Key words: Paleoenvironment, Pliocene, Hajnáčka, Slovakia

INTRODUCTION

The paleontological site Hajnáčka I, a type locality of the European Neogene Mammal time scale dated to the MN 16a zone (FEJFAR & HEINRICH, 1987), represents the Late Pliocene site, where the conservative taxa lived in the suitable environment together with the progressive ones. Fossils of vertebrates (especially mammals) buried in the tuff are known from the site since 1863, when first evidence about that was published by KUBINYI (FEJFAR, 1964). In the following years, many scientists have dealt with this locality. However, only some of them studied the site from the point of view of the paleoenvironmental reconstruction and evolution (e. g. VASS et al., 2000; SABOL, 2001). The new data, obtained during the new systematic research of the site at the end of the last century and the beginning of new one, allow to specify the reconstruction and evolution of Hajnáčka paleoenvironment in the period of the early Late Pliocene.

AGE OF THE SITE

The Hajnáčka site belongs to the Cerová Basalt Formation, built up by the alkali basalts and basanites. The radiometric age of the basaltic rocks varies from 5.03 to 1.16 Ma (BALOGH in VASS et al., 2000). The fossiliferous layers are situated in an elliptical maar depression (the Bone Gorge maar) on the northern foothills of Matrač Hill. The size of the maar is approximately 580 × 370 m (KONEČNÝ & LEXA in VASS & ELEČKO eds., 1992). The base of the maar filling consists of the redeposited Eggenburgian sandy rocks of the Fiľakovo Formation (Tachty Sandstone) with overlying autochthonous tuff, (lapilli) tuffite, basalt fragments, and fine sand. Redeposited palagonite tuff and breccias are less frequently occurring in the maar filling. Locally, blocks of laminated bituminous rock are situated in the upper part of this filling with the Quaternary loamy and loamy-argillaceous deposits, covering the marginal parts of the maar.

More or less broken fossiliferous sediments are often in allochthonous position. They were disintegrated by water erosion after the bones deposition (VASS et al., 2000). Also, the process of erosion, soliflunction and repeated landslides during the Quaternary Period took part in the mixture and redeposition of the Hajnáčka depression bottom sediments. The common occurrence of loess from the Late

Pleistocene (PRISTAŠ in VASS & ELEČKO eds., 1992) together with the Pliocene sedimentary rock is evidence of that. Besides of malacofauna, when the loess taxa (e. g. *Pupilla sterri, Chondrula tridens, Columella columella, Vallonia tenuilabris, Succinella oblonga*) and forest thermophilous ones (*Aegopinella pura, Vitrea diaphana, Monachoides incarnatus* and others) have been found, the Quaternary deposits also contain the fossil remains of mammoths and horses. The occurrence of these Pleistocene elements together with the fossil remains of the Pliocene fauna has been early referred from this site by SZABÓ (1865) (fossil remains of bison, mammoth and horse) and FEJFAR (1964) (*Coelodonta antiquitatis, Microtus ratticeps, Clethrionomys glareolus*). On the base of that sedimentological and stratigraphical data, it is difficult exactly to reconstruct the thickness and the original position of the Pliocene sedimentary maar filling.

The different opinions on the stratigraphical age of Hajnáčka I and its fauna were present in older literature. Whereas THENIUS (1955, 1959) placed the Hajnáčka fauna to the so-called Levantinian (Middle Pliocene), DIETRICH (1953) suggested the Early Pleistocene age. However, FEJFAR (1964) correlated the faunal assemblage from the site with the Villafranchian, mainly on the base of rodent record. Later, FEJFAR and HEINRICH (1987) placed this fauna to the Late Pliocene MN 16a biozone (3.3 to 2.8 Ma). The determination of the progressive association *Mimomys (Mimomys) hassiacus – Mimomys (Cseria) stehlini* is the evidence of that. Thus, this fauna distinctly differs from the Late Ruscinian assemblages with *Mimomys gracilis, Dolomys occitanus* or *Propliomys hungaricus*, missing in Hajnáčka. On the other hand, the conservative representatives of the subfamily Prometheomyinae (*Germanomys* and *Ungaromys*) are also present in Hajnáčka I. However, these taxa are not as abundant as representatives of predominant genus *Mimomys*. On the basis of that, it is possible to correlate the Hajnáčka I site with other Early Villanyian sites: Jucar (Carrasco, Valdeganga), Moreda, Teruel (Concud) in Spain; Seynes and Valensole (Cornillet, Grenouillet) in France; San Giusto, Arcille, Vialette, Arondelli-Triversa in Italy; Hambach, Frechen, Gundersheim „Findling" in Germany; Beremend 1-3 and 5 in Hungary; Barault C. in Romania; Uryv 1, Akkulaevo, Livencovka 5, Kotlovina, Kryzhanovka in former Soviet Union; and Kadiözü, Sivricek, Ziyaret in Turkey etc. (FEJFAR et al., 1990; LINDSAY et al., 1997; FEJFAR, 2001).

Tab. 11.1. The quantity of the mammal fossils found during the new research of Hajnáčka I (fossils of artiodactyls and lower vertebrates are under study).

Mammalian taxa	Number of all finds	Number of studied finds
Lagomorpha	3	3
Rodentia	109	50
Carnivora	3	3
Lipotyphla	9	9
Artiodactyla	32	-
Perissodactyla	571	352
Proboscidea	243	100
Mammalia sp	879	-
Sum (Σ)	1.849	517

From the paleomagnetic polarity time scale point of view, the Hajnáčka section is correlated with the Gauss magnetic chron (C2An) (LINDSAY et al., 1997) with the beginning of the forming of the Bone Gorge maar during the early period of this chron with normal polarity (3.5 – 3.3 Ma) (VASS et al., 2000).

FAUNAL COMPOSITION

More than 1,800 specimen of mammals have been found during the new research of the site (Tab. 11.1). Other vertebrate finds of are especially represented by fossils of fishes (*Scardinus* sp., *Tinca* sp., *Esox* sp., Percidae gen. et spec. indet.), amphibians (*Pliobatrachus* sp., *Bufo bufo, Rana temporaria, R. arvalis, R. ridibunda*) (HODROVÁ, 1981) and reptiles (*Emys orbicularis, Chelydra* aff. *decheni* (FEJFAR et al., 1990), Serpentes gen. et spec. indet.).

Tab. 11.2. List of mammals from three Central European sites (Wölfersheim, Ivanovce, and Hajnáčka). 1 – according to DAHLMANN (2001), 2 – according to FEJFAR and HEINRICH (1985), 3 – according to FEJFAR et al. (1990), 4 – on the basis of new research (1996 – 2000).

Mammalian taxa	Wölfersheim (MN 15b)	Ivanovce (MN 15b)	Hajnáčka I (MN 16a)	
	1	2	3	4
LAGOMORPHA				
Ochotonidae				
Prolagus bilobus Heller, 1936	+			
Ochotonoides csarnotanus Kretzoi, 1959		+		
Leporidae				
Hypolagus beremendensis (Petényi, 1864)	+			
Hypolagus brachygnathus Kormos, 1934		+	+	
Alilepus sp.	+			
Pliopentalagus dietrichi (Fejfar, 1961)	+	+		
Lagomorpha gen. et spec. indet.				+
RODENTA				
Sciuridas				
Sciurus warthe Sulimski, 1964	+			
Sciurus maltei Dahlmann, 2001	+			
Sciurus sp.		+		+
Miopetaurista thaleri (Mein, 1970)	+			
Pliopetaurista dehneli (Sulimski, 1964)		+		
Pliopetaurista pliocaenica (Depéret, 1897)	+	+	+	
Pliopetaurista raui Dahlmann, 2001	+			
Blackia miocaenica Mein, 1970	+			
Pliopetes hungaricus Kretzoi, 1959	cf.			
Eutamias sp.		+		
Sciuridae gen. et spec. indet. 1 and 2	+			
Castoridae				
Castor praefiber Depéret, 1897	+			
Castor fiber ssp.		+	+	+
Trogontherium covurluiensis (Simionesco, 1930)	+			
Trogontherium minus Newton, 1890			+	
Trogontherium (Boreofiber) wenzensis (Sulimski, 1964)	cf.			
Palaeomys sp.		+		
Dipoides problematicus Schlosser, 1902		cf.		
Eomyidae				
Estramomys sp.		+		
Eomyops sp.		+		
Leptodontomys bodvanus Jánossy, 1972	+			
Seleviniidae				
Selevinia sp.		+		
Seleviniidae gen. et spec. indet.			+	
Gliridae				
Glirulus pusillus (Heller, 1936)	+			
Muscardinus helleri Fejfar et Storch, 1990	+			
Muscardinus pliocaenicus Kowalski, 1956		+		
Glis minor Kowalski, 1956	+	+		
Gliridae gen. et spec. indet.	+			
Zapodidae				
Eozapus intermedius (Bachmayer et Wilson, 1970)	cf.			
Cricetidae				
Trilophomys depereti Fejfar, 1961		+		
Trilophomys vandeweerdi Brandy, 1979	+			
Baranomys loczyi Kormos, 1933		+	+	
Baranomys longidens (Kowalski, 1960)	+			
Baranomys kowalskii Kretzoi, 1962	+			
Cricetus sp.		+		
Kowalskia intermedia Fejfar, 1970		+		
Allocricetus bursae Schaub, 1930		cf.		
Germanomys parvidens Fejfar, 1961		+		

Mammalian taxa	Wölfersheim (MN 15b)	Ivanovce (MN 15b)	Hajnáčka I (MN 16a)	
	1	2	3	4
Germanomys weileri heller, 1936	+	+		
Germanomys sp.			+	+
Ungaromys sp.				+
Mimomys (Mimomys) hassiacus Heller, 1936	+		+	+
Mimomys (Cseria) gracilis (Kretzoi, 1959)	+	+		
Mimomys (Cseria) stehlini Kormos, 1931			+	+
Mimomys sp.				+
Dolomys occitanus (Thaler, 1955)	+	+		
Tobienia kretzoi Fejfar et Repenning, 1998	+			
Lemmini n. gen., n. sp.	+			
Arvicolinae gen. et spec. indet.				+
Muridae				
Apodemus sp.		+	+	
Rhagapodemus frequens Kretzoi, 1959		+		
Sylvaemus atavus (Heller, 1936)	+			
Sylvaemus sp.	+			
Anomalomyidae				
Prospalax priscus (Nrhring, 1897)		+	+	+
Hystricidae				
Hystrix primigenia (Wagner, 1848)		cf.		
CARNIVORA				
Mustelidae				
Pannonictis sp.	cf.			
Enhydrictis ardea (Bravard, 1828)	+			
Lutra bravardi Pomel, 1843			cf.	cf.
Lutra sp.		+		
Baranogale sp.	+			
Mustela sp.	+			
Procyonidae				
Parailurus anglicus (Dawkins, 1888)	+	cf.		
Parailurus hungaricus Kormos, 1934			+	
Ursidae				
Ursus minimus Devéze et Bouillet, 1827	+			
Ursidae gen. et spec. indet.				+
Viverridae				
Hesperoviverra carpathorum (Kretzoi et Fejfar, 1982)		+		
Viverridae gen. et spec. indet.		+		
Felidae				
Megantereon sp.			+	
Hyaenidae				
Hyaena perrieri Croizet et Jobert, 1828			+	+
LIPOTYPHLA				
Soricidae				
Sorex minutus Linnaeus, 1766	+	+		
Sorex sp.	+			
Drepanosorex praearaneus (Kormos, 1934)		+		
Deinsdorfia hibbardi (Sulimski, 1962)	+			+
Deinsdorfia kordosi Reumer, 1984	+			
Deinsdorfia sp.		+		
„Zelceina soriculoides (Sulimski, 1959)"	+	+		
Petenyia hungarica Kormos, 1934	+	+	+	
Petenia dubia Bachmayer et Wilson, 1970	cf.			
Paenelimnoecus pannonicus (Kormos, 1934)		+		
Alloblarinella europaea (Reumer, 1984)	+			
Blarinoides mariae Sulimski, 1959	cf.	+	+	cf.
Beremendia fissidens (Petényi, 1864)	+	+	+	
Episoriculus gibberodon (Petényi, 1864)		+		
Allosorex stenodus Fejfar, 1966		+		
Soricidae gen. et spec. indet.	+			+

Mammalian taxa	Wölfersheim (MN 15b)	Ivanovce (MN 15b)	Hajnáčka I (MN 16a)	
	1	2	3	4
Talpidae				
Talpa gilothi Storch, 1978	+			
Talpa minor Freudenberg, 1914	+			cf.
Talpa fossilis Petényi, 1864	+			+
Talpa sp. 1 and 2		+		+
„Scalopoides" agrarius (Skoczen, 1980)	+			
„Scalopoides" copernici (Skoczen, 1980)	cf.			
Talpinae gen. et spec. indet.	+			
Archaeodesmana acies Dahlmann, 2001	+			
Desmana nehringi Kormos, 1913	+	+	+	+
Desmana amutriensis Radulescu, Samson et Stiuca, 1989	cf.			
Storchia wedrevis Dahlmann, 2001	+			
Desmanella woelfersheimensis Dahlmann, 2001	+			
Dibolia sp.		+		
CHIROPTERA				
Rhinolophidae				
Rhinolophus variabilis Topál, 1970		cf.		
Rhinolophus lissiensis Mein, 1964		+		
Rhinolophus kowalskii Topál, 1979		aff.		
Rhinolophus sp.	+			
Vespertilionidae				
Barbastella sp.	?			
Myotis kormosi Heller, 1936		+		
Myotis podlesicensis Kowalski, 1956		cf.		
Myotis exilis Heller, 1936		cf.		
Myotis mystacinus (Kuhl, 1818)		cf.		
Myotis delicatus Heller, 1936		cf.		
Myotis sp.	?			
Nyctalus sp.	?			
Chiroptera gen. et spec. indet.	+			
PRIMATES				
Cercopithecidae				
Mesopithecus monspessulanus Gervais, 1849	?			
Dolichopithecus ruscinensis Depéret, 1889	+			
Colobinae gen. et spec. indet.		+	+	
ARTIODACTYLA				
Suidae				
Sus minor Depéret, 1890	+	+	+	
Cervidae				
Cervus perrieri - Ardenoceros ardei			+	
Cervus pardinensis Croizet et Jobert, 1828			+	
Croizetoceros ramosus (Croizet et Jobert, 1828)			+	
Cervocerus wenzensis Czyzewska, 1960	cf.			
Capreolus sp.		+	+	
Muntiacus sp.			+	+
Cervidae gen. et spec. indet. 1 and 2	+			+
Bovidae				
Parabos boodon Depéret, 1890		+		
PERISSODACTYLA				
Equidae				
Hipparion sp.	+			
Rhinocerotidae				
Dicerorhinus jeanvireti Guerin, 1972			+	+
Dicerorhinus megarhinus de Christol, 1835	+			
Dicerorhinus sp.				+
Rhinocerotidae gen. et spec. indet.		+	+	
Tapiridae				
Tapirus arvernensis Devéze et Bouillet, 1827	+	+	+	+

Mammalian taxa	Wölfersheim (MN 15b)	Ivanovce (MN 15b)	Hajnáčka I (MN 16a)	
	1	2	3	4
PROBOSCIDEA				
Mammutidae				
Mammut borsoni (Hays, 1834)	+	+	+	+
Gomphotheriidae				
Anancus arvernensis Croizet et Jobert, 1828	+	+	+	+

From all mammal finds, the fossils of perissodactyls are the most frequent, especially tapirs represent the dominant element of the Hajnáčka Late Pliocene biocenosis. On the other hand, insectivores and rodents are represented by the highest number of taxa (so far, 9 insectivore taxa and 14 rodent ones are known from the site) (Fig. 11.1). The study of new finds of these both mammalian groups yield also minimally 7 new taxa (*Talpa* cf. *minor*, *T. fossilis*, *Talpa* sp., *Deinsdorfia hibbardi*, Soricidae gen. et spec. indet., *Sciurus* sp., and *Ungaromys* sp.), which were not known in the Hajnáčka assemblage up to now (also, one new taxon (Ursidae gen. et spec. indet.) have been found among the fossils of carnivores). In addition, the cricetids are the most frequent group of the micromammals, represented by the both finds (min. 36) (Tab. 11.3) and taxa (6-7) (Tab. 11.2).

According to the frequency of occurrence, FEJFAR (1964) divided the fossil assemblage from the Hajnáčka to three groups: 1. taxa abundant in all facies of the sedimentary filling (*Tapirus arvernensis*, *Dicerorhinus jeanvireti*, *Mammut borsoni*, and *Anancus arvernensis*); 2. taxa regularly occurring in the coarse tuff or arenaceous tuffite of the coastal facies (*Mimomys stehlini*, *Trogontherium minus*, *Muntiacus* sp., *Capreolus* sp., *Castor fiber*, *Hypolagus brachygnathus*, and *Prospalax priscus*); and 3. isolated finds of taxa found in 1 or 2 specimens (*Desmana nehringi*, *Petenyia hungarica*, *Beremendia fissidens*, Colobinae sp., *Mimomys hassiacus*, *Baranomys loczyi*, *Apodemus* sp., *Pliopetaurista pliocaenica*, *Hyaena perrieri*, *Parailurus hungaricus*, *Lutra* cf. *bravardi*, *Megantereon* sp., *Sus minor*, *Croizetoceros ramosus*, etc.). New research confirms mentioned mammal distribution in maar sediments, especially with the regard of the first two groups. However, the numerous finds of *Mimomys hassiacus* allow to relocate this vole species to the second group. On the other hand, the third group is „enriched" by other rare taxa (e. g. *Talpa* cf. *minor*, *T. fossilis*, *Deinsdorfia hibbardi*, *Sciurus* sp., *Ungaromys* sp. Ursidae gen. et spec. indet., etc.). In addition, the occurrence of the vertebrate fossil remains in the lenses and intercalation of gravel rusty-brown tuffaceous sand with limonite concretions and pyroclastic rocks has repeatedly been validated.

Tab. 11.3. The composition of the micromammal assemblage found during the new research of Hajnáčka I.

Mammalian taxa	Nr. of taxa	Nr. of finds	Sum of m1	Percentage of m1
Rodentia				
Sciuridae	1	1	?	?
Castoridae	1	6	-	-
Cricetidae	6	36	6	55 %
Anomalomyidae	1	7	1	9 %
Lipotyphla				
Talpidae	4	5	2	18 %
Soricidae	3	4	2	18 %
Sum (Σ)	**16**	**59**	**> 11**	**100 %**

HAJNÁČKA PALEOENVIRONMENT

According to KORMOS (1917), the Hajnáčka biocenosis lived on the bank of the shallow lake at the beginning of one of the basaltic eruption. FEJFAR (1961, 1964) also had considered lake basin, which arose by the blocking of a water flow by the basaltic stream. The Bone Gorge site was identified as a maar structure by KONEČNÝ and LEXA (in VASS & ELEČKO eds., 1992). VASS et al. (2000) refer about the accumulation of the vertebrate bones in an inflow and outflow lake (Fig. 1.26.4) situated in the former basaltic maar, destroyed by the erosion after the rise of Cerová vrchovina dome.

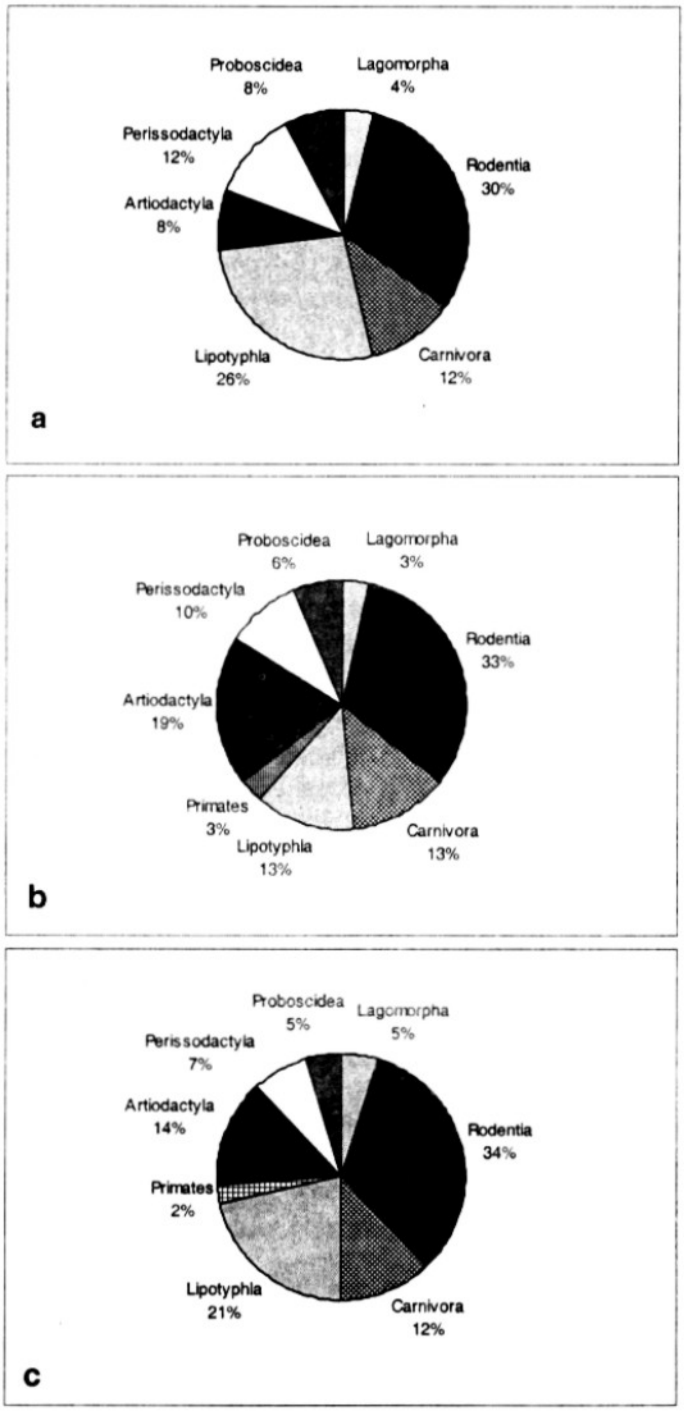

Fig. 11.1. Percentage of mammal groups found in the Late Pliocene sediments of the Hajnáčka I. site.
a – during new research in 1996 – 2000, b – during research in 50s of the last century (FEJFAR et al., 1990), c – compilation of the present researches.

The fossils occur in the both so called „older" (limnic sand, sandy tuffite and lapilli ash with baked limonite sandstone) and „younger" sections of the lake sediments. Whereas the finds from the „older section" are irregularly dispersed, those from the „younger one" are concentrated in the layers of coarse tuff or arenaceous tuffite (FEJFAR, 1964).

According to VASS et al. (2000), the sediments found in trenches represents the secondary sedimentary filling of the maar depression. This secondary filling originated in the inflow and outflow lake after removal of the primary filling, whose fragments are rarely found as blocks of the fine laminated sediments. The laminated sediments have been deposited in original maar lake under eutrophic conditions.

Besides tuff and tuffite, the repeatedly deposited sandy material from the disintegrated underlying Eggenburgian sandstone of the Fiľakovo Formation (light, faintly cemented sea Tachty Sandstone) (VASS & ELEČKO eds., 1992) took part in the forming of the maar primary filling. Hereby, these sediments have been redeposited after the removal of this original filling during the erosive post-volcanic period in the time of the maar secondary filling deposition. The common occurrence of the Pliocene vertebrates with redeposited Miocene foraminifers (*Ammonia* cf. *vienensis*, *Cyclammina* cf. *Praecancellata*, *Cyclammina* sp., *Heterolepa dutemplei*, *Reticulophragmium acutidorsatum*, and *Rotalia* sp.), sponge spicules, echinoids spines, and shark teeth (*Carcharhinus priscus*, *Carcharias cuspidatus*, *Carcharias acutissimus* and/or *Mitsukurina* sp., ?*Carcharias* sp.) is the evidence of that.

Additional, the deposition of secondary filling in the inflow and outflow lake was also accompanied by the gravitational slumping and landslides from slopes to the maar centre. However, this secondary maar filling has been partially destroyed by the erosion and redeposited together with osteological remains of vertebrates to the allochthonous position.

In the time of the secondary maar filling formation, the swamp were situated on the coast of this lake (FEJFAR, 1964). These swamps were surrounded by the bushy humid (but after LINDSAY et al. (1997) not swampy!) primeval (deciduous to mixed) forest with the flowing streams and backwater, in which the mammals as *Anancus arvernensis, Mammut borsoni, Tapirus arvernensis, Dicerorhinus jeanvireti, Muntiacus* sp. occurred. On the other hand, the finds of the genera *Hyaena, Megantereon, Hypolagus* and *Prospalax* (FEJFAR, 1964) or *Baranomys* (FEJFAR et al., 1990) are the evidence of the presence of the steppe or open grassy land in the Hajnáčka paleoenvironment too.

On the basis of the secular research, the mammal assemblage could be divided to three main ecological groups (Fig. 11.2): 1. inhabitants of the aquatic and semi-aquatic environment (*Desmana*, *Lutra*, *Castor*, *Trogontherium*); 2. inhabitants of the forest (shrews, primates, ursids, *Parailurus*, *Pliopetaurista*, *Sciurus*, *Tapirus*, *Dicerorhinus*, *Sus*, cervids, proboscideans); and 3. indifferent inhabitants of the open land (*Hyaena*, *Megantereon*, cricetids, murids, *Prospalax*, *Hypolagus*). FEJFAR (1964) considers the finds of inhabitants of the first two groups to be autochthonous, whereas indifferent elements of the third ecological group identifies as allochthonous.

Thus, this biotope with its composition was differing from that, which existed during the formation of primary maar filling, when the eutrophic lake with the domination of the unicellular heterotrophic peridinioid dinoflagelates filled the maar. In the same period, the forest with the predominance of the thermophile species of coniferous (*Tsuga*, *Abies*, *Picea*, *Pinus*) and sporadic occurrence of the angiosperms (*Carya*, *Acer*) grew on a dry substratum far from the lake bank.

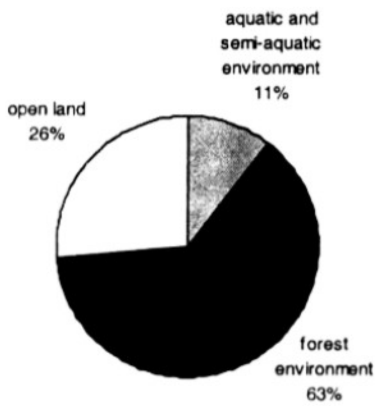

Fig. 11.2. The dividing of the Hajnáčka mammal assemblage to the ecological groups.

From the point of view of the faunal diversity, it is possible to observe a decrease of the number of taxa in the Villanyian assemblages in comparison with the faunas of the Ruscinian. Whereas some species were already missing in the western part of Central Europe during the Villanyian, they were still relatively abundant in the eastern part (DAHLMANN, 2001). These changes of the character of the faunal (and floral) assemblages were probably a result of the climatic changes at the end of the Early Pliocene (Ruscinian, MN 15) and the beginning of the Late Pliocene (Villanyian, MN 16) approximately

3.4 Ma ago. In this period, the warm and humid climate of Central Europe became cooler and this cooling distinctly separated the previous warm climatic phase (THOMPSON & FLEMING, 1996).

The fauna and flora, living in the vicinity of maar during the forming of its secondary filling, constituted probably the uniform unit destroyed by the eruption of some near volcano (FEJFAR, 1964). However, it is not known so far, which volcano was a „killer". The answer to this question is maybe concealed in the vicinity of the site, where relics of former active volcanoes are present (it is not excluded, the volcanic activity of the locality Ostrá skala with lava neck dated to 2.60 ± 0.22 Ma could be the potential reason of the Hajnáčka taphocenosis extinction, but the exact evidence for that is missing).

The first, who connected the extinction of the Hajnáčka taphocenosis with the eruption and fall of the volcanic ash was SCHAFARZIK (1899). FEJFAR (1964) supported this mutual context of the finds of vertebrate bones and teeth in the basalt agglomerate facies. The bones with the presence of the point corrosion testify that, and FEJFAR (1964) connects this corrosion phenomenon with the falling ash. However, as it results from finds, some animals have been killed by the gas emanations at the lake bank still before the volcanic eruption and subsequent tephra fall. Additionally, some bones gnawed by the hyenas mention the dead animals were lying for some time on the coast (FEJFAR, 1964). The carrion of animal, which were killed by the gas emanations during the water drinking or by the fall of the volcanic ash, have been washed to the lake later and deposited on its bottom near of the coast. The presence of fish bones, fragments of bivalve shells (*Anodonta* sp.) and also ostracod shells (*Darwinula* sp., *Candona* sp., *Pseudocandona* sp., *Ilyocypris* sp.) together with the vertebrate osteological remains in the fossiliferous sediments is evidence of that. On the other hand, records of *Anodonta* closed shells can also indicate a rapid sedimentation of the volcanic ash. VASS et al. (2000) suppose the skeletons of perished animals have been disintegrated by a current in the inflow and outflow lake. But some fossils have been found in the autochthonous attitude too (FEJFAR, 1964). On the basis of that, it is not out of the question the most vertebrate skeletons have been disintegrated together with the sediments during the later geological processes.

Many fossils of the Pliocene vertebrates (especially mammals) are known either from the fluviolacustrine deposits or from the fillings of karst fissures. The individual sites differ by their faunal composition, which also reflect the changes of the climatic conditions. The main climatic change during the Pliocene occurred at the end of the Early Pliocene (MN 15) and the beginning of the Late Pliocene (MN 16). In this period, the warm and dry climate finished in the Iberian peninsula (MONTUIRE, 1994), whereas the warm humid climate retreated from the territory of the Central Europe as impact of the cooling (DAHLMANN, 2001). The paleobiogeographical situation was changed. The single changes are visible in the composition of assemblages from individual sites. Also, the differences are regarded in the various European regions, where sites dated to the same age differ from themselves by the similarity of their faunal assemblages (Tab. 11.4).

Tab. 11.4. The comparison of the similarity of the faunal assemblages from three Central European sites on the basis of the Sorensen Index (2B/(F1+F2)). A small index of the similarity between faunal assemblages of Wölfersheim and Ivanovce, which are dated to the same age is interesting.
B – number of common taxa from the compared sites; F1 – number of taxa of the first compared site; F2 – number of taxa of the second compared sites.

Localities	Wölfersheim (MN 15b)	Ivanovce (MN 15b)	Hajnáčka I (MN 16a)
Wölfersheim	-	0.25	0.25
Ivanovce	0.25	-	0.34
Hajnáčka I	0.25	0.25	-

From the palaeobiogeographical point of view, the Hajnáčka taphocenosis is an evidence of the common existence of the ancient faunal elements together with the progressive taxa in the refuge areas with adequate conditions in spite of the climatic changes. Also, the inorganic background surely played the important role, when the character of landscape has been shaped during the single volcanic phases and in periods between them. Thus, on the basis of presented results, the age of the Hajnáčka fauna (Early Villanyian, MN 16a) corresponds with the time span between the second (5.43 – 3.58 Ma) and the third phase (2.92 – 2.60 Ma) of the volcanic activity evolution on the territory of southern Slovakia.

Current knowledge enables the various stages of the environmental evolution of the area around the Hajnáčka I site to be reconstructed:

1. Phreatic explosions began to form the dish-like depression of the Bone Gorge maar at the beginning of the Gauss magnetochron, which is characterised by normal polarity (C2An, approximately 3.55 Ma), after the end of the second (5.43 to 3.58 Ma) of six phases of volcanic activity in the territory of southern Slovakia. The phreatic explosions also ejected sandy material from disintegrated Eggenburgian sandstones, which accumulated as a layer at the bottom of the maar.
2. Successive phreatomagmatic eruptions of pyroclastic material formed the tuff ring. Gravitational slides, produced by seismic shocks and repeated explosive activity, caused the transportation of tuff material from the inner slopes of the ring to the lower levels of the maar depression.
3. After the phreatomagmatic eruptions ended, the finely laminated sediments of the primary maar filling accumulated in the central part of lake under eutrophic conditions. Whereas unicellular heterotrophic peridinioid dinoflagelates dominated the lake itself, a forest mainly consisting of thermophilous coniferous taxa, but with sporadic occurrences of angiosperms, grew farther away from its shores.
4. At approximately 3.3 Ma, the tuff ring was partly destroyed and eroded by domatic uplift of the Cerová vrchovina Upland. As a result, the sediments of primary maar filling were removed and replaced by the ones of secondary maar filling (limnic sand, sandy tuffite, lapilli ash and limonite sandstone fragments). These accumulated in the lake, which by now possessed an inflow and an outflow.
5. At the time these secondary maar sediments were accumulating (between 3.3 to 2.8 Ma), the area around the lake was covered in bushy, humid (but not swampy) primeval forest (LINDSAY et al. 1997), with steppe or open grassland areas present. Tapirs, „mastodons", rhinos and cervids dominated the forest, whereas representatives of hyenas, machairodontids, lagomorphs and some rodent species were present on the warm, open steppe.
6. The extinction of the Hajnáčka fauna and flora was probably caused by the eruption of a nearby volcano and the subsequent volcanic ash falls and/or poisonous gas emissions. During the next period (the third volcanic phase: 2.92 to 2.60 Ma), volcanic activity in proximity to the site continued and the entire area was uplifted. The sediments of the secondary maar filling, and the vertebrate skeletons they contained, were reworked, most probably by water erosion.
7. During the Quaternary, geological processes (erosion, solifluction and repeated landslides) destroyed what remained of the maar and re-deposited its sediments elsewhere. Hereby, the maar sediments were again disturbed and partly mixed with the Late Pleistocene sediments and fauna (*Coelodonta*, *Mammuthus*, etc.).

CONCLUSION

On the basis of researches of Hajnáčka I, this paleontological locality has been dated to the Early Villanyian, the MN 16a biozone (the Late Pliocene). The fossils of vertebrates are especially found in the lenses and intercalation of gravel rusty-brown tuffaceous sand, often with the presence of the limonite concretions and pyroclastic rocks. The bones and teeth of tapirs, rhinos, proboscideans and micromammals (especially rodents) have been found the most frequently of all terrestrial vertebrates in these fossiliferous layers. Part of new finds verified the older ones, and part of them has been determined as new taxa (*Talpa* cf. *minor*, *T. fossilis*, *Talpa* sp., *Deinsdorfia hibbardi*, Soricidae gen. et spec. indet., *Sciurus* sp., *Ungaromys* sp. Ursidae gen. et spec. indet., etc.), unknown from the site so far. Besides of the Pliocene faunal remains, the fossils of redeposited Miocene (foraminifers, shark teeth) and Pleistocene (gastropod, mammoth and horse remains) elements have been found too.

The plants and animals lived on the bank of the inflow and outflow maar lake in the environment of the humid primeval forest. This Late Pliocene biocenosis has been destroyed by the eruption of some near volcano and buried by the volcanic ash. Successive geological processes, accompanying the next volcanic activity, disintegrated remains of vertebrates together with the maar filling. Other geological processes finished the annihilation of the Bone Gorge maar and its sediments with the fossils in the time of the Quaternary Period. Thus, the new research of the site supplements the results of former excavations.

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