CASE STUDY OF THE IPOLYTARNOC TRACK SITE, HUNGARY

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Abstract—The Ipolytarnoc Fossil Site is situated in Northern Hungary. The Lower Miocene stratum contains both marine and terrestrial fossils, including shark teeth, petrified trees, leaf impressions and tracks. Footprints of 11 vertebrate species have been described on the footprint-bearing sandstone, which was preserved by a layer of volcanic tuff. The fossil tracks were first found in 1836 and damage to them was observed then. Protective measures proved ineffective even after the designation of the site as a protected area in1944. The site has been developed as an interpretive center, including buildings over the track layers and is safeguarded now, but lacks continuous scientific research.

INTRODUCTION

The 510 hectare-large Ipolytarnoc Fossils Nature Conservation Area (IFNCA) is situated in NE Hungary (Fig. 1), 2 km from the village of Ipolytarnóc, near the Hungarian–Slovak border (48º14'12" N; 19º39'25" E). The site is considered the prime fossil locality of Hungary.

The chronostratigraphic framework for the site uses the Central Paratethys regional stages of Eggenburgian, Ottnangian and Karpatian, correlated with the standard Burdigalian Stage (Fig. 2). The Lower Miocene stratigraphy is well established for the vicinity of Ipolytarnóc (Fig. 3) The uppermost part of the basinal, deep-water siltstone's (Szécsény Schlier Formation) outcrops in some places in the area and is overlain by up to 50 m of locally glauconitic sandstone of a nearshore facies (Pétervására Sandstone Formation). This unit is transitional to the Budafok Sand Formation, exposed farther to the west. At certain levels the sandstone contains unusually abundant marine Eggenburgian mollusk fauna and shark teeth. It is in turn overlain by terrestrial strata of the Zagyvapálfalva Formation. An unconformity between the two formations is indicated by an irregular erosion surface (Pálfy et al., 2007). The Zagyvapálfalva Formation is represented by 1–8 m of fluvial conglomerate overlain by 2-4 m of the track-bearing sandstone (Ipolytarnóc beds). The latter stratum is known and developed only within IFNCA . The whole sequence is capped by a 10–30 m thick rhyolite tuff, the Gyulakeszi Rhyolite Tuff Formation (GRTF). The excellent preservation of the tracks is the result of the sudden volcanic catastrophe, which buried and conserved the paleohabitat so that the fossil remains survived in such abundance.

TYPES OF FOSSIL RESOURCES AT IPOLYTARNOC FOSSILS NATURE CONSERVATION AREA

Shark Teeth

The reworked shoreline sandstone layers of the 23 Ma old sea sediments bear a very rich marine fauna. The so called "shark tooth-bearing beds" contain- besides shark teeth (Fig. 4) - a mixture of bones from rays, dolphins, manatees and crocodilians. After the 1903 description of Koch, the "Ipolytarnóc shark tooth-bearing bed" became the characteristic marker bed of the Eggenburgian stage of the Lower Miocene in the Central Paratethys. The original fauna as described more than 100 years ago was revised recently based on new finds. The result shows a very diverse Lower Miocene shark community that includes 19 genera with 16 certain species (Kocsis, 2007).

Petrified Forest

The giant petrified tree trunk, 42 m long that bridged a stream of the Borokas ravine was exposed at the beginning of the 19th century. Its discovery initiated the scientific research of the site.

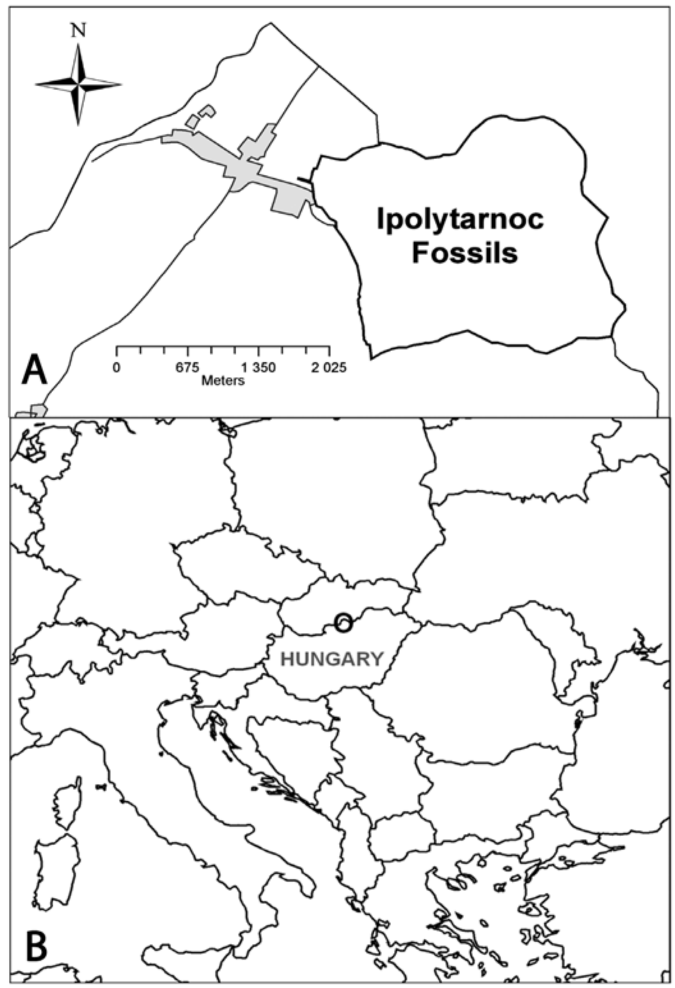

FIGURE 1. Location of Ipolytarnoc Fossils Nature Conservation Area.

The first scientific research activities and excavations began in 1836, led by Ferenc Kubinyi (Fig. 5). Later investigations demonstrated that a whole forest was destroyed by the volcanism, the trees were toppled on top of the paleosurface by the nearby volcanic blast. Most of the tree remains are embedded at the sandstone-tuff transition, under the plinian ash fall unit. A detailed analysis of the petrified tree trunks revealed that the 20 Ma old rainforest held at least 7 coniferous, 4 deciduous and 1 palm species.

Leaf Impressions

A recent paleobotanical study identified 64 taxa among the large

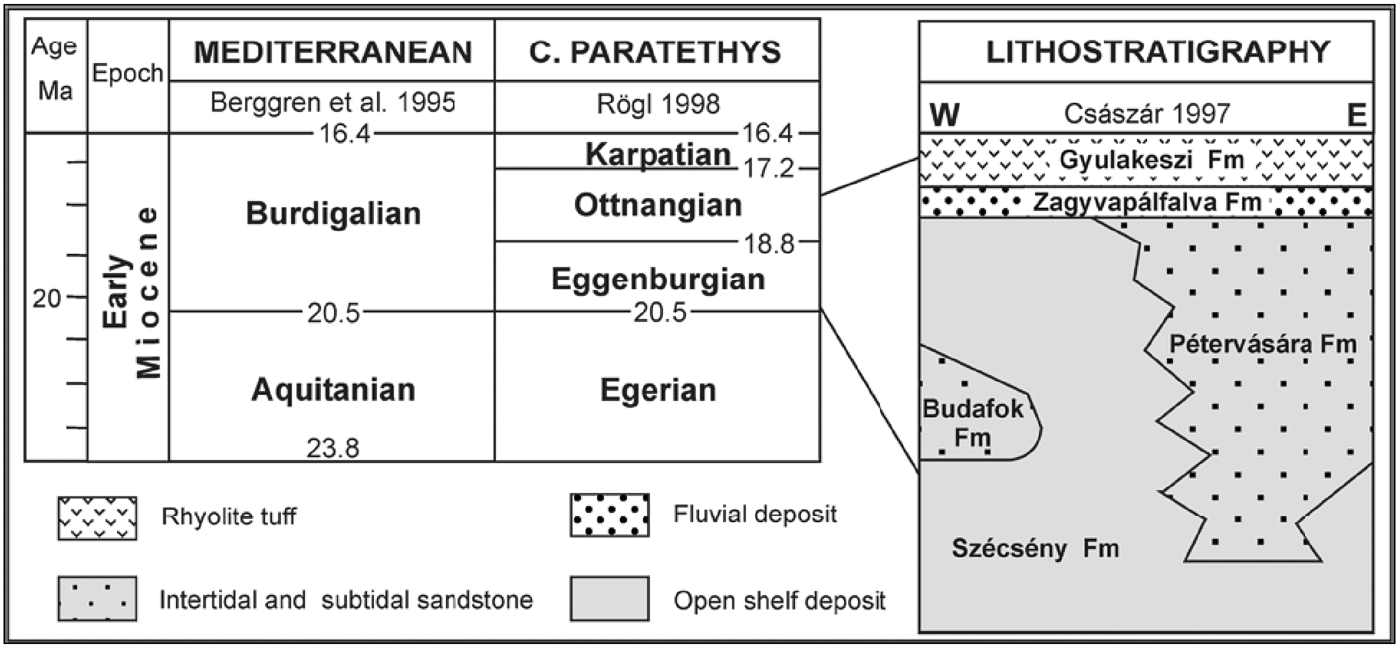

FIGURE 2. Stratigraphic position of the Lower Miocene beds at Ipolytarnóc (after Hamor, 1985; Kocsis, 2007).

collection of macrofloral remains, based on a sample of nearly 15 thousand leaves (Hably, 1985). The assemblage is dominated by laurophyllous plants, indicative of a vegetation in a warm and humid, subtropical climate. (Fig. 6). Most of the abundant plant remains are in the basal part of the rhyolite tuff, but 27 plant species have been identified from leaf imprints on the palaeosurface (footprint sandstone), too.

Fossil Tracks

Abundant and well-preserved fossil vertebrate tracks are exposed on the topmost bedding planes of the Miocene river bank sandstone (Table 1; Fig. 7). The preservation of the tracks has been attributed to volcanic activity that instantly covered the paleosurface.

It was Hugo Böckh, who, at the base of the giant tree, originally discovered the prehistoric animal footprints in 1900. The original discovery, a 4x4 m slab with footprints was transported to Budapest within a year, where it is still displayed in the Hungarian Geological Institute's (HGI) well-known lecture hall, hence known as "Footprint Hall." In the 1920's, 30's and 60's Ferenc Nopcsa, and later Tasnádi also enriched the Institute's collections by excavating more footprints (Tasnádi, 1976).

In the early 1980's, the footprints were mapped during the construction of the first of several facilities built to protect them; 1298 tracks were registered on the site, while the total number reached 1644, together with the specimens in the HGI collections (Kordos, 1985). Explorations in the 1990's doubled the figure of footprints on the site to 2762.

The extent of the known area with footprints explored at Ipolytarnóc in the last hundred years exceeds 1500 sq. m. The whole site, which is estimated as being 50-100 times larger then the currently exposed areas and is mostly continuous can only be explored after removing the rhyolite tuff bed. Such exposure of the surface containing the footprints should only be undertaken if they can be preserved from weathering. Therefore, scientific exploration only takes place gradually, and requires subsequent protective measures.

Analysis of the footprints started immediately after their discovery, and it was known a hundred years ago that there were tracks of rhinoceroses, ungulates and birds.

The first scientific description of the footprints was in 1935, in a book by Othenio Abel (Abel, 1935), who identified footprints of a rhinoceros, a proboscidean, cervids, an ancestral triungulate horse, a large carnivore as well as birds. He illustrated them with photographs. Following the studies of Tasnádi, the "Ipolytarnóc" monograph of Geologica Hungarica series Palaeontologica was issued in 1985, for the Regional Committee on Mediterranean Neogene Stratigraphy (RCMNS) congress, where L. Kordos identified 11 animal species based on all footprint known at the time. The taxonomic analysis of the Ipolytarnóc footprints was carried out simultaneously, and in competition, between the Hungarian Kordos (1985) and the Soviet Vialov (1985, 1986). Based on the priorities, 11 animal species could be identified, all of which were new to science (Fig.7).

The commonest avian species are the medium-sized *Ornithotarnocia lambrechti* with three toeprints and the similar-sized *Tetraorniothopedia tasnadii* that left four toeprints behind, while *Aviadactyla media* is characterized by rod-like, straight toeprints. Tracks of the small songbird-type, *Passeripeda ipolyensis*, are present but not as common as those of the other birds.

The most common mammalian footprints include the rounded and three-hooved footprints of adult and juvenile, prehistoric rhinoceroses (*Rhinoceripeda tasnadyi*) as well as those of smaller (*Pecoripeda hamori*) and larger (*Megapecoripeda miocaenica*) ungulates. Numerous carnivores lived here 20 million years ago. Amongst them, the largest footprints belong to the rare *Bestiopeda maxima*, first illustrated by Abel (1935). Astonishingly fresh-looking and distinct are the three footprints of a single individual of *Carnivoripeda nogradensis*, the blurry tracks of *Bestiopeda tarnocensis*, and the clawprints of a peculiar mustelid, *Mustelipeda punctata* (Kordos, 1985).

History of Protection

Unfortunately, after surviving the volcanic catastrophe and 20 Ma, the fossil finds could not withstand the onslaught of humans. Not just laymen but scientists also caused irretrievable damage to the track and other fossil remains.

Devastation already began in the year of discovery of the petrified pine, in 1836. Kubinyi at first thought of *ex situ* protection. He had the trunk unearthed and dragged out of the ravine by "11 pairs of oxen". The trunk was then broke into pieces and the number of resulting fragments were then transported to nearby private museums.

Later, realizing his mistake, Kubinyi had the remaining exposed parts covered with earth, "lest it fell prey to vandal hands, that are

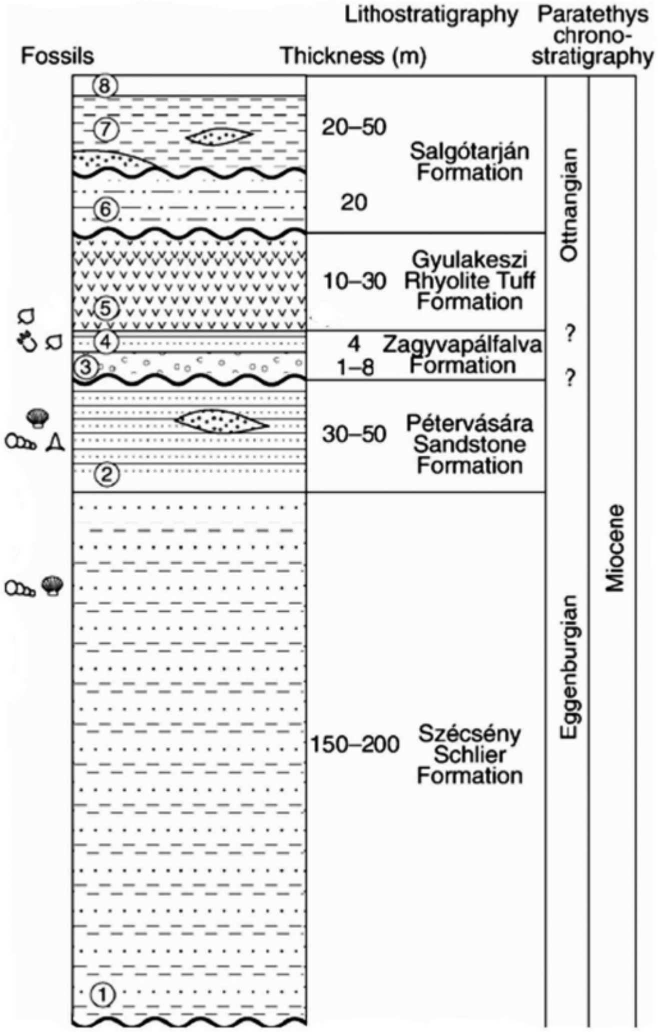

FIGURE 3. Generalized Miocene stratigraphy of the Ipolytarnóc area (after Bartko, 1985; Pálfy, 2007). Lithology: 1, silty and clayey sandstone; 2, glauconitic sandstone with conglomerate lenses; 3, pebble conglomerate; 4, trackbearing sandstone; 5, rhyolitic ignimbrite; 6, redesposited tuff and sandstone; 7, variegated clay; 8, sand.

FIGURE 4. Shark teeth-bearing sandstone.

FIGURE 5. The giant petrified tree of Ipolytarnoc (after a drawing by K. Marko the elder, 1840).

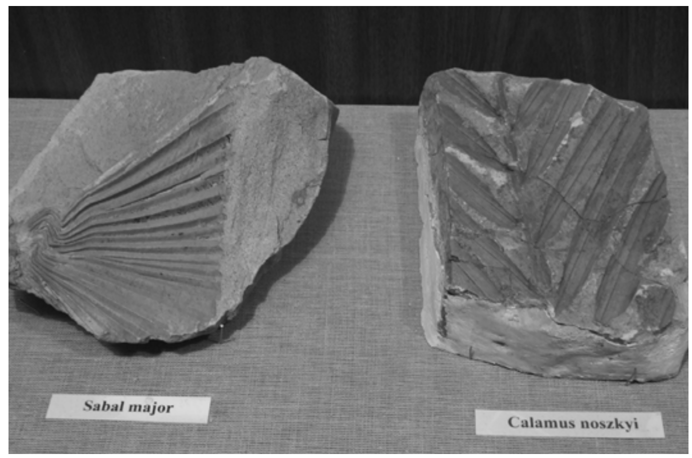

FIGURE 6. Palm leaf impression in the rhyolite tuff.

lamentably so common in this country and that let the so-called stone-bench come to nothing".

Unfortunately, neither Kubinyi's efforts, nor the building, which was erected around 1860 to shelter the most endangered parts of the giant pine, could save the trunk from vandalism. Locals collected fragments of it for building stone and whetstone, swarms of "souvenir collectors" broke pieces from it, local landlords took bigger fragments of it as ornaments for their gardens, and it became a favored material for gravestones. Museums were also frequent visitors and contributed to the damage. Even the protective shelter of the tree was destroyed within two decades after its construction.

The shark teeth also attracted the attention of the locals. They imaginatively called them petrified bird tongues and sold them in necklaces to the tourists, who came to visit the wonders of petrified nature.

The footprint sandstone proved to be ideal cobble, building stone and was used even for the building of the protective cellar for the fossil tree. Locals held picnics on the eroded surface of the paleosurface and danced on top of the prehistoric footprints. Paleontologists excavated and collected the most exotic tracks, and left the exposed surfaces to weathering and accessible to private collectors. Several tracks were lost, and only sketches of them survive.

Those, who cared for the site, stopped publishing papers, because they realized, that new discoveries generated a new flow of collectors to the site. The most pro conservation scientists finally decided to stop further excavations, until everything already exposed was sheltered (Tasnádi,1976).

Despite the fact that the site officially became protected in 1944, several decades went by before the protection became effective. Permanent staffing with guided tours along the established geological study

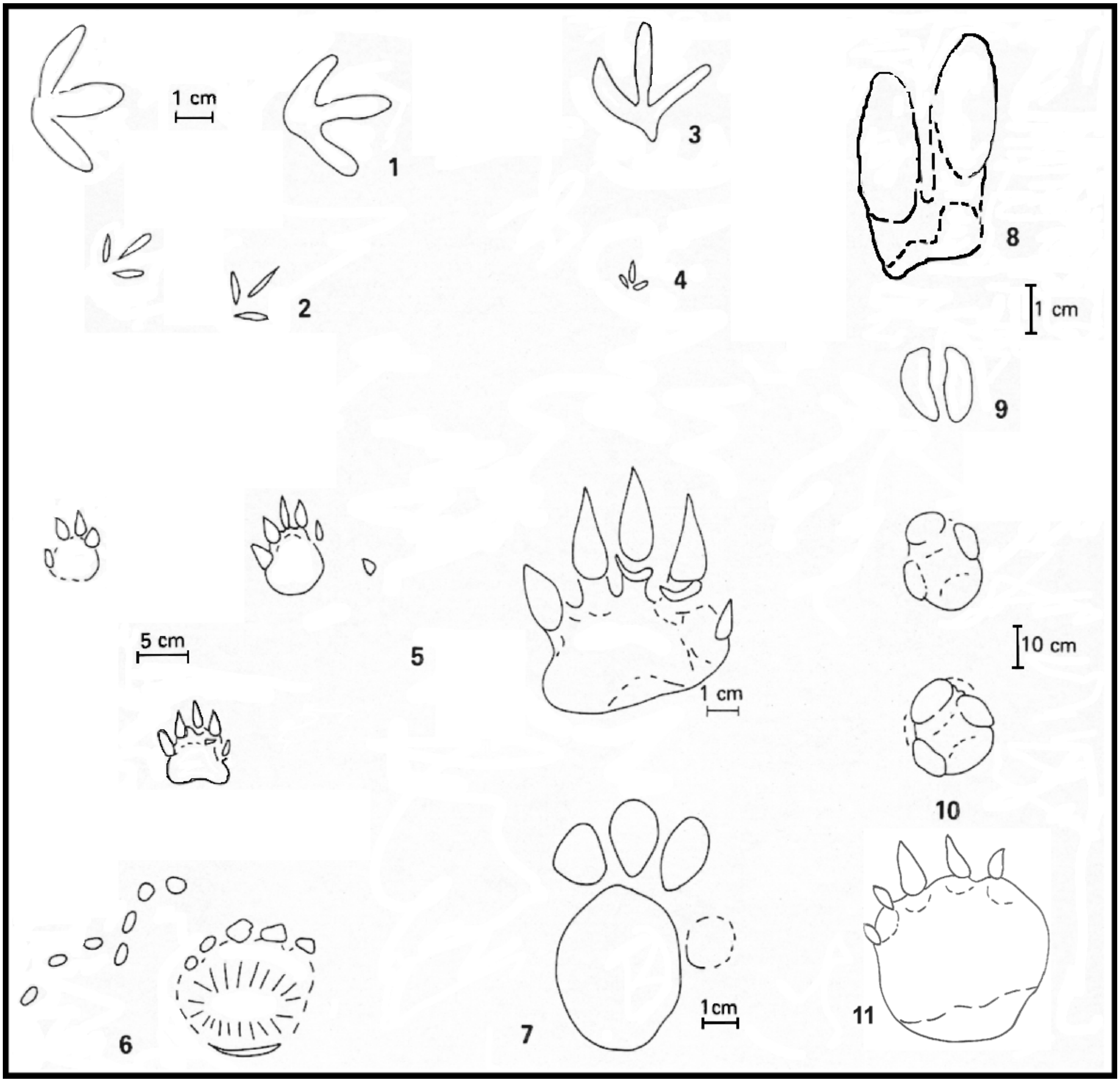

FIGURE 7. Examples of tracks preserved at Ipolytarnóc. 1, *Ornithotarnocia lambrechti*; 2, *Aviadactyla media*; 3, *Tetraornithopedia tasnadii*; 4, *Passerpeda ipolyensis*; 5, *Carnivoripeda nogradensis*; 6, *Mustelipeda punctata*; 7, *Bestipeda tarnocensis*; 8, *Megapecorapeda miocaenica*; 9, *Pecoripeda hamori*; 10, *Rhinoceripeda tasnadyi*; 11, *Bestiopeda maxima* (after Kordos, 1985).

trail in the early 1980's was the solution. Excavated areas where tracks were exposed became covered by conservation buildings, and new interpretation trails were opened later. The site has become a favored destination for tourists.

Land ownership problems were solved as the area was acquired by the Hungarian state, and the Bükk National Park Directorate (BNPD) gained land manager status; thus the number of factors impeding conservation management was reduced significantly.

The site was declared a part of the Pan-European natural heritage by the Council of Europe in 1995. The area is on the tentative list of the world heritage and an European diploma holding site, it has the potential for success, but still something is missing.

Despite the focused attention of the Neogene Congress of 1985 (8th Congress of the Regional Committee on Mediterranean Neogene Stratigraphy) on Ipolytarnoc, no further development enhanced the site's recognition till the end of the century.

The following was conceived about the site at the Congress:

> "…we envisage Ipolytarnóc to become an international treasury of universal geosciences, a national training ground and a base for the propagation of knowledge, the training of students of geology and the cultivation of science, and to serve as a model for those who seek to conserve the irreproducible geological assets of Nature for the generations to come."

The period since the Congress up till now was a time of recruit-

TABLE 1. Footprints of Ipolytarnoc

Birds	
	Ornithotarnocia lambrechti Kordos, 1985
	Aviadactyla media Kordos, 1985
	Tetraornithopedia tasnadii Kordos, 1985
	Passeripeda ipolyensis Kordos, 1985
Mammals	
	Bestiopeda maxima Kordos, 1985
	Bestiopeda tarnocensis Vialov, 1985
	Carnivoripeda nogradensis Kordos, 1985
	Mustelipeda punctata Kordos, 1985
	Rhinoceripeda tasnadyi Vialov, 1966
	Megapecoripeda miocaenica Kordos, 1985
	Pecoripeda hamori Vialov, 1986

ment and slow accretion, with a more or less passive role in the field of geological research and of growing into a scientific centre. Unfortunately, the vision has not come true yet.

Despite further developments of the reconstruction of the Visitor Center, recent budget cuts seriously threatened the running of the site and continued protection of the tracks and other fossil resources. The area has no paleontologists on the staff, research is sparse, so it is no surprise that it has been relatively overlooked by the global paleontological community until recently.

It was a kind of window opening, when two US NPS paleontologists, Greg McDonald and Ted Fremd came to Ipolytarnoc in 2002. As a consequence of that visit, Ipolytarnoc is presented here. What kind of lesson can be learned from isolated track sites like Ipolytarnoc?

· A network is needed, to make them part of the mainstream in both geology and paleontology, but even beyond.

· Congresses are very important, where specialists can share their results. Track specialists are enthusiasts, work together voluntarily, yet the spotlight is still not so intensive on the ichnofossil domain as it should be.

· A vast amount of track sites are left unprotected, thrown to the fate of erosion or human development.

· Flagship protected areas are needed to protect them. There must be track sites where no one has privileges or exclusiveness, where research is open for debates and encouraged (either for remapping or for further excavations), where researchers can work together like in communities.

Yes, excavating previously unknown tracks is the feast for the paleontologist, to be first to describe them is laurelled fame.

Yet, those already known sites, which still have huge potentials and can be ideal for establishing research centers, some kind of training schools, need a boost, to be supported and enhance their chance to survive and being valued along with the other still less protected ones.

It is not an unfounded pledge to consider such an option; it would be beneficial to designate at least one such a site for each of the continents, and to establish a network from them for the benefit of all!

May our congregating tracks we leave behind be memorable ones.

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