Geoconservation Research
2021, Volume 4 / Issue 2 / pages(459-470)

European UNESCO Geoparks: Review Article

A Unique Late Cretaceous Dinosaur Locality in the Bakony-Balaton Geopark of Hungary (Iharkút, Bakony Mts.)

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Abstract

Iharkút is a Late Cretaceous (Santonian) vertebrate-bearing locality in the Bakony Mountains of western Hungary, where productive and continuous paleontological excavations have been carried out in the last twenty years. Fieldwork resulted in a very rich and diverse assemblage of terrestrial and freshwater animals, including fishes, amphibians, turtles, lizards, a freshwater mosasaur, pterosaurs, crocodilians, dinosaurs, and birds. This abundance and diversity of fossil taxa contribute to understanding of European Late Cretaceous continental vertebrate faunas. Furthermore, the site's paleogeographic position in the western Tethyan archipelago and its Santonian mean that it fills an important gap in the Late Cretaceous record of continental vertebrates in Europe. The locality is among the geological high points of the Bakony-Balaton UNESCO Global Geopark. The fossils are internationally important, which draws the attention of both scientific and non-scientific geopark visitors.

Keywords: Dinosaur, Geopark, Vertebrate fossils, Hungarian Dinosaur Foundation, Hungarosaurus

Article information

Received: 2021-01-29 Accepted: 2021-07-17
DOI: 10.30486/GCR.2021.1922052.1081
How to cite: Botfalvai G, Makádi L, Gáspár G & Ősi A (2021). A unique Late Cretaceous dinosaur locality in the Bakony-Balaton Geopark of Hungary (Iharkút, Bakony Mts.). Geoconservation Research. 4(2): 459-470. doi: 10.30486/gcr.2021.1922052.1081

Geoconservation Research e-ISSN: 2588-7343 p-ISSN: 2645-4661

Introduction

The Late Cretaceous (100.5–66 Ma) is one of the most interesting epochs in Earth's history, with a well-documented fossil record that gives an insight into a world of enigmatic extinct animals. These include dinosaurs, mosasaurs, and pterosaurs, which disappeared at the end of the Cretaceous. Besides the famous Late Cretaceous dinosaur faunas of North America (including the iconic *Tyrannosaurus*, *Triceratops* and giant sauropods), there are many important dinosaur localities in Europe (e.g., France, Romania, Italy, Spain and Portugal), where century-long large-scale fieldwork programs have revealed a rich assemblage of dinosaurs and other reptiles (Csiki-Sava *et al.* 2015 and references therein). The Hungarian dinosaur locality Iharkút is one of the most famous Late Cretaceous sites in Europe, where remains of more than 40 vertebrate species were discovered during the last 20 years (Ősi *et al.* 2012 and see below).

During the Late Cretaceous, a large part of future Europe was covered by sea (Mediterranean Tethys area), in which land was represented by islands of an archipelago, on which diverse terrestrial ecosystems could evolve. The "Iharkút Island" was part of the Austroalpine Domain surrounded by Tethys. Mesozoic terrestrial vertebrate remains from present-day Hungary are extremely rare because most of the sediments are marine deposits that yielded only a few vertebrate remains. As an exception, the Iharkút open-pit mine exposes a 60–70 m thick sequence of terrestrial sediments from which more than 100,000 vertebrate remains were collected in the last twenty years (see below).

The purpose of this work is to summarize the history and the scientific significance of the Iharkút dinosaur locality and discuss its role in scientific work and science popularization.

Short History of the Iharkút locality from the Bauxite Mining until the Dinosaur Research

The Iharkút vertebrate site is in the Northern Bakony Mountains, close to the villages Bakonyjákó and Németbánya (Fig. 1A). The bone-bearing sedimentary succession in Iharkút became accessible through extensive open-pit bauxite mining from the mid-1970s to the mid-2000s (Fig. 1B–C).

Generally, the quality of the Iharkút bauxite was the best in the country and was an important economic asset in socialist Hungary. This resulted not only in the later discovery of Cretaceous vertebrates but also in a tragic event. At the end of the 1970s, Iharkút village was demolished because some productive bauxite deposits were located immediately under the settlement practically without any overburden. The inhabitants were evacuated and moved to nearby towns and villages. The mining continued for decades with dozens of open pits all around the area, also reaching the periphery of nearby villages. Usually, the excavated mining waste (overburden) from newly opened pits was used to refill the depleted ones. The large number of separate pits was the result of the peculiarity of the Iharkút bauxite deposits: the bauxite accumulated in multiple series of narrow but deep sinkhole fillings (Károly *et al*. 2006; Legeza 2007; Bárdossy & Mindszenty 2013).

With mining slowly declining, in 2003 a memorial park was created where once Iharkút stood. Former citizens gather here each year to commemorate the tragic loss of their homes and their way of life. The bauxite mining at Iharkút finished in 2005 and recultivation procedures were also completed in the following few years (Károly *et al.* 2006; Legeza 2007; Bárdossy & Mindszenty 2013).

However, the area of the pits Nb-II (Németbánya-II), Nb-III, and Nb-XVII have not been refilled completely to allow access to the vertebrate-bearing strata (especially to sites Sz-6 and Sz-4), as well as to preserve the geological features such as fault planes, karst formations, etc. Excavations were helped by the Mining Company since the beginning and recultivation also incorporated the removal of tens of thousands of cubic meters of over-

lying rocks that covered the main vertebrate site. In this area of app. 5000 m^2, cover sediments only 1–2 m thick were left on top of the bone-bearing horizon for protection, making further excavations possible. Slopes, trenches and roads were formed to allow access to the sites, to drain rainwater, and provide protection against erosion, also slowed by trees planted on refilled areas. Therefore, the Iharkút open pits are not considered anymore as a mine but as a dinosaur excavation locality and geological site.

It is worth mentioning that there were some other pits, which, according to geological maps, also exposed the terrestrial Csehbánya Formation (thus, potential bone-bearing horizons) but these had been mined and refilled already in the 1980s, long before the discovery of the first dinosaur remains.

The first dinosaur remains were discovered at Iharkút in spring 2000 when one of the authors (Attila Ősi) and his friend (András Torma) found a few poorly preserved bones, some later identified as possibly ankylosaurian, in a sandstone bed in the northeastern wall of pit Nb-XIII, when they tried to clean and investigate the sedimentary succession of the wall. This was soon followed by a rhabdodontid tooth that became the first identified dinosaurian fossil at the locality. After the first discoveries, dozens of bones and teeth were collected from the same part of pit Nb-XIII, and the area was recognized as a potential Cretaceous vertebrate locality. Next year, a two-week excavation of this first site (Sz-1; see Fig 1B) with ten people was conducted, during which some well-preserved bones and the first partial skeleton were discovered in rocks poured on the mine dump. To find their origin, shorter surveys were made in the following months. As a result, by 2002, new, richer sites were discovered in the walls of the neighboring (and at that time just depleted) Nb-III pit and the still growing Nb-II pit. Since then, each summer, a large-scale, multi-week excavation is conducted, involving students and colleagues from different universities and institutions, as well as friends. As a result of 20 years of excavations, approximately 100,000 bones and teeth have been collected, including remains of at least 40 vertebrate species including fishes, amphibians, turtles, crocodiles, lizards, pterosaurs and dinosaurs. This is complemented by plant remains (leaf imprints, carbonized tree trunks, seeds, amber, etc.) and invertebrates (gastropods, bivalves, ostracods), as well as vertebrate and termite coprolites (Ősi *et al.* 2012; Botfalvai *et al.* 2015, 2016 and references therein). The fossils collected at Iharkút are deposited and inventoried in the vertebrate collection of the Hungarian Natural History Museum, Budapest.

The Iharkút locality is among the geological values of the Bakony-Balaton UNESCO Global Geopark, located in the western part of Hungary and mostly covering the Balaton Uplands north of Lake Balaton and a large part of the Bakony Mountains. The total area of the Park is more than 3,200 km^2, representing outstanding rich geological and cultural-historic heritage (Tardy 2021). The leading organization of the Geopark is the Balaton Uplands National Park Directorate. These organizations have a common mission to protect the rich geological and geomorphologic heritage of the Park with the involvement of local people and communities (see more information about the Bakony-Balaton UNESCO Global Geopark on this website: http://www.geopark.hu/en/home/bakony-balaton-geopark/introduction). Though the Iharkút locality is not registered yet as a site protected by law, the area is owned by the Hungarian Dinosaur Foundation and the nearby villages. Thus, collecting fossils and rock samples is prohibited, except for scientific purposes with the permission of these owners, so the protection, preservation and future access of the site is ensured.

Geology and Palaeoenvironment

Five geological formations are exposed in the vertebrate-bearing Iharkút open pits, the oldest being the Upper Triassic Dolomite (Main Dolo-

mite Formation) which was affected by intense karst formation during the Late Cretaceous under tropical climatic conditions, resulting in several tens of meters deep karst cavities (Haas 1983; Jocha-Edelényi 1988 and Fig. 1C). These cavities were filled with the bauxite that was mined, assigned to the Nagytárkány Bauxite Formation (Mindszenty 1985). The dolomite and its bauxite-filled cavities were originally covered by alluvial sediments of the Upper Cretaceous Csehbánya Formation (Fig. 1C). This formation, dominated by paleosols, siltstones and sandstones yielded thousands of vertebrate fossils in the last twenty years which were investigated in detail (Botfalvai *et al.* 2016 see below). Sediments of the Csehbánya Formation were deposited by a relatively small, branching, low-energy river system, a fluvial environment that consisted of multiple, relatively shallow channels and an extended floodplain area (Botfalvai *et al.* 2016). Paleofloral data from the Upper Cretaceous sediments of Iharkút suggest a subtropical floodplain forest vegetation under humid but seasonal climate conditions, where heavy seasonal rains could have triggered significant flooding events. The sediments indicate a wetland environment, where the water table was situated near the surface for most of the year, resulting in a relatively wet, marshy paleoenvironment which was inhabited by different freshwater animals and covered by relatively dense vegetation. This low-land environment was interrupted by many shallow fluvial channels that transported coarser grained sediments from the background area into the fine-grained floodplain sediments and formed channel fill deposits dominated by a few meter-thick sandstones.

The most important fossiliferous horizon (named as site Sz-6; see Fig. 1B) is a 2 to 3 m thick channel fill deposit. This was formed during an ephemeral high density flash flood which collected the carcasses from the large area of the river system, as well as killed many animals which could not escape (Botfalvai *et al.* 2016). These vertebrate remains (and other organic material, such as logs), carried by the flooding river were deposited when the flood achieved a topographical depression in the lowland where the flow energy suddenly dropped. Thus, thousands of transported bones and teeth could accumulate in a relatively small area, resulting in an unusually high bone concentration (about 23 vertebrate fossils/m^2; Botfalvai *et al.* 2015). Palynological investigations on samples from different horizons of the Csehbánya Formation exposed at Iharkút indicate an age of c. 85 Ma (Santonian) for this vertebrate locality.

After and during the Santonian and the Campanian, transgression and deposition of marine sediments took place. Later the area emerged; further tectonic processes broke up the sedimentary successions and erosion occurred. Consequently, the Upper Cretaceous terrestrial sediments at the Iharkút locality were uncomformably covered by Middle Eocene (Lutetian) nummulitic limestones (Szőc limestone Formation), or/followed by various sediments of the Oligocene fluvial Csatka Formation (Botfalvai *et al.* 2016), or/followed by even younger sediments. The youngest deposit is Pleistocene loess which forms a discontinuous blanket over most of the area. Consequently, due to the heavily tectonized nature and subsequent erosion of the area, a continuous sequence of these formations is not visible at the dinosaur site. Nevertheless, not all bauxite deposits preserved a terrestrial Cretaceous cover (i.e., potential bone-bearing beds), and other formations could also be missing.

Overview of the Fauna

Most of the vertebrate fossils in the Iharkút assemblage are isolated elements from various animals, but research over the past 20 years has also uncovered 12 partial skeletons, the latter of which belong to armored dinosaurs (Ősi *et al*. 2019). Based on this assemblage, we were able to identify at least 40 different terrestrial and freshwater vertebrate species (Fig. 2). The most characteristic fish fossils are the teeth, vertebrae and shiny scales of predatory fish, almost identical to those of to-

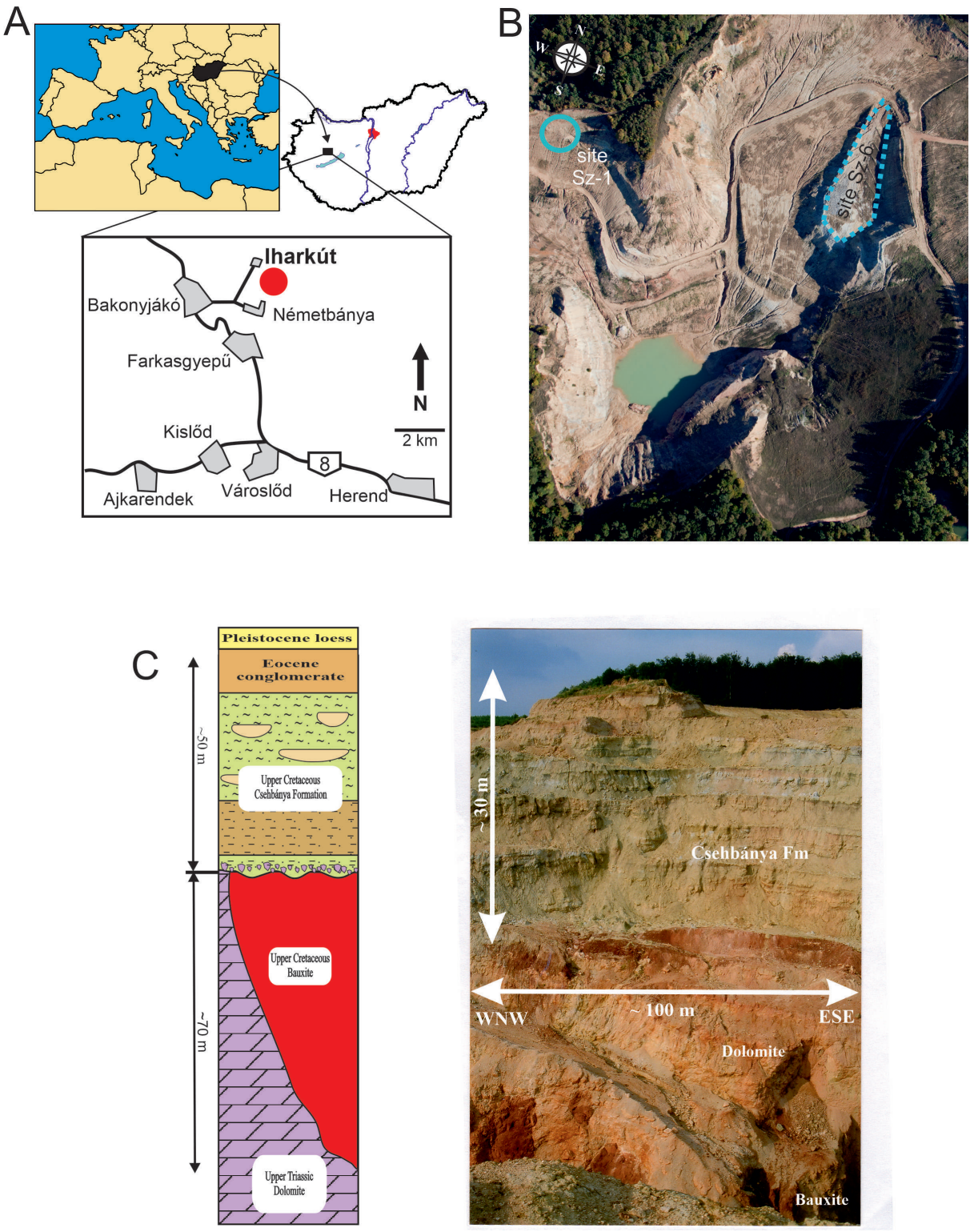

Figure 1. Location and geological background. A) Location map of the Iharkút vertebrate locality. B) Aerial view of the Iharkút mine indicating the vertebrate sites. C) Schematic section of the Iharkút open pit mine.

day's gars, but jaws of pycnodontiform fish with flat, broken teeth are also frequently found. Amphibians are represented by two or three species of frogs and a species of the now-extinct amphibian group Albanerpetontidae, whose tiny bones are often found in the screen-washed sedimentary rocks (Ősi *et al.* 2012).

At least four species of turtles have been identified so far, including a unique member of the extinct Bothremydidae family, *Foxemys trabanti* (Rabi *et al.* 2011; and Fig. 2B).

The lizards include both terrestrial and freshwater forms. While the remains of small to medium sized terrestrial lizards with typical (sometimes complex, multicusped) teeth (Fig. 2C) are abundant, the remnants of freshwater mosasaurs, described as *Pannoniasaurus inexpectatus*, are very frequent. The largest specimens of this were more than 6 m long and were apparently the top predator of the aquatic environment (Makádi *et al.* 2012).

As at similar Cretaceous vertebrate sites around the world, crocodiles are represented by a rich and varied assemblage (e.g., Csiki-Sava *et al.* 2015). So far, four crocodilian species have been identified based on well-preserved skull and jaw material, teeth, and postcranial remains. One of the most peculiar forms is the small crocodile *Iharkutosuchus makadii* (Fig. 2I), which could chew food with its multicusped teeth and was predominantly an omnivore-herbivore. Among crocodiles, there is also a completely terrestrial scavenger of uncertain origin, *Doratodon* sp., whose fragmentary skull bones and serrated, flattened teeth are rarely found at the locality. The air was dominated by the extremely thin-boned flying reptiles and birds. The former group includes *Bakonydraco galaczi* (Fig. 2H), whose remains of more than 80 jaws suggest that these flying reptiles with a maximum wingspan of 3–4 m might have been common. Birds are rare, represented by two species of the clade Enantiornithes, of which the buzzard-sized *Bauxitornis mindszentyae* was described based on limb bones (Ősi *et al*. 2012).

In addition to birds, seven dinosaurs are known from Iharkút. Predatory forms are represented by small to medium-sized dinosaurs, the most common fossils of which are flattened, serrated, backward-curving teeth. The top predator of terrestrial environments was a tetanuran whose body length reached 3–4 m. Herbivorous dinosaurs are represented by a small-bodied ornithopod (*Mochlodon vorosi;* Fig. 2E), small to medium-sized ankylosaurian dinosaurs (Fig. 2J), and the small-bodied ceratopsian *Ajkaceratops kozmai* (Fig. 2G). Among armored dinosaurs, we can distinguish two forms, the larger and more common *Hungarosaurus tormai* and the slightly smaller *Struthiosaurus* sp. In the case of *Hungarosaurus tormai*, in addition to skeletons, hundreds of isolated teeth and bones are also known, being the best-known Late Cretaceous ankylosaurian in Europe (Csiki-Sava *et al.* 2015).

The significance of the Iharkút finds is that they are from a time in the Cretaceous when little was known regarding continental vertebrate faunas in Europe (Csiki-Sava *et al.* 2015). In addition, this exceptional site, like other European sites (e.g., Hațeg Island, Romania, see Grigorescu and Csiki-Sava in this volume), preserves the memory of a former island fauna characterized by dwarf and relict forms or specially adapted species due to their long-lasting isolation (Ősi *et al.* 2012).

Mapping the Past

Maps are an integral part of the history of the Iharkút locality. Geological mapping of the area started during Austro-Hungarian times (e.g., Taeger 1915). The bauxite was surveyed in the early 1950s by Hungarian and Soviet scientists, but systematic geological mapping of the area started in the 1960s by the geologists of the Geological Institute of Hungary, who surveyed the area at 1:10 000 scale and compiled published versions in 20 k with explanatory booklets (Bárdossy & Mindszenty 2013; Albert 2019). Although these maps

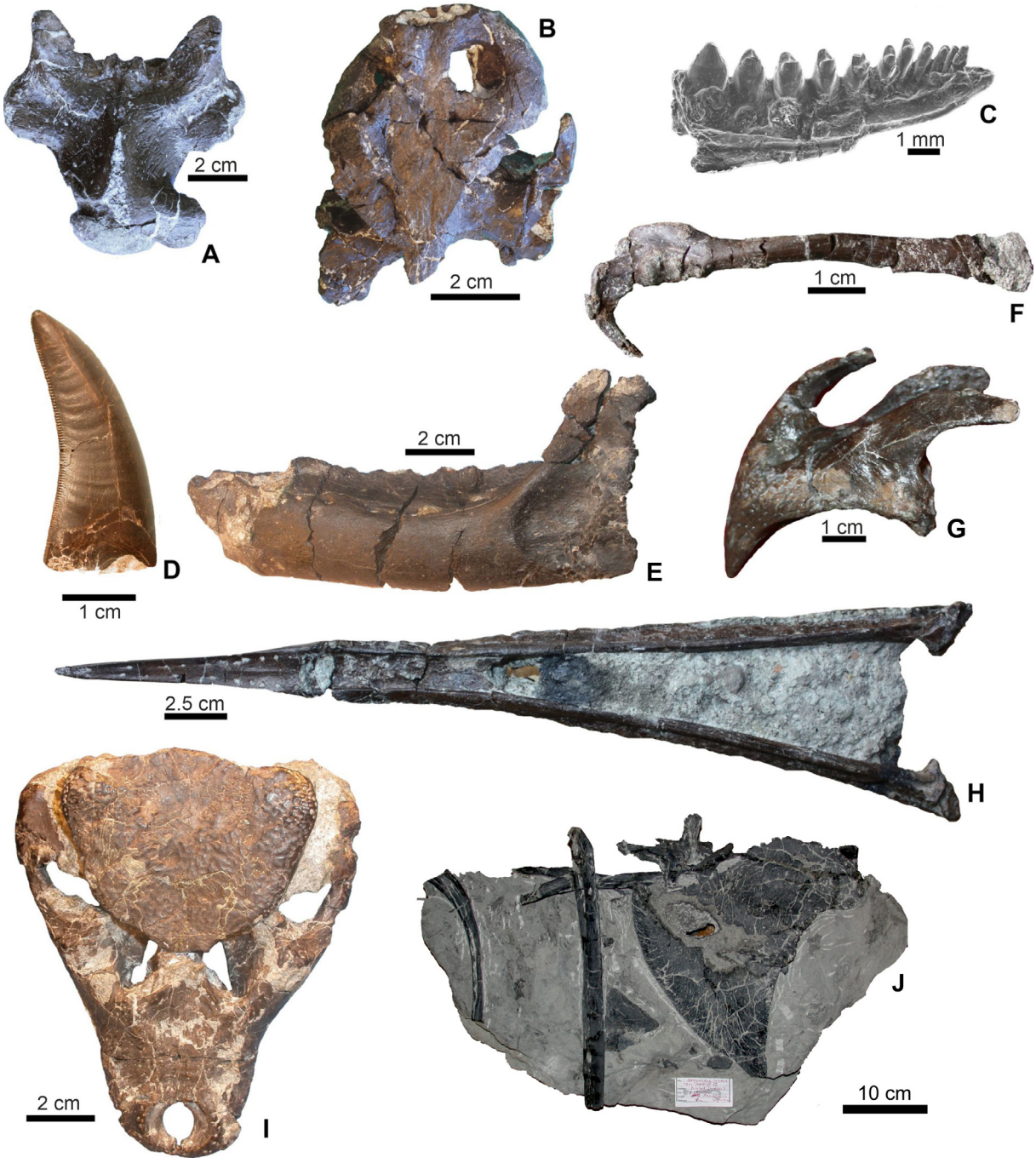

Figure 2. Representative specimens of the Santonian Iharkút fauna, Bakony Mountains, western Hungary. A) *Pannoniasaurus inexpectatus* dorsal vertebra in dorsal view. B) *Foxemys trabanti* skull in dorsal view. C) *Bicuspidon* aff. *hatzegiensis* left dentary in medial view. D) Basal tetanuran theropod tooth in ?lingual view. E) *Mochlodon vorosi*, left dentary in lateral view. F) *Pneumatoraptor fodori* left scapulocoracoid in lateral view. G) *Ajkaceratops kozmai* fused rostral and premaxillae in lateral view. H) *Bakonydraco galaczi* mandible in dorsal view. I) *Iharkutosuchus makadii* skull in dorsal view. J) *Hungarosaurus tormai* partial skeleton.

mention the Upper Cretaceous terrestrial formations, the emphasis was rather on the bauxite and other industrial raw materials. Geological maps were created for scientists and mining experts at that time, and non-expert people were not aware of the local geodiversity for a long time.

When the paleontological excavations started in 2000, the concepts of geoheritage and geoconservation were already at tracting wider attention. Parallel with the increasing number of finds, the Iharkút locality was registered as a key element of geodiversity of the Bakony-Balaton region. Paleontological excavations, however, are destructive: the fossil-bearing formations are systematically processed and removed. The only possibility of conservation is accurate documentation both in analogue (= specimens) and digital ways. From 2013, high precision geodesic instruments were used in the Iharkút excavations mainly at site SZ-6 to record the original spatial positions of the findings (Albert *et al.* 2018). The data records and maps preserve the information of what was destroyed by the excavation and provide invaluable information to analyze spatial patterns of the fossils.

The Iharkút vertebrate database has been maintained since 2013, and 800–1100 new records are added each year (except for specimens found by screen-washing). Currently it contains 6714 records of which teeth represent the most numerous category with more than 1100. The base and top surface of the bone-bearing bed were also regularly measured before further excavation. Based on precisely measured coordinates, a 3D model of the bone-bearing bed was prepared and used to draw paleoenvironmental and taphonomic conclusions (Ősi *et al.* 2019, Botfalvai *et al.* 2021). The 2D map of site SZ-6 can give clues about the spatial distribution of the fossils for future excavations (Fig. 3) but is also an appropriate tool for demonstration when communicating with non-professionals.

The Hungarian Dinosaur Foundation and its

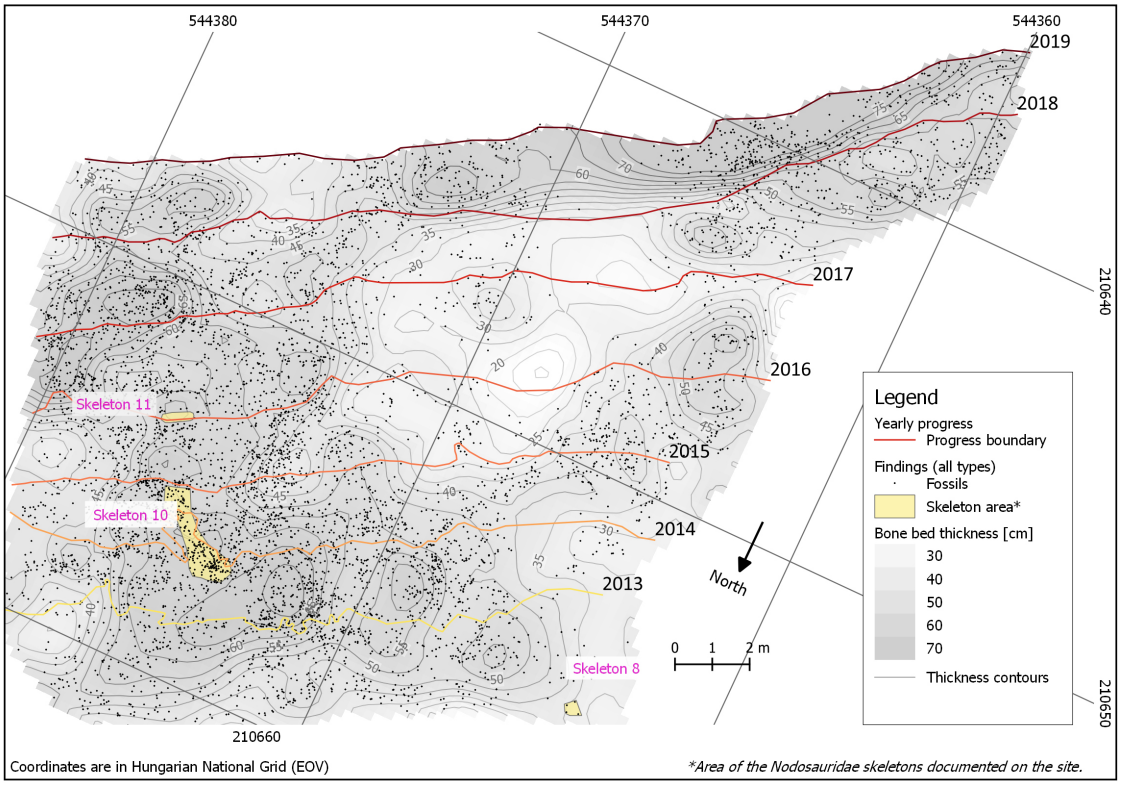

Figure 3. Detailed map of the site Sz-6 at the Iharkút locality showing the yearly progress of the excavation since the beginning of high-precision surveying. Three Nodosauridae skeletons were also found during this period, which are also shown on the map.

Role in Scientific Work, Science Popularization and Maintenance of the Iharkút locality

In 2010, a few years after bauxite mining ended at Iharkút and recultivation was finished, the pits containing the localities and surrounding previously mined lands were offered for sale by the Bakony Bauxite Mining Company. The Hungarian Dinosaur Foundation was established in 2014 mostly to acquire the area, to ensure that the bone-bearing horizons would be available for the further excavations and scientific investigations. Thanks to an extensive fundraising campaign, the total necessary amount was collected from donations. Thus, the Hungarian Dinosaur Foundation acquired 97.4% ownership of a 17-ha area that contains the most important sites, the Iharkút vertebrate locality, generally speaking, while the remaining 2.6% is divided equally between the neighboring villages of Bakonyjákó and Németbánya.

After this period, while annual excavations and scientific work continued (Fig. 4A), the presentation of the area to the public could also begin. Although there are no infrastructures, buildings or showrooms in the area yet, every year there are open days during the three-week excavation. On these days, hundreds of visitors can visit the site (under controlled circumstances) and learn about current and past paleontological work at the Iharkút vertebrate locality (Fig. 4B–D). In addition to visiting the excavation, visitors can choose from multiple other activities in nearby Németbánya and Bakonyjákó, organized by various organizations of natural sciences (e.g. the Bakony-Balaton UNESCO Global Geopark itself, Bird Life Hungary, Pannon Observatory), local governments, associations and enterprises. These include geotours, scientific presentations, interactive exhibitions, programs and fairs related to local ethnography or local products, as well as activities for small children. Sanitation, food and beverages and parking are available in the

Figure 4. Snapshots of activities at Iharkút. A) Excavation. B–D) Visitors at Iharkút during open days.

villages. Visitors are transported to the excavation site on a trackless "dotto" train, greatly enhancing the experience.

Apart from these open days, the site is only open to the public as part of a guided geotour allowing a sight only from a safe distance. Warning signs are placed all around the pits to prohibit visitors from unsupervised entry until infrastructure is improved in the future with marked educational trails with explanatory signs, information boards, safety rails, benches, bins etc.

Conclusion

The Late Cretaceous Iharkút vertebrate locality is one of the most important dinosaur sites in Europe, from which thousands of vertebrate fossils have been collected in the last 20 years. These include the remains of at least 40 taxa including fishes, amphibians, turtles, lizards, a freshwater mosasaur, pterosaurs, crocodilians, and dinosaurs including birds. These are complemented by diverse records of invertebrates and plants. The Iharkút vertebrates lived in a fluvial paleoenvironment characterized by shallow channels and extended wetland, where the climate was dominantly humid but seasonal. In accordance with the paleoenvironmental interpretation, the known vertebrate material is dominated by bones of aquatic and semi-aquatic animals, while terrestrial animals are less frequent. The terrestrial fauna is dominated by herbivorous dinosaurs such as ankylosaurs, ornithopods and ceratopsians, with ankylosaurs the most abundant. Carnivorous non-avian dinosaurs are represented by three taxa, but they are less common than the herbivores. The area may once have been an island surrounded by sea, so most of the identified taxa belongs to species new to science. Furthermore, there are unusual forms whose way of life differs significantly from that of related species known from elsewhere. For instance, the small-sized *Iharkutosuchus makadii* was an herbivorous-omnivorous crocodile with multicusped teeth to crush and chew the food, and the mosasauroid *Pannoniasaurus inexpectatus* was the first of its kind known from freshwater.

The rich paleo-fauna and flora of the Iharkút locality are invaluable additions to the region's geodiversity. Iharkút represents values both for the scientific and non-scientific community. For now, it is assured that the excavation area will be available for future research and the public, as well, because the area exposing the bone-bearing horizons is owned by the Hungarian Dinosaur Foundation and nearby villages. The foundation is led by researchers and scientists who are committed to scientific work on the Iharkút dinosaur locality. Besides the scientific work, science popularization is a priority of the foundation, manifested in educational books, presentations, and open days during the excavation period (more information is available on the website of Hungarian Dinosaur Foundation; https://magyardinoszaurusz.hu/?lang=en).

Acknowledgments

We thank the 2000–2019 field crews for their assistance in the fieldwork and preparation of fossils. We are especially grateful to Rita Németh for her logistic help during the excavations and open days. We are grateful to the Bakony Bauxite Mining Company Ltd. and to Geovol Ltd. for assistance. Excavations, research and the purchase and maintenance of the locality have been supported by numerous persons and organizations who cannot be listed here. Field and laboratory work were supported by the Hungarian Natural History Museum, the Eötvös Loránd University, the Mining and Geological Survey of Hungary, The National Geographic Society (Grant nos. 7228-02, 7508-03), National Research, Development and Innovation Office (Grant no. OTKA T-38045, PD 73021, NF 84193, K 116665, K 131597, PD 131557), the János Bolyai Research Scholarship (BO/00024/19/10), and the Lendület Program of the Hungarian Academy of Sciences (Grant no. 95102), the ÚNKP-20-5 New National Excellence Program of the Ministry for Innovation and Technology from the source of the National Research (ÚNKP-20-5-ELTE-129), Development and Inno-

vation Fund, Jurassic Foundation and the Hungarian Dinosaur Foundation. Support was provided from the NRDI Fund of Hungary, financed under the Thematic Excellence Programme TKP2020-NKA-06 (National Challenges Subprogramme) funding scheme.

Conflict of Interest

The authors declare that they have no competing interest.

References

Albert G (2019). The changing use-cases of medium and large-scale geological maps in Hungary. Proceedings of the International Cartographic Association. 2(4):1–8.

Albert G, Botfalvai G & Ősi A (2018). Mapping the past: GIS and intrasite spatial analyses of fossil deposits in paleontological sites and their applications in taxonomy, taphonomy and paleoecology. Palaeontologia Electronica. 21(3):1–22.

Bárdossy Gy & Mindszenty A (2013). The Iharkút bauxite - Az Iharkúti bauxit-előfordulás. Budapest: Geological and Geophysical Institute of Hungary.

Botfalvai G, Ősi A & Mindszenty A (2015). Taphonomical and palaeoecological investigation of the Late Cretaceous (Santonian) Iharkút vertebrate assemblage (northwestern Hungary; Bakony Mts.). Palaeogeography, Palaeoclimatology, Palaeoecology. 417:379–405.

Botfalvai G, Haas J, Bodor ER, Mindszenty A & Ősi A (2016). Facies architecture and palaeoenvironment implications of the Upper Cretaceous (Santonian) Csehbánya Formation at the Iharkút vertebrete locality (Bakony Mts, Northwestern Hungary. Palaeogeography, Palaeoclimatology, Palaeoecology. 441:659–678.

Botfalvai G, Prondvai E & Ősi A (2021). Living alone or moving in herds? A holistic approach highlights complexity in the social lifestyle of Cretaceous ankylosaurs. Cretaceous Research. 118:104633.

Csiki-Sava Z, Buffetaut E. Ősi A, Pereda-Suberbiola X & Brusatte SL (2015). Island life in the Cretaceous - faunal composition, biogeography, evolution, and extinction of land-living vertebrates on the Late Cretaceous European archipelago. Zookeys. 469:1–161.

Haas J (1983). Senonian cycle in the Transdanubian central range. Acta Geologica Hungarica. 26:21–40.

Jocha-Edelényi E (1988). History of evolution of the Upper Cretaceous Basin in the Bakony Mts at the time of the terrestrial Csehbánya Formation. Acta Geologica Hungarica. 31: 19–31.

Károly F, Legeza M & Stubán Z (2006). Remediation of the Iharkút-Németbánya open pits. Bányászati és Kohászati Lapok. 139(6):31-40.

Legeza M (2007). Bauxite mining in the Iharkút area 1975-2007. Bányászati és Kohászati Lapok. 140(6):23–28

Makádi L, Caldwell MW & Ősi A (2012). The first freshwater mosasauroid (Upper Cretaceous, Hungary) and a new clade of basal mosasauroids. PLOS ONE. 7(12):e51781.

Mindszenty A (1985). The lithology of some Hungarian bauxites - a contribution to the palaeogeographic reconstruction. Acta Geologica Hungarica. 27:441–455.

Ősi A, Makádi L, Rabi M, Szentesi Z, Botfalvai G & Gulyás P (2012). The Late Cretaceous continental vertebrate fauna from Iharkút, western Hungary: a review. In Bernissart Dinosaurs and Early Cretaceous Terrestrial Ecosystems (Ed. Godefroit P, pp. 533–568). Bloomington: Indiana University Press.

Ősi A, Botfalvai G, Albert G & Hajdu Z (2019). The dirty dozen: taxonomical and taphonomical overview of a unique ankylosaurian (Dinosauria: Ornithischia) assemblage from the Santonian Iharkút locality, Hungary. Palaeobiodiversity and Palaeoenvironments. 99:195–240.

Rabi M, Tong H & Botfalvai G (2011). A new species of the side-necked turtle *Foxemys* (Pelomedusoides: Bothremydidae) from the Late Cretaceous

of Hungary and the historical biogeography of the Bothremydini. Geological Magazine. 149:662–674.

Taeger H (1915). Ujabb megfigyelések a tulajdonképeni Bakony nyugati végéről és középső részéből. (Jelentés az 1914. évi részletes felvételről.) A Magyar Királyi Földtani Intézet évi jelentése 1914-ről. 1915:339–355.

Tardy J (2021). Geoparkok Magyarországon. Budapest: Hungarian Society of Natural Sciences.