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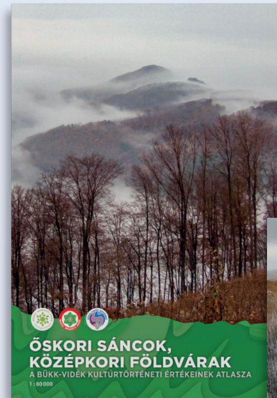


LEGEND

BÜKKI NEMZETI PARK
BÜKK-VIDÉK GEOPARK

50 GEOSITES

IN THE BÜKK REGION UNESCO GLOBAL GEOPARK

Legend

45. Lake Baktai — **Geosite presented in the booklet**

Zsidó Meadow — **Other sight**

Hiking trail section(by foot)

Trail section (by car)

24 — **Secondary road**

Gravel or compacted dirt road

Paved road

Forest road

Other paved or drivable road

Track

Normal-gauge railway

Narrow-gauge railway

Bélapátfalva — **Town**

Mályinka — **Village**

ÓMASSA — **Part of settlement**

Forest

Meadow, arable land

Orchard, vineyard

Built-in area

Bushy area

Quarry

The contour interval for the maps in this volume is 10 meters (sheets 1, 2, and 6) and 20 meters (sheets 3, 5, and 7).
Since the maps are not drawn to the same scale, the size of the symbols may vary from sheet to sheet.
A 1-km grid on sheets 1, 2, 3, 5, 6, and 7, and a 5-km grid on sheet 4, assist in travel and hiking planning.

Hike 1

Hike 2

Hike 3

Hike 4

Hike 5

Hike 6

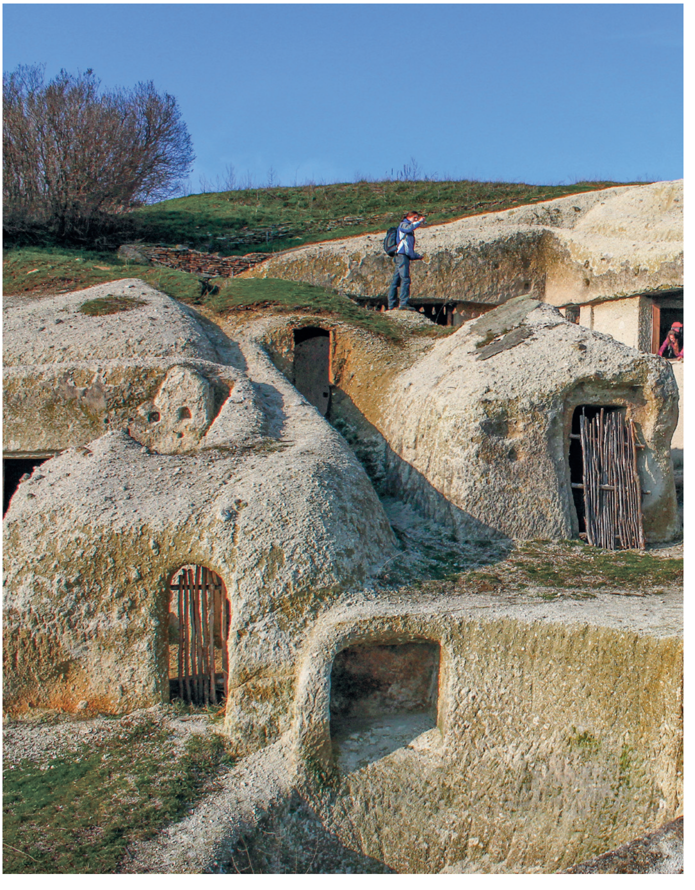
Hike 7

Hike 8

Hike 9

Bükk50

50 GEOSITES
IN THE BÜKK REGION UNESCO GLOBAL GEOPARK



BÜKK NATIONAL PARK DIRECTORATE,
EGER, 2026

CONTENT

Where is the Bükk Region UNESCO Global Geopark?

Located in the northeastern part of Hungary in the North Middle Mountains, the Bükk Region covers one of our county's most complex and intricate geological environments. Its geodiversity is unique in the Carpathian Basin. The most important geological heritage of the Bükk Region Geopark is the almost continuous The most important geological value is the diverse landforms of the Bükk Mountains, which form the central unit of the geopark, and the Uppony Mountains to the northeast, both shaped by tectonic processes and karstification.

The Bükk Region UNESCO Global Geopark covers an area of 2817 km2. It includes 109 settlements, the Bükk National Park, two landscape protection areas and six nature conservation areas.

What does the Bükk Region UNESCO Global Geopark present?

The geopark is based on the geological values and on the area's living natural, landscape, cultural and cultural-historical heritage. This geoheritage includes, for example, geological outcrops, geological key sections, different geomorphic variations, rock towers, beehive stones, gorge valleys, various karst forms and caves. From a prehistoric and cultural-historical perspective, the prehistoric human caves are of particular importance. These are accompanied by the mining and industrial heritage of the area record the human land use and landscape shaping activities. In addition to the natural and landscape environment, the geopark also provides an opportunity to learn about the region's cultural and historical values and traditions.

The unique geological values of the Bükk Region Geopark are the karst landscape of the Bükk Plateau, the Anna Cave, the Bükkalja Stone Culture and the beehive rocks, the prehistoric human caves – especially the Szeleta Cave, Balla Cave, Istállós-kő Cave and Suba-lyuk – are among the most significant sites, along with the Várhegy Gorge and Tóbérc Quarry at Szarvaskő, the Bálvány-North geological reference section near Bánkút, and the fossil forest discovered in the Bükkábrány Lignite Mine.

Visit our visitor sites!

Szeleta Park Visitor Centre, Miskolc
Bükk Star Observatory, Répáshuta
Anna Cave and St Stephen's Cave, Lillafüred
Millennium Lookout Tower, Szilvásvárad
Western Gate Visitor Centre, Felsőtárkány

www.bukkvidekgeopark.com

1. Looking for the most ancient rocks of the Geopark

Csernely Valley, abandoned quarry; Nekézseny

Oldest rocks of Bükk Region UNESCO Global Geopark visible on the surface can be found on the southern edge of Upponyi-hegység (Upponyi Hills), in the periphery of the villages of Dédestapolcsány and Nekézseny.

Starting from the northern periphery of Nekézseny, a small, abandoned quarry, previously utilised by local communities, is exposed on the western side of Csernely Valley, near the entrance of Bótai (Bóti) Valley. Rock walls reveal metasandstones formed at the end of the Ordovician period of the Palaeozoic era, about 450 million years ago. According to currently accepted stratigraphic classification, experts assign the rocks to be found here to the Csernelyvölgy Metasandstone Member of the Tapolcsány Formation. Let's pick up a piece of rock and observe it carefully.

Fine- and medium-grained clastics of the light grey to grey metasandstone are composed predominantly of quartz grains and various rock fragments, cemented together by a siliceous matrix. A geologists describe the rock as massive and thick-bedded, lacking distinct bedding and sedimentary structures. These textural characteristics suggest that the original sandy sediment was transported over only a short distance and deposited rapidly under calm intertidal marine conditions. This rock does not contain fossils.

Hard siliceous sandstone is called metasandstone because it underwent a low degree of metamorphism, that is, rock transformation in the depths of the Earth's crust characterised by higher pressure and temperature during the Cretaceous (about 120 to 110 million years ago). As a result, its grains were weakly recrystallised, and initial cleavage and oriented grain-size distribution developed in its structure/texture.

Let us note here that geological formations up to the Miocene are not in their original geographical locations nowadays. The reason is that tectonic plate fragments carrying the present Uppony Mountains and the Bükk region were located hundreds and even thousands of kilometres away from their present-day positions during the periods of geological history in question. Complex tectonic movements brought them to their current locations. Thus, the sandy base material of the oldest rock of the Geopark settled somewhere in the equatorial region.

Walking into Bótai Valley, oriented towards north from the quarry, we can also encounter black siliceous shales of the Tapolcsány Formation, deposited in a deeper and oxygen-free marine basin during the Silurian, in addition to the metasandstone.

2. Imprints of submarine volcanism from the Devonian

Harka Peak/Strázsa Hill, geological key section; Nekézseny

Oriented from northeast to southwest, the double peaks of Harka Peak and Strázsa Hill rise on the northern periphery of Nekézseny that we already mentioned in the previous section. This arranged geosite, with its Geopark information boards, provides insight into a special stage in the geological history of Uppony Mountains.

At the border of the early and middle stages of the Devonian (approximately 400 to 390 million years ago), the tectonic plate supporting the present-day Nekézseny region was in a paleogeographic environment where magmatic and sedimentary formations were deposited on the seabed in parallel. Basic, i.e., low silica-dioxide basaltic magma was rose up from the depths onto the seabed that opened up along the cracks, that is, it was rifting in technical terms. This basaltic melt mixed with loose marine lime mud of high-water content deposited at the beginning of the Devonian. The result of the process was a hybrid rock called "Schalstein" using a German term, exposed in two levels in the disused quarry of the western ridge of Strázsa Hill called Harka Peak. Schalstein contains basically angular limestone, clay shale as well as volcanic clasts and xenoliths, up to the size of a fist, embedded in greenish-grey metabasalt.

Walking on top of the hill above the quarry, formations of the so-called olistostrome level crop up for our study. Here, rounded limestone blocks ranging from the size of a fist to dozens of metres are embedded in strongly weathered greenish-grey to greenish-brown metabasalt and calcareous metabasalt tuff. After examining the material of the limestone olistostolites, geologists distinguished two main rock types rich in fossils, one being a dense-textured purple-red or greenish-red pelagic limestone from the Silurian and the other a light grey crinoid limestone from the earliest Devonian, the latter being the more common. The oldest macrofossil of the Carpathian Basin, that is, remains of an orthoconic Nautilus (Kopaninoceras sp.), was found in the Silurian limestone. Dozens of millions of years older than the embedding metabasalt, limestone blocks of varying sizes slid from higher levels of the former marine sedimentary basin into the basalt lava that spilled onto the seabed for reasons of gravitation.

Finally, remember that the so-called Strázsahegy Formation also underwent a low degree of metamorphism in the Cretaceous, as illustrated by the term metabasalt.

3. Flashback to Uppony Gorge 400 million years ago

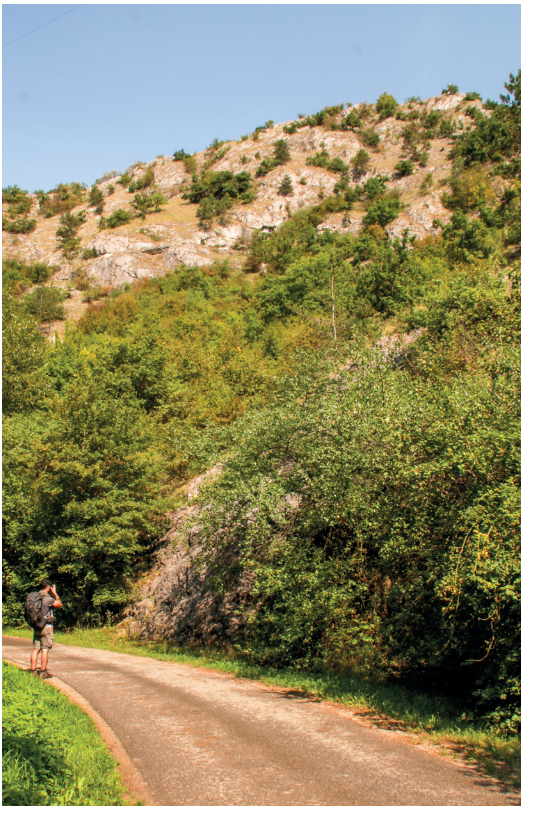
Kalica Peak, the Cross of Father Herkó; Uppony

In the eastern periphery of the picturesque village Uppony, Kalica Peak rises to 402 m. On its rocky ridge descending to the southwest, let's choose a marked tourist trail right to the Cross of Father Herkó, offering a fabulous panorama. Looking down at the cross, we can notice light grey rocks under our feet, while a monumental canyon called Uppony Gorge unfold below us.

To be able to understand the formation of the landscape stretching all around, let's begin our investigations with the earliest event, the formation of the rocks supporting the gorge. At the border of the Middle and Late Devonian (about 385 to 375 million years ago), a shelf (or a carbonate platform, using the technical term) covered by tropical shallow sea was built on the tectonic plate carrying Uppony Mountains, and, as we have already mentioned it, the latter was not in its present geographical location at that time. The seashore was full of reef-lined lagoons. Lime mud deposited in the lagoons turned into a carbonate sequence called Uppony Limestone Formation, predominantly composed of highly pure, massive or bedded light grey limestone, free from fossils. Just like the rock formations presented so far, this Devonian limestone also underwent a low degree of metamorphism in the Cretaceous, and it is evidenced by the recrystallization of the rock-forming calcite.

The predecessor of Csernely Creek cut into this hard Devonian limestone, thus creating Hungary's largest, though not really known gorge, called Uppony Gorge. The spectacular limestone gorge together with its caves is relatively young compared to the other rocks going back to hundreds of millions of years, since it was formed in the last few million years only. The region of Uppony Mountains has risen several hundred metres since the beginning of the Pleistocene (the Ice Age). The predecessor of the watercourse, that used to have a much higher flow rate than the present one, entrenched its valley into Palaeozoic metamorphic rocks in parallel to this process.

From the Cross of Father Herkó, we can enjoy a wonderful view of the Uppony region, the gorge, Lázbérci Reservoir, and farther, the Bükk Mountains. According to popular tradition, the Cross, originally erected at the very beginning of the 19th century, separated the regions inhabited by Catholics and Calvinists.



4. Palaeozoic rocks in the walls of a medieval castle

Dedevár, castle ruins and geological key section; Uppony

In the periphery of Uppony, at the western end of Lázbérci Reservoir, we can find the remains of one of the few medieval fortresses of Uppony Mountains, that is, Dedevár (Dede Castle).

We have no documented information about the castle, nor are its former builders and owners known. Most likely it was built during the times of the Árpád dynasty. The castle hill, currently looking like a peninsula in the reservoir, is actually a low western extension of Fekete-kő Peak. With its triangular ground plan, this small castle stood at the end of this ridge. The castle was protected by a rock ditch from the more gentle-sloping eastern side only, while steep slopes provided natural protection in the rest of the area. Nowadays, only the heavily damaged remains of the former tower, built of Devonian and Carboniferous limestones of the area, can be spotted.

The region of Fekete-kő Peak is within the Abod Formation belt of the late Devonian (ca. 385 to 360 million years old), deposited in a marine basin deeper than the Uppony Limestone Formation presented at Kalica Peak. A characteristic sericite-chlorite network can be observed in the texture of the greenish-grey or bluish-grey or weathered yellowish-brown limestone. This network is the alteration product of volcanic basalt tuff that fell into the former marine sedimentary basin. The outcrops of the Abod Formation can be observed along the dirt road leading to Dedevár, along the former highroad on the other side of the reservoir, and at the eastern exit of the Uppony Gorge in a narrow tectonic belt.

However, sides of Dedevár Hill also contain outcrops of a Carboniferous limestone, and this is where the name of the Dedevár Limestone Formation comes from. Bluish-grey, but often with characteristic purple tones, this layered or thin-bedded, dense-textured crystalline limestone was also deposited in a deeper sea basin. Based on the conodonts found within, it was formed in the first half of the Carboniferous (about 360 to 340 million years ago). Similar to other formations of Uppony Mountains, this Carboniferous limestone also underwent a low degree of metamorphism and deformation in the Cretaceous, evidenced by the folded layers of the geological key section southwest of Dedevár, on the shore of the reservoir.

Sedimentation, which began at the end of the Ordovician (about 450 million years ago), can be traced within the Uppony Mountains, one of a complex geological structure, until the Middle Carboniferous, about 320 million years ago. Limestones and clay shales of the Carboniferous Lázbérc Formation can be observed, among others, near the eastern exit of the Uppony Gorge, in the cut of the old highroad. The Carboniferous and the entire Palaeozoic sequence is capped by the Éleskő Formation in Uppony.

5. Studying the most ancient rocks of the Bükk mountain

Mártus Cliff, the valley of Baróc Creek; Mályinka

Now that we have just got acquainted with the geological values of the Uppony Mountains, let's focus on the Bükk region proper. Northern areas of the Bükk are mainly formed by clay shales and aleurolite shales from the Palaeozoic, into which limestone blocks of varying sizes were deposited.

In the Late Carboniferous (approximately 320 to 315 million years ago), the tectonic plate carrying the present-day Bükk region was located somewhere in the southern hemisphere, on the southwestern coast of the ocean called Paleotethys, on the northern edge of the African plate. In the deeper sea basin, predominantly argillic, silty and sandy sediments were deposited, the formation of which was from time to time interrupted by the deposition of lime mud in the depressions of the seabed. The sedimentary layer deposited over millions of years lithified (diagenised) later. Then, in the Cretaceous, it underwent a low degree of metamorphism and plastic deformation (folding) as mentioned in the Uppony Mountains section. The rock called Zobóhegyese Formation by geologists can be studied on the surface today in a steep, 600 m wide range. Spectacular outcrops of the oldest rocks of the Bükk are present, among others, along Baróc Creek, in and around Mártus Cliff (Mártuskő Limestone Member).

The main mass of the Carboniferous formation is made up of black or weathered grey-green or yellow, argillic and fine sandy aleurolite, in which grey or weathered brown sandstone beds alternate. It is this folded and foliated sequence, less resistant to erosion, that the hard limestone ridge of Mártus Cliff oriented northeast to southwest was weathered out from, to be followed from the bend of the highroad between Mályinka and Bánkút all the way to the valley bottom. Its material is grey to dark grey, fine-grained, strongly compressed, recrystallized limestone poor in fossils (few crinoid fragments), containing clay and sand to a varying degree. The exposure in the cut of the highroad is particularly spectacular, with shale deposited between limestone layers "bent" towards east.

Here we should note that the rocks of Pirító-kő (Pirító Rock), Kisvár (Small Castle) and Dédesvár (Dédes Castle) towering above the Baróc Creek area are likewise composed of resistant limestone blocks exhumed from the surrounding Carboniferous shale sequence by differential erosion. As regards Pirító Rock and Kisvár, these are also Carboniferous limestone blocks (Mályinka Formation, Kapubérc Limestone Member), while Dédesvár consists of Late Permian (Nagyvisnyó Limestone Formation) and Early Triassic (Gerennavár Limestone Formation) limestone.

6. Secrets of centuries-old shale quarries in Nagyvisnyó

Bán Valley, disused shale quarry; Nagyvisnyó

After the deposition of the Zobóhegyese Formation, marine sedimentation did not stop in the later stages of the late Carboniferous but continued in an even deeper marine basin. However, only fine-grained clastic sediments were deposited in this marine sedimentary basin, without lime mud formation. And now we are in the period of the formation of roofing slates in the Bükk.

The Szilvásvárad Formation, which is slightly younger (ca. 315 to 310 million years old) than the formation presented previously, is predominantly composed of dark grey, black or weathered greenish grey and greenish brown, strongly foliated and folded aleurolite. The dark colour of the Carboniferous slates comes from finely dispersed organic matter, indicating the oxygen-poor conditions of the bottom of the former sedimentary basin. In some sections of the formation, bedding is graded, that is, the grain size within a layer decrease from bottom to top. This type of bedding occurs when sediment masses pour down as mudflows from a higher seafloor, from the direction of the land into a deeper level, and first the larger grains, then the smaller grains are deposited from the mixed mud over time. This formation does not contain fossils.

The thick, fine-grained deep-sea sedimentary sequence was deposited in the Cretaceous (about 130 to 120 million years ago) at a depth of 6 to 9 kilometres in the Earth's crust, characterised by higher temperatures (about 250 to 300 °C) and pressures (about 2 to 3 kbar), undergoing a low degree of metamorphism. Directed pressure resulted in the folded and foliated structure of this formation that can be clearly observed in the field. Due to its foliated structure, slates had been quarried in the area of Nagyvisnyó for a long time, with the main quarries to be found in Bán Valley.

Open-pit quarrying of the so-called "Visnyó slates" began at the end of the 18th century and ceased around 1910 in the Bán Valley region. Over the course of more than a century, local high-quality slates reached all parts of the country and were used in large amounts in the cities of Pest, Eger and Miskolc. For quarrying, hand tools, such as crowbars, hammers, wedges were used. Slate was shaped in the quarries. Apart from slate boards used for writing, their most typical use was roofing (shingles). Ceramic tiles replaced the popular Bükk slates gradually by the beginning of the 20th century only.

In the disused slate quarry of Bán Valley, a Geopark information board presents the history of Bükk slate quarrying. In the Geopark, a Jurassic rock (Lökvölgy Formation) was also used for roofing. This is presented at Zsindelybánya-lápa (Slate Quarry Bog) in Felsőtárkány.

7. Kapu-bérc, a keeper of the shale ground surface

Kapu-bérc, a limestone block embedded into clay shale; Mályinka

Following the deposition of Szilvásvárad Formation, sedimentation continued on the tectonic plate carrying today's Bükk in a shallow marine environment. Here, alongside clastic sediments of various grain sizes, limestone formation returned, albeit only for a short time. Another formation from the late Carboniferous called the Mályinka Formation (ca. 310 to 305 million years old) is spread over a large area in the northern part of the Bükk, presenting a number of geological values, including in the area of Kapu-bérc (Kapu Ridge).

The main mass of the Mályinka Formation consists of alternating dark grey to black claystone, aleurolite and fine sandstone layers and blocks, with a varying carbonate content. A specialty of the formation is that three limestone blocks, 10 to 50 m thick each, extremely rich in shallow marine fossils, were deposited within it, to be followed for several kilometres and arranged in sequences of a foliated structure in the northern part of the Bükk. Ravages of time were not able to erode the limestone blocks embedded in clay shales, that are less resistant to erosion, and that's why they guard the top regions of the same height of the shale ground surfaces of lower topographic positions as protruding rock towers.

The two lower limestone ranges deposited in the Mályinka Formation are assigned to the Kapubérc Limestone Member. Carbonate rocks of Kapu-bérc (722 m high) belong to the lowermost bedded limestone range of a deeper stratigraphic position, rich in various shallow marine fossils. Among these, the most notable are calcareous algae, fusulinids, corals, shells, snails, trilobites, brachiopods and conodonts. Fossils embedded in the limestone suggest a well-lit and ventilated warm shallow sea of a normal salt content at the end of the Carboniferous on the tectonic plate carrying the Bükk. Apart from being the key section and namesake of this formation, Kapu-bérc also offers a fantastic vista. From here, limestone cones of the previously mentioned Kisvár and Dédesvár can be admired in their fullest splendour.

Those who are looking for a more thorough study of limestone blocks deposited in the Mályinka Formation should walk about 200 metres up the highroad from the Kapu-bérc junction towards Bánkút. In the "rock gate" of the road cut, outcrops of the youngest, dark grey Csikorgó Limestone Member, deposited in clay shale but in slightly deeper seawater, rich in fossils (e.g. fusulinids, crinoids), can be studied. Such outcrops stay with us along the tourist trail marked with the red line, along the paths of Csikorgó also marked on the maps.

8. Vistas of the Bükk from Látó Cliffs

Látó Cliffs and Mária Spring; Málylinka

The deposition of the Málylinka Formation put an end to sedimentation in the Bükk at the end of the Carboniferous. This pause lasted for about 30 to 35 million years, until the Middle Permian. The reason was the elevation and erosion due to mountain formation on ancient continents.

The area of the tectonic plate carrying today's Bükk was flooded by sea about 270 million years ago again. The interruption of continuous Carboniferous sedimentation is reflected in the fact that the Middle Permian Szentlélek Formation deposited on the Málylinka Formation with angular unconformity. The latter formation consists of a sequence of sandstone, aleurolite, claystone, dolomite and gypsum-anhydrite of various colours, deposited on a flat seashore of a dry climate, with a desert background, dominated by tides. The formation, which is easily eroded on the surface, has not developed any spectacular geological values. Its exposures and outcrops are to be found in road cuts around Szentlélek and Garadna Valley.

Famous for its medieval Pauline monastery ruins, and also one of the cradles of Bükk tourism, Szentlélek boasts huge stone colossuses in its northern periphery. Látó Cliffs are assigned to the Kapubérc Limestone Member of the Málylinka Formation presented in the previous section. Carboniferous limestone blocks, which are harder and more resistant than their surroundings, were weathered out by erosion from the mass of clay shales and aleurolite shales more prone to erosion. These shales border the rock towers from the north. Protruding from the northwestern edge of the Kis Plateau), Látó Cliffs, with their more than 20 metres of height and beautiful panorama, are bordered by the sandstone material of Szentléleki Formation (Farkasnyak Sandstone Member) presented above from the south, which, in turn, is bordered by the Garadnavölgy Evaporite Member also from the south. These geological formations are less resistant to erosion processes, too.

It is also worth descending to the nicely constructed Mária Spring in Szalajka Meadow below Látó Cliffs, on the so-called "Route of Metallurgists" marked with a blue line. Originating from the previously presented carbonate lens, the water of the spring, usually of a relatively high yield, flows down towards Csondró Valley. Formerly known as Szalajka Spring, the actual name "Mária Spring", was given commemorating the daughter of a late forester, just like in the case of Ágnes Spring and Szilvia Spring nearby, which is evidenced by the closeness of two foresters' lodges (namely, Kelemen and Lőrinc Lodges).

9. Folded limestone blocks from the Early Triassic in Csondró Valley

Csondró Valley, Odvas Cliff and Bartus Cliff; Mályinka

Permian sequences of the Bükk are topped with the deposition of the Nagyvisnyó Limestone Formation following the Szentlélek Formation. Dark grey and black Late Permian limestone, approximately 260 to 250 million years old, formed in shallow marine waters with interbedded marl and lime marl, is exposed over large areas in the northern regions of the Bükk. Its best-known exposures are the sequence in Mihalovits Quarry in the periphery of Nagyvisnyó, and the railway cuts between Nagyvisnyó and Nekézseny. Boundary key sections presenting the continuous Permian/Triassic marine sequences are also very important for research purposes. Take the Bálvány North section for example.

Most easily accessible from Mályinka, the wildly romantic Csondró Valley area presents rocks deposited at the end of the Permian and the beginning of the Triassic on the surface. The upper section of the valley of Csondró Creek fed by the water of the previously introduced Mária Spring, which is more gently sloped, is a Carboniferous clay shale bedrock surface interspersed with weathered limestone blocks, such as Cakó Cliff. The middle section of this long valley, however, passes through an area built of harder and more resistant Early Triassic limestone. The latter is illustrated by the shape of the valley, as the predecessor of the creek used to carve out gorge-like valley sections interspersed with caves in the region of Odvas Cliff. As a result of the etching process of the creek, the rock mass of Odvas Cliff and Bartus Cliff was "sawed off" from the largest continuous Early Triassic limestone karst ridge in the region, carrying Kemesnye Hill, Közép-bérc (Közép Ridge) and Szilas-Peak.

In this area characterised by a complex structural geology, the main mass of these strongly folded rock formations is the Gerennavár Limestone Formation, which is a well-layered grey carbonate rock formed on a shallow marine ramp. Next to this rock type, the slightly younger Ablakoskővölgy Formation, still Early Triassic, also appears as its subordinate, whose clastic and carbonate sequences were also deposited on parts of a ramp with varying water depths. Their age is ca. 252 to 247 million years.

The Early Triassic carbonate rocks of the Csondró Valley are well karstified, that is, they dissolve in carbonated water. In addition to caves, this is also proven by the fact that Csondró Valley has engulfing riverbed sections where the stream completely disappears underneath when the flow rate is low. Water not only destroys, but also builds in this valley, as indicated by travertine barriers of various sizes. Water of the creek proceeds through smaller and larger waterfalls here.

Last but not least, our Csondró Valley hike ends at the limestone tower of Bartus Cliff, offering a beautiful view. It was weathered by erosion from the more easily destroyed Carboniferous and Permian rocks of its surroundings (the material of the rock otherwise belongs to the Gerennavár Limestone Formation).

10. Walking on the seabed of a Triassic shallow-marine ramp

Savós Valley, a series of geological exposures of a road cut; Miskolc–Újmassa

We have already mentioned in the section about Csondró Valley that sedimentation took place on a shallow marine ramp in the Bükk in the Early Triassic (ca. 252 to 247 million years ago). A ramp is practically a shelf with a very gentle slope, usually less than 1 degree. On this Bükk ramp, the Gerennavár Limestone Formation was followed by the Ablakoskővölgy Formation. Here, in addition to carbonate mud, fine clastic (siliciclastic) sediments in variable quantities flowing in from the former mainland also played a significant role in sedimentation. The sequence consisting of clastic and carbonate sedimentary rocks can be studied in its fullest development for a length of about 200 metres in the cut of the forestry road leading from Garadna Valley to Jávorkút along Savós Valley.

If we want to study this protected geological key section of national importance, which is also equipped with an information board, the best way is to start at the northernmost point of the section, right at the bend in the road. Of the four members of Ablakoskővölgy Formation, the initial outcrop of this section is the Lillafüred Limestone Member while the oldest member, that is, the Ablakoskővölgy Sandstone Member, does not appear in the section. It is exposed in Garadna Valley, in the slope of the road below Lencsés. Studying the rocks of the road cut, a grey and dark grey, lamellar and thin-bedded limestone shows up, several metres high above the road. Here and there, hard and tilted limestone layers are interrupted by long and narrow inlets, which are actually clay deposits more prone to erosion than their surroundings. The sediment falls out of these in the form of small plates.

As we walk further along the road, steep limestone walls tend to disappear and a highly erodible grey and greenish grey sequence of a lamellar structure emerges, composed of clay shale, clay marl and marl shale. Limestone laminae and lentils embedded in the fine-grained sediments are visible to the naked eye here. This sequence is the Savósvölgy Marl Member of the formation. Further on, harder limestones reappear, that is, outcrops of the Újmassa Limestone Member made up of dark grey to black nodular and lamellar fine-crystalline limestone with thin argillic intercalations. The dark colour of the rocks indicates an oxygen deficient environment during sedimentation. The rocky valley slope behind the information board features the top Middle Triassic Hámor Dolomite Formation (this is the next one in the sequence). We present it in more detail in the section on the Nyavalyás Hill quarry.

At the key section in Savós Valley, we can walk along overturned, almost vertical strata deposited over some million years on a Triassic shallow marine ramp. Sediments were formed in varying water depths, below the tidal belt, accompanied by clasts flowing in from the mainland at varying intensities.

11. Studying Middle Triassic shelves on Nyavalyás Hill

Nyavalyás Hill quarry; Miskolc–Újmassa

Sequences in the Bükk Region Geopark can be best studied at places where they were exposed by open-cast quarrying. This is especially true for the Middle Triassic Hámor Dolomite Formation, the largest exposures of which can be found in disused open quarries. Such are the Várhegy quarry next to Felsőtárkány and the Nyavalyás Hill quarry in Újmassa. Let's see the latter in more detail.

After the ramp sedimentation in the Early Triassic already described in the Savós Valley section, less terrigenous material flowed in from the mainland by the beginning of the Middle Triassic (Anisian epoch) and a huge rimmed shelf (carbonate platform) was built on the tectonic plate carrying today's Bükk. The material of the Hámor Dolomite Formation was first deposited on an evenly slowly sinking and protected inner shelf covered by well-lit and ventilated tropical shallow sea no deeper than 200 metres (in lagoons) ca. 247 to 242 million years ago. Let's not forget that dolomite was not precipitated directly from seawater, but first lime mud was deposited just like in the case of limestone formation. The deposited lime mud was dolomitised during its induration later, due to magnesium ions incorporated into the carbonate system, since dolomite is calcium-magnesium carbonate in the mineralogical sense.

The almost complete sequence of the Hámor Dolomite Formation, which is hundreds of metres thick, can be studied in the seven-level open quarry of Nyavalyás Hill. The main mass of the formation is made up of grey and dark grey dolomite, partly unbedded and massive, but often bedded, with fine-grained stratification within the beds. The dolomite rock has a cyclic structure, with tidal and subtidal developments. Among its fossils, the most notable are calcareous algae, foraminifera, snails and corals. Structural movements in the Cretaceous rather tangled this formation, as the layers are turned upside down in the quarry.

Dark grey dolomite, interwoven with calcite veins, had been quarried for many decades for the Diósgyőr steel factory. However, past quarrying not only destroyed the place but it also exposed new caves for science. The top of the system of quarries, now recultivated, can be reached by walking 3 kilometres on the former quarry road with a 200-metre elevation gain. It is definitely worth making the effort, as you shall enjoy a wonderful view of the Garadna Valley and the rock towers of the southern edge of the Kis Plateau.

12. Where does the water of Garadna Spring come from?

Garadna Spring and Garadna Spring Cave; Miskolc–Ómassa

The Hámor Dolomite Formation from the Middle Triassic, as presented in the section on Nyavalyás Hill, is a common geological formation of the northern areas of the Bükk. Carbonate rocks of the formation are moderately karstified, with moderate permeability and good water-retention properties. It follows from the latter that there are several karst springs in the Northern Bükk where water bursts out of the Hámor Dolomite Formation. Such is one of the region's largest cold karst springs, Garadna Spring with an average discharge of 5000 l/min and a spring cave behind.

Studying karst springs, the big question is always where the water flowing through the discharge point comes from. Arising 497 meters high above sea level in the southern periphery of Ómassa, the water of Garadna Spring originates mostly from the Middle and Late Triassic Bükkfennsík Limestone Formation (formerly called Fehérkő Limestone Formation) of the recharge area, interwoven with karstic aquifers, while a smaller part from the Middle Triassic Hámor Dolomite Formation. Rainwater falling on fissured Triassic carbonate rocks is conveyed through these rocks towards Garadna Spring, as confirmed by water tracing tests conducted by karst researchers, for example, with fluorescein in the previous decades. Such measurements support that water absorbed by Bánkúti-visszafolyó, also called Diabáz Cave, the sinkholes around Csipkéskút and Jávorkút, and Bolhási Sinkhole in the Bolhás–Jávorkút Cave System reappears in Garadna Spring.

Behind the spring, the iron door hides the passages of the protected Garadna Spring Cave. The spring actually emerges from the mountain at the end of the artificial adit cut under the former highroad. 22 metres long and 4.5 metres in vertical extent, this active spring cave supplies water from the previously presented Middle Triassic dolomite. Since its passages are narrow and filled with water, the currently active aqueduct opening is virtually unexplorable.

From Garadna Spring Cave, a walk of about one kilometre shall take us to the entrance to Vadász Valley. Walking up the valley, its northern side reveals the transition between the Hámor Dolomite Formation and the Szentistvánhegy Metavolcanic Formation, presented in the next section. Next, we can observe the transition between metavolcanic rocks and the Bükkfennsík Limestone Formation and then a part of the latter formation.

13. Sequences in Lillafüred shaped over millions of years

Szinva Valley, geological exposures of the highroad; Miskolc–Lillafüred

In addition to sedimentary rocks, Triassic sequences of the Bükk include rock blocks created by magmatic processes, too. Such rocks, consisting of lava and volcanic clasts, underwent a low degree of metamorphism in the Cretaceous, were deformed, and penetrated by solutions of various compositions. Due to these post-effects, the original rock texture is difficult or impossible to study. Outcrops of various (rhyolitic, dacitic, andesitic, basaltic) types of metavolcanites are present in the areas of Bükkszentlászló, Bükkszentkereszt and Lillafüred.

In Lillafüred, after the sidewalk next to the highroad reach from Pávai Vajna Ferenc Promenade running along the southern shore of Lake Hámori Lake, and then heading towards Eger, we can notice a giant rock wall. The dark grey rock exposed here is exactly the previously presented Middle Triassic (247 to 242 million years old) Hámor Dolomite Formation with its layers tilted into a vertical position. From here, a few minutes' walk shall take us to the tunnel of the forest railway, where rocks of a completely different appearance compared to dolomite, that is, greenish meta-andesite of a foliated structure, can be spotted next to the bus stop.

After the deposition of the Hámor Dolomite Formation, intense volcanic activity began on the tectonic plate bearing the Bükk, following a short period of uplift and destruction (Sebesvíz Conglomerate Formation). In the Ladinian epoch of the Middle Triassic (about 240 million years ago), a large amount of calc-alkaline lava and volcanic clasts were brought to the surface, partly in the form of terrestrial and partly underwater accumulations, along extensional fractures in the Earth's crust. The rock to be seen in the road cut used to be andesitic lava, significantly transformed deep in the Earth's crust later in the Cretaceous, developing its present characteristics. This formation, called the Szentistvánhegy Metavolcanic Formation, can be studied in a continuous stretch of about 20 kilometres from Mély Valley in Diósgyőr to Nagy István-erőse, among the ridges of Bükk.

If we continue our walk in Lillafüred further south, the sides of Szinva Valley reveal the Middle and Late Triassic Bükkfennsík Limestone Formation (former Fehérkői Limestone Formation), including, for example, the famous Szent István Cave attracting crowds of visitors every year.

It is important to note that, in addition to the Triassic metaandesite presented above, metarhyolite and metabasalt (Szinva Metabasalt Formation) are also present in the region. These are magmatic blocks embedded in various Triassic marine sedimentary layers. The Bagolyhegy Metarhyolite Formation should be highlighted among them, from whose silicified material our Stone Age ancestors made tools tens of thousands of years ago, called the Szeleta quartz porphyry hand axes.

14. Geoheritage values of the gorge hollowed out by the Szinva Creek

Szinva Gorge and its caves; Miskolc–Lillafüred

We have already seen in the previous point that the Szinva flows through areas of extremely diverse lithological structures. The slow incision of the creek, keeping pace with the periodic uplifts of the area, exposed most of the Triassic formations of the Bükk in the past millions of years. An excellent example is Szinva Gorge and its area between Felsőhámor and Alsóhámor, where the shape of the strait also reveals its lithological structure.

Having built up an approximately 45 metres thick travertine deposit exposed behind the waterfall of Szinva and in Anna Travertine Cave, Szinva takes up the water of Garadna Spring and goes on eastward. The predecessor of the Szinva expanded a valley in the more erodible sandstone, marl and argillic sediments (Early Triassic Ablakoskővölgy Formation), in which the village of Felsőhámor (now part of Miskolc) emerged later. However, east of Felsőhámor, the path of Szinva was crossed by a narrow belt of hard limestone through which it cut itself forming a narrow gorge called Hámori Gorge.

The Middle and Late Triassic (ca. 240 to 225 million years old) carbonate rock, formerly called the Fehérkő Limestone Formation and now collectively the Bükkfennsík Limestone Formation, was deposited on a carbonate platform. It means that carbonate sedimentation returned on the tectonic plate carrying the Bükk after the andesitic volcanism described earlier. The light grey bedded and thick-bedded hard limestone dissolves very well in carbonated water, as proven by the caves found within.

In addition to the previously mentioned cut of the Szinva, the collapse of caves dissolved deep in the rock block may have also played a role in the formation of the 220 m long Hámori Gorge. Among its caves still existing today, Szinva-szorosi Cave on the left side of the lower end of the gorge, Herman Ottó Cave on the right, and Puskaporosi Rock Shelter above are worth mentioning. After the hard limestone range, the Szinva developed a small valley expansion on the clay shale surface of the late Triassic Vesszős Formation. This is where the once independent village of Alsóhámor (now part of Miskolc) lies today.

The most spectacular part of the Hámori Gorge opens in the eastern periphery of Felsőhámor, where a 550 m long, 10 to 20 m high, southwest-facing escarpment of layers was formed on the strata of the Triassic limestone interspersed with dissolution forms. The steep cliff on the left side of Szinva Valley runs diagonally down from Szeleta Peak to the upper end of the gorge. This peak hosts one of the best-known and most spectacular prehistoric caves in the Bükk called Szeleta Cave. On the northern side of the gorge, the so-called Szeleta reverse fault is very clearly visible. Here the Bükkfennsík Limestone Formation thrust onto Early Triassic formations along a southwest-verging surface.

15. Following a disappearing creek in Bolhás

Bolhási Sinkhole Cave
(Bolhás–Jávorkút Cave System); Miskolc–Jávorkút

Jávorkút can be reached from Újmassa, from the Garadna Valley through the previously presented Savós Valley passing through three areas, called Létrás, Sebes and Bolhás, respectively. These small areas, one following the other, on the northern edge of Bükk Plateau are important for geologists because, due to their well-karstified Triassic rocks, they include extensive surface and subsurface karstic areas.

Bolhási Sinkhole Cave opens in the immediate vicinity of the Jávorkút highroad, on its southern side, opposite Bolhási Meadow 649 m above sea level. This karstic cave swallows up Bolhási Creek, which has a constant flow but a varying flow rate. A look at the tourist map of the area shall confirm that several sinkholes occur in linear arrangement with the Bolhási one. It is due to the geological structure of the area.

In the southern neighbourhood of the sinkholes, there is a narrow non-karstic rock strip, assigned into the Vesszős Formation. The Late Triassic, black and greenish-black clay shale and aleurolite shale, formed in the Carnian epoch (ca. 235 to 230 million years ago), was deposited in a deeper marine basin, which underwent a low degree of metamorphism in the Cretaceous. This fine-grained foliated rock acts as a water-retaining formation compared to its environment, that is, waters arriving at the surface are not led into the depths but transported in stream beds. This is what happens to the water of Bolhási Creek coming from the south until it reaches the area of the Bükkfennsík Limestone Formation of the Middle and Late Triassic (ca. 240 to 225 million years old) platform facies. Upon reaching the well-karstified carbonate rocks, interwoven with cracks and fissures and having good water-conducting properties, water disappears in the depths of the mountain through a sinkhole cave. This cave is the highly protected, 125 m deep Bolhási Sinkhole Cave in which its meandering main passage, decorated with stalactite formations, and divided by shorelines, is divided by several clay and gravel siphons and sections filled with water.

400 metres west of the sinkhole cave, we find the entrance of another highly protected cave, Jávorkúti Sinkhole Cave. This cave was explored independently of the Bolhási one, but they have formed a single system called the Bolhás–Jávorkút Cave System since 1997. The total length of its discovered passages is 5314 m, making it the 12th longest cave system in Hungary. Water lost in the above-mentioned sinkhole caves reappears at Garadna Spring.

16. Kő-köz, the western gate of the Bükk

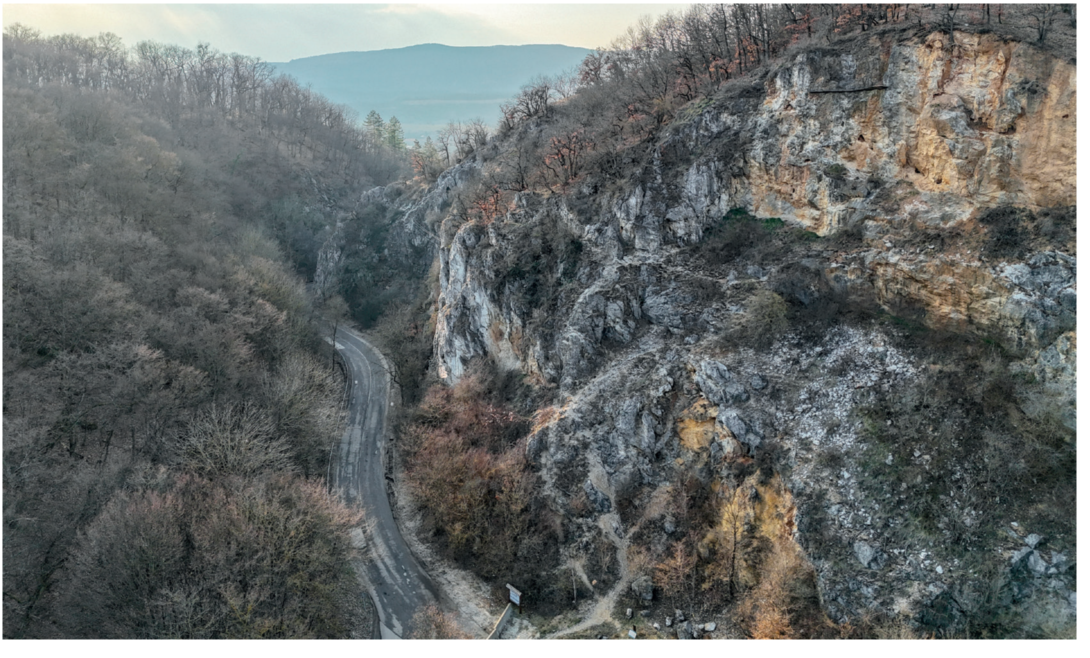
Kő-köz and its caves; Felsőtárkány

Leaving Felsőtárkány at its northeastern end, the highroad towards Miskolc passes through a short but particularly spectacular limestone gorge. The steep-walled valley called Kő-köz (Stone Gorge) or Barát Gorge in Felsőtárkány has been carved by Tárkány Creek continuously incising into the slowly rising area since the Ice Age.

The carbonate rock, previously called Berva (Subalyuk) Limestone Formation, is now assigned to the Bükkfennsík Limestone Formation according to the latest stratigraphic classification. The sedimentary sequence was deposited on a large carbonate platform (marginal shelf) over millions of years, at the boundary of the Middle and Late Triassic (in the Ladinian and Carnian epochs, approximately 240 to 225 million years ago). At that time, the tectonic plate carrying the present-day Kő-köz region was on the shelves covered by shallow, well-lit and agitated seawater of the ancient ocean called Tethys, of course not in its present geographical location. On the edge of the shelves, organisms with calcareous skeletons (sponges, calcareous algae) formed reefs enclosing shallow lagoons of calm water next to the mainland. Carbonate material of reef-building and reef-dwelling organisms turned into light and dark grey limestone, forming the walls of the gorge.

Just like Hámori Gorge, this gorge was created by an incising watercourse, together with cave collapses. The walls of the gorge feature small forms resulting from dissolution and precipitation (such as caves, potholes, calcite precipitation, dripstone fragments) supporting the theory of cave collapsing. The observation regarding Hámori Gorge applies here, too, meaning that the valley widens after the gorge as we move towards Barát Valley, since the predecessor of Tárkányi Creek developed a widening valley in the "softer" Jurassic Lökvölgy Formation. This observation is also true for the area of the village of Felsőtárkány called Tárkányi Basin, where predominantly Miocene clastic sedimentary formations occur.

The gorge of Kő-köz was transformed by the construction of the Eger-Miskolc highroad and by quarrying activities in the 20th century. The so-called Tárkány grey marble was quarried near Szikla Spring and used for decorative purposes in several churches in Heves county, including the one in Felsőtárkány. The gorge is now presented by the Kőköz Educational Trail, but there is a "via ferrata", too, for adventure-seekers.



17. Suba Cave, a former habitat for Neanderthals

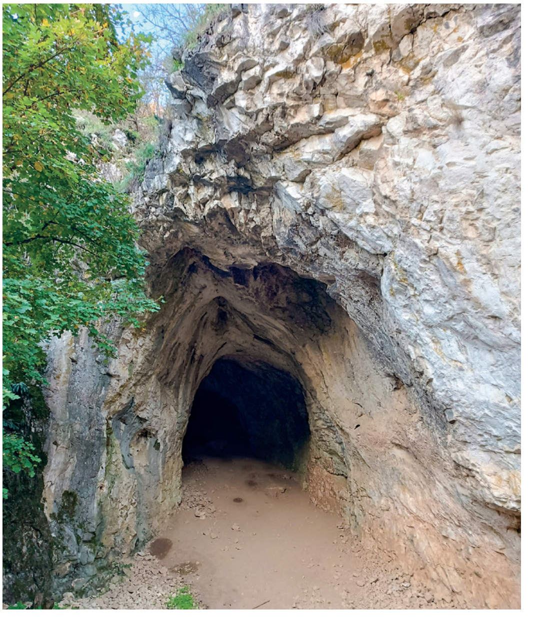
Suba Cave; Cserépfalu

One of the best-known and most spectacular prehistoric caves in the Bükk region is the highly protected Suba Cave, located in the periphery of Cserépfalu, on the western side of Hór Valley, 45 metres above the valley bottom.

The predecessor of Hór Creek, which had a higher water flow, had to cut its way in this lower section of the valley through the hard carbonate sequence of the Middle and Late Triassic (ca. 240 to 225 million years old) Bükkfennsík Limestone Formation (former Berva Limestone Formation), presented in detail in the section on Kő-köz. The rock block deposited on the one-time Tethys carbonate platform also carries the passages of Suba Cave. This cave is the decaying remnant of a now inactive spring cave, that has risen to its current height since the Ice Age. Former spring activity in the cave is indicated by shorelines visible on the side walls. Gravel and sand deposits found on the rock base confirm that once a stream flowed through it. Consisting of a foreland, a hall and a corridor, the V-shaped karst cavity is 45 m long, with a 30-metre-long pit-like opening at its end to the surface. As the cave functioned as a sediment trap during the Ice Age, and our ancestors used to live in it from time to time, Suba Cave is one of the most important paleoarchaeological sites in Hungary and in the Bükk.

Named after the Bükk outlaw Lukács (or Mihály) Suba, archaeological excavations in the cave were started by an amateur speleologist, János Dancza in 1932, to be later followed by Ottokár Kadić. Researchers divided the cave fill into 18 layers, deposited during the Pleistocene (in the Ice Age) 130,000 to 65,000 years ago. The real sensation came from layer No. 11 from the Würm glacial. This layer contained the jaw bones of a 25 to 35-year-old Neanderthal woman as well as the remains of the skull of a child of about 3–4 years old. Hunting Neanderthals most likely represented another branch in human evolution, that is, they were not direct ancestors of the Homo sapiens.

In addition to the human remains, animal bones were also found in Suba Cave, allowing us to draw conclusions about the fauna of the time and the hunting habits of its inhabitants. As regards the fauna, the ibex, the red deer, the aurochs, the chamois, the wild horse, the woolly rhinoceros, the cave bear, the bison and the mammoth should be highlighted. Apart from the remains of once hunted animals, a large number of chipped stone tools were also found in the cultural layers.



18. Koporsós Sinkhole Cave – sometimes a spring, sometimes a sinkhole

Koporsós Sinkhole Cave; Répáshuta

In Hór Valley, between the entries to Balla Valley and Szarvaskúti-Csúnya Valley, the dark entrance of Koporsós Sinkhole Cave or otherwise called Gyertyán Valley Sinkhole Cave opens next to the old cemetery of the Gyertyán Valley glassworks, which will be presented later. Otherwise not much of a sight in dry periods, this cave is a special karstic object of the Bükk region, namely, an estavelle.

Estavelles or inversacs are special cave openings that function either as springs or as sinkholes, depending on the underlying karst water level. After heavy rains and prolonged snowmelt, waters flowing down the valleys of the region reach Hór Valley and Gyertyán Valley and then disappear in this sinkhole. Absorbed water is drained by the sinkhole into the depths of the karstic rock block through the passages below it, thus feeding the connected karstic water system stored there.

During spring or early summer when precipitation is particularly abundant, saturation and rise in the level of the karstic water system causes Koporsós Sinkhole Cave to act as a spring, that is, as a natural overflow of the system, and to discharge water into the creek bed at the valley bottom. Such karstic objects are referred to in Hungarian as "shifting spring" since after long periods of absorption they actually switch to spring mode. Koporsós Sinkhole Cave is widely considered the only estavelle in the Bükk region by the literature, although Balla Valley Sinkhole Cave nearby can also act as an estavelle in periods of high rainfall.

The area of Koporsós Sinkhole Cave is predominantly covered by the Jurassic Lökvölgy Formation, which is hydrogeologically impermeable, but the well-karstified limestone beneath has also come to the surface (or exhumed) in several places. The water of the Koporsós Sinkhole Cave is absorbed in the previously mentioned Middle or Late Triassic (that is, ca. 240 to 225 million years old) Bükkfennsík Limestone Formation, opened by the erosion of Hór Creek in the valley bottom.

The small cemetery of the former Gyertyán Valley glassworks where glassworkers and their family members were buried between 1843 and 1926 is next to Koporsós Sinkhole Cave.

19. A prehistoric cave near Répáshuta

Balla Cave; Répáshuta

Répáshuta is situated in a small intermontane basin and is habited by the descendants of Slovak workers who used to work in old glassworks, forests, charcoal kilns, and lime kilns of the region. After the closure of the Gyertyán Valley glassworks, which will be presented later, its workers and their families founded Répáshuta at the end of the 18th century. However, the area has been inhabited since prehistoric times, proven by the finds in Balla Cave, among others.

Balla Cave has a 10 m wide and 8 m high entrance, which is, a strikingly large opening on the northern rocky slope of Balla Ridge, 566 meters above sea level. Its surrounding rock and formation are similar to those of Suba Cave This cave was dissolved and eroded by descending cold karstic water in fissured and highly soluble carbonate rocks of the Bükkfennsík Limestone Formation of a Middle and Late Triassic (ca. 240 to 225 million years old) platform facies. Originally located in the valley bottom, this cave reached its height near the top as the area slowly rose. Today it looks like a decaying, fossilised spring cave. Stratification of the Triassic limestone also played a role in the formation of the cave by the end of the Pliocene. It is also proven by the sloping ceiling formed along the layers. The cave hall is 54 m long, 6 m high on average, and 8 to 10 m wide, with traces of entrances of eight smaller or larger side branches.

Balla Cave is one of the most significant speleoarchaeological sites in the Bükk. Its excavations began in 1909. Of the 8 archaeological layers excavated, the upper two are Holocene (modern), producing Bronze Age and Neolithic finds. Lower layers were formed at the end of the Ice Age (in the Pleistocene), and archaeologists excavated stone tools and Ice Age animal bones (those of cave bears, cave hyenas, and ancient bisons). The skull of a one-and-a-half-year-old child was also found here in 1909.

It is worth paying a visit to another important archaeological site, the highly protected Pongor Cave nearby on the side of the mount called Kövesvárad.

20. The case of Italian prisoners of war with Triassic limestone

Olasz-kapu; Szilvásvárad

From Szilvásvárad towards Bükk Plateau, leaving Gerennavár, the narrow paved forestry road leads us to a small rocky corridor with a plaque on its wall. This artificial cut called Olasz-kapu (Italian Gate) has a really extraordinary story.

Walls of the cut reveal greyish layers of the Middle and Late Triassic (ca. 240 to 225 million years old) Bükkfennsík Limestone, that is, the bedrock of Bükk Plateau. Lime mud within the formation was deposited in lagoons covered with shallow sea and bordered by reefs, thousands of kilometres from their present location, somewhere in the tropical zone. It is impossible to decide with the naked eye whether its fine bands reflect the original sedimentary stratification or are foliated bands resulting from low-grade metamorphism during the Cretaceous. Previously, researchers identified conodonts belonging to the genus Gondolella from a sample taken from the wall rocks of Olasz-kapu, clearly linking it to the Late Triassic (Carnian epoch).

In World War I, nearly half a million Italian soldiers were taken prisoner by troops of the Austro-Hungarian Monarchy. Of these, 18 soldiers ended up at Marquess Pallavicini's estate in Szilvásvárad. Their task was to cut a passageway under the command of Gáspár Thurzó on the edge of Bükk Plateau, in the rocky ridge of the saddle between Vörös-sár Hill and Huta Ridge. In 1918, the soldiers carved out the corridor with painstaking labour. The construction of the corridor was necessary due to the route of the planned forest railway. The narrow-gauge railway line built between Káposztáskert-lápa (Káposztáskert Vale) and Őserdő (Virgin Forest) operated until the 1940s. Today forestry roads and tourist paths run along its route. The plaque on the wall of the Italian Gate says the following: „Őrgróf Pallavicini Alfons Kapuja. Áttörte Thurzó Gáspár b. m. 18 olasz hadifogollyal. 1918. VII. 22. [The Gate of Marquess Alfons Pallavicini. Broken through by Gáspár Thurzó mining engineer with 18 Italian prisoners of war. 22 July 1918.]".

In the artificial geological exposure created by Italian prisoners of war, let's contemplate the blood, sweat and tears of the prisoners of war, and then the Triassic limestone, too. Olasz-kapu is also one of the stations on the Olasz-kapu Educational Trail. Starting from Olasz-kapu, karstic terrains with rows of dolines extend all the way to the northern foot of Három Cliff.

21. Cserepes Cliff ploughed by the devil

Cserepes Cliff, limestone pavement and Cserepes-kői rockshelter; Szilvásvárad

One of the most spectacular and perhaps best-known areas of Bükk Region UNESCO Global Geopark is that of the so-called Bükk Rocks. The steep and rocky slope to south and southwest of Bükkfennsík between Három Cliff and Bél Cliff offers wonderful viewpoints, including those in the area of Cserepes Cliff. This marked edge of Bükk Plateau was formed as a result of the geology and the structural setting of the area.

Bükk Plateau and its bordering rocks consist of the previously mentioned Middle and Late Triassic (ca. 240 to 225 million years old) Bükkfennsík Limestone Formation. Lime mud constituting its material was deposited in shallow lagoons of the former sedimentary basin, the Tethys, divided by reefs, on a giant carbonate platform, i.e. a rimmed shelf. Well-karstified limestones are in contact with much younger shales (Lökvölgyi Formation), deposited in a deep-sea environment during the Middle and Late Jurassic (ca. 170 to 165 million years ago). Due to the complex structural development of the Bükk in the Cretaceous, Jurassic shales are found crumpled under the Bükk Rocks, too, in addition to their southern foreland.

More easily eroded shale sequences have, over time, fallen from the limestone. Bold breaks of the Bükk Rocks, with their blindingly white fronts in direct sunlight, formed mainly for lithological reasons, on the border of rock blocks of differing types, depositions and weathering rates, with structural reasons also playing a minor role. The edge of Bükk Plateau can therefore be considered a structural step formed by selective denudation, corresponding to the rock quality

Walking along these giant cliffs of the erosion edge, the wealth of karst forms is also worth mentioning, apart from the magnificent panorama. Easily soluble and steeply folded top layers of the Triassic limestone of the precipitously sloping rock edges present a spectacular set of solution forms resulting from rainwater permeating the soil, on the one hand, and directly contacting the bare limestone, on the other. One of the most typical limestone pavements or karren (and in Hungarian folk tradition referred to as the devil's plough) of Bükk is revealed on Cserepes Cliff. On the surface of the top layers inclined along the mountainside, the so-called root karren are the most spectacular forms. Their cylindrical, narrow and deep channels were dissolved by the organic acids of one-time plant roots.

Cserepes Cliff features the first cave ever in Hungary to be furnished as a refuge for hikers, especially those walking along on the Blue Trail. The inactive spring cave of Cserepes Cliff Cavity 6 m long, 7 m wide and 2.5 m high, is closed by a door, with wooden bunks and a stove within. You shall find the National Blue Trail stamp here, too.

22. Mély-sár Valley where dolines are arranged in a line

Mély-sár Valley, a valley with a line of dolines; Nagyvisnyó

Extended 20 to 22 km from west to east and 5 to 7 km from north to south, Bükk Plateau is the most typical karstic plateau in Hungary also with the highest average altitude (600 to 950 m). To be able to understand its formation, let's go back to the Eocene in historical geology.

The main mass of the Bükk is built up by sedimentary rocks of predominantly marine origin deposited between the Late Carboniferous (ca. 320 to 315 million years ago) and the end of the Middle Jurassic (ca. 165 to 160 million years ago). We do not know any geological formations from the Cretaceous, the Paleocene, nor from the Early and Middle stages of the Eocene, because the Bükk region used to be a strongly eroding prominent dryland at that time. Warm and rainy climate and the strong weathering of the rocks resulted in a peneplane, that is, a leveled eroded surface. Bükk Plateau is a tectonically prominent remnant of this Eocene peneplane. During the Oligocene and the Miocene, this plateau was repeatedly buried with and uncovered from marine and volcanic clastic sediments. Over the past few million years, Bükk Plateau was rising more quickly, and well-soluble Triassic limestones gradually came to the surface. This is where the karst formations basically determining the current appearance of the landscape developed. The area of Mély-sár Valley is an excellent example of this.

Basic karstic forms of the plateau are dolines. Shapes of the dolines of varying depths and extents, deepening because of karstic solution, reveal the underlying processes. Cross-sections of dolines that once functioned or currently function as sinkholes are funnel-shaped, and significantly deep compared to their respective diameters. Dolines that cannot be associated with sinkhole activities are bowl-shaped and shallower. Dolines rarely occur solitarily, rather their combination is typical.

The field of twin dolines of the lower section of Mély-sár Valley was originally connected to the polje of Nagy-mező a few kilometres away from here to the east. So its original water network had an outflow towards Nagy-mező. Solitary dolines coalesced in such a way that, due to impermeable sediments accumulated in their bottom, solution went on only laterally, and then, due to the widening of each doline, they developed into bowl-shaped twin, triple, and rarely quadruple uvalas after a while.

From the Blue Trail route passing by the lower section of Mély-sár Valley, dolines of varying depth and extent, formed by solution in well-karstified Triassic rocks of Bükkfennsík Limestone Formation, and uvalas formed by their coalescence, can be clearly observed.

23. Miracle rocks in Bükkszentkereszt

Boldogasszony Cliffs; Bükkszentkereszt

Formerly called Újhuta, Bükkszentkereszt is a popular holiday resort in the eastern part of the Bükk. The name Újhuta refers to the fact that the village was inhabited by Ruthenian and Slovak craftsmen in the 18th century, working in local glassworks. After the glassworks had been closed, villagers made their living from forestry, lime and charcoal burning. A museum in Bükkszentkereszt displaying the relics of the former glassworks.

The southwestern end of the village (on Zrínyi Miklós Street) features mystical healing rocks called Boldogasszony Cliffs. A legend says that, after the death of Jesus, the Virgin Mary went out into the world in her deep sorrow and rested on one of the rocks here. While she was sitting, the rock beneath her softened, and when she stood up, it hardened again. This rock still displays the imprint of her body. According to another story, those setting out for the feast day of the church in the village Kács used to gather here and then returned here after their nearly 20-kilometre walk. Resting on the stones, tired pilgrims regained their strength remarkably quickly. Still popular today, these rocks attract thousands of tourists seeking healing, who, after resting on the bizarrely shaped stones, can feel recharged.

As regards the geological perspective, Boldogasszony Cliffs are limestones with a karstified surface from the Triassic (called a limestone pavement or karren). The geological structure of the area is founded on the well-karstified Middle and Late Triassic Bükkfennsík Limestone Formation, which has already been presented in detail previously. The area of today's Boldogasszony Cliffs used to be covered by soil in which rainwater became carbonated, that is, chemically aggressive. Water became carbonated due to dissolved carbon dioxide which, in turn, was produced by microbes living in the soil.

Carbonated water carried out dissolution processes beneath the soil, the traces of which can be studied on the surface of these rocks today Rock surfaces are visible because the soil, probably because of previous deforestation, was washed down into the valley below and top limestone layers, round and perforated by solution, became exhumed. Most spectacular solution forms on the surface of Boldogasszony Cliffs are root karren, dissolved by the organic acids of former plant roots. Due to the lack of soil cover, now the surface of the limestone rocks is slowly destroyed by the flow solution effect of rainwater flowing sheet-like or in channels, and by rock fragmentation.

You can visit the Monument of King Béla IV, commemorating the victorious battle against the Tatar hordes nearby the rocks.

24. Örvény Cliff, a pagan altar for Mór Jókai

Örvény Cliff; Varbó

Bükk Plateau is the most uniform-looking part of the Bükk, divided by the Garadna Valley into a higher southern part (Nagy Plateau) and a lower northern part. The latter is called Kis Plateau. It extends from the uppermost section of Harica Valley to Csanyik Valley. The plateau descends gradually towards east, and therefore its highest point is in the west, in the block of the aforementioned Örvény Cliff, 764 m high.

The main mass of Kis Plateau is formed by Middle and Late Triassic (ca. 240 to 225 million years old) carbonate rock, previously called the Kisfennsík Limestone Formation, now assigned to the Bükkfennsík Limestone Formation in the new lithostratigraphic classification. The lime mud that built up this carbonate platform facies of the light grey, thick-bedded or massive limestone forming Kis Plateau deposited on tidal flats, in lagoons and on reefs. Its most notable fossils are foraminifera, calcareous algae, sponges, corals, snails and shells. As to the latter, large cross-sections of the Megalodus mussel genus form spectacular, heart-shaped structures on the limestone surface. Just like other Bükk formations discussed so far, this carbonate rock underwent a low degree of metamorphism during the Cretaceous.

Here we note that Kis Plateau is now considered to have a nappe structure (Kisfennsík nappe). Its rock masses were separated from their original bedrock due to compressional structural movements at the end of the Jurassic and the beginning of the Cretaceous, to be pushed onto other types of sedimentary rocks. The westernmost point where platform carbonates forming thrusted structure occur is Örvény Cliff.

Walking from the Szentlélek highroad towards the peak of Örvény Cliff, first we cross a gentler terrain consisting of Early Triassic formations (Ablakoskővölgy Formation, Gerennavár Limestone Formation). Below the peak, we reach the edge of the Bükkfennsík Limestone Formation, weathered out from its more eroded environment, and deposited as a nappe fragment in the Örvény Cliff area, as mentioned in the previous paragraph. Exposed by erosion, the southwestern, western and northwestern edges break down to the lower terrain of the Northern Bükk, producing 20 to 28 m high rock walls. Such walls, often visited by rock climbers, display the remains of a cave that was ruined until becoming a rock gate, as well as 15 karstic caves (fissure cavities, domepits, passages).

On the top of Örvény Cliff, a monument was erected to the Hungarian novelist, Mór Jókai, surrounded by the solution forms of a small limestone pavement rich in root karren on top layers of the Triassic limestone. The monument commemorates the fact that Mór Jókai often visited Örvény Cliff (also called Pagan Altar) after the suppression of the 1848–1849 war of independence – during his exile in the nearby village of Tardona. From the monument, there is a limited view to the north.

25. Visiting former quarries of the Felsőtárkány shale

Zsindelybánya-lápa, disused shale quarries; Felsőtárkány

Bükk carbonate platforms, providing the setting for the development of the Bükkfennsík Limestone Formation, as presented in detail previously, began to sink at the end of the Middle Triassic and the beginning of the Late Triassic. The Hegyestető Formation, the Répáshuta Limestone Formation, and the Felsőtárkány Limestone Formation, consisting mainly of limestone, cherty limestone, and dolomite, were deposited in emerging marine basins. Sedimentation stopped in the Late Triassic (ca. 210 million years ago) and resumed only in the Early Jurassic (ca. 190 million years ago; Jómarcikő Limestone Formation) and the Middle Jurassic.

One of the characteristic formations of the Middle Jurassic in the Bükk is the Lökvölgy Formation, the material of which was formed ca. 170 to 165 million years ago. Clastic sediments of the formation were originally deposited in a deeper marine basin. From the margins of the elevated platforms surrounding the basin, turbidity currents slid down towards the deeper terrain, with their clastic material accumulating as deep-sea fan-shaped deposites at the base of the steep slopes. Closer to the feet of continental slopes (proximal part), coarse-grained sandy sediments (Vaskapu Sandstone Formation) while in the more distant (distal) parts only fine rock flour and clay grains were deposited. The rock underwent a low degree of metamorphism in the Cretaceous, ca. 130 to 120 million years ago, during which its main mass was transformed into strongly folded, laminated and foliated clay shale.

The Jurassic Lökvölgy Formation actually owes its foliated structure to the fact that it had been one of the most popular roofing slate types (called shingles) in the region for centuries. Slates that could be easily split and drilled along foliation plains was discovered by Henrik Fazola, who was otherwise searching for ores, in the Felsőtárkány area around 1767, but its quarrying began at the end of that century only. The first major quarry was established by the Archbishop of Eger, Károly Eszterházy, in 1793. The main market for shingles was Eger, where they were used on the buildings of the bishopric (later archbishopric). In addition to roofing slates, school slates were also made from this rock. Initially, only a few people worked in the quarries using manual tools, but industrial quarrying also began in 1868. The quarrying of the Felsőtárkány slates ended in the early 1900s. Jurassic clay shale was mined around the villages of Bükkzsérc and Kisgyőr, too. Experts can distinguish it from Carboniferous clay shale (Szilvásvárad Formation), as presented in the Bán Valley section, based on Radiolaria (silica-skeletoned single-celled organisms) found in it.

Its name meaning 'Slate Quarry Bog' in Hungarian, Zsindelybánya-lápa was a major slate quarrying area in Felsőtárkány, where open pit methods were used mainly. We can also find smaller and larger artificial cavities in clay shale, probably linked to quarrying. There are collapsed adits and waste heaps at the junction of Zsindelybánya-lápa and Lök Valley.

26. A radiolarite tower next to the highroad to Bátor

Nagy Cliff; Bátor

Sedimentation in the Jurassic of the Bükk went on in deep-sea conditions, with clastic (siliciclastic), carbonate and siliceous sedimentary sequences deposited, together with magmatic formations. Widely known are the exposures of Jurassic formations around the villages of Egerbakta and Bátor, apart from Szarvaskő.

Between Egerbakta and Bátor, the incision of Laskó Creek exposed Jurassic formations arranged in a blanket structure. Let us highlight the Oldalvölgy Formation, belonging to the so-called Mónosbél Formation Group. Dating back to the Middle Jurassic (ca. 169 to 167 million years), Oldalvölgy Formation is built up of aleurolite and clay shale with dark grey and black sandstone lenses as well as limestone layers and lenses of varying thickness. This formation also includes the Csipkéstető Radiolarite Member, previously considered an independent formation, and the Rocskavölgy Member, containing iron and manganese carbonate nodules and lenses. The rock consisting of clasts and carbonate of the sequence formed in a deep-sea environment, was transported by turbidity currents from more prominent shelves to the deeper ocean basin. This deep-sea rock underwent a low degree of metamorphism in the Cretaceous, transforming into a folded and foliated formation.

1 km from the southern periphery of Bátor, we can spot Nagy Cliff on the eastern side of the road, one of the most spectacular outcrops of the Csipkéstető Radiolarite Member. Radiolarite is a deep-sea siliceous sediment formed by the solution and subsequent recondensation of the skeletons of siliceous single-cell organisms (Radiolarians). This grey or dark grey, sometimes spotted green or red siliceous sediment usually consists of a mass of thinly layered Radiolarian skeletons, the base material of which was recrystallized (thus resembling chalcedony) to varying degrees. This hard and resistant rock body, 'stained' by iron and manganese solutions, was weathered out, giving rise to Nagy Cliff near Bátor.

If we start from Nagy Cliff towards the north, in the direction of Bátor, a small abandoned quarry shall stop us about 150 m to the right of the road. In the southern part of the exposure, dark grey and black, foliated aleurolite is to be spotted, with limestone and olistostrome beds deposited in the northern part. Shallow-sea Jurassic limestones were deposited by gravity mass movements among the fine-grained clastic sediments of the deep-sea basin (Laskóvölgy Formation). We can see tight, small-scale folds in the limestone, formed during the Cretaceous.

27. A mystical horseshoe print in the southern part of the Bükk

Patkó Cliff and abandoned quarry; Bükkzsérc

Bükkzsérc lies not far from Eger, at the junction of the Bükk (Southern Bükk region) and the Bükkalja microregion, along Cseresznyés Creek. To the northwest of Bükkzsérc rises a mount called Hódos, covered with forests and the remains of an ancient earthwork, forming a horseshoe-like shape with a diameter of 100 m on its southern side. The so-called Patkó Cliffs (Horseshoe Cliffs) and the abandoned quarry (commonly referred to as the 'kis patkó' Small Horseshoe) below reveal the sequence of the Bükkzsérc Limestone Formation from the Jurassic.

The formation is predominantly dark grey or sometimes grey limestone containing black chert nodules. Its surface whitens when weathered and has a characteristically rough feel. Its structure is bedded and thick-bedded, with fine stratification and occasionally weak grading within the beds. Beds are separated by black layers of aleurite and shale, varying in thickness. Carbonate grains of the rock are composed of ooids and angular limestone fragments mostly, the latter having the same material as the host sediments. Certain levels are rich in external rock fragments (e.g. mica schist, phyllite, sandstone, volcanite), sizes of which are usually below 2 mm but pieces over 5 cm also occur. Beds containing coarse clasts are always graded, that is, the grain size tends to decrease from the bottom of the bed upwards. Cherty nodules in the formation were formed by the concentration of silica released from siliceous sponge spicules and Radiolarian skeletons. The sequence was formed in the Middle Jurassic (ca. 168 to 167 million years ago) in a zone where a sea basin met a continental slope, with clastic and carbonate grains pouring down as mudflows from the edge of the elevated carbonate platform.

A local legend says that Patkó Cliffs were formed on the side of the Hódos when a horseshoe fell from Jesus Christ's donkey or our knight king, Saint Ladislaus's horse. The typical horseshoe shape of the rocks, once playing an important role in the lives of the inhabitants of Bükkzsérc, were actually formed by the layers folded into an anticlinal of the Bükkzsérc Limestone Formation. Coarse clasts of the Jurassic limestone, less weatherable than its surroundings, are exposed where soil cover is thin and vegetation is sparse.

It is also worth visiting the small disused quarry, considered the key section of the Bükkzsérc Limestone Formation. The rock material of this open-pit quarry, worked until the 1980s, was basically not suitable for lime burning. Referred to by locals as 'csalakő', stones produced here were used for road construction and, less often, for construction works.

28. Rare plutonic rocks in the valley of Eger Creek

Tardos quarry; Mónosbél

Between the villages of Szarvaskő and Mónosbél, the rock walls of disused quarries strike the eye on both sides of a narrow valley formed by Eger Creek. Still a remarkable sight, although gradually reclaimed by vegetation, these open-pit quarries feature gabbro, a rare rock type in the Bükk and throughout Hungary.

Gabbro is a plutonic or intrusive rock, greyish-green or reddish-brown when weathered and also tough and resistant. Its main minerals are plagioclase feldspar, pyroxene (augite), amphibole (hornblende) and chlorite. It was mined for road and railway construction works and waterworks due to its good petrophysical properties. So how was this plutonic rock formed and how did it reach the surface?

Revealing a magmatic intrusion formed in the Jurassic (ca. 166 to 165 million years ago), the Tardos quarry is located between Szarvaskő and Mónosbél, next to the railway halt called Tardos quarries. At that time, the area of the plate supporting the Bükk, which was of course not in its current geographical location, was reached by a fissure in a rift zone from which molten rock was pushed up. Rising from great depths, this basic magma (having a low silica-content) could not always reach the surface, but rather it intruded into deep-marine argillic, silty and sandy formations (Vaskapu Sandstone Formation, Mónosbél Formation Group) that had already been deposited in the ocean basin to cool and crystallise over millions of years slowly. This is how gabbro, this coarse-crystalline plutonic rock containing minerals up to centimetre size, was born.

This rock with its multitude of colours was mined in the Tardos quarry, to be transported for road and railway construction works. Crystallised several kilometres deep, gabbro can now be seen on the surface because erosion due to the rise of the area, especially that of Eger Creek, has removed the rocks situated on the top, bringing gabbro closer to the surface. The name of the quarry is also included in the petrographic name, since the currently valid classification calls the formation the Tardos Gabbro Unit of the Szarvaskő Complex.

This spectacular exposure is perhaps the most diverse of all the quarries in mineralogical terms. Examining the walls, there is a light gabbro variant, richer in plagioclase, and a darker one, richer in pyroxene, in contact with each other along a relatively sharp boundary, with a difference in their respective grain sizes, too. Previously mentioned deep-marine sedimentary sequences that originally covered the rock can also be spotted in the quarry.

29. The Castle of Szarvaskő and the history of ocean-floor pillow lava

Várhegy; Szarvaskő

The village of Szarvaskő lies along the Eger Creek in a small valley formed in Jurassic clay shale, guarded by the majestic Jurassic basalt tower of Várhegy (Castle Hill), with the remains of a medieval castle on it. Crossing Eger Creek and then the railway tracks in the village, a short but steep climb shall take us up to the ruins of the castle. On the way, quite a few geological treats are awaiting us.

When presenting the Tardos quarry, we have already mentioned that the Szarvaskő region is made up of deep-marine clastic sedimentary formations from the Jurassic, with basaltic magmatic intrusions from which gabbro was formed. However, lava also spilled onto the floor of the ancient ocean about 166 to 165 million years ago, from which basalt crystallised (Szarvaskő Complex, Keselyűbérc Basalt). Walking along the geological trail, first we shall study how the basalt forming Várhegy and the foliated Lökvölgy Formation consisting of clay, rock flour and fine sand grains meet. A little higher up, we can observe clay shale of a darker and lighter surface, with manganese nodules and lentils. Turning west on the Várhegy trail, the road cut shall feature outcrops of the Lökvölgy Formation, in which the lighter bands are composed of fine sandstone, while the darker ones consist of argillic rock flour. After crossing clay shales thermally altered by basalt lava and disintegrating into matchstick-like blocks, we reach the old castle moat. Although not intentionally, the one-time builders of the castle created an artificial geological exposure here, where we can venture into the depths of the Jurassic ocean by studying basaltic pillow lavas making up Várhegy.

Rounded, rounded pillow-lava forms were developed because of the interaction of cold ocean water of a high hydrostatic pressure and hot magma of 1500 °C. The outer part of the erupting magma dose quickly crusted in the water, while the next lava had to break through this crust to be able to continue to flow, creating pillow-like formations. Pillow lavas have an ovoid cross-section, slightly convex on their original upper side, while their lower dented part resembles the letter V opened wide. Such pillow lava structures can be studied in sections in the artificial moat under the castle. Their full beauty opens up on the eastern side of Castle Hill, which can be reached via a small path.

Not much remained of the ruins of the medieval castle, but the panorama is worth walking to the viewpoint of Castle Hill. If time permits, let's walk on along the National Blue Trail to Akasztó Peak to enjoy a unique view of Szarvaskő Gorge, formed in Jurassic basalt, below. This narrow gorge was created by the etching of Eger Creek over the past few million years.

30. Cretaceous conglomerates in the vineyards of Dédestapolcsány

Geological exposure of Bántapolcsány vineyards; Dédestapolcsány)

Two villages merged to form the present Dédestapolcsány, one being Dédes, closer to the Bükk, and the other Bántapolcsány or Tapolcsány, closer to Uppony The exposure is in the periphery of the former Bántapolcsány. In the Bükk, no rocks are known to have been formed from the end of the Middle Jurassic (about 165 million years ago) to the Late Eocene. However, Uppony Mountains, which we presented when discussing the Carboniferous period, however, feature Cretaceous sediments. The only proven Cretaceous formation of Northern Hungary, that is, the Nekézseny Conglomerate Formation, appears in an 8 km long strip on the southern edge of Uppony Mountains, between Csokvaomány and Dédestapolcsány. The closest Cretaceous rocks on the surface are in the Gerecse Mountains, in the area of Lábatlan.

The formation is composed of grey cyclic conglomerate beds with sandstone and clay marl intercalations, 1 to 10 m thick. Pebbles are usually in close contact, have a grain structure, are well worn and of variable sizes (3 to 6 cm on average, 20 cm as a maximum). Their material is predominantly Triassic and Jurassic limestone from Rudabánya Mountains but metamorphic pebbles (e.g. lime phyllite, sandstone shale, siliceous shale) from the Uppony Mountains are also common. It is proven that the formation does not contain any pebbles from the Bükk. The Late Cretaceous (ca. 85 to 80 million years old) clastic rock is a submarine slope sediment redeposited by gravitational sediment movement. Its base material was deposited in a shallow marine environment next to a mountainous area, where short water flows of high energy arrived. Sediments accumulating on an underwater alluvial cone slid down the slopes and were resedimented in clastic flows and mudflows towards the deeper sea basin.

It is interesting that shallow marine fossils were discovered in the conglomerate of the Bántapolcsány outcrop. Shallow marine coral reefs and bioherms consisting of rudist shells formed on the top of the coastal alluvial cone. The aforementioned mass movements caused such shallow-sea organisms to be transported downslope, too, mixed into the conglomerate.

Two other important exposures of the Cretaceous conglomerate are the Nekézseny railway cutting and the small disused quarry next to the Csokvaomány access road. However, no limestone containing shallow-sea fossils were found in these otherwise spectacular outcops.

31. On the border of the Eocene and the Oligocene

Síkfőkút, abandoned quarry; Noszvaj

In the area of the Bükk considered in the narrow sense, we do not know any rocks originating from the period between the end of the Middle Jurassic (about 165 million years) and the end of the Eocene (about 35 million years ago). During that nearly 130 million years, the structural unit supporting the Bükk sank deep into the Earth's crust with a low-grade of metamorphosis, foliation and folding already mentioned, continued to develop, then it emerged again by the beginning of the Eocene, and its surface was intensively eroded. This is when the ancestor of Bükk Plateau was formed. The Bükk was again flooded by a sea from the southwest in the Eocene period within the Cenozoic era, that is, during the Age of Mammals. Eocene and subsequent Oligocene marine sediments can be studied between Eger and Noszvaj.

There is a large bend in Cseres Street in Noszvaj-Síkfőkút, not far from Kánya Creek, where a disused quarry with a well-layered sedimentary sequence stands out, and we also have a Geopark information board there. This protected geological key section is important because it reveals the boundary between the Eocene and Oligocene. At its bottom, the Late Eocene Szépvölgy Limestone Formation emerges, on which the early Oligocene Buda Marl Formation is deposited.

The lower part of the exposure, represented by the Kosd Formation of terrestrial origin, reveals the nummulitic bedded limestone of the Late Eocene Szépvölgy Limestone Formation, with thinner to thicker marl layers deposited within. From among the nummulites, that is, large foraminifera with calcareous skeletons, it is Nummulites fabianii that demonstrates that this sedimentary rock originates from the Eocene. The Szépvölgy Limestone Formation is overlain by well-layered and bedded sandy marl, called the Buda Marl Formation. In the sequence consisting of beds cemented to a varying degree, the aforementioned nummulites species is no longer present. The Nummulites vascus clearly indicates the Oligocene. Ichnofossils of mud-eating organisms also occur in the marine sedimentary rocks of the exposure. Sedimentary rocks, extending with a 10-degree inclination towards southwest, indicate a deepening sea, since the Szépvölgy Limestone Formation was deposited on a shallow marine ramp, while the Buda Marl Formation was deposited in a deeper marine basin.

As regards geological key sections, the so-called stratigraphic key sections are important because they help to delineate geological eons, eras, periods, and epochs in continuous marine sequences. The boundary of the Eocene and Oligocene can be spotted in Síkfőkút, while that of the Permian and the Triassic (in the Paleozoic and the Mesozoic eras, respectively) is exposed on the northern side of the rock called Bálvány.

32. A deep-sea alluvial cone from the Oligocene halfway between Eger and Noszvaj

Kavicsos Peak, abandoned gravel quarries; Eger

The sea continued to deepen on the plate carrying the Bükk from the end of the Eocene, resulting in the depositon of fine-grained deep-marine formations to be deposited during the Oligocene. At the beginning of the Oligocene, the Tard Clay Formation was formed, with layers rich in plant and fish remains emerging around the hill Kis-Eged. The Tard Clay Formation is followed by the Kiscell Clay Formation, the sandy and pebbly sediments of which can be best studied around the village Noszvaj.

Kavicsos-Peak rises southwest of Noszvaj featuring disused gravel quarries on its southeastern side. The sequence of the Noszvaj Member, characteristic of the uppermost part of the Kiscell Clay Formation, can be spotted all along from Cseres Peak to the Szőllőske gravel quarry in question, from northeast to southwest, approximately 5 km long and 1–1.5 km wide. The abandoned quarry walls primarly reveal poorly stratified sandy gravels and, less frequently, siltstones containing more cohesive conglomerate beds and sand beds. The matrix between the clasts of the gravelly and conglomerate rock consists of sand, or the grains are in direct contact with others. The gravel material is unsorted, meaning that grain sizes vary from coarse sand to large pebbles. The gravel material shows normal gradation, meaning grain sizes become finer upwards in each layer. The degree of wear of the grains decreases as grain diameter increases, and many small pebbles are well rounded. The material was formed in the Mesozoic era of the Bükk, and is mainly made of chert, quartzite, sandstone, basalt and limestone. The maximum thickness of the Member in this quarry is ca. 100 m, laterally wedged out within a short distance. The Member is poor in fossils.

The pebbly rock used to fill up the submarine canyon and remained as alluvial fans at the deltas of rivers flowing down from the Bükk, which "emerged" from the sea in the Oligocene. This is confirmed by that the gravel material originates exclusively from the Bükk, by the elongated shape of the sedimentary body and its wedging towards south, and by sedimentological indicators of the gravity-driven mass movement of the deposited clasts in the form of a mudflow (fluxoturbidites). The paleo- sea was approximately 50 to 300 m deep. The gravel material probably originates from the resedimentation of a previously deposited gravel mass (e.g., the Late Eocene Kosd Formation).

Formations of the Noszvaj Member can also be studied in the Vesszős gravel quarry near Noszvaj and also in the cellars of Nagyimány, Noszvaj.

33. Petrified vineyards in Istenmezeje

Noé vineyard; Istenmezeje

The Novaj Formation and the Eger Formation lead us into the Miocene from the end of the Oligocene. At that time, various clastic sedimentary (e.g. sandstone, siltstone, marl) and pyroclastic (volcanic clastic) rocks were deposited in the Bükk region. Sandstone sequences of the Early Miocene Pétervására Formation cover large areas in the western and northwestern parts of Bükk Region UNESCO Global Geopark. One of the most spectacular outcrops of this formation is in the outskirts of the village Istenmezeje in the valley of the river Tarna.

Formed at the onset of the Miocene (Eggenburgian epoch; ca. 23 to 19 million years ago), the Pétervására Formation is predominantly made up of fine- and coarse-grained sandstone several hundred metres thick, deposited in the shallow seashore zone of the Paratethys that once undulated here. The formation generally has a yellow, greyish-white or greenish-grey surface, composed of sandstone with carbonate cement, cemented to varying degrees, featuring conglomerate intercalations. The sequence is characterised by large-scalecross-beddings, indicating coastal currents and tidal activities.

In sandstone-covered areas, the diversity of forms is very spectacular. Their formation is related to varying degrees of the cementation of the sandstones and subsequent weathering processes. The calcium carbonate source for the calcite ($CaCO_3$) cement in these hard „stone loaves" was provided by the dissolution of calcareous fossils, such as bivalve shells, embedded within the sandstone. During diagenetic processes, that is, the formation of sedimentary rocks, calcite started to crystallise around certain points from the pore solutions. As they grew in a circular or layered manner, grains were actually glued to each other and cemented in the sandstone block. Thus, hard carbonate concretions of various shapes and sizes were formed inside the looser sandstone over a long period of time, nowadays reemerging from the matrix of softer rocks as a result of erosion.

Folk tradition links interesting legends of crime and punishment to the formation of these rows of loaf-shaped concretions reminding us of devastated rows of vines. Such legends are told in various versions. One says that a pregnant woman or a beggar or Jesus Christ and the apostle Peter, in other versions, wanted grape but the vineyard owner did not give them the fruit, so he petrified. Someone living in Istenmezeje said that the area called Noah's Vineyard got its name after a rich landlord who did not give grape to an ill little girl, so he turned to stone together with all his vineyard after being cursed by the child's mother. Here let us note that such loaf-shaped concretions were believed to be petrified cannonballs of the Turks in the Salgótarján area. There is another interesting feature of Noah's Vineyard, is the apse of an 18th-century chapel carve in the bottom of a cross-bedded sandstone wall, closed by an iron grate.

34. Stone relics carved into the tuff of Egerszalók

Betyárbújó and Kőasszony; Egerszalók

The name of Egerszalók evokes the so-called "Salt Hill" on the southern outskirts of the village in most people. This hill is actually a spectacular travertine mound formed by the mineral precipitation from hot thermal water reaching the surface. However, the area of Egerszalók is mainly built up by Miocene volcaniclastic (pyroclastic) rocks, where natural erosion processes and human activity created special landforms.

Volcanic activity began in the Ottnang epoch of the Early Miocene (about 18 million years ago) and ended in the Badenian/Sarmatian epoch of the Middle Miocene (about 14 million years ago) in the region called Bükk Foothills. Long but interrupted explosive volcanic activities resulted in volcaniclastic rocks several hundred metres thick, instead of lava rocks. Acidic rhyolite and dacite lapilli tuffs, tuffs, tuff breccias and tuffites surged down the sides of the volcanic structures as avalanche-like glowing pyroclast flows or were deposited after falling back from the atmosphere. The material of the pyroclastic sequence of various colours, sometimes welded, containing torn rock fragments and pumice originates from eruption centres buried by younger sediments in the southern foreland of the Bükk Foothills. The erupted material was deposited mostly under terrestrial conditions, though some pyroclasts fell into lacustrine and marine environments, too.

Let's walk up an east-oriented small path from Ady Endre Street, Egerszalók, to the so-called Betyárbújó (Outlaw Shelter) on Öreg Hill. Betyárbújó is also classified as a beehive stone, too. The haystack-shaped stone hut was carved into the rock with a 2×2 m base area with a solitary beehive stone niche to be discovered on its surface with carvings from unknown times. The surface of the cone-shaped beehive stone reveals typical characteristics of rhyolite tuff (Harsányi Rhyolite Lapilli Tuff Formation), that is, pumice formed from foamed rhyolite magma, fragmented magmatic rock pieces (lithoclasts) embedded in the rock texture, darker weathering crusts of the rhyolite tuff surface, red-

dish bands oxidized along the fractures, and rock surfaces furrowed by runoff water. Walking 250 m southeast from the rock offering a beautiful view, there is another small outlaw shelter.

Between the previously mentioned "Salt Hill" and the southern edge of Egerszalók, we find Menyecske Hill, with several rock groups on it. On its southwestern side, a lonely rhyolite tuff cone rises without niches, called Kőbojtár (Stone Shepherd). To the north lies the Kőasszony or Kőbújó (Stone Woman or Stone Shelter), a tuff shelter with stone niches and stone beds. Menyecske Hill used to be the village pasture, and this latter may have been used night shelter for herdsmen. East of these two rocks, there are two rock ranges, into which four beehive stone niches were carved by ancient people. It is also worth visiting the cave dwellings in Sáfrány Street, presenting local history in the exhibition within.

35. A message from the cave dwellings carved into the Noszvaj rhyolite tuff

Pocem, Caves Art Colony; Noszvaj

With its wonderful natural environment, Noszvaj is notable not only for its built heritage (for example, the De la Motte Castle and the Peasant House), but also for its geological values. In addition to exposures presenting Oligocene sediments, Miocene pyroclastic rocks also occur in a large area in and around the village.

Noszvaj features forms of the lithostratigraphic unit formerly referred to as the "lower rhyolite tuff" (Gyulakeszi Rhyolite Tuff Formation), now called the Tihamér Rhyolite Lapilli Tuff Formation. Clasts once falling (mainly) to the land surface were formed during explosive volcanic activities in the Early Miocene, about 18 to 17 million years ago. As thick as several hundred metres in the Bükk Foothills, this formation originates from volcanic eruption centres assumed to have been located in the southern foreland of Bükk Foothills now covered by young sediments. The formation is predominantly composed of massive lapilli tuff and tuff, sometimes welded, with a varying pumice and lithoclast content. Containing more than 70 % silica, the main minerals of rhyolite tuff are quartz, plagioclase and biotite.

Yellowish-grey rhyolite tuff is easy to carve and that's why it has been used by local people for centuries to make cave dwellings, wine cellars and places for other farming purposes. Without any written record of the making of the first cave dwellings, we can assume that such dwellings were probably made as early as the Middle Ages. Poor landless inhabitants of the village may have been forced to live in cave dwellings at that time because the landlords of the area did not want to enlarge the inhabited area at the expense of arable land which was scarce. Others say that peasants left their homes of their own free will and fled to cave dwellings to escape the burdens imposed by landlords.

The first cave dwellings may have been built in the area called Pocem in Noszvaj sometime in the early 19th century, but we do not have any written sources about it. These dwellings are no longer inhabited, but an art colony was established in the premises. The latter is really welcome, since most such dwellings in the Bükkalja are unfortunately in serious decay. Visiting the premises, we shall find interesting, mystical works that are related to the rhyolite tuff in several senses, and besides, we may also observe the petrological characteristics of the formation. Such are, for example, the pumiceous, lithoclastic rock texture, the weathering, argillation and ironisation of tuff along fracture zones, and also the weathering crust on the surface of the rock. Another interesting feature of the site is that we shall find a carved beehive stone niche above the cornered cave dwelling of this tuff range called Farkas Rock.

Here we should recommend visiting an abandoned quarry in the western side of Láz Peak in the periphery of Noszvaj, where the characteristics of the formation presented above can also be studied on the surface of the 20 m high vertical rock walls cut smooth by quarrying machines.

36. A special tuff gorge next to Cserépfalu

Kőporos Gorge; Cserépfalu

The area of the village of Cserépfalu is mainly built up by the Early Miocene (approx. 18 to 17 million years old) pyroclastic formations of the Tihamér Rhyolite Lapilli Tuff Formation, already described in detail in the previous section. People carved beehive stone niches, cave dwellings, wine cellars, outlaw shelters and stables into this volcanic material, giving rise to a unique stone culture in the region. In addition to man-made carvings, the watercourses etching into the pyroclastic rocks have formed spectacular gorges, of which the canyon of Mész Creek called Kőporos Gorge is an excellent example.

The above-mentioned Early Miocene rhyolite tuff is exposed by Mész Creek, flowing from Hidegkút-laposa towards Cserépfalu. Its spectacular gorge is within an about 2.5-kilometre walk from the centre of Cserépfalu. Formed in a relatively loose ignimbrite rock, this ca. 50 m long, 2–3 m wide and 6 to 8 m high canyon is surrounded by nearly vertical walls. Ignimbrite is a volcanic clastic rock formed by the collapse of an explosive eruption cloud. The resulting hot mixture of clasts of solid particles (such as pumice, rock fragments, crystal and glass fragments) and gases, flowed down the slopse of the volcanic structure like an avalanche. Hence its name, ignimbrite, originates from Latin, words ignis fire, and imber rain "fire rain". The thick blanket of volcanic clasts was deposited in depressions of the one-time primordial surface, in varying thickness. A thin tuff sheet was formed in more prominent areas, while a much thicker volcanic layer was deposited in the deeper valleys. Within the still-hot mass, welding and compaction processes took place due to the sediment's own weight (called overburden pressure) and high temperature, thus creating harder horizons within the pyroclastic rock that became more resistant to erosion. Mész Creek etched into the material of a less welded and more loosely compacted tuff flow containing small and flattened pumice pieces.

Mész Creek was able to form its gorge in the soft volcanic material over a few millennia. Walking in the bed of this creek, which has a significant water flow after spring melts and considerable summer rainfalls, we can witness the continuous change of the gorge. Slow etching still going on today is evidenced by erosion potholes formed by the water flow and retreating rock steps in the bedrock. Terrain obstacles entering the creekbed, such as tree branches, large boulders typically cause sediment accumulation, where deposits 30–100 cm thick may form within a short time.

After walking through the small tuff canyon of Mész Creek, it is worth checking out a hollow road within the tuff above the eastern side of the gorge, with its small outlaw shelter carved into the rock. The western side of Kőporos Gorge features a small terrace previously formed by Mész Creek. Climbing up the hill called Túrbucka, we can observe ignimbrite towers resembling lava formations. If that wasn't enough, just check out the nearby beehive stone called Ördögtorony (Devil's Tower), recently formed erosion gullies on the tuff slope of Ördögcsúszda (Devil's Slide), and the tuff stable with its wide opening on Hidegkút-laposa.

37. A medieval castle and grain stacks in Miocene rhyolite tuff

Cserépvár and grain stacks; Cserépváralja)

The region of the village Cserépváralja is predominantly built up by Miocene pyroclastic rocks (e.g., rhyolite tuff, dacite tuff), and therefore natural and man-made stone culture is also present in the village. The former is evidenced by spectacular gorges, while the latter by beehive stones, cave dwellings and grain stacks.

The main mass of Várhegy (Castle Hill), rising at 265 m, east of the village, is built up by the already presented Early Miocene Tihamér Rhyolite Lapilli Tuff Formation, created by violent explosive volcanic activity about 18 to 17 million years ago. Grain stacks, to be presented later, were also carved into this formation.

However, the cap of Várhegy is formed by a younger pyroclastic rock, called the Tari Dacite Tuff Formation (or Middle Rhyolite Tuff) previously, and the Bogács Dacite Lapilli Tuff Formation now. This formation, being 17 to 16 million years old, that is, of Carpathian-age, is predominantly composed of welded and unwelded lapilli tuff, and of some tuff and tuff breccia, the material of which comes from terrestrial eruptions, pyroclastic flows and fallout pyroclastic material. This approximately 50 to 70 m thick rock was created by several volcanic eruptions in the Bükk Foothills. Its eruption centres are buried now but are likely to have been south of the Bükk Foothills, as mentioned previously. The main mass of the formation is made up of greyish and reddish dacitic lapilli tuffs with a silica content of 65 to 70 %, consisting of quartz, plagioclase, pyroxene, amphibole and biotite. Pumice and lithoclasts are also typical in this rock.

The small cone, formed by Miocene rhyolite and dacite lapilli tuffs, rising out of its surroundings and squeezed between the Lator Creek and the Tardi

Streamlet, practically offered itself on a silver platter in the Middle Ages for our ancestors to build a fortress upon its summit. Built at the end of the 14th century, the fortress was first recorded in writing in 1408. At that time, it was owned by the Queen of Hungary, and later it was transferred to the bishopric of Eger. The Turks were able to occupy it after the fall of Eger in 1596 only, and Turkish soldiers left the fortress in 1687. Later, it no longer played a significant role in history, and its stones were transported for building a new castle for the new owner, the L'Huillier family.

The twelve pear-shaped granaries carved into the southwestern side of Várhegy, the upper parts of which open to the surface in the form of squares, are also extremely important from the perspective of geology and cultural history. Also mentioned in the inventory of 1568 when they were filled with barley from the Tard estates, the granaries are 4.5 to 9.5 m deep and have a diameter of 3 to 6.5 m. In addition to their unique cultural and historical values, the granaries are also considered geological exposures, revealing the Miocene rhyolite tuff of the hill.

Pay a visit to the beehive stones of the Cserépváralja region, too. Such are, for example, Mangó Peak, Furgál Valley, Csordás Valley, as well as the ignimbrite gorge of Felső Gorge. The Cave Dwelling Exhibition is also worth visiting.

38. The cave dwellings of Tibolddaróc from a geological perspective

Cave dwellings, Tibolddaróc

The area of the village of Tibolddaróc is predominantly made up of Miocene pyroclastic rocks, slightly younger than the volcanic clastic formations presented so far. These are classified as the Harsányi Rhyolite Lapilli Tuff Formation.

This pyroclastic formation was deposited during explosive volcanic activity during the Badenian epoch of the Middle Miocene (ca. 15 to 14 million years ago) can be as thick as 100 metres in the area. This greyish-white, rhyolitic rock is basically composed of lapilli tuff with pumice, and to a lesser extent of tuff as well as tuffite and resedimented volcaniclastite. Clasts accumulated from pyroclastic density flows and ash clouds, mostly on the land. This rock contains lithoclasts and pumice, too, the size of the latter being up to 30 to 40 centimetres in the Tibolddaróc area. Gas escape channels and carbonised plant remain can also be present here and there in the volcanic clastic rock. Poor inhabitants of Tibolddaróc built their homes into this Baden volcanic clastic formation since it was easy to carve.

Inhabited since ancient times, Tibolddaróc features largest numbers of cave dwellings in Hungary and also in the Bükkalja, as; for example, 60 % of the village's residents lived in such cavities in 1930, meaning that 1,463 people lived in 215 cave dwellings. Statistical data of the village reflected it in an interesting way during this time, as the population was constantly growing but at the same time, the number of built houses decreased, thanks to the constant proliferation of cave dwellings. The reason is that the arable land in the Tibolddaróc region amounting to 3,000 hectares was owned by a few major landowners. The majority of the village's inhabitants were smallholders farming only a few hectares, and 1,900 out of the 2,200 people inhabiting the village were landless. Such poor families lived in cave dwellings, as they could not find any other way to live, and landlords would not let any arable land go for the purposes of house building.

Partly caused by social pressure, the government started to eliminate these unhealthy and often life-threatening shelters, where usually several generations lived together, in the Horthy era. Thanks to the construction of new residential areas in the village, the number of the residents of cave dwellings fell to 29 by 1970, and the last cave dweller was an elderly man in 1986. Nowadays, one-time cave dwellings function as wine cellars or are used for tourism. Many of them have already decayed, partly due to their being planted with goji berries and some of them were exploded. Cave dwellings, located on several levels, can be visited from Vörösmarty Street on the north-western edge of Tibolddaróc. It is also worth walking up to the lookout tower on the hilltop, to enjoy the wonderful panorama of the Bükk Foothills.

39. A last reminder of one-time coal-mining in the Bükk

The coal loader of the Egercsehi mines; Mónosbél

Arriving at the settlement of Mónosbél, we are welcome by a huge wooden monster with the inscription “Egercsehi szénbánya szénrakodója” (The coal loader of the coal mine of Egercsehi). A visit to this industrial monument takes one back to a time when coal mining was still going on throughout the Bükk.

Approximately 16 to 15 million years old, the Salgótarján Brown Coal Formation is located in the Early and Middle Miocene sequences of areas west and north of the Bükk. The buried plant material of one-time marshy and swampy seashores underwent carbonisation under the influence of increasing pressure and temperature, turning into brown coal. Here in the West Borsod basin, the coal seam formation consists of five main seams and accompanying seams, mostly paralic, that is, formed in a seashore environment. Coal seams are surrounded by clastic sedimentary formations, considered dirt from a mining perspective, especially aleurite, sand and sandstone. However, resedimented rhyolite tuff and tuffaceous clay also appear at the bottom of the sequence. Such Miocene brown coal seams have been exploited by the people of the Bükk for centuries.

The coals of the Bükk region were explored as early as in the 1760s, including in the periphery of the villages of Bélapátfalva and Egerbakta, to be primarily used for brickmaking. From the mid-19th century, industrial coal production began in the Szarvaskő and Bátor regions, too. The most significant underground mines in the region operated near the villages of Egercsehi, Szúcs and Bekölce between 1891 and 1990. Next to Szúcs, landowner György Beniczky opened a coal mine called Antónia Adit in 1891 on a previously known coal outcrop. This was when continuous coal production in the region began. In order to exploit coal seams under the above-mentioned villages, the Egercsehi Coal Mining Company was founded on 27 December 1906, to implement major large-scale investments from the following year on. These mines, considered modern with their continuous developments, not only developed the infrastructure of the villages, but also transformed their social structure, the workers of the mines formerly being peasants.

Since coal mines were far from the railway lines, the transportation of coal to the consumers was a problem. To solve the issue, an 11.5 km long cableway was built from the mines to the Mónosbél loader. Side branches of the Y-shaped cableway ended in the Lipót and Ödön Inclined Shafts. A sorting plant with a coal washer, dryer and settling basins was also built next to the loader, completed by 1911. The latter was necessary because the extracted “mine coal” was not yet suitable for use due to its sand content. For example, the Hungarian Railways accepted sorted (cube- and nut-shaped) coal only.

Coal mining in Egercsehi ceased on 31 January 1990 when the last mine car transporting coal came up from what used to be the largest mining plant in the region at noon. Not much remains of the memories of one-time coal mining. One of the last survivors is the construction of the former coal loader, now an industrial monument next to the Mónosbél railway station.

40. Seashore with breaking waves in the northern edge of the Bükk

Disused pebble quarry; Dédestapolcsány

Halfway between Dédestapolcsány and Nekézseny, south of the highroad, the sedimentary rock of a disused gravel quarry awaits us, providing an insight into the marine sedimentation of the Bükk region in the Miocene.

Northern areas of the Bükk witnessed marine sedimentation during the Carpathian and Early Badenian epochs of the Miocene about 16 to 15 million years ago, during which thick clastic sedimentary sequences were deposited. In the area of the villages of Dédestapolcsány, Nagyvisnyó and Nekézseny, the so-called Égeralja Gravel Member of the Egyházasgerge Formation records the initial stage of marine transgression, when the sea was bordered by steep and rocky shores consisting of Late Permian and Early Triassic carbonate cliffs. These cliffs were ground by erosion activity, that is, abrasion, by seawaves, resulting in layers of limestone and dolomite cobbles deposited on the shoreline, sometimes up to 10 m thick. This seashore formed by the Late Permian Nagyvisnyó Limestone Formation can be studied in the disused quarry located on Határ Peak, Nagyvisnyó, while the seashore formed by the Early Triassic Gerennavár Limestone Formation here, in the gravel quarry in question.

The entrance to the quarry featured a cliff made of Early Triassic limestone previously, the surface of which was perforated by piddocks. Moving eastwards from here, quarry walls reveal an increasingly thick sandy gravel formation. Limestone and dolomite grains are unsorted, being of various grain sizes, and rounded to varying degrees. This poorly layered rock slopes flat towards east. Such features can lead us to conclude that this clastic rock was formed locally, and the limestone cliff material protruding from the Miocene Sea had been shaped and accumulated by seawaves. This high-energy seashore environment was populated by a special flora and fauna. Holes created by piddocks can also be observed on the surface of cobbles and large boulders, too. In addition to the traces of boring sponges, we can find Ostrea shell fragments, Balanus attached to cobbles, and, rarely, shark teeth.

In the northern wall of the quarry, the sequence is gradually refined from east to west, with sand becoming dominant, while pebbles appear only as small pebble cords and lenses until disappearing completely. Such finer-grained sediments were deposited on a calmer and quieter seashore, below the wave base. This is indicated by thin-shelled shells (such as Chlamys) and small snails. The mud surface of the seafloor was torn up by larger storms only, appearing as clay lentils in the sandy sediments.

The quarry entrance reveals a cross-section of a Pleistocene creek bed filled with alluvium, too.

41. A solitary volcanic cone closely embraced by the Mátra and the Bükk

Várhegy, disused quarry; Tarnaszentmária

On the western border of Bükk Region UNESCO Global Geopark, a small volcanic cone called Várhegy (Castle Hill), truncated by quarrying, emerges shyly from the valley of the River Tarna in Verpelét. This geosite is the odd one out in the Geopark, since its formation and rocks clearly link it to the mountain Mátra.

The main mass of the Mátra was built in the middle of the Miocene, in its Badenian epoch, about 16 to 15 million years ago. Huge stratovolcanoes tended to produce andesitic rock types, including lava rocks reflecting quieter volcanic activities as well as explosive pyroclastic rocks, such as andesite tuff. The alternation of such eruption products builds up the main mass of the Mátra, with a thickness up to several thousand metres in some places. Stratovolcanic rocks assigned to the Nagyhársas Andesite Unit of the Mátra Andesite Complex form the material of Várhegy. Officially belonging to the municipality of Tarnaszentmária but closer to the inhabited area of Verpelét, Várhegy rises about 60 m above its surroundings. Further away from the main mass of the Mátra, this small solitary eruption centre was formed at the end of the aforementioned long volcanic activity, in its fading phase.

This small volcanic cone of a diameter of about 250 m is surrounded by Holocene fluvial formations of the Tarna alluvium and marine sedimentary formations of the middle Miocene (Sarmatian) Kozárd Formation. The volcano of Várhegy was created by the alternation of the above-mentioned explosive and effusive (lava-pouring) events, and therefore volcanic clasts and lava rocks are present in its structure alike. The volcanic cone and its fan are mainly composed of pyroclastic rocks (andesite tuff), the grain size of which gradually decreases moving away from the former crater. Pyroxene andesite lava plug rocks, solidified in the pipe of the one-time small volcano and considered of good quality from a petrophysical and technical point of view, was quarried here.

An 1892 report by the Miskolc Chamber of Commerce and Industry described the Várhegy quarry in Verpelét as one in which 100 daymen and 25–50, mostly Italian, stonemasons worked there every day. Quarrying activity that continued until 1934 opened the interior of the andesite volcano to reveal formations of the Miocene volcanic activity. Strongly cracked and brecciated andesites, sometimes displaying exfoliation, and andesite tuffs weathered to the extent of argillisation (seawater sedimentation) can be well studied in the walls of the one-time open pit and on both sides of the road cutting entering the quarry yard. The inner wall of the crater also displays traces of fumarolic gas outflows, argillic and sulfate rock transformations, and also post-volcanic silica precipitation.

We should not forget about the medieval fortress on the top of the volcano. It was still there during the 1848–1849 War of Independence and its last remnants were finally cleared away by quarrying.

42. Ice Age layers within Bükkszenterzsébet

Pleistocene key section; Bükkszenterzsébet

Between the towns of Pétervására and Borsodnádasd, a village called Bükkszenterzsébet lies in a picturesque setting at the foot of the region of Vajdavár, along Leleszi Creek and Darázs Creek. It is worth roaming in the village for a while to study a geological key section, presenting the most complete Pleistocene (Ice Age) sequence of the region at the junction of Szabadság Street and József Attila Street.

The significance of this locally protected geological key section lies in the two paleosols (fossil soils) revealed in the sequence, as well as in the fact that it was the first place in Northern Hungary where formations previously thought to be Late Pleistocene were confirmed to have been formed in the Early and Middle Pleistocene, based on fossil remains found in the sediments. Near the village, Quaternary formations appear in patches, deposited on the uneven surfaces of Late Oligocene and Early Miocene schliers and sandstones.

The lowest and oldest, 1.5 m thick horizon of the exposure is composed of cross-stratified river pebbles and sand. A 0.5 to 1.5 m thick argillaceous aleurite sedimented in a marshy floodplain is deposited on top of this, with a Mollusc fauna indicating marsh formation characterised by slow-flowing water. The next horizon is the lower paleosol of the exposure, ranging in thickness from 0.1 to 1.5 metres. Based on its Mollusc fauna, the lower part of the layer is a marsh soil formed under stagnant water or a marsh mud rich in humus. In the upper level, we can trace processes following the accretion and getting subaerial exposure of the area. A 0.5–1.5 m thick river sand with small pebbles and mud was deposited on the unevenly eroded surface of the paleosol. The rhinoceros (Rhinoceros etruscus) tooth fragment discovered here indicates the Early and Middle Pleistocene. This is followed by the upper paleosol of the exposure with a thickness of 1.5 to 2 metres, then the exposure is closed by the so-called "Palóc" loess (max. 1.8 m) and recent soil 10 to 20 centimetres thick.

Summing it up, the lowest layer seems to be a terrace formation of a major Ice Age River. Due to a change in the orientation of the river, or possibly a decrease in its discharge, the grain size of the sediment refines moving upwards. Later, it was disconnected from the living river and lakeand, afterwards, swamp sediments were deposited. The first soil layer was deposited under similar climatic and vegetation conditions as the soil levels of our loess formations. The next layer is again a fluvial formation. The rhinoceros species found in this became extinct at the end of the Mindel glacial period. Characteristics of the Mollusc fauna refer this layer to the Mindel 2, and the sequence below it to the Mindel 1–2 interstadial. The next, also double, soil level following the sand layer is therefore a Mindel–Riss interglacial sediment.

43. Sedimentation in progress in the valley of Sebes Stream

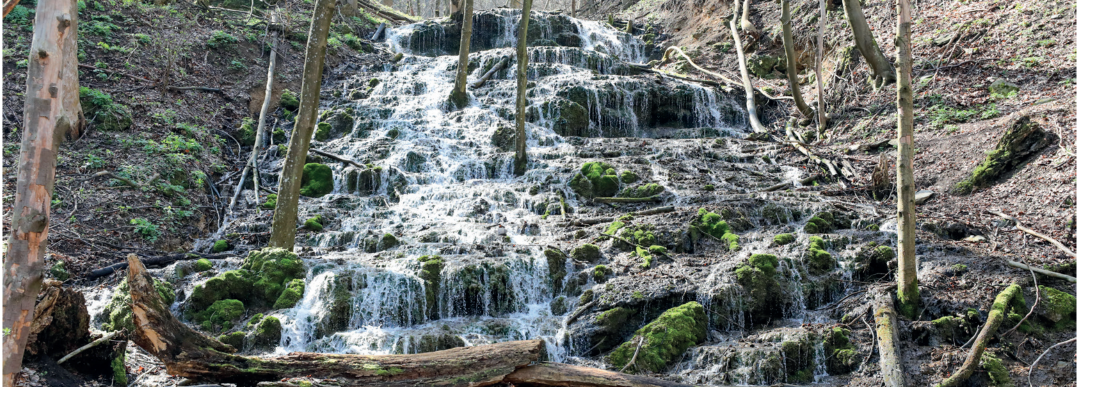
Alsó-Sebes Stream; Miskolc–Újmassa

On the southern side of Garadna Valley, short valleys run down from Bükk Plateau, losing several hundred metres towards the valley bottom. A well-known highlight, also a marked tourist trail, is Alsó-Sebes Stream), with one of the most wonderful Pleistocene travertine accumulations throughout the Bükk region.

Since the main mass of the Bükk, including Bükk Plateau, is mainly built up of well-karstified Triassic limestones that are easily soluble by carbonated water, the dissolved carbonate content of karst water moving under the surface is significant. Carbon dioxide keeping the balance of the calcareous solution in karst water emerging from the depths to the surface through spring mouths leaves the system sooner or later. As a result, solid calcium carbonate may precipitate closer to or further from the spring mouth, and significant accumulations of travertine (freshwater limestone) may form. The precipitation of calcium carbonate dissolved in water and the degassing of carbon dioxide are also assisted by the vegetation covering a large surface, such as algae and mosses, and by objects in the streambed, such as rock steps, tree trunks, tree branches. When the surface area increases, the so-called surface tension decreases, thus facilitating the precipitation of calcareous material. The best-known travertine blocks can be found in Szalajka Valley called Fátyol Waterfall, in the Lillafüred area (Szinva Valley Garadna Valley), and on the outskirts of Mónosbél (Darázskő Quarry).

Sebes Stream disappears in the sinkholes of the plateau above the valley, on the border of the Vesszős Formation and the Bükkfennsík Limestone Formation, reappearing again at the Huba Spring in the valley. Water emerges from a spring cave here, also at a rock junction, namely that of the aquiferous Bükkfennsík Limestone Formation and the water-retaining Szentistvánhegy Metavolcanite Formation. Water flowing out of the cave proceeds over a wide, horizontally spreading ridge with a small drop of 50 metres, in a shallow bed. Then, reaching the edge of the dam, it begins to form a series of waterfalls dotted with dams and ponds (on metaandesite bedrock). The tetarata system forms a convex travertine cushion of a length of about 500 m, a width of 45 m, and a height of 8–10 m, with a triple facade. Along Sebes Stream, you can find the deepest ponds confined by rimstone dams, often as deep as 80 cm, as compared to other Bükk travertine deposits.

Boasting a high-mountain atmosphere, the valley features not only geological processes going on before our eyes, but also the rock sequences deposited hundreds of millions of years ago. From the upper section of the valley towards Garadna Valley, we cross increasingly older Triassic formations, following an anticlinal structure, with a reverse fault plane in between. The Bükkfennsík Limestone Formation and Szentistvánhegy Metavolcanite Formation mentioned above are followed by the Hámor Dolomite, the Ablakoskővölgy Limestone Formation, and then the Gerennavári Limestone Formation. Close to the base of Garadna Valley, the deposit is a Late Permian Nagyvisnyó Limestone Formation.



44. Travertines in Darázskő Quarry in Mónosbél

Darázskő Quarry; Mónosbél)

One of the largest travertine accumulations in the Bükk region and also Europe, the 15-hectare hill of the protected Darázskő Quarry, equipped with Geopark information boards, hides shyly on the outskirts of Mónosbél.

This yellowish and greyish-white, porous and cellular freshwater sedimentary rock (freshwater limestone or travertine), containing plant and animal fossils, is one of the youngest geological formations of the Geopark, going back to a few hundred thousand years only instead of hundreds of millions. Exposed in a length of 400 m, a width of 600 m and a thickness of 25 to 30 m, the volume of the semicircular, double-rimmed travertine hill is estimated to be 5 million cubic metres. Its floor consists of Triassic cherty limestone and Miocene (Carpathian) sand. This large travertine body was created by the predecessor of the Vízfő springs flowing out at an altitude of 400 m from the western side of Hársas Peak. The water of the spring is slightly warmer (13 to 14 °C) than other cold karst springs in the region. The rock material of Darázskő Hill was precipitated from these karst waters of a high dissolved carbonate content. We discussed the process of travertine precipitation from supersaturated calcareous waters in more detail in the previous section.

Written sources prove that travertine on the periphery of Mónosbél was quarried as early as in the 18th century but had probably been known to the population of the area even earlier. People called it "darázskő" in Hungarian (meaning wasp stone), referring to its structure resembling a wasp's nest. The quarry was definitely operational in 1794, because this rock was used for the restoration of the facade of the abbey church in Bélapátfalva. Statistician Elek Fényes mentioned it in 1851 and archaeologist Gyula Bartalos in 1892. In 1904, the quarry was owned by municipal landowners. At that time, this hard but low-density rock, which was easy to saw and process and also had good heat-insulating properties, was used for construction purposes, including chimney construction. About 100 cubic metres were produced from the quarry annually. The softer travertine deposited in the Darázskő Quarry block was ground, with the lime dust used for the improvement of saline soils in the Hungarian Great Plain or for whitewashing after sieving. However, surfaces whitewashed by this travertine powder could not withstand plastering.

In 1955, planned mechanised quarrying replaced manual extraction, and went on until 1959, causing irreparable damage to the travertine which used to be full of cavities. We suppose that one of these caves collapsed or was filled up during quarrying might have been the third longest travertine cave in Europe and the second longest in Hungary. Smaller cavities visible today end up in debris after a few metres.

45. Mystical bogs deep inside the Egerbakta forests

Lake Baktai; Egerbakta

Lake Baktai or, more precisely, the Lake Baktai Complex lies northeast of the village of Egerbakta, in the forested area of Tó Hill, a 3.5-kilometre walk from the centre of the village following the red tourist trail marker. These peat moss bog lakes have been protected as nature reserves since 1978.

Located inside the ridges of Tó Hill arranged in a regular circle, the origin of the lakes has long been studied by experts. Just like other peat bogs in northern Hungary, the beds of these lakes are considered to originate from an Ice Age landslide, after which the depressions were filled with groundwater and rainwater. The lake region is built up by Miocene pyroclastic rocks (Harsány Rhyolite Lapilli Tuff Formation) and clastic sedimentary rocks (Salgótarján Brown Coal Formation, Kozárd Formation). Geological formations here also include siliceous rocks, such as hydroquartzite, siliceous sandstone and quartz varieties (opal, jasper).

There are three larger lakes called Lake Baktai or Lake Nagy, Lake Kis and Lake Felső and several small lake beds on Tó Hill. Lake Baktai is at an altitude of 285 m above sea level, with a regular circular ground plan, and a diameter of 110 m. Lake Kis is located at an elevation of 280 m , its elliptical bed having a longer diameter of 90 m, while the shorter one is 70 m. The highest lake basin (315 m) has a diameter of 50 m. This one is called Lake Felső and water is only temporarily present in it. Next to the three large lakes, there are five small, circular depressions without water at even higher elevations.

With thorough botanical and zoological research taking place for more than a century, the research history of the Lake Baktai Complex is one of the longest as regards bogs. In the lake complex, surrounded by Turkey oak forests and oak-hornbeam forests, Lake Kis and Lake Felső are in the late phase of sedimentation. These are characterised by bog shrubs (willows), swamps and small peat moss bog remains. The basin of Lake Nagy, on the other hand, has an open water surface in its central part of nearly 3,000 square meters. The area is covered with duckweed for most of the vegetation period. Towards the shore of the lake, vegetation typical of bogs and swamps is present, dominated by bulrush, but hop sedge also appears. A floating bog islet appeared on the surface of Lake Nagy, too, tending to change its location. The advanced bog-forming processes in the lake are indicated by peat moss appearing in the grey willow border. Regarding the fauna of the lakes, reptiles and amphibians, as well as birds, are worth highlighting. Of the latter, the mallard, the little grebe and the black stork frequently visit the Lake Baktai Complex.

Please take extra care not to leave the marked tourist trails.

46. A Quarternary bog in the Nyírjes in Sirok

Sirok; Lake Nyírjes

Following the route of the National Blue Trail, a tourist trail marked with information boards diverges from Nyírjes Street within the village of Sirok to the northwest. After walking 600 metres on this path, we come upon the only real bog in the Mátra called Lake Nyírjes in the Sirok Lake Nyírjes Nature Conservation Area, protected since 1961. Two botanists, namely Imre Máthé and Margit Kovács discovered the bog in the summer of 1957 and were the first to report on its plant species.

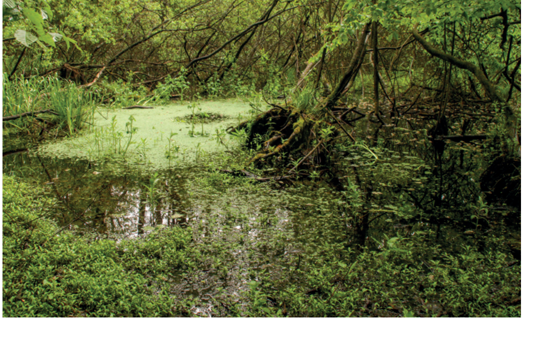
Lake Nyírjes, located southeast of Darnó Hill, on the side of Cinegés at an altitude of 210 m above sea level, has an area of 1 hectare. This 3 m deep, closed lakebed was formed on Miocene rhyolite tuff bedrock, covered by dark grey, water-retaining argillaceous silt. Lake Nyírjes, fed exclusively by rainwater, is surrounded by Turkey oak forests and oak-hornbeam forests.

180 m long in a northwest-southeast direction and 80 m wide, the alluvial basin of Lake Nyírjes was formed 10,000 to 9,500 years ago, at the beginning of the Holocene. This was determined based on the results of peat drilling conducted at Lake Nyírjes. A system of clear and deep-water lakes, referred to as oligotrophic, developed in the place of the future bog of Lake Nyírjes some 9500 to 7500 years ago. The peat bog kept expanding for a short time in the open-water lake 8200 years ago. The oligotrophic state, meaning that it was poor in nutrients, developed in a cool and rainy climate, where the main water source was precipitation, and therefore the dissolved salt content of the water was minimal.

This oligotrophic state was replaced by a mesotrophic state in Lake Nyírjes with shallow water some 7500 to 2300 years ago, where the water level showed a strongly fluctuating and then rising tendency. Drilling samples revealed the remains of oaks indicating the type of the one-time deciduous forests surrounding the lake. Some 6800 to 3900 years ago, the peat bog expanded for a shorter period, due to a rainier and cooler climate. Mesotrophic lake and bog systems were still fed by precipitation, but water richer in minerals and nutrients washed in from the watershed surface gained an important role, too. The mesotrophic state was replaced by an oligotrophic one again 2300 years ago, and from then on, peat moss kept disappearing and reappearing due to cooler climate periods. The quantity of peat moss suggests that the coolest summers of the past 3000 years were in the middle of the Little Ice Age, at the end of the 16th century, but at least five cooler periods occurred before that.

Lake Nyírjes has gradually dried with the peat bog degrading for the past 400 years. Human intervention caused intensive soil erosion around the bog basin, parallel to the eutrophication of the system. The chemistry of eutrophic bogs was linked to a significant amount of dissolved groundwater and water washed in from the surface of the watershed. It is interesting that the analyses of peat drilling indicated significant deforestation in the area of Lake Nyírjes in the second half of the 13th century. It coincides with the period of the construction of Sirok Castle. Thus, the wood needed for the castle could have been provided by the forests around the bog (e.g. oak, linden, ash, and hornbeam).

When visiting Lake Nyírjes, please take care not to leave the marked tourist trails.



47. Lake Arló formed by a landslide

Lake Arló; Arló

In the Bükk Region UNESCO Global Geopark, there is a small village called Arló not far from Ózd, embraced by hills. Geographers or those proficient in geography may associate Arló with a lake, a textbook example of lake basins formed by mass movement.

Lake basins can be formed on the surface of the Earth in many ways. Long, narrow and deep lake basins can be shaped by tectonic subsidence along fault lines. Deep and rounded lake beds can be created in crater or caldera structures resulting from volcanic activities. Glacial abrasion, wind erosion, karst dissolution, and the cutoff of river meanders can all also create water-filled depressions. In Arló, it was mass movement that formed the lake bottom, not too long ago.

Hills around Arló are made up of Miocene marine sediments and sedimentary rocks. Of these, the argillaceous, silty and sandy formations of the Early Miocene Zagyvapálfalva Formation formed on riverbanks and floodplains, as well as the Early and Middle Miocene Salgótarján Brown Coal Formation, described in detail earlier, are worth highlighting. The material of this thick sedimentary sequence is extremely heterogeneous, with coarser-grained sands occurring along with finer-grained silt and clay. So we can say that sedimentary horizons conducting water either well or poorly alternate. The properties just mentioned play an important role because fine-grained clays block the path of water seeping from the surface into the depths. If the clay is water-soaked, it will serve as an excellent slip plane for the sediments deposited above it. This is what happened in the case of Csahó Hill, high above Arló Creek.

A landslide is a type of mass movement in which displacement occurs relatively rapidly along a well-defined surface, known as the slip plane. In the sedimentary mass of Csahó Hill, the sedimentary rock mass moved along the slip plane of a more argillaceous layer on three occasions (in 1863, 1910, 1929). This is how a ca. 300 m long and 50 to 60 m high articulated headwall was formed. The collapsing huge mass blocked the course of the creek flowing below in Szohony Valley, causing it to swell, and this is how Lake Arló, or more precisely, its basin was created. Brown coal mining in the area also played a role in the development of the mass movements, as the slopes lost their stability due to the collapse of the former mine openings and the subsidence of the surface. The picture clearly demonstrates the unevenness resulting from the landslide. The lake now serves tourism, with a resort area built around it.

48. Remnants of ancient ironworks in the Bükk

Fazola Furnace; Miskolc–Újmassa)

The territory of historical Hungary was extremely rich in mineral raw materials, including ores. A typical deposit of iron ores was the Bükk, where industrial activities based on iron ores, such as mining and iron smelting, began as early as in the 18th century.

During the reign of Queen Maria Theresa, it was Count Ferenc Barkóczy, Bishop of Eger, who invited a Würzburg blacksmith, namely Henrik Fazola (1730–1799), to Eger. Fazola was one of the most talented ironworking experts of his time. Fazola spent the wealth he gained from his activities on the research, exploitation and use of the iron ores of the region. Then he began to implement his dream plan, the construction of the Ómassa Furnace. Fazola researched for ores first in the region of Uppony, Nekézseny and Dédestapolcsány in the 1760s and 1770s, and then continued it in the Bükk.

These ores formed the basis of Fazola's first ironworks to be established in Garadna Valley and Szinva Valley in 1765. The Ómassa ironfurnace (at that time called Felső-Hámor) was put into operation in 1772, with specialists from Styria and the Hungarian Highlands (now Slovakia) employed for its construction and commissioning. After the low-quality iron ore deposits in the Bükk were depleted, and also due to the high transportation costs and the lack of state subsidies, the dreams and money of Henrik Fazola, a pioneer of industrial capital in Hungary, quickly floated away. After his death in 1779, his smelter continued to operate until 1820. Later on, the local school was built from its stones. This was when his son, Frigyes Fazola (1774–1849), entered the scene.

Pursuing his father's dreams, he began to build a charcoal-fired smelter in Újmassa to be completed in 1813. Water at the confluence of the Garadna and Szinva Springs was swelled so that it could provide the smelter with water. Today this is called Lake Hámor. Built on the banks of Garadna Spring, the robust smelter built from ashlar stones was intended to produce molten pig iron from the mined iron ore. 11.4 m high, the smelter stands on four corner pillars, with its three levels resembling a truncated pyramid. There are basket arches on the three sides away from the mountainside. Air was blown into the eastern and western openings. The northern opening was used for tapping. Average daily production was 1300 kg of pig iron. The floor area of the furnace is 9.5×8.5 m, and its working volume is 22 m^3. There were foundries around the furnace to cast household items from the iron.

The furnace was rebuilt in 1831. Iron was last smelted here in 1872. Iron production then centred in Diósgyőr, where production went on with some interruptions as late as until 2009. The original smelter was renovated between 1951 and 1954 due to its quite deteriorated state. Once a year, during the Fazola Days in September, there is a symbolic tapping in the so-called Ancient Furnace of Újmassa, one of the most significant industrial monuments of Hungary. The Massa Museum next to the smelter offers a more thorough look at the history of iron production in the Bükk, while the collection of the Museum of Metallurgy provides an insight into the relics of this famous Bükk industry in Felsőhámor.

49. Ruins of a glassworks village deep inside the Bükk forests

The glassworks of Gyertyán Valley; Répáshuta

Glassmaking stands out among the ancient industries of the region. It provided work to communities living deep in the forests of the Bükk for centuries. The ancient Gyertyán Valley glassworks are where we can still learn about the history of this ancient industry today.

In the Bükk, the first glassworks were founded at the beginning of the 18th century in Óhuta (now called Bükkszentlászló), operating between 1712 and 1750. From there, glassmaking moved to Újhuta (now Bükkszentkereszt) in 1755. Glassmaking was an extremely wood-intensive industry, and it also required a large amount of water. A new plant was founded in Répáshuta in 1790, due to its favourable conditions it had in terms of raw materials and water power. Since its tenants went bankrupt one after the other, the Répáshuta plant and its equipment were purchased by József Schir, a resident of Újhuta, in 1834 to move everything to the Gyertyán Valley.

The Gyertyán Valley glassworks proved to be an excellent choice, also due to the wood and water power available, good transport conditions and the occurrence of quartz sand. The latter was the most important raw material for glass production. Where it was not available, quartz-rich rocks or crushed river pebbles were used. High quartz parts of Triassic silicified metarhyolite were quarried on Bagoly Hill above Bükkszentkereszt. Now there are dents on the ridge in the former quarry's location.

In 1865, the Czech Gusztáv Schusselka leased the plant and it developed into an independent village in the valley far from other villages. Consisting of nine buildings, the glassworks, considered modern for the time but still keeping its small-scale character, included the furnace building, the owner's residence and an office building, the workers' residences, a pub, stables, a barn, and beehives.

Workers of the glass factory were mainly Slovak, Polish and German people from the Hungarian Highlands. During its heyday, 70 workers of the factory produced glass worth 50,000 forints on average annually. In addition to traditional window glass, the plant produced mainly hollow glass, but it was here that glass decorated by polishing, cutting and engraving was made for the first time in the Bükk.

The small glassworks, far from everything, could not compete with the modern manufacturing industry. In 1897, Gusztáv Schusselka went bankrupt, and the Gyertyán Valley glassworks gradually decayed. Stones of the buildings were used to build the road running through the valley. Between 2001 and 2005, archaeological excavations and conservation works were carried out in the area several times, and some old residential houses were given protective roofs.

Nowadays, the landscape is rearranged, and information boards help us to learn about the history of the one-time glassworks. Used between 1843 and 1926, the small cemetery of the glassworks is next to the previously described Koporsós Sinkhole Cave. In addition to the glassworkers and their family members, the Schusselka family is also buried here. There is a belfry northeast of the former glassworks.

50. An exercise in petrography in the walls of a Medieval church

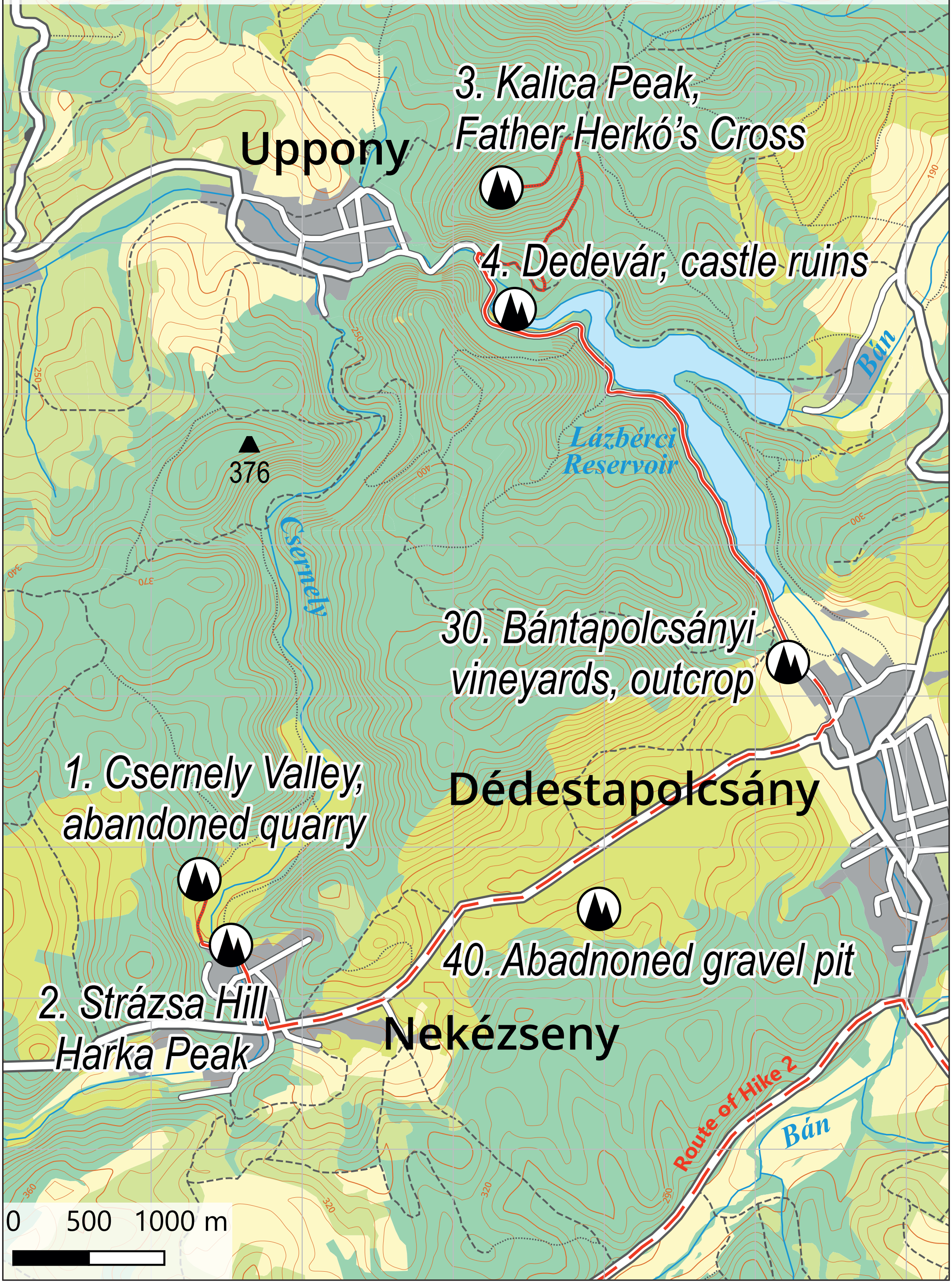
Medieval church; Bükkszentmárton

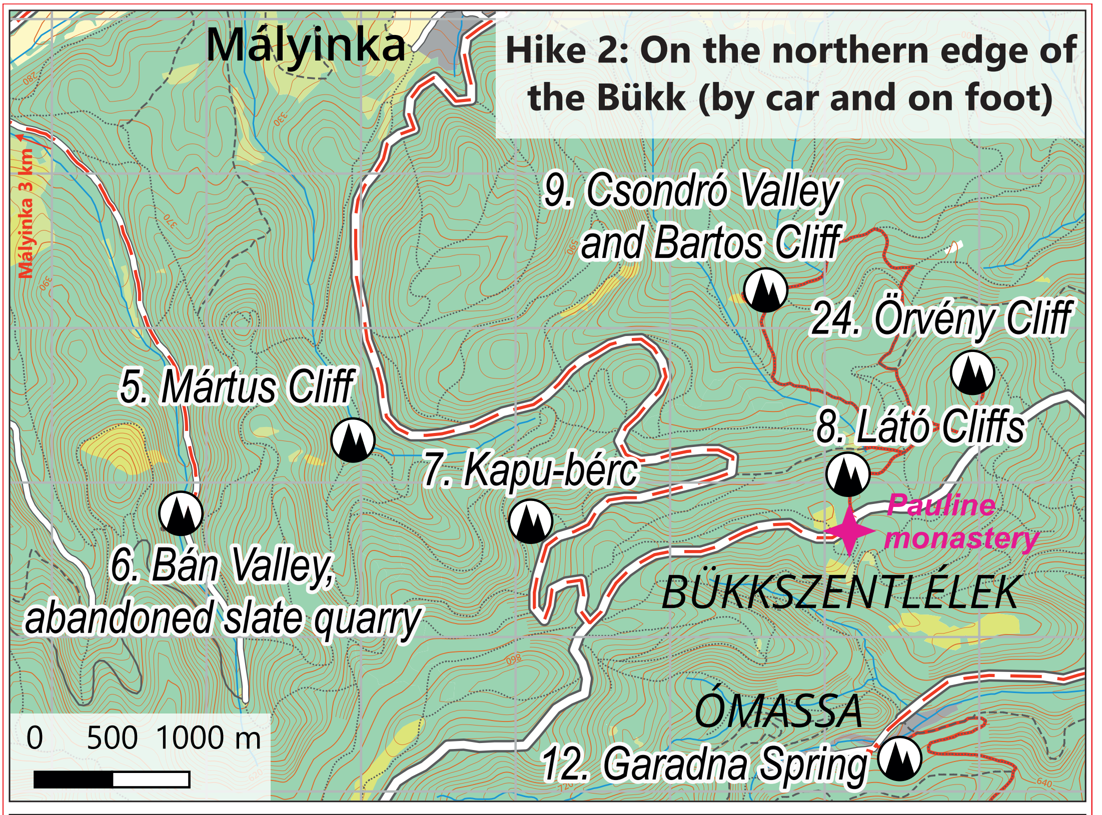
South of the small village of Bükkszentmárton, next to Bélapátfalva, a Roman Catholic church dedicated to Saint Martin is shyly hidden on a small hilltop. Originally built in the Romanesque style, the 12th-century church was destroyed by the Turks in 1554 and after that, the village was also depopulated for a good two hundred years. A hermit, namely István Baranyai, had the church rebuilt from money collected from the people of the area in 1736, using medieval stones and stones from the Cistercian monastery of Bélapátfalva. At that time, a sacristy was added to the north, together with a small wooden tower above the entrance, and the Baroque interior was also completed. The building cannot be visited inside, but there is plenty to see on its exterior.

Having a look at the building stones and decorative stones of the church, most of the rock types making up the area can be observed. Especially in the northern wall, we can encounter a great number of light grey, calcitic-veined specimens of the Middle to Late Triassic Bükkfennsík Limestone Formation, which are, for example, the building rocks of the nearby Bél Cliff. We checked this formation in connection with the geosites of Bükk Plateau. The same wall section reveals reddish and coffee brown decorative rocks with splintery fractures and sharp surfaces, being much younger radiolarites of various ages from the Middle Jurassic. Such rocks were to be found in Nagy Cliff next to Bátor. To the right of the main entrance, dark-coloured, coarse-crystalline plutonic rocks strike the eye in the buttress, namely Jurassic gabbro from the Szarvaskő area. In this booklet, we presented this deep plutonic rock in connection with the Tardos quarry.

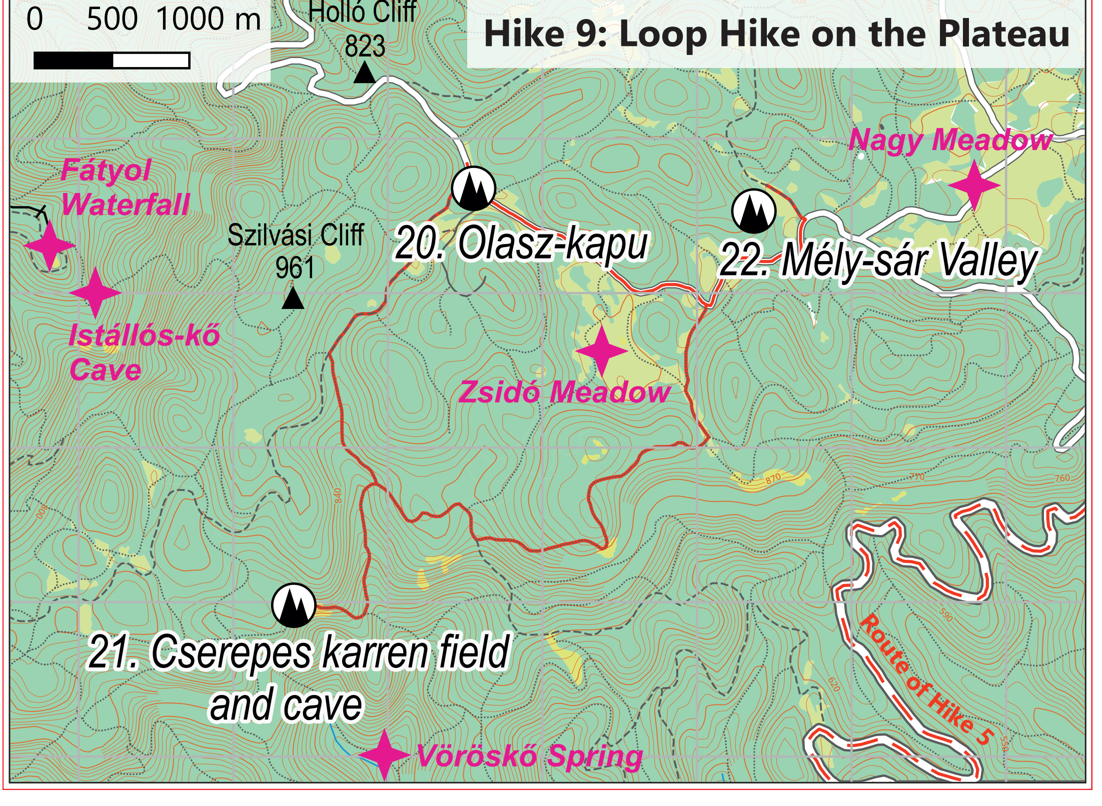
The most common rock in the walls of the church, especially in its southern wall, is a Miocene sandstone, standing out with its yellowish and reddish colour and, in places, its coarse grains. It is this Egyházasgerge Formation that the surrounding hills are mainly made up of. Browsing further, we can recognize Miocene rhyolite tuffs with biotite mica glittering within, but the youngest rocks of the region are also represented by the travertine (popularly called wasp stone). A few hundred thousand years old and precipitated from the water of Bükk karst springs, such rocks had been quarried not far from here, in the periphery of Mónosbél for a long time. The walls also contain reddish artificial building materials, that is, bricks, here and there. Bricks were made by burning fine-grained argillaceous sediments in brick kilns.

Hike 1: NW Gate - the Uppony Mountains and the surroundings of Dédestapolcsány (by car and foot)

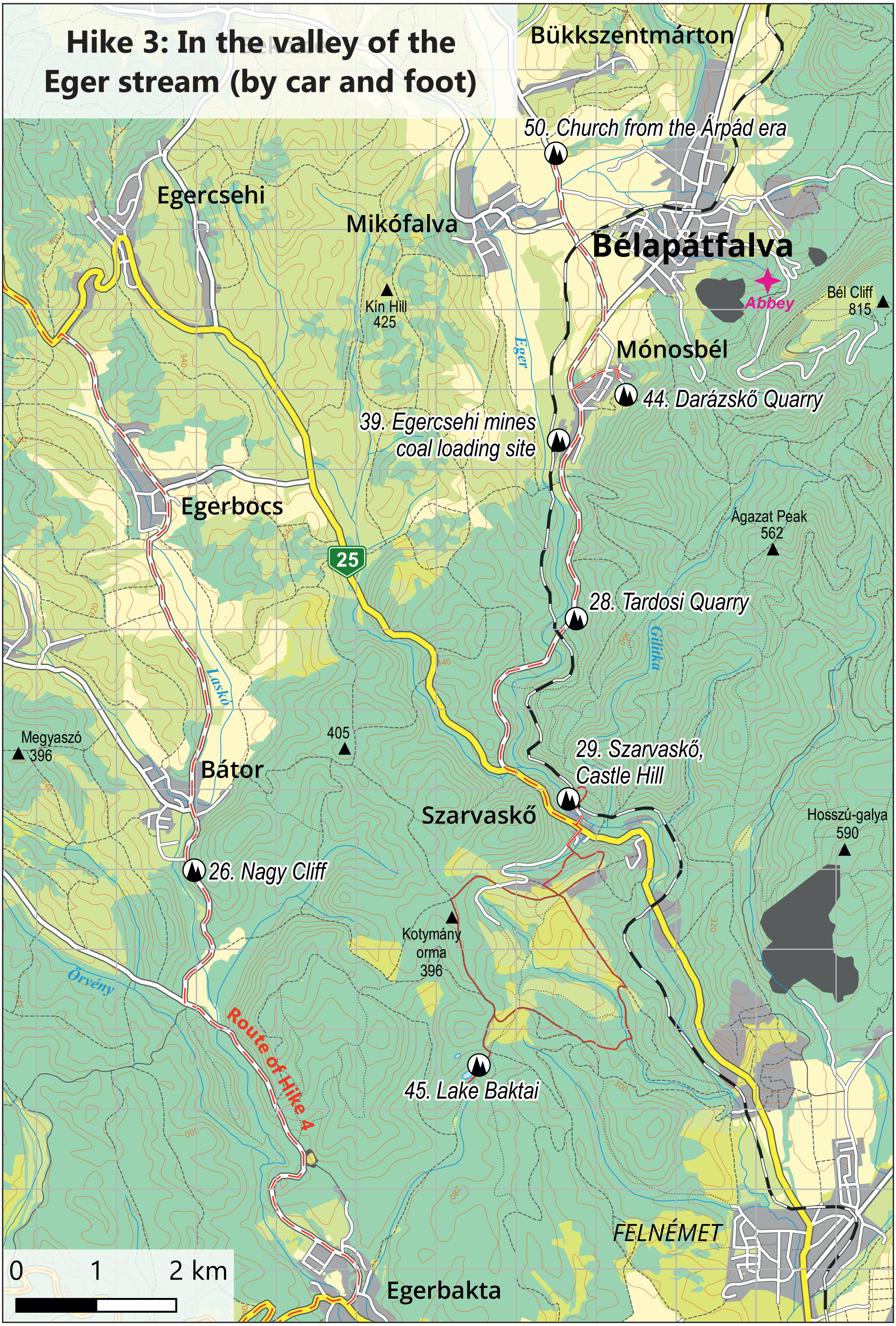




Hike 2: On the northern edge of the Bükk (by car and on foot)
Mályinka
Mályinka 3 km
9. Csondró Valley and Bartos Cliff
24. Örvény Cliff
5. Mártus Cliff
8. Látó Cliffs
7. Kapu-bérc
Pauline monastery
6. Bán Valley, abandoned slate quarry
BÜKKSZENTLÉLEK
ÓMASSA
12. Garadna Spring
0 500 1000 m

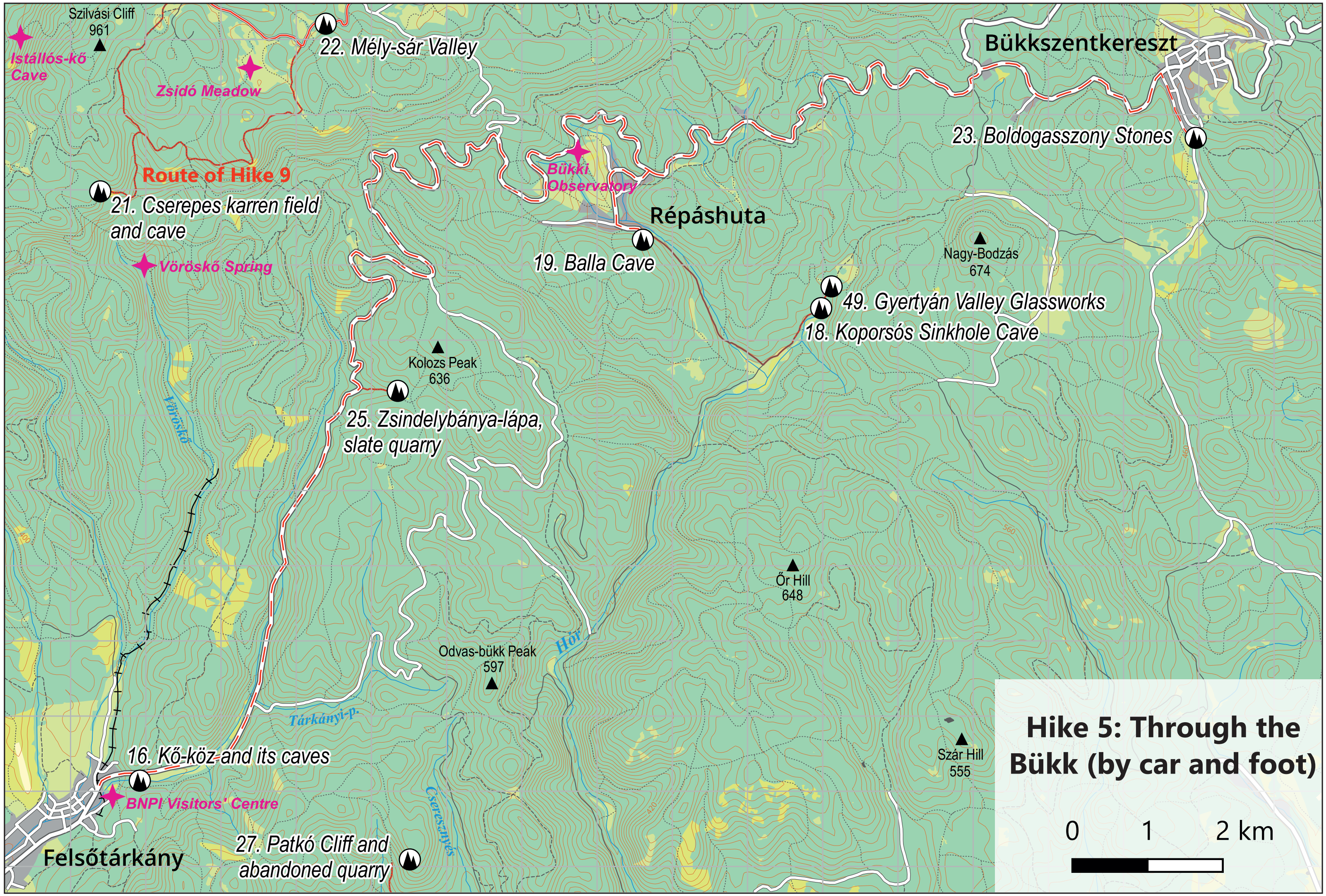


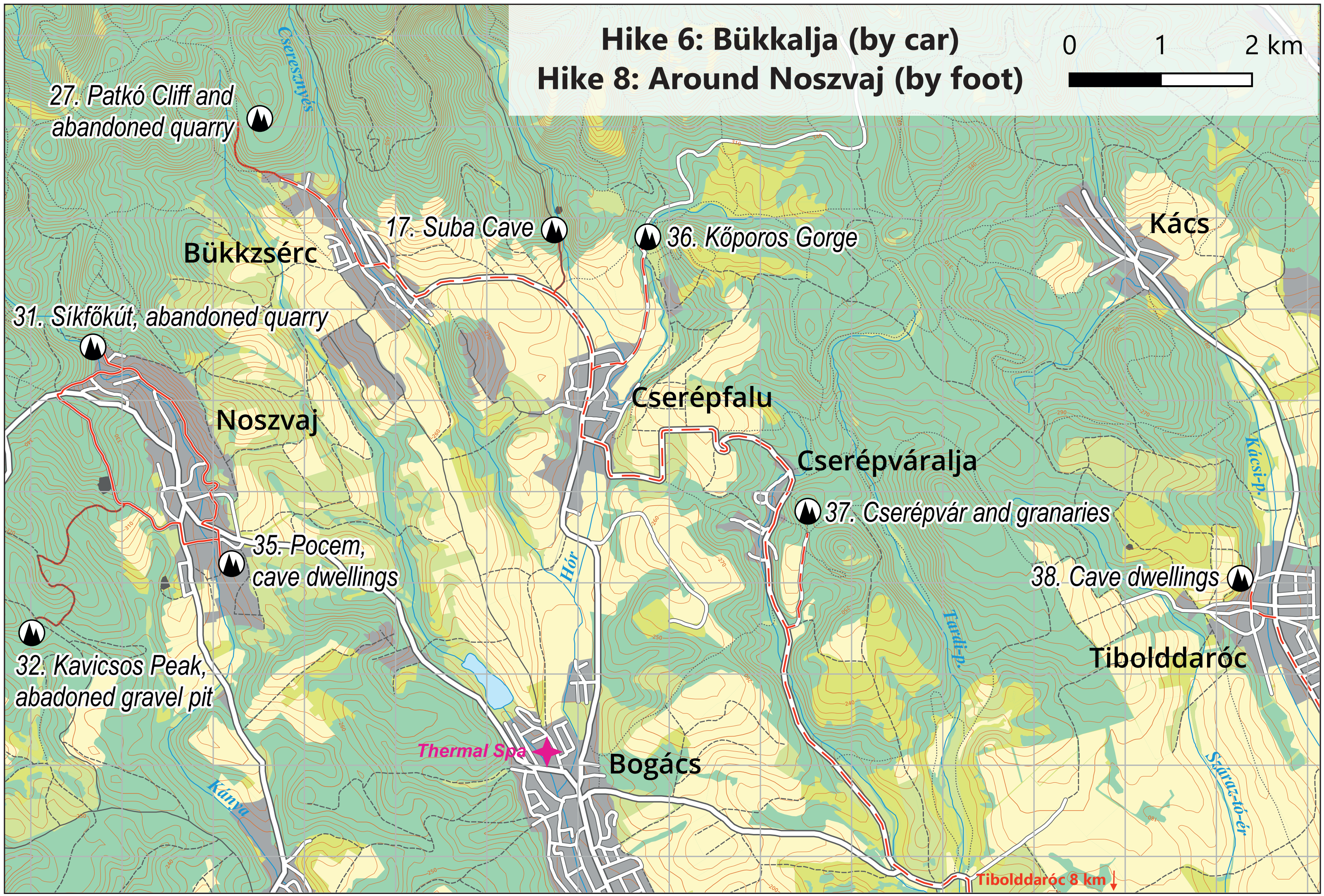
Hike 9: Loop Hike on the Plateau
0 500 1000 m
Holló Cliff 823
Nagy Meadow
Fátyol Waterfall
20. Olasz-kapu
22. Mély-sár Valley
Szilvási Cliff 961
Istállós-kő Cave
Zsidó Meadow
Route of Hike 5
21. Cserepes karren field and cave
Vöröskő Spring



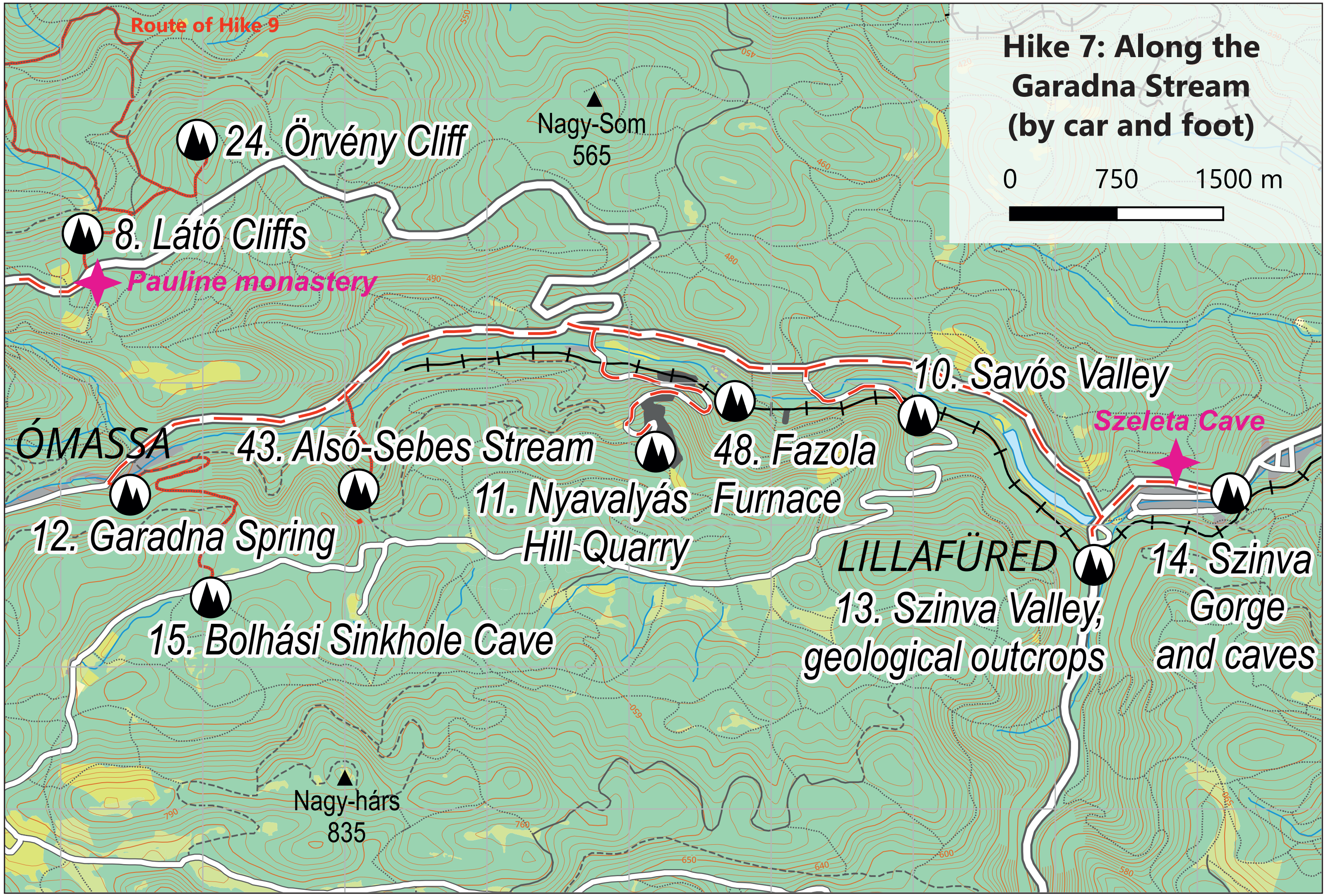
Hike 3: In the valley of the Eger stream (by car and foot)
Bükkszentmárton
50. Church from the Árpád era
Egercsehi
Mikófalva
Bélapátfalva
Abbey
Bél Cliff
815
Kín Hill
425
Eger
Mónosbél
44. Darázskő Quarry
39. Egercsehi mines coal loading site
Egerbocs
Ágazat Peak
562
25
28. Tardosi Quarry
Gilitka
Laskó
Megyaszó
396
405
Bátor
29. Szarvaskő, Castle Hill
Szarvaskő
Hosszú-galya
590
26. Nagy Cliff
Kotymány orma
396
Örvény
Route of Hike 4
45. Lake Baktai
FELNÉMET
Egerbakta
0
1
2 km

Hike 4: In the western part of the Geopark (by car)


Hike 5: Through the Bükk (by car and foot)
0 1 2 km
Szilvási Cliff 961
Istállós-kő Cave
Zsidó Meadow
22. Mély-sár Valley
Bükkszentkereszt
23. Boldogasszony Stones
Route of Hike 9
21. Cserepes karren field and cave
Vöröskő Spring
Bükki Observatory
Répáshuta
19. Balla Cave
Nagy-Bodzás 674
49. Gyertyán Valley Glassworks
18. Koporsós Sinkhole Cave
Kolozs Peak 636
25. Zsindelybánya-lápa, slate quarry
Vöröskő
Őr Hill 648
Odvas-bükk Peak 597
Hór
Tárkányi-p.
Szár Hill 555
16. Kő-köz and its caves
BNPI Visitors' Centre
Cseresznyés
27. Patkó Cliff and abandoned quarry
Felsőtárkány



Hike 6: Bükkalja (by car)
Hike 8: Around Noszvaj (by foot)
0
1
2 km
27. Patkó Cliff and abandoned quarry
17. Suba Cave
36. Kőporos Gorge
Bükkzsérc
Kács
31. Síkfőkút, abandoned quarry
Cserépfalu
Noszvaj
Cserépváralja
37. Cserépvár and granaries
35. Pocem, cave dwellings
38. Cave dwellings
32. Kavicsos Peak, abadoned gravel pit
Tibolddaróc
Thermal Spa
Bogács
Cseresznyés
Hór
Tardi-p.
Kácsi-p.
Kánya
Száraz-tó-ér
Tibolddaróc 8 km


Hike 7: Along the
Garadna Stream
(by car and foot)
0 750 1500 m
Route of Hike 9
24. Örvény Cliff
Nagy-Som
565
8. Látó Cliffs
Pauline monastery
ÓMASSA
43. Alsó-Sebes Stream
48. Fazola
Furnace
10. Savós Valley
Szeleta Cave
12. Garadna Spring
11. Nyavalyás
Hill Quarry
LILLAFÜRED
14. Szinva
Gorge
and caves
13. Szinva Valley,
geological outcrops
15. Bolhási Sinkhole Cave
Nagy-hárs
835

DEFINITIONS

Abrasion: decay of seashores and large still water bodies due to surges
Aleurite: sediment in fine clasts, with its ingredients composed mainly of silt-sized grains (0.002 to 0.06 mm)
Aleurolite shale: metamorphic aleurolite of a foliated structure
Aleurolite: lithified aleurite
Anticline: the dome of a folded structure formed by compressive forces during tectonical movements with spatial shortening; with rock layers ageing towards the core along the anticlinal axis
Balanus: living organisms belonging to the order of Sessilia (sea acorns), species of which live on seashore rocks and on shells and crabs
Bioherm: a lens- or mound-shaped biogenic carbonate formation consisting of the skeletons of organisms having lived onsite that are cemented parallel to sedimentation, surrounded by rocks developed in different ways
Brachiopoda (lamp shell): a class in the phylum of Tentaculata, characterised by an asymmetrical double shell resembling a clam shell, but with a completely different structure, and a stem attached to the base
Carbonate platform (rimmed shelf): a large and complex structure made of carbonate rocks formed on a seashore shelf with a nearly flat or slightly sloping surface, ending with a steep rim towards the open sea; with reefs often forming at the rim of the platform (reef-rimmed platform)
Carbonate sedimentary rocks: a large group of sedimentary rocks of chemical and biogenic origin the rocks of which mainly consist of carbonate minerals (e.g., calcite, aragonite, dolomite); also including limestone and dolomite
Chlamys: sea shells belonging to the family of comb shells, to be recognised by their fan-shaped, ribbed shells
Clastic sedimentary rock: a rock type formed from the accummulation of mineral and rock aggregates by fragmentation and weathering, which remained in place or are transported, deposited, and subsequently lithified
Clay marl: sedimentary rock in fine clasts with a lime content of 20 to 40 %; transitional rock between clay and limestone
Clay shale: shaley rock formed from fine-grained sediment by very low-grade metamorphism at low temperature and pressure
Complex: a lithologic unit of intrusive magmatic formation assemblages of a more diverse composition and metamorphites of various rock types, also of a complex composition
Conglomerate: sedimentary rock with coarse clasts; its base material consisting predominantly of rounded clasts (mainly cobbles) larger than 2 mm
Conodonta: tooth-like fossils of a microscopic size typical of Palaeozoic and Triassic open-sea strata, which come in hand extremely well for the biostratigraphic classification of sequences
Crinoid: a class within the phylum of Echinodermata whose plant-like skeletons, consisting of a calyx and arms, are made of calcium carbonate and are attached to the seabed with a long stem
Cross-stratification: inclined layers in clastic sediments formed by deposition from flowing water or air, typically dipping in the direction of flow
Disconformable bedding (discordance): the bedding of sedimentary rocks one on the other in such a way that there is a time gap between them (its types being erosional and angular discordance)
Evaporites: the collective name for salt rocks (e.g. rock salt, potash, gypsum)
Facies: the general appearance, development, or composition of a rock block, and all of its characteristic petrological and paleontological features reflecting the environmental conditions in which the rock was formed
Foraminifera: a class of Rhizopoda belonging to the phylum of Protozoa, whose members build skeletons of very diverse shapes, sizes and materials (of limestone, silica or waste grains) according to their lifestyles
Formation: a mappable lithologic unit distinguishable from surrounding rocks and depicted on a map; noting that it is not necessarily homogeneous, but it can also be a sequence made up of various types of rocks or their alternation
Glacial: a very cold stage within an ice age (e.g., Riss, Würm)

Interglacial: an interval between glacials when higher temperatures prevail
Interstadial: a shorter period of temporarily higher temperatures within an ice age (glacial)
Karstification: a process in which soluble rocks (e.g. limestone, gypsum, rock salt) are dissolved by natural waters, leading to the development of surface and subsurface karst features
Lamina: a layer thinner than 1 cm, usually only few mm, still visible to the naked eye
Lime marl: transitional rock between marl and limestone containing clay in 20 to 40 %
Lithoclast: a clast piece to be found in volcaniclastic (pyroclastic) rocks whose material does not match the material of the erupting magma
Marl: sedimentary rock in fine clasts (with clay) containing carbonates in 40 to 60 %; being a transitional rock between clay and limestone
Megalodus: a genus of shells widespread in Triassic rocks; also called Devil's Hoof based on its appearance
Member: in the hierarchical system of rock masses, a lithologic unit located between formation and layer
Metamorphism: the transformation of rocks due to high temperature and pressure, during which characteristic minerals and metamorphic mineral associations indicating the degree of transformation are formed (its types being very low-grade, low-grade, medium-grade, high-grade)
Mollusca: an animal phylum, including, among others, snails (Gastropoda), shells (Bivalvia), solenoconchs (Scaphopoda) and cuttlefish (Cephalopoda); being important for historical geology as environmental and biostratigraphic indicators
Nautilus: a type of marine octopus living in skeletons resembling snail shells (chambered nautilus)
Nummulites: a group of larger foraminifera, that built a spirally coiled calcite skeleton of a diameter of up to 10 to 12 cm, abundantly living in warm tropical and subtropical shallow seas of the Paleogenic period (commonly known as coin-stones)
Olistolith: large disordered blocks occurring in olistostromes
Olistostrome: a disordered, breccia-like deposit consisting of blocks of different ages, formed by gravitational sliding, where the enclosing rock is called the matrix, while displaced, slipped blocks olistoliths
Ooid: a spherical grain of chemical origin consisting of an inner core and usually multilayered carbonate skeletons surrounding the core concentrically; its size being 0.2 to 2 mm; formed in strongly agitated water
Ostrea: a typical genus of shells (Bivalvia), its fossils frequently found in Miocene sediments
Paleosol (ancient soil, fossil soil): a brown, reddish-brown or red layer of former soil, with varying humus content, preserved in a fossil form, appearing in sedimentary layers, especially loess layers
Paleotethys: an ancient ocean at the end of the Palaeozoic and the beginning of the Mesozoic, wedging into the supercontinent Pangaea from east
Paralic: an attributive for coal formed from the organic matter of seashore and saltwater marshes
Paratethys: a sedimentary basin in the Tertiary (succeeding the Tethys) extending from Western Europe to the present-day Aral Sea
Pelagic: an environment in open sea and ocean areas far from the shores
Polje: a large karstic form, a steep-sided, closed, flat-bottomed karstic depression
Pyroclastics (pyroclastic rock): a rock composed of volcaniclasts ejected during an explosive eruption, to be classified, like clastic sedimentary rocks, based on the size of the grains that make up the rock
Radiolarite: a marine sedimentary siliceous rock formed from the silica skeletons of plankton single-celled organisms floating in open sea (Radiolaria)
Reverse fault: a type of structural movement where a rock mass breaks due to compressive forces and one half slides onto the other along a flat (<45 degree) fault plane
Rifting: a rupture or breaking of the Earth's crust, during which a rift-valley system emerges in the continental crust above the upwelling zone of the Earth's mantle; the spreading of continents may begin with this process
Rudist: a collective name for horn-shaped, thick-shelled, reef-building molluscs that lived from the Late Jurassic to the end of the Cretaceous, attached to the shallow seabed
Tethys: a huge equatorial ocean stretching from east to west between the Eurasian and African continents from the end of the Palaeozoic to the end of the Neotertiary, divided into several smaller ocean branches bordered by microcontinents from time to time

Trilobite: arthropods belonging to the phylum of Arthropoda; numerous species of them having been inhabitants of Palaeozoic marine habitats; significant as excellent biostratigraphic indicators in Paleozoic stratigraphic sequences

Tuff: a type of rock formed from dust and clasts ejected to the air during volcanic eruptions and then deposited on the surface, typically of grain diameters below 2 mm (e.g., rhyolite tuff, dacite tuff, andesite tuff, basalt tuff)

Tuffite: a type of sedimentary rock containing disseminated volcanic material in 25 to 75 %

Uvala: a karstic landform; a long and elongated depression formed by the connection of dolines along a line

Volcanic clast: a sedimentary rock composed primarily of grains of volcanic origin

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Szeleta Park Visitor Centre, Miskolc

www.szeletapark.hu

At the Miskolc gateway of the Bükk Region UNESCO Global Geopark, the Szeleta Park Visitor Centre serves as a key exhibition site of the Bükk Mountains. This four-season, interactive family experience centre introduces visitors to the natural treasures, as well as the outstanding geoheritage, natural heritage and cultural heritage of the Bükk.

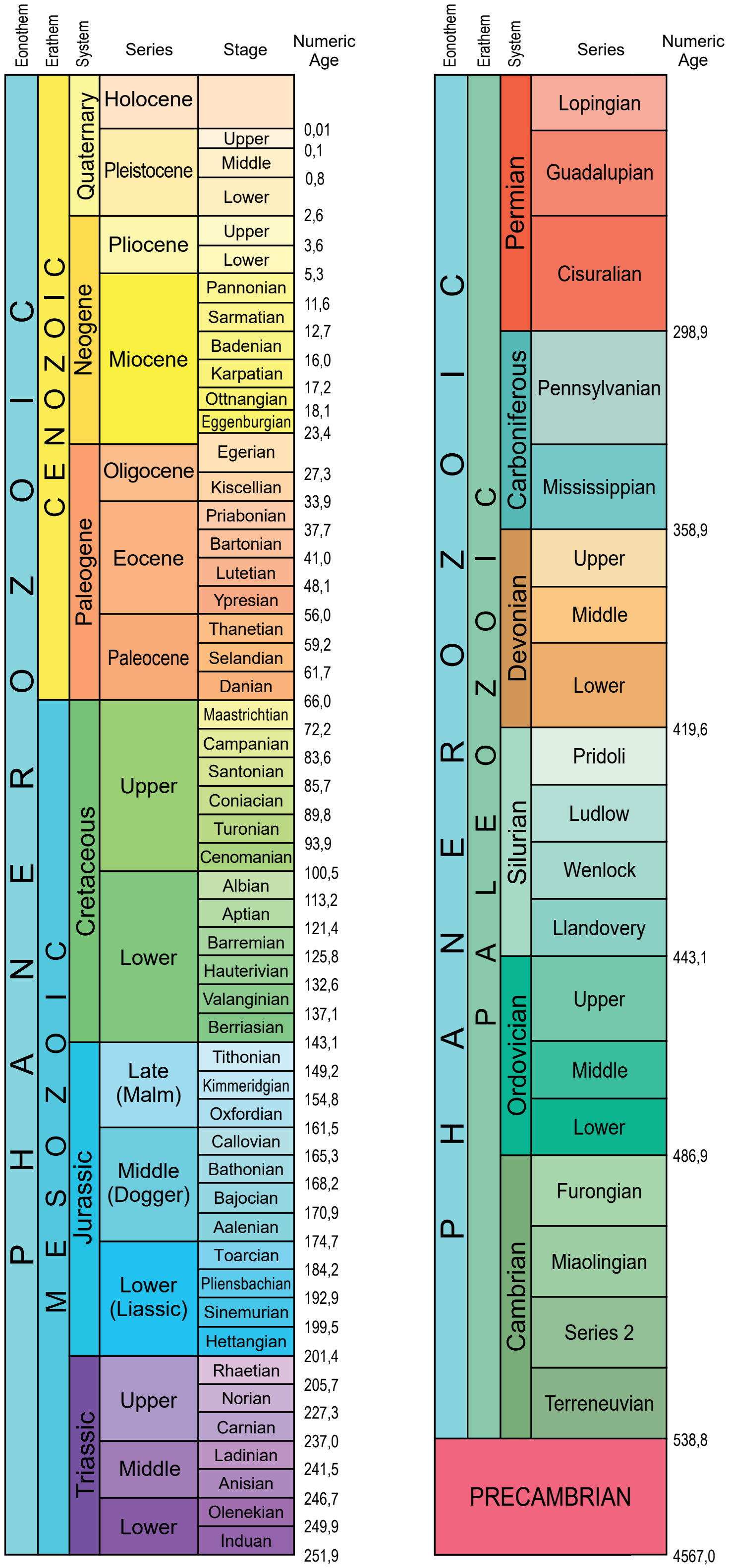
The namesake Szeleta Cave is considered the cradle of prehistoric research in Hungary. The exhibition presents the karstification of the Bükk, its caves, and the everyday life of Ice Age humans, along with their characteristic tools, including the beautifully crafted leaf-shaped bifacial stone tools.

The modern complex combines scientific education with interactive experiences and guided tours. School groups are offered dedicated "nature school" modules, where students can explore karst phenomena, forest ecosystems, wetlands, or pollinators with specialist guides. They can also take part in interactive bird identification, "animal detective" activities, and an exciting prehistoric time-travel experience along the network of nature trails.

Visitors are welcomed by a 3D film screening, as well as themed outdoor "Spider Silk" playground and the indoor "Stone Age Karst Adventure" playhouse.

Simplified Chronostratigraphic Chart

– based on the 2026 chart of the International Commission on Stratigraphy,
and the figure in the volume 'Hydrocarbons in Hungary' (ed. Zsolt Kovács) –



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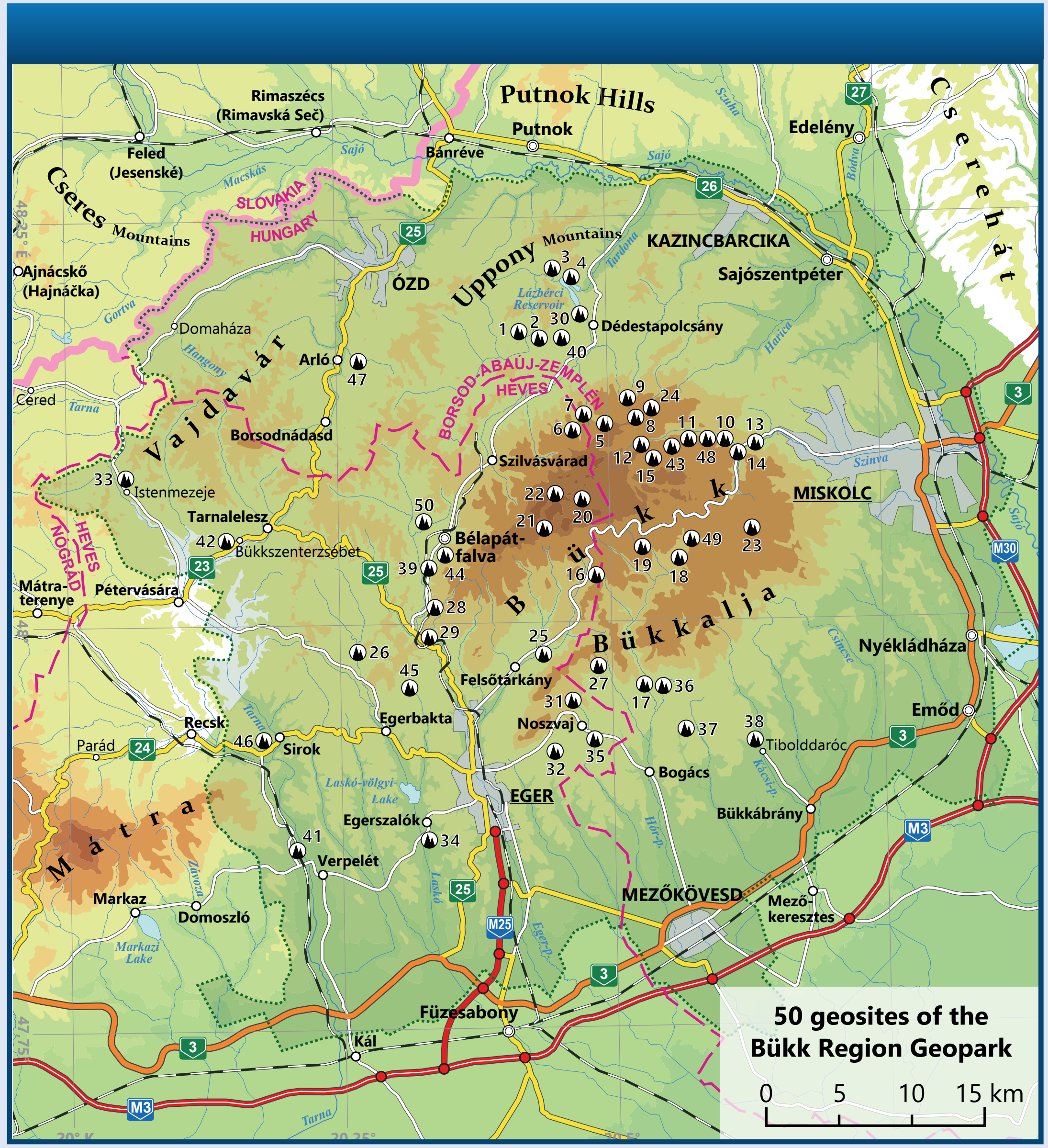

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