APPLICATION DOSSIER FOR UNESCO GLOBAL GEOPARKS

ASPIRING BÜKK-REGION GEOPARK

BÜKK-VIDÉK GEOPARK

BÜKKI NEMZETI PARK

November, 2020

CONTENTS

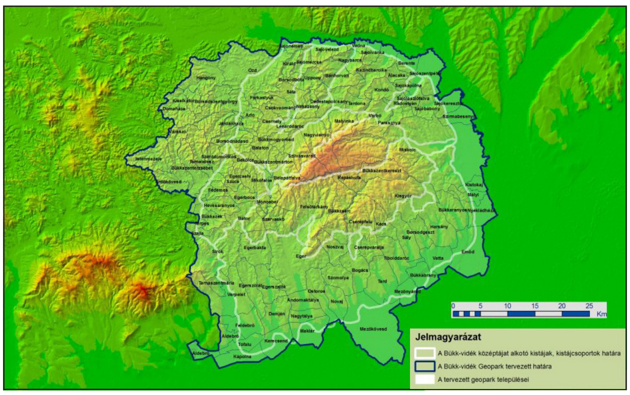
A. GENERAL INFORMATION

Name of the proposed aUGGp

The name of the geopark applying for the title UNESCO Global Geopark is Bükk-Region Geopark. Bükk Region is a geographical unit (mesoregion) the centre of which is the Bükk Mountains with Uppony Mountains related to it geologically and also with the low hills surrounding the Bükk Mountains in the south and in the north northwest.

Representatives of the 109 settlements included in the geopark in Borsod-Abaúj-Zemplén and Heves counties signing a declaration of intent initiated the foundation of Bükk-Region Geopark asking at the same time Bükk National Park Directorate to prepare the scientific material of the application for the Hungarian Geopark Committee first and then for the UNESCO Global Geopark Network (GGN) and also to cover the coordination of the programme and the associated operative tasks.

Location



The proposed geopark is located in Heves and Borsod-Abaúj-Zemplén counties in the north-eastern part of Hungary, Europe. Bükk Region, i.e. the Bükk Mountains and Uppony Mountains belong to the North Hungarian Range. The latter is the Hungarian part of Mátraerdő, the south-easternmost range of the North-western Carpathians. The microregion group of Bükk Mountains is surrounded by two microregion groups with hilly appearance: Bükkalja in the south and Bükkhát in the north northwest. Only a couple of settlements can be found in the Bükk Mountains the marginal areas of the mountains and the hilly areas, however, are densely populated. In the territory of the planned geopark 109 settlements can be found.

Surface area

The area of the aspirant Bükk-Region Geopark is 2,817 km^2.

Short physical and human geography characteristics

Bükk-Region Geopark covers one of the most complex geological environments in Hungary. Geodiversity of the area is unique in the Carpathian Basin. The central zone of the Geopark is formed by Bükk, with the most complex structure in the North Hungarian Range composed mostly of Palaeozoic and Mesozoic rocks. The rocks of the main mass of the mountains were not formed at their current location as their relatives can be found in the Dinarides. Palaeozoic-Mesozoic rocks forming the mountains can be found in various depths in the basement of the surrounding younger basins to NE, E, S and SW. Consequently, those areas are related to the Bükk regarding their geological development.

The structural unit neighbouring the mountains from the NW is Bükkhát containing the Uppony Mountains and Heves-Borsod Hills (Oligocene and Miocene sandstone region and belonging to the sinistral strike-slip structural unit of the Darnó Zone. It differs from Bükk in its surface and basement rocks and also in its structural characteristics. Its Palaeozoic and Mesozoic rocks can be related to the Southern Alps and the Carpathians.

Geodiversity in the Geopark is also clear from a brief summary of its geological structure and development. The Uppony Mountains and the Bükk reveal an almost continuous sediment series of about 300 million years, from the Early Ordovicium in the Palaeozoic to the Jurassic period of the Mesozoic in the history of the Earth. The rocks of the area are younger and younger from north to south. The oldest formations in the area, from the Palaeozoic, are found in the Uppony Mountains. Carboniferous and Permian formations also occur in the Northern Bükk. A special geological value of the Bükk Mountains is an outcrop on the northern side of the Bálvány exposing the Permian – Triassic boundary when a significant extinction took place. Considering rock formation, the most significant period is the Triassic when the most typical limestone rocks were formed dissected by volcanic rocks, marl, sandstone, aleurite and dolomite. Mostly fine clastic deep sea sediments were formed in the Jurassic apart from limestone and also basalt and gabbro were formed as a result submarine volcanism and subvolcanic activities. A long sedimentary hiatus follows the Jurassic. Cretaceous sediments can be found only in the Uppony Mountains while Tertiary sediments occur only in the southern of the Bükk Mountains and in the hills. The sea covered the foot of the Bükk from the south in the Late Eocene. Marine sediment deposition continued in the Oligocene as well with marl and euxine facies laminated clay reflecting the deepening of the basement. Finally, clay was deposited in a more oxygen rich environment. In the basins north and west of the Bükk Schlieren occurs on the surface that was formed from the end of the Oligocene to the Early Miocene. The hills of Vajdavár Region composed on Late Oligocene – Early Miocene glauconitic sandstone are separated from the Bükk by the structure of the Darnó Zone. Sediments of the rhyolitic tuff explosion started at the Early Miocene can be found almost everywhere except for the Bükk and Uppony Mountains, however, on the surface it covers mostly the southern foothills of the Bükk, the Bükkalja region. Geology in this area is characterized by younger Miocene volcanic tuff horizons (dacitic tuff and upper rhyolitic tuff). North, northwest of the Bükk marine and marsh sediment formations containing 3-5 coal seams in the coal basin separated into two parts by the occurrence of the lower tuff horizon. Karpatian shoreline – coastal plain abrasion formations and deeper marine schlieren deposited onto the coal bearing sediments. Along the southern foot of the mountains the subsiding basin was filled with inland sea, delta and marsh sediments containing Pannonian lignite seams in the upper parts and sloping towards the Great Hungarian Plain. River and stream valleys together with the southern foreland of the Bükk were filled with fluvial gravel, sand and clay during the Pleistocene – Holocene. Loess and wind-blown sand covers were formed on the southern foothills and foothill foreground during the Ice Age. At the same time, carbonate rocks in the mountainous areas were karstified and strongly eroded.

The Bükk Mountains and the Uppony Mountains belong to the North Hungarian Range from a physical geographical point of view. The Bükk has the greatest average height in Hungary with 50 peaks reaching above 900 m, the highest of them, Istállós-kő is 958 m high. The most characteristic part of the mountains is the Bükk Plateau, surrounded by steep cliffs and slopes while being almost horizontal with an average height of almost 800 m, rich in karst forms and characteristic vegetation.

The two mountains are separated by the valley of Bán Stream filled with young sediment.

A folded – overturned-folded – thrust folded (nappe-folded) structure was formed in the two mountains during the Cretaceous orogeny that fundamentally determines the morphological character of the area. Karst is the most typical landform in the mountains. The Bükk Plateau and the range of „Stones" are the richest in surface karst forms. Waters seeping deep into sinkholes, dolines and karst cracks form caves and cave systems in limestones. The number of currently known caves in the Bükk Mountains, which comply with the legal conditions, is more than 1100, 52 of which are strictly protected. Also the deepest and fifth longest cave in Hungary can be found here.

Water seeping into the karst appears in karst springs on the edge of the limestone areas. Travertine often precipitated out of the water of karst springs, and water that falls through the travertine steps forms small waterfalls. The cavities closed by the travertine hill built by the waterfall of Szinva Stream compose Anna Cave at Lillafüred. Warm karst water in limestone plunged into great depths in the edge of the mountains and covered with young sediments, emerges in lukewarm springs, and the 13,000-15,000 years old warm karst water has been exposed by deep boreholes in several places.

Karst water in the Bükk plays an important role in the drinking water supply of the area.

Bükk Region belongs to the cool mountainous areas of Hungary. Except for Bükkhát and Bükkalja, winter in the mountains is long and cold, but the harshness of winter is compensated by a large number of clear days. Compared to the neighbouring lowlands and hills, spring is generally late. At the end of spring – early summer, the amount of precipitation usually increases, and 1/5 of the average annual precipitation of 600-800 mm falls at this time. Summer is cool except for the southern forelands. The varied relief significantly modifies the climate of some small areas. Southern slopes get more sunshine, melting and flowering begin earlier there, and certain vegetation zones go higher.

On the northern slopes and on the north-facing side of the karst depressions snow remains for the longest time, vegetation zones descend and cold-tolerant species are common.

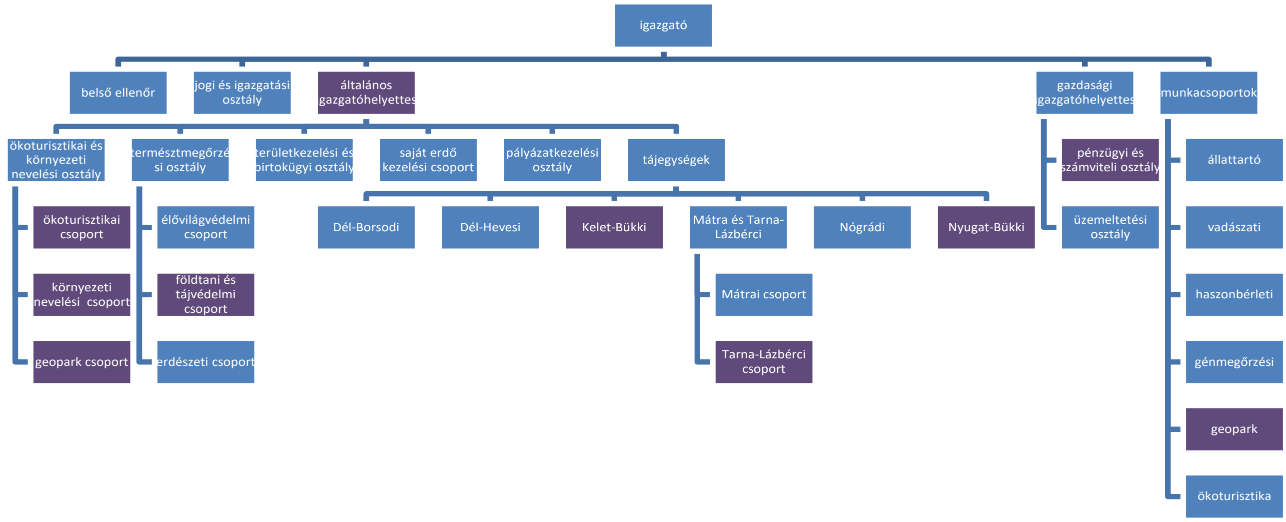
The effects of climate change are also felt in the area of the Bükk Region. Precipitation is less and more extreme in distribution both in space and time. The amount of winter precipitation is small, the number of snow-covered days and the thickness of the snow have been declining for more than a decade. Rain in spring and early summer is sudden, downpouring in large amount, causing serious damage more than once. Temperature is also changing. In winter, extremely cold (below -15 – -20°C) days occur more often, while summer temperatures rise, and days with temperatures above 35°C also occur.

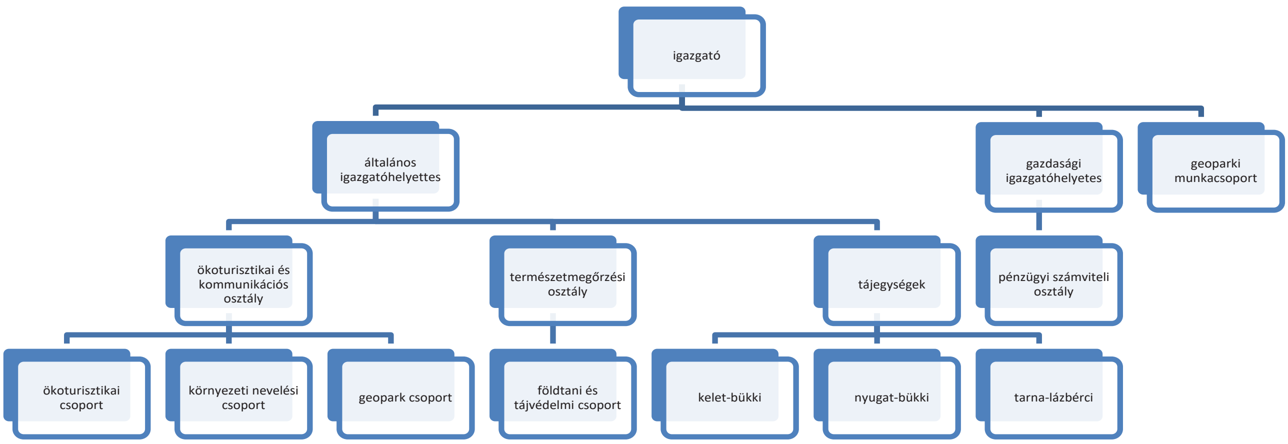
The rich wildlife of the Bükk Region is determined by climatic characteristics and varied relief conditions. In Hungary, mountainous vegetation zones have developed most regularly in the Bükk, from the dry loess steppe oaks representing the forest steppe zone of the southern margin to the montane beech forests that dominate above 700 m. Regarding herbaceous levels, 1,300 plant species occur in the area, from ice age remnant species to warm-loving meadow steppe species, 18 of which are known only from the Bükk Mountains. Examples include Alpine rock-cress, thrift, northern dragonhead, Sesleria hungarica, Ox-eye daisy, Alpine yellow violet.

Diverse geomorphological conditions and diverse vegetation are associated with a fauna also rich in species. The number of species living in the Bükk is estimated to be 22,000. Valuable endemic species include duvalius gebhardti (Gebhardt's Ground Beetle) and sub-endemic butterfly species, Entephria cyanata, or northern brown argus. For example, in the northern gorge valleys lives the Carpathian blue slug, an endemic species of the East Carpathians. Bükk caves are associated with a significant part of the Hungarian bat population. Rarities of the bat fauna in the Bükk include for example Savi's pipistrelle, the Brandt's bat and the western barbastelle. Among birds of prey, eastern imperial eagle and peregrine falcon are the most valuable.

The planned Bükk-Region Geopark is located in the area of two counties: Heves and Borsod-Abaúj-Zemplén counties. Both county centres are located within the border of the geopark. The centre of Borsod-Abaúj-Zemplén county is Miskolc, the fourth most populous city in Hungary, with a population of nearly 156,000 people. It is an important industrial, scientific and cultural centre. It has a university, research institutes, museums, exhibition sites, theatre and other cultural facilities. Due to its cultural and historical importance and the proximity of the Bükk Mountains, the city is a major tourist centre. The centre of Heves County is Eger, with a population of about 53,000 people. It is a scientific, cultural and tourist centre with a significant industry and grape and fruit production. Until the 1990s, the municipalities of Bükkhát were part of the catchment area of the heavy industry and coal mining of Miskolc and Ózd. Since the closure of the mines and the fall in large-scale industrial activity, local businesses and services have been employing the population. Unemployment is relatively high in several small settlements and there are few services available locally other than basic infrastructure. Besides industry, a greater role has been played by agricultural activities, especially grape and fruit growing in Bükkalja. Due to favourable landscape and climatic conditions in the area, tourism is significant.

Organization in charge and management structure





The decision-making organisation of Bükk-Region Geopark is the Bükk National Park Directorate (BNPI). Within the directorate there is a Geopark Group, which is responsible for the professional management of Bükk-Region Geopark. Within the Bükk National Park Directorate, a Geopark Working Group has been established, the members of which come from several different organizational units.

Members of the Working Group

Head of the Working Group is the head of the Department of Ecotourism and Environment, BNPI.

Permanent members:

- Director
- General Vice Director
- Economics Vice Director
- Head of the Department of Ecotourism and Environment
- Specialist officer of the Environmental Education Group (geography-drawing teacher, geographer)
- Head of the Geology and Landscape Protection Group (geologist)
- BNPI representative of Novohrád-Nógrád Geopark (geologist)
- Geologist head of the Foundation of Nature Protection, Culture and Ecotourism in the Bükk

Contact person

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Social media

Facebook: https://www.facebook.com/bukkvidekgeopark/
Instagram: https://www.instagram.com/bukkgeopark/
Twitter: https://twitter.com/BukkVidek

B. DOCUMENTS

1/ Declaration of intent
Composed separately, to be submitted by 1st July 2020.

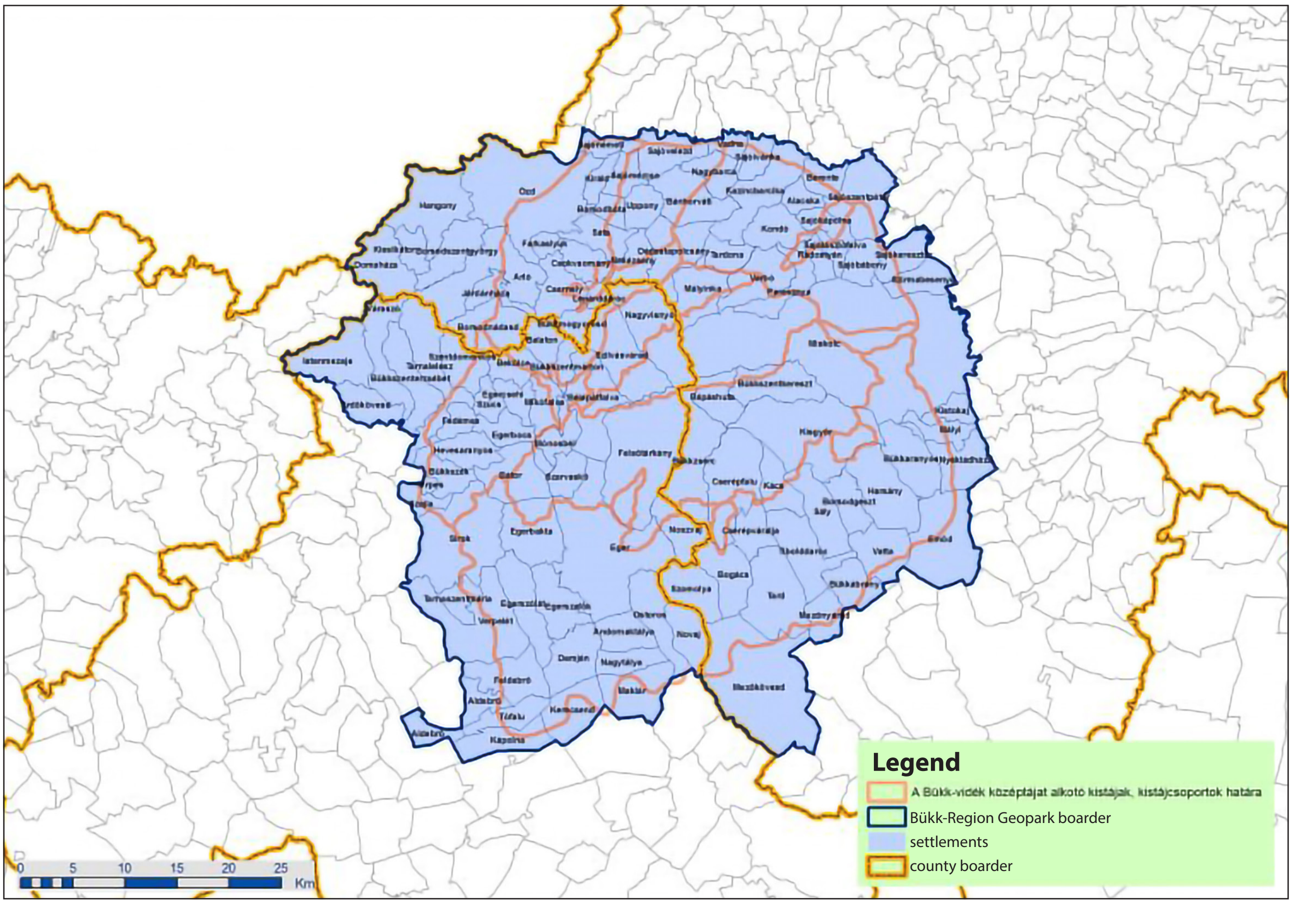
2/ Documentation of the application
In Appendix 2

3/ Self-assessment form
Separate document – given in an Excel table: Appendix 1

4/ Appendices of the documentation of the application
Appendix 1: Self-assessment document
Appendix 2: A. E. 1.1 Geological heritage and protection
B. Assessment of geosites
Appendix 3: Declarations of support – declarations of intent of the involved local governments, support of either the National Geopark Committee or the government body responsible for relationship with UNESCO
Appendix 4: High resolution map of the aspirant Geopark
Appendix 5: One page geological and geographical summary
Appendix 6: Full bibliography of the field of earth sciences with special regard to international publications

C. LOCATION OF THE AREA

Geographical coordinates (latitude, longitude), shape file and maps are given in the appendix.



D. MAIN GEOLOGICAL HIGHLIGHTS AND OTHER ELEMENTS

The most important geological values and other important elements, sites and activities of the aspiring Geopark.

The most important geological value of Bükk-Region Geopark is the 300 million years old, almost continuous sediment series of the Uppony and Bükk Mountains and also the rich landforms developed in the series as a result of tectonic processes and karstification.

I Uppony Mountains

The SW part of Uppony Mountains is formed by Lower Carboniferous rocks uplifted like horsts along fault planes representing a time period of 140 million years. The sediment series from shallow marine limestone formed in the Late Ordovician epoch of the Palaeozoic age through dark grey shale and siliceous shale rocks formed in the Silurian – Early Devonian and to Carboniferous formations is exposed along the road running along the shores of Lázbérc Reservoir that represents a landscape and hydrological value. Towards the northern end of the road Devonian sediments re-appear in the form of limestones as a result of structural movements, folding. Industrial historical memories are represented by ore-exploring tunnels. Csernely Stream cutting through the sediment series via structural lines formed one of the most spectacular gorges in Hungary representing a fine example of epigenetic valley formation. Light grey limestone walls of Uppony Pass reach the height of 50 m. In the karstic Uppony Limestone 50 caves can be found. Stone hole No. 1 at Uppony is rich in Pleistocene palaeontological findings (bones of bats and rodents). Pottery fragments of the Bükkian Culture were also found in the upper layers of the sediments filling the cave. Two castles were guarding the area of Uppony once. The earthworks was constructed on the top of the southern side of the Pass. The remnants of a small castle can be found on the western side of the steep crest of Dedevár, a peninsula in Lázbérc Reservoir.

II Bükk Mountains

The oldest rocks of the Bükk Mountains composed of fine clastic sediments eroded from land were formed in deep sea conditions in the Palaeotethys nearly 320 million years ago, during the Carboniferous period of the Palaeozoic. In the filling tropical sea layers of shallow marine limestone, reef limestone, rich in fossils were formed. Following nearly 30 million years of sediment hiatus first arid, land-based sediments were formed, and then shallow marine black limestone rich in fossils was deposited as a result of sea level rise in the Permian. The development of the carbonate platform was interrupted by a volcanic activity in the Middle Triassic about 240 million years ago causing a partial uplift in the area. As a result of structural movements in the Middle and Late Triassic diverse depositional environments developed. In the shallow-water marine basins lagoon and basin sediments were formed in a thickness exceeding occasionally one thousand metres composing the main mass of the Bükk Plateau capable of excellent karstification. In the deep sea basins cherty limestone was formed. Jurassic formations – slate, radiolarite – lying on Upper Triassic rocks with a discordancy indicate deep water environments. Deep sea sediments in the South Bükk are combined with pillow basalts and intrusive gabbro.

Considering karst landforms, the richest area in the Bükk Region is the Bükk Plateau.

Its majority are composed on Triassic limestone prone to excellent karstification. Garadna Valley divides it into the Big Plateau with heights of 900→600 m and the Little Plateau with heights of 750→350 m. Landforms of the two plateaus are very similar. The vast majority of them are mostly open mixed karsts, the most typical landforms of which – valleys captured by sinkhole doline rows and inherited onto limestone – were formed in the course of the erosion of non-karstic covering layers. Among these mostly shallow valleys, peaks and tops rise that have karren fields (devil plough), hanging dolines, avens, dried-up, ruined spring caves. Peaks and tops are remnants of a Late Cretaceous – Early Eocene pediment the erosion of which started it to uncover in the Late Sarmatian from under Middle and Late Miocene covering sediments.

The "inner peaks" are truncated cones with ellipsoid or circular base and 60–120 m average height relative to the floor of valleys in the plateau. Only a couple of them have steep cliffs (Kerek-rét-fő, Őr-kő)

"Marginal peaks" are the "bounding crags" of the Bükk Plateau. Their outer slopes are 400–600 m long, steep, occasionally vertical or even overhanging. Their most spectacular members are the "stones" that were formed where the almost vertical limestone layers meet slates of similar position and these fast disintegrating slates were eroded from under the more resistant rock layers. Besides rock boundaries, the location of the plateau margin was determined by thrust planes as well.

Karstification of limestone peaks is significant both above and below the surface. Most frequent karst forms are karren belts developed on the heads of beddings.

These are most typical on the slopes of Istállós-kő, Őr-kő, Tar-kő, Cserepes-kő, Örvény-kő, Pes-kő, Küllő and Körös Hills and Fekete-Sár Bérc.

The much rarer "aven near the tops" are the oldest karst forms in the Bükk. These are remnants of sinkhole caves from the Late Pliocene or older that lost their catchment area and funnel (Kálmán-rét, Kis-Kőhát, Lyukas-gerinc, Mély-sár-bérc avens).

"Hanging valleys" found alone also in near-top positions, at the back of peaks are clogged remnants of Late Pliocene sinkholes that were widened by solution. Their depth is small and their floor is almost horizontal. The most spectacular of them is Tányéros-teber north-east of Istállós-kő.

Only a couple of tunnels with the size of a cave can be found among the inner-peaks. One of them, Kőris-lyuk (Kőrös Cave) is a spring cave with the highest elevation (930 m) in Hungary.

Marginal peaks, especially the stones are rich in cavities, however, these are short. The length of only four of them exceeds 30 m and that of only two exceeds 50 m. Several of them belonged together earlier as parts of a greater cave and were separated only as a result of the destruction of those caves. On the face of the "stones" destructed caves in various stages of deterioration, sinkhole, spring and crossable cave parts together with stalks and arches occur (Három-kut Cliff, Magos-kő Cliff). Stalks losing their outer sides turn into cracked chimneys, then narrow stalk alleys, short, gorge-like corridors. The remaining ribs, rock towers between them become more and more separated and protrusive.

Spectacular gorge valleys cut among the northern marginal peaks of the two plateaus from the North Bükk. The sides of the deep (150–250 m) Istállós-kő-lápa, Leány and Ablakos-kő Valleys crossing the steep beds of Early Triassic sediment belt with variable composition, are decorated with wall-like limestone and dolomite rowels, „devil ribs", formed and separated sharply by selective denudation corresponding with rock quality.

The majority of sinkhole doline row valleys among the peaks run from the margin of the plateau towards its central areas. All sinkhole doline row valleys have moderate or shallow depth, wide floor, gentle, or moderately steep sides and their gradient is small. The shape of dolines and in many cases their operation as well indicate their sinkhole character or origin.

Their cross-section is funnel-shaped and their depth relative to their diameter is significant. At the bottom of some of the dolines in the row there is still a periodically functioning sinkhole cave, while others are more filled, with flatter bottom and no open sinkhole can be seen in them. Since solution mainly widens the dolines filled with impervious slope debris, neighbouring ones are often merged into twin dolines (uvalas), poljes. The wide tray of Nagy-mező and Zsidó-rét was formed by the merging of dolines in the mouth of valleys facing each other.

Cave Systems in the Bükk Mountains

The diverse geological structure of the mountains, the presence of karst and non-karst rocks, their intense cracking, folding, the long time available for the formation of caves allowed the formation of a rich underground world. Extensive cave systems with multi-storey, diversified passages and several surface openings are typical.

The Bükk is the most "caveful" region in Hungary with 1148 caves that is more than a fourth of the Hungarian caves. Out of the 145 strictly protected caves in Hungary 52 are found in the Bükk and many of them were used by ancient humans. Out of the 311 caves with special protection in Hungary 127 are found in the Bükk.

Large caves in the Bükk are caves or cave systems with a total length of passages greater than 1000 m and/or deeper than 100 m. Caves listed in the Table belong to the 52 strictly protected caves in the Bükk.

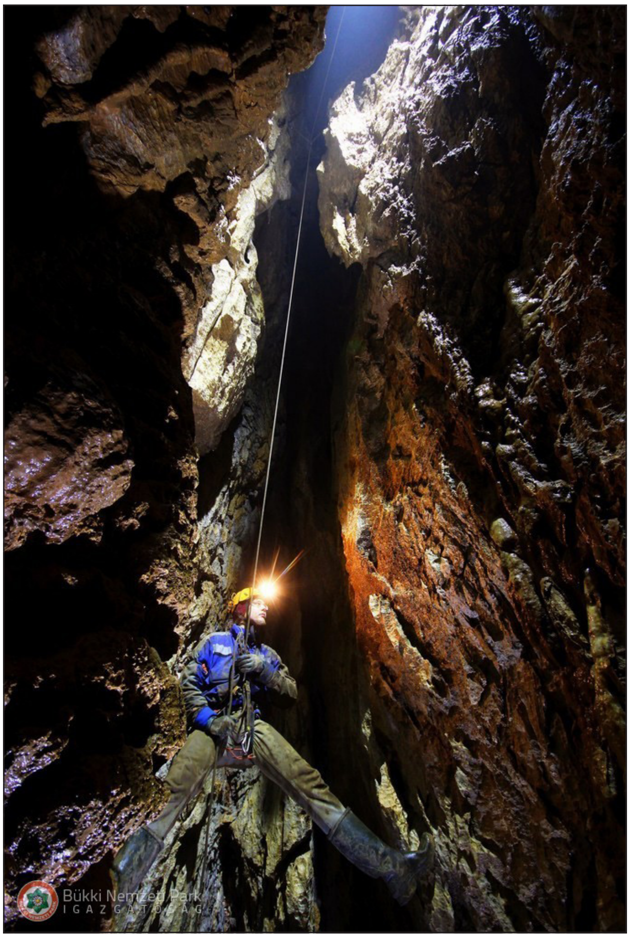
The caves, cave systems below belong to the large caves:

Name of cave	Total length of passages [m]	Vertical size [m]
István-lápa Cave	8,700 (1.)	254 (2.)
Bolhás-Jávorkút cave system	5,314 (2.)	132 (8.)
Hajnóczy Cave	4,250 (3.)	125 (9.)
Létrás Cave	3,757 (4.)	74 (22.)
Szivárvány-Sebes cave system	3,000 (5.)	106 (12.)
Fekete Cave	3,000 (6.)	174 (4.)
Szepesi-Láner Cave	2,500 (7.)	159 (6.)
Pénz-patak sinkhole cave	1,989 (8.)	156 (7.)
Szent István Cave	1,470 (9.)	101 (15-16.)
Jáspis Cave	1,051 (10.)	190 (3.)
Diabáz Cave	1,000 (11.)	161 (5.)
Bányász Cave	931 (13.)	275 (1.)
Speizi Cave	715 (15.)	101 (15-16.)
Szeleta Aven	645 (17.)	102 (13-14.)
Borókás-tebri sinkhole cave No. 4	550 (23.)	121 (10.)
Vár-tető Cave	550 (24.)	102 (13-14.)
Kis-kőhát Aven	480 (26.)	117 (11.)

Rankings according to length or vertical size are given in brackets.

The longest cave in the Bükk is 5th in the Hungarian ranking while the two deepest caves in the Bükk (Bányász Cave, István-lápa Cave) are also the two deepest in Hungary.

István-lápa Cave having the greatest total length in the Bükk has its entrance in a doline at the eastern edge of the Big Plateau formed in Triassic limestone (Fehérkő Limestone Formation). The shaft series deepening with steps are connected to an extensive passage below the depth of 200 m closed by siphons at both ends. There are stalk systems and passages at higher levels above the main passage. The passages of the cave are rich in karstic solution landforms and dripstone formations as well. The Szivárvány-Sebes cave system is the first crossable cave in the Bükk that can be crossed by humans entirely from the sinkhole opening to the exit of the spring.



Szalajka Valley

Szalajka Valley is a deep valley with NW-SE direction and tectonic origin opening towards Szilvásvárad settlement in the NW part of the Bükk. Szalajka Stream runs in it bringing the water of Szalajka, Szikla and Szökevény springs. The largest spring of the valley is Szalajka Spring that has been exposed with a 160 m long tunnel to utilise its water supply. Divers exposed an underwater cave behind the spring with a length of about 100 m and depth of 24 m. Water yield from Szalajka Stream varied between 138 and 37800 l/min. based on 797 measurements between 1940 and 1999.

The most well-known travertine structure in the Bükk is Fátyol waterfall in the Szalajka Valley that exposes the travertine of the valley excellently. The height and width of the tiny multi-storey travertine terracettes – tetaratas – are different. The greatest height is around 2 m in the case of Fátyol waterfall.

The travertine filling the valley below the waterfall decreases to a thickness of 3–4 m after about 1 km, and after another 400 m it is pinched out at Tótfalus Valley.

Another spectacular feature of the valley is Szikla Spring, which comes a steep dipping Lower Triassic limestone striking perpendicular to the axis of the valley, with a discharge approaching that of Szalajka Spring during a small water period.

On the valley side Istállóskő Cave with a single large hall can be found at 546 m a.s.l. in Triassic limestone. This cave preserved significant caveman findings. It is a spring cave. Findings recovered during excavations in its 57 m long hall prove two distinct stages of development of the Aurignacian.

The caveman's stove, found here, surrounded by stones and scattered with bones and tools, is now preserved in the National Museum. The caveman's bone flute, found here, is one of the earliest instruments made by humans.

Vár Hill and the gorge of Eger Stream at Szarvaskő

Typical rocks around Szarvaskő are Jurassic basic (basaltic) volcanites, intrusions and clastic sediment deposited in the sea. Most typical on the surface are pillow lavas. Such pillow lavas are exposed excellently by the deep gorge of Eger Stream – into which Archbishop János Pyrker of Eger blasted the road in 1840 – and also the rocks of Vár Hill, rising spectacularly above the valley, consist of pillow lavas. Along the path climbing up to the former castle, the slates contacting the volcanites (Vaskapu Sandstone Formation), are exposed in natural outcrops and in the outcrop of the former wagon road. At one point, the contact of volcanites and sediments can be studied, and in the outcrop of the old wagon road „slate with manganese nodules" can be seen. The trench on the mountaintop, on the NE side of the castle was deepened into the pillow lava. Considering the reverse position of the convex-concave forms of the pillow lavas on the SW side of Vár Hill, their tilted or overturned position can be suggested.

The pillow lava structure suggests deep sea eruptions. In basalts contacting with ocean water veins filled with calcite-prehnite-pumpellyite-quartz-(epidote) formed as a result of pseudo-hydrothermal effects are frequent.

Basic magma intruded and stuck in sediments forms greater and smaller gabbro – and in their marginal zones – ultramafic bodies. In the latter, V, Fe, Ti mineral enrichment resulted in ore containing wehrlite bodies. Such an occurrence was explored using Denevér Tunnel constructed near Vasbánya-lápa in the late 1800s. In the contact zone of gabbro bodies and the surrounding sediments a thermal contact marginal zone, „hornfels" was formed. This is best exposed in the abandoned quarry of Tó-bérc Mine that was turned into a geological site. The contact zone between the magma intrusion (Tardos Gabbro Formation) and the sediment (Vaskapu Sandstone) can be clearly observed along the high quarry wall. In the sediment melted in the contact zone, muscovite containing "hornfels" was formed. Some of the sediment blocks mixed inside the magma body were assimilated resulting in biotite containing gabbros, while other blocks only melted creating rocks of special composition, such as garnet containing quartz-plagioclasite, albitite.

Geological curiosities around Szarvaskő are presented along a study trail established in 1998.

Nagyvisnyó – Bálvány North, geological key section

The section in a forestry road cutting exposes rocks formed at the time of the boundary between the Permian and the Triassic, i.e. the Palaeozoic and Mesozoic (around 252 million years ago). At the end of the Permian a global extinction event happened: 70% of the terrestrial species of Earth and 95% of the marine species went extinct. A continuous marine sediment series of this catastrophic event can be studied in the key section, which is one of the most important marine Permian/Triassic boundary sections in Europe.

At the bottom the beds of the Late Permian black limestone of Nagyvisnyó Formation rich in fossils can be seen. The age of the strata is the very end of the Permian based on conodonts and plant spores. In the top 0.5 m, the thick limestone beds become gradually but rapidly thin, the sand content of the marl layers increases. This also reflects a slight deepening of the sea. At the very top, the shell fragments of fossils suddenly become rare.

Above this, the carbonate content of the rock decreases dramatically. An almost 1 m thick clay marl layer follows in the series that barely contains traces of life.

From the upper third of the clay marl layer, spores typical for the earliest Triassic flora have been detected. At the beginning of this section, the ratio of stable isotopes of carbon (13C/12C) is significantly reduced. This phenomenon has been observed also at other boundary sections in the world. It is likely to be closely related to the natural phenomenon causing mass extinction. The most accepted cause, at present, is the huge Siberian basalt eruption that coincides with the extinction event at the Permian/Triassic boundary.

Above the clay marl of the boundary the limestone layers of the lower Triassic Gerennavár Limestone Formation occur with lighter and darker, slightly wavy laminae of a couple of millimetres - stromatolites formed during the life of cyanobacteria.

A protective mesh has been installed at the outcrop exposing the internationally renowned Permian-Triassic boundary

III Bükkalja

Separated from the limestone and shale mountains of South Bükk by structural lines, the rock composition of Bükkalja, having a top level of 200-400 metres, is different, however, it is directly related to it. Here, enormous rhyolite and dacitic tuff surfaces alternate with ignimbrite plateaus which were created by violent volcanic activities 20-10 million years ago in the Miocene. In the southern foreland of the Bükk Mountains lies modestly the undulating stretch of hills of Bükkalja, where villages hiding in the valleys of the streams rushing down from the Bükk and the hills covered with forests, meadows and orchards hide many natural and cultural historical treasures and rarities. A specific local architectural culture developed, which always used organically the conditions of volcanic tuff that covers the Bükkalja. It is a unique stone world in which the villages of the area live: stone-walled houses, stone fences connected to them, stone barns, cave dwellings and cellars carved into tuff, stone bridges spanning streams and trenches, gravestone cemeteries, roadside crucifixes, stone benches and the mysterious beehive rocks. This beautiful region is crossed by the Stone Road of Bükkalja, which includes 16 settlements from Sirok to Kács. Along the way the natural values of Bükkalja, the cultural historical sights of the settlements can be explored, the deservedly famous wines of the region can be tasted and the hospitality of locals can be enjoyed. Here in Bükkalja, one of the most extraordinary and at the same time the most mysterious natural and cultural historical values of Hungarian landscapes, the beehive rocks can be visited in greatest number, which were declared nationally protected as natural monuments in November 2014.

"Beehive stones" are specific natural values of Bükkalja that are also interesting cultural historical monuments. The material of these stone towers and rock domes are mainly rhyolitic tuff. The most typical tuff cones and stone towers weathered out from their surroundings can be found in the vicinity of Eger (Nyerges-hegy, Mész-tető, Cakó-tető), near Szomolya (e.g. Vén-hegy–Kaptár-rét) and around Cserépváralja (Mangó-tető Great and Small Cones, Csordás Valley, Furgál Valley, Kő Valley Nagybába-szék, Köves-lápa).

On the SW slopes of Vén Hill in Szomolya, the most extensive group of beehive rocks in the Bükkalja can be found, which contains the highest number of niches. The rocks of the cones are mostly fallen, avalanche, phreatomagmatic and reworked rhyolitic tuff, tuffite variants of Gyulakeszi Rhyolitic Tuff Formation. The time of their formation ranges from 18.5 to 14.5 million years ago based on radiometric age dating.

The rhyolitic tuff range stretching above the Kaptár Valley over more than 100 metres has been divided into eight large groups of rocks with 117 niches. The most beautiful is the IV. range, also called Királyszéke, which is divided into a larger cone resembling a beehive oven and several smaller ones containing 48 niches.

The size and depth of niches is variable. The largest niche is 112 cm high, their average height, width and depth are 60 cm, 30 cm and 25–30 cm respectively. A frame runs along the edges of the intact niches and in certain places holes can be detected in their margins.

IV. Who visits the Geopark?

Many sites of the Geopark are known and frequent destinations for Hungarian and foreign tourists and also for geologist-geographer professionals. The most popular tourist destinations are the two cities with county rights. The Bükk Region is abundant in attractions for geotourism. Further frequent geotouristic destinations include the Bükkalja, where the beehive rocks and folk stone monuments are connected by marked hiking trails and study trails, and also the surroundings of Szarvaskő, Szilvásvárad and Lillafüred, as well as the Uppony Mountains.

The cities and their surroundings are visited by a large number of Hungarian and foreign tourists, but both cities – being university cities and educational centres – regularly hold geo-events and related field activities. The geological sites of the Bükk Region are frequent destinations for primary and secondary school excursions. Families and tourist associations also often visit these sites.

From a geological point of view, key sections are visited most frequently, both for educational purposes and as venues for scientific events. The latter events are attended by both Hungarian and foreign professionals. Caves are also high-profile destinations in the mountains. The two caves in Lillafüred, in the vicinity of Miskolc, are visited by nearly 100000 visitors each year, mostly Hungarians. The number of foreign guests is smaller. Cave tours in overalls are also popular especially among young people.

E. VERIFICATION OF UNESCO GLOBAL GEOPARK CRITERIA

E.1 Territory

E.1.1 Geological heritage and conservation

A Geological overview

I. Uppony Mountains

The history of the Palaeozoic development of the mountains is supported by dating based on fossils (conodonts) established for carbonate rocks, while in the case of clastic formations, it can only be established on the basis of Alpine analogies.

The oldest rocks in the Geopark can be found in the **Tapolcsány sub-unit** of the Uppony Mountains in the form of shallow marine and nearshore sandstones formed 450 million years ago in the **Late Ordovician**:

- the clasts of the sublittoral medium and coarse grained quartz sandstone of *Rágyincsvölgy Sandstone Formation* ($^{r}O_3$) is exclusively quartz, even its matrix is siliceous. It is regarded to be the first member of the Variscan depositional cycle on the basis of analogues from Szendrő and the Alps.

- *Csernelyvölgy Sandstone Formation* ($^{c}O_3$) is a littoral fine and medium grained "greywacke" with silica cement. Apart from quartz that dominates among the grains, rock fragments are also abundant. The high ratio of lithoclasts and their high feldspar content indicates short transport and fast accumulation.

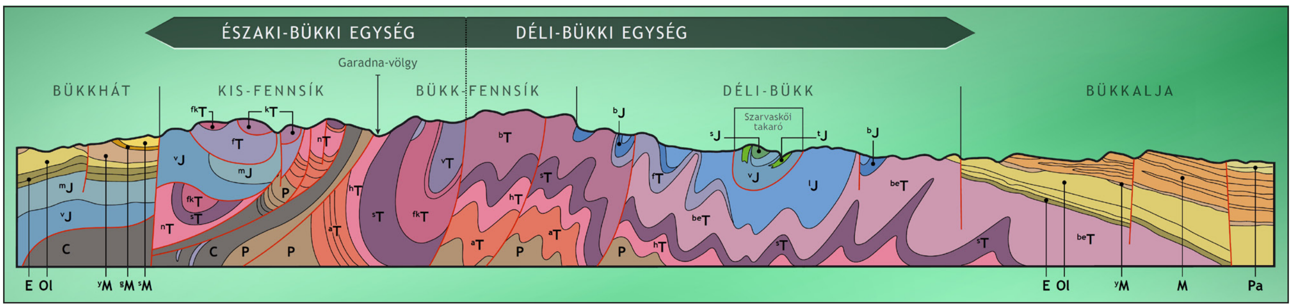
With the deepening of the depositional basin in the **Silurian**, the alternating thin layers of shale, siliceous shale and lidite of the *Tapolcsány Formation* ($^{t}S\text{-}D_1$) were formed, which can be correlated with the Bischofalm facies of the Carnic Alps. Its hydrothermal-metasomatic iron manganese ores were used in iron production in the 18th and 19th centuries. Numerous old mine tunnels were constructed in the rock. Basic volcanites in the Tapolcsány Formation indicate the onset of rifting (*Strázsahegy Formation* – $^{sh}D_{1\text{-}2}$). The metamorphosed basalt tuffites (Schalstein) have orthoceras containing **Silurian** pelagic and Lower Devonian crinoid containing limestone olistoliths. Éleskő Formation (^{e}C) is an olistostrome-like sediment consisting of 1-20 m limestone blocks embedded in calcareous shale, aleurolitic shale and fine grained sandstone matrix. Conodonts of Early, Middle and Late Devonian age can be found in the limestone olistoliths. It is classified in the Carboniferous on the basis of Alpine analogies (Graz, Carnic Alps).

The sedimentary development of the Uppony sub-unit shows significant similarities with that of Alpine Palaeotethys units. The oldest member has a carbonate platform character and it is a crystalline limestone (*Uppony Limestone Formation* – $^{u}D_{2\text{-}3}$) due to its later metamorphism. Its most beautiful outcrop is the Uppony Pass. It contains no interpretable fossils; based on its appearance, it could be of reef lagoon facies. Based on stratigraphic considerations and analogies, its age can be **Middle Devonian, the very beginning of Late Devonian**. In the deepening basin, the so-called „cippolino" type limestone with metatuffite, sericite-chlorite mesh and pelagic basin facies of *Abod Limestone Formation* ($^{a}D_3$) developed. The chloritized material present in the rock is related to the volcanic material of the *Zsinnye Metabasalt Member* ($^{a}_{z}D_3$) in the western part of the mountains. The basic volcanic rock and the limestone are interfingered with intraconglomerate levels. As a result of sediment slides, the unconsolidated lime-mud and the volcanite were mixed syngenetically. The age of the Formation is **Late Devonian** based on conodonta findings.

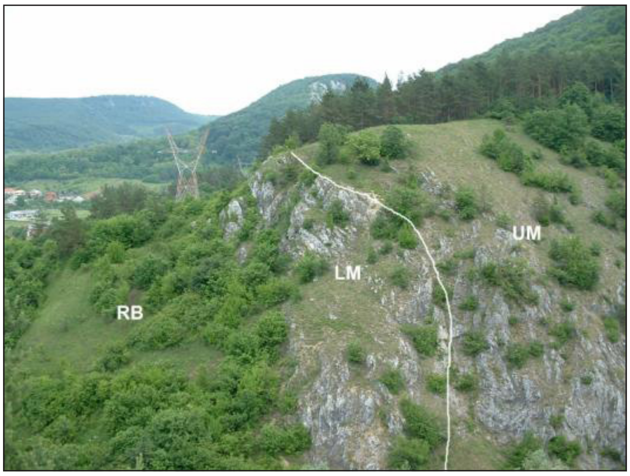
Pelagic limestone formed from the Devonian/Carboniferous boundary after the disappearance of the traces of volcanic activity is classified in the *Dedevár Limestone Formation* ($^{d}C_1$). Metasomatized variants are made of ankerite-siderite and dolomite. In the Lower Viséan section a typical calcareous, thin layered lidite level occurs. Based on conodonts, its age is **Early Carboniferous**, Tournaisian, Early Viséan (about 360-340 million years). Its thickness ranges from a few metres to a maximum of 20 m. The most common formation of the Uppony Unit on the surface is *Lázbérc Formation* (^{l}C). The formation is composed of alternating thin-layered – thick-bedded, rarely laminated limestone and calcareous shale. The texture of limestones is usually completely crystalline, but in some places it is less metamorphic, contains fossils. The formation is of pelagic facies, deposited on the sea floor in calm, depositional conditions. Its age was determined to be **Early–Middle Carboniferous** based on conodonts. *Derennek Formation* (^{de}C) is calcareous sandstone and sandy limestone that occurs in the area of the Lázbérc Formation. In certain levels, conglomerate with small gravel, partly crinoidea containing limestone and limestone breccia occur within the formation. Crinoidea fragments and foraminifer cross-cuts from the limestone cannot be determined more accurately due to the metamorphisation of the rock. Quartz and lidite pebbles found in the formation indicate orogenic uplift and erosion of the denudation area, the sediment is of marine molasse character. Among the rocks of the Uppony Mountains this is the most similar to the sandstones of the Zóbóhegyese and Mályinka Formations of the Carboniferous in the Bükk, and this is why it was classified into the Carboniferous.

Probably some Rudabánya Triassic blocks of Bódva type were moved next to the Palaeozoic rocks of the Uppony Mountains by a sinistral strike-slip fault along the Uppony Thrust that borders the mountains on the north. Two blocks of *Guttenstein Formation* ($^{g}T_2$) are exposed just south of Uppony village and slightly further SW. The rock composed of an alternation of limestone and dolomite, was strongly sideritized by metasomatism. Another moved Triassic block is a limestone block of *Steinalm Limestone Formation* ($^{st}T_2$) located at the NE entrance to the Uppony Pass. This limestone was formed the tidal zone and below it. In the latter type, large masses of calcareous algae (Dasycladaceas) occur.

On the Palaeozoic rocks of the Uppony Mountains a Mesozoic sediment of Late Cretaceous age (85-80 million years) lies with a very large sediment gap (at least 220 million years), which is the only formation in north Hungary of this age on the surface. *Nekézseny Conglomerate Formation* ($^{n}K_3$) is a thick-bedded conglomerate with sandstone and clay marl interbeddings. The sediment is made up of gravel accumulated in shallow seas by wide rivers and reworked by sub-marine debris flows and torn fragments of rudist bioherms that were built on the gravel at low sea levels. Limestone blocks appear in the formation only in one place (N of Dédestapolcsány). The gravel material of the conglomerate does not contain Bükkian rock material. Based on its stratigraphic position and non-metamorphic nature, the formation may have been deposited after the Alpine tectono-metamorphic event of the Uppony Mountains.



The north-eastern part of the Uppony Mountains is covered by Miocene andesitic agglomerate. Három-kő is a cliff of the rock dissected by lava bombs with a nice view. Damasa Ravine is located north of this cliff. This special landform was created by one of the greatest, largest and youngest block landslides in Hungary. Among the blocks leaning onto each other is one of Hungary's most significant pseudo-cave systems.



Uppony Fault, part of the Darnó Zone at the western entrance of Uppony Pass. UM – Uppony Limestone, LM – Lázbérc Formation (limestone), RB – ore containing formations of Rudabánya (Steinalm Limestone)

II Bükk Mountains

The Palaeozoic of the Bükk rising south of the Uppony Mountains is almost a continuation of the Uppony series in terms of geological periods, but based on structural geological and tectonic considerations, the continuity of the strata is not considered verifiable. The Palaeozoic and Mesozoic rocks of the Bükk show Dinaric relations instead of Alpine.

The two mountains can be separated along the Nekézseny Thrust, where the Permian – Lower Triassic sediments of the Bükk are thrust onto the rocks of the older (Silurian – Lower Devonian) Tapolcsány Formation and the younger (Upper Cretaceous) Nekézseny Conglomerate.

1. Variscan cycle

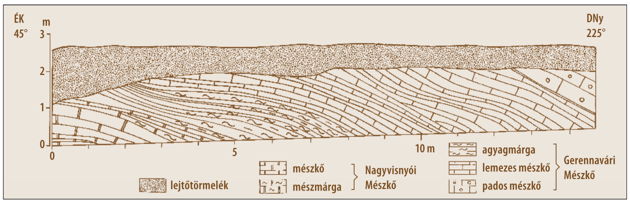
The geological development of the Bükk can be arranged basically into three sedimentary cycles. In the regression section at the end of the Variscan cycle periodical but rapid filling of the Carboniferous deep sea took place. The lowest, pelagic member of the continuous sediment series of the **Carboniferous** period is the *Zobóhegyese Formation* (^{z}C). Limestone bodies are located in between clay, fine sandy aleurolite and sandstone layers. The clastic sediment is strongly foliated. Terrigenous sediments were provided only by debris inflows in the Late Bashkirian – Early Moscovian stage. Well bedded aleurolite often with graded bedding in great thickness together with some claystone and fine-grained sandstone (*Szilvásváradi Formation* – $^{s}C_2$) were deposited. The formation has the characteristics of a distal turbidite. It was foliated as a result of anchizonal metamorphism and is the most widespread foliated rock in the North Bükk. As the flysch basin was filled a shallow sea environment occurred. The *Mályinka Formation* ($^{m}C_2$) evolved continuously from the Szilvásvárad Formation. Siliciclastic debris continued to play a major role in its formation, but conditions for shallow marine limestone were also prevailed temporarily. The main mass of the formation is made up of foliated claystone, aleurolite and fine sandstone with variable carbonate contents. It contains limestone interbeddings with varying thicknesses in three ranges. The lower two limestone ranges are called *Kapubérc Limestone Member* ($^{mk}C_2$). The wildlife of a very shallow, well-illuminated sea of normal salinity can be studied at the level of lower limestone. Reef-forming calcareous algae prevail, beds containing Rugosa and Tabulate corals appear in some places. The upper limestone level was formed in deeper conditions containing fusulines and crinoids. The 5 m thick sandstone bed dividing the two limestone levels indicates an increase in terrestrial debris inflow. The gravel material of the *Tarófő Conglomerate* ($^{m}_{t}C_2$) was probably supplied by the same river. The third limestone range (*Csikorgó Limestone Member* – $^{m}_{c}C_2$) occurring after the thick fine clastic interbedding, is of shallow marine conditions with crinoids–fusulines. The sediment series proves a slight but continuous deepening of the depositional basin. Following un uplift at the very end of the Carboniferous, erosion interrupted sedimentation in the **Early Permian**.

Among the shale layers of the Upper Carboniferous Mályinka Formation shallow marine limestone beds rich in fossils (fusulines) are interbedded. The limestone crests of the Csikorgó Limestone Member occur near the Mályinka-Szentlélek-Bánkút junction.

2. Alpine cycle

Upper Permian beds lying on Carboniferous formations have a slight, few-degree erosional angular discordance. The cycle of the *Szentlélek Formation* ($^{s}P_2$) begins with green, red, purple sandstone (*Farkasnyak Sandstone Member* – $^{s}_{f}P_2$) deposited on a near-flat seashore with a desert climate. The sediment deposited initially in lakes gradually develops into shallow marine in character. The *Garadnavölgy Member* ($^{s}_{g}P_2$) is made up of claystone, dolomite and gypsum-anhydrite evaporite layers deposited on a tidal flat, together with limestone interbedding. The latter suggests a short period of continuous water cover. By the **Late Permian**, shallow marine conditions became permanent. Thin bedded black limestone is formed with black marl and calcareous marl layers (*Nagyvisnyó Limestone Formation* – $^{n}P_2$). Dolomite bodies with varying thickness are common in the lower levels. The tropical shallow sea with normal salinity (sometimes slightly too saline) and sometimes good ventilation, was home to a rich wildlife. At other times, sediments were deposited in euxinic conditions, as shown by the high bitumen content of the formation and the presence of well-preserved fossils. Although the formation occurs only in the North Bükk on the surface, it has also been detected in deep boreholes in the W (Bükkmogyorósd) and SW foreland of the mountains.

The Permian Szentlélek Formation deposited along a shallow, flat, sometimes drying seashore. The clay-gypsum-anhydrite-dolomite layers of the Garadnavölgy Evaporite Member are exposed in a roadcut near a trout farm in the valley of the Garadna Stream.



Geological cross-section of the key-section Bálvány North (after Csontosné Kis K. and Pelikán P. 1990)

The global extinction event of the **Permian/Triassic boundary** can be studied in continuous marine sediment series in several places in the mountains. In an opening sea in the beginning of the Triassic, ooidal rocks of the *Gerennavár Limestone Formation* ($^{g}T_1$) were formed showing strong water movement and good oxygen supply. The shallow shelf with a slight slope returned only slowly to life, as indicated by the stromatolite laminites characteristic of the lower part of the formation. The nearshore, shallow sea environment with strong water movement, was replaced by a slowly deepening sea, and the transport of terrigenous material into the basin increased (*Ablakoskővölgy Formation* – $^{av}T_1$). The lower part of the formation, *Ablakoskővölgy Sandstone Member* ($^{av}_{a}T_1$), develops from Gerennavár Limestone with a transition of changing layers. Its thick laminae of the sandstone are finely stratified, often cross-bedded. The following *Lillafüred Limestone Member* ($^{av}_{l}T_1$) is finely stratified and thin bedded due to clay interbeddings. The series of *Savósvölgy Marl Member* ($^{av}_{s}T_1$) composed of alternating shale, clay marl and foliated marl layers indicating a re-intensifying terrigenous material inflow. Once again, the closing member of the formation is limestone (*Újmassa Limestone Member* – $^{av}_{u}T_1$), which is deposited under deeper, subtidal conditions, with nodular and laminated clay interbeddings. The rocks of a total of five members of the two formations give the **Lower Triassic** of the Bükk a characteristic division into five parts.

With the slow but steady subsidence of the seafloor the building of a carbonate platform started by the early Anisian at the beginning of the **Middle Triassi**c. *Hámor Dolomite Formation* overlies Újmassa Limestone with a continuous transition and Savósvölgy Marl with a sharp boundary. Subsidence was offset by the carbonate accumulation of of lime secreting flora and fauna abundant in the shallow water. Peritidal (stromatolitic, oncoidic) and subtidal beds alternate with each other. Unsorted, rounded clasts with variable grain size of *Sebesvíz Conglomerate Member* ($^{h}_{s}T_2$) occurring in the highest level of the formation indicate the change at the end of the Anisian beforehand: the building of the carbonate plateau was interrupted by a calc-alkaline volcanic activity (*Szentistvánhegy Metaandesite Formation* – $^{sh}T_2$). The mixed composite volcanic series of the formation is composed by lava, tuff, agglomerate, ignimbrite and sedimentary-volcanic mixed rocks. Submarine and land layers also occur. Fine-grained tuff versions and the mixed rocks were strongly compressed by metamorphic processes therefore these show lamination. Volcanism was accompanied with the partial uplift of the area supported by the presence of welded volcanic tuff, lacustrine sediments lying on the volcanites and the presence of Sebesvíz Conglomerate.

Following the elimination of partial terrestrial conditions developed by the end of the volcanic activity the conditions of carbonate formation were restored. Thick limestone formations were formed giving the karst character of the mountains. These limestones can be related to the "Wetterstein type" Ladinian carbonate platform of the Western Tethys. In the course of the Ladinian-Carnian the development of the North and South Bükk slightly differed.

The main mass of the *Fehérkő Limestone Formation* ($^{fk}T_2$) of the Ladinian carbonate platform developing in the northern unit is bedded, thick bedded, Lofer cyclicity is increasingly characteristic upwards. On its base nodular limestone with clay inwash (*Bolhás Limestone Member* – $^{fk}_{b}T_2$) was formed due to the effect of Szentistvánhegy Metaandesite. Isolated lenses deposited in shallow basins are frequent in the formation: e.g. limestone with flint lenses, limestone clasts with clay matrix and re-worked volcanic material. The formation upwards has a transition to Vesszős Formation with a laminated limestone with flint lenses (*Disznós Limestone Member* – $^{fk}_{d}T_2$) *Vesszős Formation* ($^{ve}T_3$) is composed of calcareous shale and aleurolite schist, and some foliated sandstone. (*Létrás Metabasalt Formation* – $^{l}T_3$ regarded to be a magma intrusion, however, with uncertain stratigraphic classification is known solely in the Vesszős Formation). Limestone lenses and layers with flint nodules are frequent. The formation is not regarded a true basin facies but the product of events disturbing carbonate formation and causing increased clast inflow. Its cover, the *Hegyestető Formation* ($^{ht}T_2$) has a continuous transition. The three members of the formation also have continuous transitions from basin facies towards carbonate platform facies. Its lower part is composed of the alternation of marl, aleurolite schist, limestone (*Limpiász Member* – $^{ht}_{l}T_2$). The middle member was formed by the secondary dolomitisation of thick bedded limestone (*Bányabükk Member* – $^{ht}_{b}T_2$). The upper part is dolomite fészkes limestone with volcanic tuff interbeddings (*Gamóca Member* – $^{ht}_{g}T_2$). The facies of this (slope close to a platform, slope foot) is a transition towards the platform facies but the development of this was interrupted again by volcanism (*Bagolyhegy Metarhyolite Formation* – $^{bh}T_2$). Two characteristic types can be identified in the volcanite. One of them is a massive, slightly silicified metarhyolite, while the other is a greenish, strongly compressed to a laminated appearance, foliated, rhyodacite in composition. As the volcanic activity ceased the carbonate platform revived and basin facies prevailed only from the end of the Carnian – beginning of the Norian.

In the southern unit, the laminate of *Várhegy Formation* ($^{v}T_2$) composed of limestone and marl laminae while at higher levels the volcaniclastics of the formation with radiolarite interbeddings can be found on top of the volcanic formation (tuff, tuffite) related to the Vár Hill in Felsőtárkány. In this area, the building of the carbonate platform did not continue, flint containing limestone (Felsőtárkány Limestone Formation) deposited in a deep basin is next in the series.

In other areas of the southern unit carbonate platform facies developed undisturbedly in the Ladinian-Carnian.

Berva Limestone Formation ($^{be}T_{2\text{-}3}$) appears in large patches on the surface in the southern margin of the mountains, but petroleum exploration deep boreholes also reached it in the „Demjén block" deep down, covered with Cenozoic layers south of Eger. It is generally „Wettersteinian" type biogenic reef and cycle lagoonal in nature. In the limestone of Kő-köz in Felsőtárkány, „Dachsteinian" type of reef development was also shown. The deepening of the platform parts belonging to the formation, the termination of the conditions of reef formation differed over time. According to age data determined on the basis of the fossil (conodont) content of the covering formations with basin facies, reef building ceased in certain parts in the Early Norian and elsewhere in the Middle Norian. This can be placed on the Norian-Rhaetian boundary in Kő-köz.

The most significant platform facies formation regarding surface distribution is the *Bükkfennsík Limestone Formation* ($^{bf}T_{2\text{-}3}$). This constitutes the karst plateau of the Big Plateau, the upland between Répáshuta and Kisgyőr and the block between Bükkszentlászló and Miskolctapolca. The lagoonal facies is the most extensive one while the proportion of the coral reef facies is smaller. The underlying formations are not known but the covering formations are the Répáshuta Limestone in the western part of the Big Plateau and in the vicinity of Répáshuta, and the Hollóstető Limestone Member in the zone between the Szinva Valley and Sugaró. The latter partly substitutes the Bükkfennsík Limestone. The reefs of the formation became inactive near the Ladinian-Carnian boundary, however, in certain zones this took place only at the end of the Carnian.

The **Upper Triassic** *Kisfennsík Limestone Formation* ($^{kf}T_3$), regarded to be a nappe, occurs on the surface only north of Garadna Valley. Tidal flat, lagoon and reef environments can be detected in its carbonate platform facies limestone with *Neomegalodon* ("Dachstein" type). It can be classified into the Carnian based on its foraminifera fossils. Its nappe structure is supported by the fact that the flint containing limestone below it is considered to be younger (Rónabükk Limestone Member).

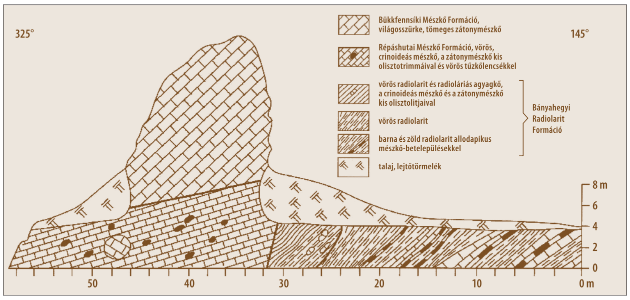
Considering the above, limestone formations developed in deeper basins gradually become more dominant from the Ladinian-Carnian boundary. In the blocks subsided to greater depths due to structural reasons in the Late Triassic pelagic limestone was formed while on blocks with higher elevation the formation of platform limestone remained continuous. The formation of shallow marine reefs ceased even on the highest blocks in the Late Triassic and only deeper marine flint containing limestone is known from later ages.

Répáshuta Limestone Formation ($^{rh}T_3$) is closely related to the Bükkfennsík Limestone. It can be detected mostly in the northern and southern limbs of the Big Plateau and Répáshuta-Kisgyőr anticlines in discontinuous ridges. A reddish shade in colour is typical for the rocks of this formation caused by its hematite content of volcanic origin (Szinva Metabasalt).

Its bedded, thin-bedded appearance shows clearly the folded structure of the mountains. Apart from clay laminae, clay lenses and flint nodules, olistolite and olistostrome intercalations of platform origin are also typical. No fossils suitable for age determination were found in the formation, however, crinoid fragments are abundant. *Felsőtárkány Limestone Formation* ($^{ft}T_3$) can be found in greatest volume in South Bükk but the flint containing limestones of the Little Plateau are also classified here. Its material is bedded or thick-laminated with flint lenses and layers, marl interbeddings are also frequent. Epigenetic dolomitisation is most typical in the lower zone of the formation, the largest occurrences of which are classified into the *Belvács Dolomite Member* ($^{ft}{}_{b}T_3$). In the surroundings of the Big Plateau, the formation is divided into two members. *Hollóstető Limestone Member* ($^{ft}{}_{h}T_3$) lies in a stratigraphically deeper position. In certain areas it lies on Bükkfennsík Limestone or it is its heteropic facies. The rocks of the member exhibit a specific rib-like structure due to strong deformation and incompetent behaviour of certain layers. *Rónabükk Limestone Member* ($^{ft}{}_{r}T_3$) lies on Bükkfennsík Limestone generally with Répáshuta Limestone interbedding. Its thick-bedded, thick-laminated structure became cross-foliated, laminated as a result of anchizone metamorphism. The products of the third volcanic activity in the Triassic, *Szinva Metabasalt Formation* ($^{sn}T_3$), can be found in Felsőtárkány Limestone. This metabasalt is composed of lava rocks and shallow depth intrusions, veins. Its character is of within-plate alkaline-tholeiitic. Its occurrence can be associated with the opening of the western part of the Vardar Zone, started in the Middle – Late Triassic.

The development of the sedimentary series was interrupted for a long time (for around 30 million years) at the boundary of the Norian-Rhaetian towards the end of the Late Triassic and started again only in the middle of the Jurassic.

The lowest member of the sedimentation starting from the middle of the **Jurassic** (Early Bajocian) is *Bányahegy Radiolarite Formation* ($^{bh}J_{2\text{-}3}$) lying on various Triassic formations, mostly on Répáshuta Limestone without angular discordance. The finely stratified radiolarite and radiolarian containing schist contain platform and basin facies reworked limestone olistoliths and allodapic limestone lenses and layers. The material of the formation is generally strongly folded and foliated. Bányahegy Radiolarite is always overlain by *Lökvölgy Formation* ($^{lv}J_{2\text{-}3}$), which is a distal turbidite (flysch) composed of cycles with a maximum thickness of 5 cm. In the frequently graded cycles the size of the sediment grains varies from sand – fine sand to aleuritic clay. It is strongly foliated as a result of anchizone metamorphism, cross-foliation is also typical. Scattered conglomerate and sandstone layers can be found in it and thin limestone interbeddings occur at places. Based on its abundant radiolarians, it can be separated clearly from the fossil free Palaeozoic schists. It was probably formed in the Early Bajocian – Early Bathonian.



Geological cross-section of Bánya Hill Bh-1 (J-47) (after Riedel et al. 1988 modified, after Pelikán P. 2005)

According to the classic interpretation, the Jurassic formations can be ordered into a single series and have sedimentary boundary with the Triassic sediments. According to the nappe model, the Lökvölgy Formation is the closing member of the Bükk paraautochthonous and the following Jurassic sediment series is in a nappe position. The disturbed structure of the rock series can be explained by its position in the accretionary wedge. According to the most recent model, the Jurassic accretionary complex of the Inner Dinarides occur in the Bükk Mountains in the form of nappes, or even more probably, in the form of olistoplacas. The rock series is called *Mónosbél Formation Group* ($^{M}J_{2\text{-}3}$), (more recently *Laskóvölgy Formation* – $^{l}J_{2\text{-}3}$). Its rocks form a sediment series reworked from a shallow marine environment into deep-sea environment via turbidity currents and debris flow. The group of rocks is divided into formations based on the dominant rock type.

Lökvölgy Formation

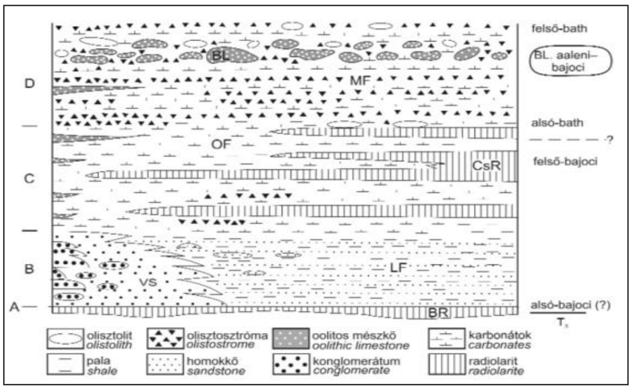
Vaskapu Sandstone Formation ($^{vk}J_{2\text{-}3}$) is composed of clayey – calcareous bond, sometimes silicified sandstone. It is generally fine-stratified but this is absent in the silicified parts. In the clayey – calcareous bond version claystone with coalified plant remnants are found in dm thick layers. Its aleurite sized version is identified as *Kishegy Aleurolite Member* ($^{vk}{}_{k}J_{2\text{-}3}$). Coarse conglomerate bodies in the formation are interpreted as channel filling sediments of deep-sea fans. This formation is closely related to the Lökvölgy Formation, the two formations seem to be interfingered and only these two show thermal contact with the basaltic bodies. More recently, the two formations are regarded to be heteropic formations: Vaskapu Sandstone was in proximal while Lökvölgy in distal position. And even the sandstone formation is not regarded to be part of the Mónosbél Formation group most recently.

Rocskavölgy Formation ($^{r}J_{2-3}$) containing iron and manganese nodules, lenses can be identified and separated typically in submarine basaltic volcanite environment. Its rock composition is aleurolitic claystone, its texture became orientated due to metamorphism. Its manganese content is sometimes so significant that raw material exploration was conducted in the 18th – 19th centuries. Small features resembling wormholes can be seen in the nodules recovered from the version showing thermal contact effects in the quarry at Reszél-tető in Egerbakta. The crust of the nodules is composed of manganese oxide, their inside is vesicular containing muscovite, quartz and in smaller amount clinochlore. Based on the manganese enrichment and the ichnofossil-like traces, the presence of "black smokers" could be suspected that could have supplied metals and energy necessary for life in a deep-sea environment.

Oldalvölgy Formation ($^{o}J_{2-3}$) is composed of the dense alternation of foliated aleurolite and flint containing limestone. Ooid containing limestone versions showing relation towards Bükkzsérc Limestone also occur in the formation. It develops from Lökvölgy formation with a sedimentary transition: the flysch character of the sediments disappears first, then limestone beds appear and become more frequent. There is also sedimentary transition from the Csipkéstető Radiolarite. According to the most recent results, the Oldalvölgy Formation and the Csipkéstető Radiolarite show interfingerings with each other. Recently the age of the formation has been considered in the interval of Early Bajocian – Early Oxfordian. Olistoliths of non-Bükkian material are known in the formation. The most significant one is an olistotrim containing basalt and red Upper Triassic Hallstatt Limestone near Kavicsos-kilátó. The latter occurs closest in the Aggtelek-Rudabánya Mountains.

Csipkéstető Radiolarite Formation ($^{cs}J_{2-3}$) is a massive, siliceous rock sometimes containing radiolarians in rock forming quantity. Certain versions are finely stratified, divided into bed bundles with clay films. Its other versions are breccia-like. It is widespread within the formation group but forms no continuous level. One of its most spectacular outcrop is the radiolarite cliff by the road at Bátor. According to the most recent research, its age is the same as that of Oldalvölgy Formation.

The last member of the formation group is *Bükkzsérc Limestone Formation* ($^{bz}J_{2-3}$). Black, platform facies limestone rich in black flint nodules. Slight gradation can be observed within the limestone beds. Although it forms no continuous level, occurs in large connected bodies (Patkó Cliffs). According to the most recent research, its age is Aalenian(?) – Bajocian.



Relations of the Jurassic formations of West Bükk and their stratigraphic position
Abbreviations: BR – Bányahegy Radiolarite; VS – Vaskapu Sandstone; CsR – Csipkéstető Radiolarite; OF – Oldalvölgy Formation; MF – Mónosbél Formation; BL – Bükkzsérc Limestone (after Haas et al. 2011)

Basaltic igneous bodies pushed into the Jurassic sediments simultaneous with sedimentation and submarine lava rocks were formed as pillow lavas. These have thermal contacts with the sediments, primarily with Vaskapu Sandstone and Lökvölgy schist. In the nappe model the magmatites and the surrounding sediments together form the Szarvaskő Nappe as oceanic crust while the higher levels of Mónosbél Formation Group belong to the Mónosbél Nappe and these cover the Palaeozoic – Triassic – Middle Jurassic formations (Lökvölgy Formation).

The extrusive rocks of *Szarvaskő Basalt Formation* ($^{sz}J_{2-3}$) are characterised by the presence of massive basalt, pillow lava and hyaloclastite. As a result of pseudohydrothermal effect, the fractures of the lava rocks are filled with calcite-quartz-prehnite-pumpellyite. The best outcrops of the formation are the cliffs of Vár Hill and the nearby gorge at Szarvaskő.

The intrusive gabbro rock bodies and dolerite veins are classified into the *Tardos Gabbró Formation* ($^{t}J_{2-3}$). It is found primarily in the Vaskapu Sandstone but in boreholes near Bátor it contacts with the Oldalvölgy Formation. In the contact zone of the magma and the sediment a thermal contact zone (hornfels) can be identified. The best outcrop of this is the Tó-bérc quarry at Szarvaskő. In the vicinity of Szarvaskő the gabbro is also accompanied by ultrabasic bodies (peridotite, wherlite) with known iron-vanadium-titanium.

The only proved Cretaceous sediment in North Hungary is the Nekézseny Conglomerate already described with the Uppony Mountains, the younger cretaceous sediments were presumably denuded. No Variscan tectonometamorphic effects can be detected in the Palaeozoic rocks of the Uppony and Bükk mountains. The first ductile deformation of the Palaeozoic-Mesozoic units took place probably in great depth in the Middle Cretaceous. The second folding of the semi-plastic rocks could have happened in smaller depth at the time of uplift and denudation in the Late Cretaceous. Probably the Uppony Mountains and the Bükk got next to each other after the above events.

3 Cenozoic (Neo-Alpine cycle)

The third sedimentary cycle belongs to the Neo-Alpine period. Continuous denudation can be presumed after the uplift until the **Late Eocene**. Transgression of the Late Eocene sea onto the folded sediments of the Mesozoic came from the south in the Bükk Mountains.

The base formation of the Palaeogene is the *Kosd Formation* ($^{k}E_{3}$). Its rock composition is variegated clay (around 90%), and a mixture of sand, gravel, limestone and dolomite fragments. It is terrestrial in the lower parts and shows transition to marine formations upward. Its best outcrop can be found near Várkút at Felsőtárkány, however, its most typical sections are found in boreholes. Its thickness varies according to the relief developed by the end of the Eocene. In swamps of lagoons formed in depressions of the softer Jurassic rocks thin coal layers also formed. The age of the formation is either the upper part of the Bartonian stage of the **Middle Eocene** or the Priabonian stage of the Late Eocene.

Onto the surface made even by Kosd Formation the Upper Eocene (Upper Priabonian) *Szépvölgy Limestone Formation* ($^{s}E_{3}$) deposited. Its main mass is composed of characteristic biogenic, thick-bedded limestone with thinner-thicker marl layers between the beds. Red algae (Corallinaceae) and larger foraminifers are typical fossils in the formation. *Nummulites fabianii* prevails among the latter. The rock was deposited onto a shallow marine carbonate platform. The fossils of its lower parts indicate an inner shelf position while the upper parts suggest the outer shelf with a slightly deeper water cover. It is known mainly in the south-west Bükk on the surface (from Eger to Kisgyőr). Its small patches occur in the vicinity of Forrás Valley in Miskolc in north-east Bükk. Its formation lasted till the end of the Eocene.

Enrichment of terrigenous material in the rocks of *Buda Marl Formation* ($^{b}E_{3}$-Ol_{1}) reflect the deepening of the sedimentary basin with basin facies. Considering its composition, it is calcareous marl with a carbonate content of 60–80%. Sudden deepening of the basin is reflected in the presence of thick beds of allodapic Eocene limestone and larger foraminifers reworked from these beds. Original larger foraminifers can be hardly found in the rocks of the formation due to the deterioration of the climate and deeper marine conditions in the Oligocene. Simultaneous with the disappearance of *Nummulites fabianii*, N. vascus emerges. Harder beds exhibit characteristic ichnofacies with large amount of Thalassionides isp. trace fossils. The boundary of the formation with Szépvölgy Limestone coincides with the Eocene/Oligocene boundary in the Bükk. The formation of Buda Marl took place in the Bükk at the very beginning of Oligocene (Rupelian according to the standard classification).

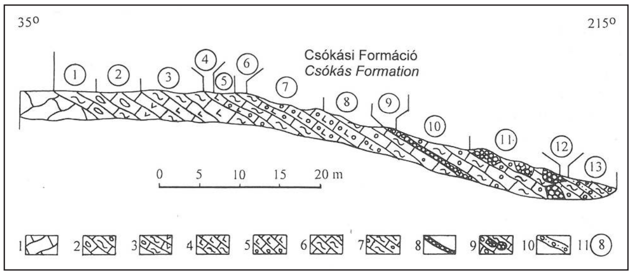
At the beginning of the Oligocene connection with the sea was broken and sedimentation continued in the basin of the developing Paratethys.

With further deepening of the sea down to bathyal conditions, oxygen supply near the seafloor. This is clearly reflected by the characteristic laminated structure and undecomposed organic matter content, suggesting euxine conditions, of *Tard Clay Formation* ($^{t}Ol_1$). Due to its high bitumen content (8‰ on average), it can be the parent material of crude oil occurrences at Bükkszék, Demjén and Mezőkeresztes. The material of the formation is aleuritic clay. In certain layers it is rich in leaf and fish imprints. Its sole outcrop is a road cut at the foot of Kis-Eged Hill near Eger exposing siliceous "menilite" shale with leaf and fish imprints, the underlying Buda Marl and also the overlying Kiscell Clay. Due to the enclosed nature of Paratethys the formation has an endemic bivalve fauna (Cardium lipoldi, Ergenica cimlanica, Janschinella melitopolitana, etc.) that can be studied on the surface exclusively in this outcrop in Hungary.

The rocks of *Kiscell Clay Formation* ($^{k}Ol_1$) were deposited in a shallower sea. Its formation depth could have ranged from sublittoral to shallow bathyal from the shore towards the basin. Sandstone and clay marl alternate in its lower parts while the upper zones are composed of aleuritic clay marl. Its carbonate content is higher (15-40‰) than that of Tard Clay. It can be found on the surface in the vicinity of Bükkszék and Fedémes, and from Eger to Kisgyőr in the Bükkalja, however, hydrocarbon exploring boreholes also exposed it west of Eger Valley. Its thickness increases continuously towards south, towards the Great Hungarian Plain. It is exposed in small outcrops NE of the Bükk near Varbó Lake and in boreholes as well. As seen in the latter, it lies directly on Szépvölgy Limestone as the heteropic facies of Tard Clay. It also contained small hydrocarbon reservoirs mainly associated with volcanic clastic lenses, however, these have been mostly extracted completely by today. The oil field at Bükkszék saw crude oil extraction for a decade from 1937. North of this area, natural gas was extracted from the Fedémes reservoir in the 1950s. In the area from Demjén to Andornaktálya crude oil mining also started in the 1950s and some oil is still being extracted from certain wells here. At the southern border of the Geopark the hydrocarbon reservoir of Mezőkeresztes also belongs to this formation. The fluxoturbidite of the *Noszvaj Member* ($^{k}_{n}Ol_1$) composed of very thick-bedded coarse gravel and aleurite containing more bond conglomerate and sandstone thick beds lies in the Kiscell Clay with a washout plane between Noszvaj and Eger-Szöllőske. The gravel from the Bükk was transported to the shoreline by short streams with a high discharge, and then the material moved towards the inside of the basin by gravity. The formation was formed in the Late Kiscellian (from the Late Rupelian until the lower third of the Chattian).

Noszvaj Gravel Member of Kiscell Clay, Noszvaj

The gravel-clay material of *Csókás Formation* ($^{cs}Ol_2$) with larger foraminifers and red algae, enclosing also limestone lenses and layers exposed in the Little Plateau on the NE side of the Bükk. Its only well-studied outcrop is a research trench at Csókás where it lies directly over Kisfennsík Limestone. It contacts with Fehérkő Limestone along with a steep fault in the sand quarry at the foundry of Diósgyőr. The formation is placed to the bottom of the Egerian stage (lower, middle third of the Chattian) based on palaeontological studies. The bio- and lithofacies of the formation suggest the ingressive inundation of a dissected relief resembling tropical cone karsts. Based on the small burial diagenesis grade measured by smectite analysis of the formation, it can be assumed that certain parts of the Bükk rose from the Palaeogenic sea like islands.



Geological section of Csókás trench, the key-section of Csókás Formation (according to Less 1991)
1 – Kisfennsík Limestone F., 2 – Lithothamnium containing marl, 3 - Lithothamnium containing tuff marl, 4 – Lepidocyclina containing marl, 5 – Lepidocyclina containing sandy limestone, 6 – Marl, 7 – Gravel containing marl, 8 – Limestone-conglomerate, 9 – Limestone-conglomerate-marl with boulder-gravel, 10 – Gravelly sand, 11 – No. of stratum

The typical mollusc fauna of *Eger Formation* ($^{e}Ol_2$) was described from the section of Wind brick factory. The Egerian (Egerien) stage at the end of the Oligocene – beginning of Miocene identified based on the molluscs, lies continuously on Kiscell Clay. It is a normal saline, deep sublittoral mollusc containing aleuritic clay marl. Its initial sediment series (*Novaj Member* – $^{e}_{n}Ol_2$) is composed of tufitic, glauconitic sandstone, then lepidocyclina containing marl, lithothamnium-lepidocyclina containing limestone, glauconitic, clay with larger foraminifers, and finally sandstone with larger foraminifers. This is overlain by the characteristic mollusc containing clay of the formation. Above this clay and sandstone layers alternate and finally brackish water – lacustrine clay and coarse sand with gravel interbeddings close the sediment series. The series of the formation show transgression after the regression closing the formation of Kiscell Clay until the mollusc containing clay followed by regression, which lasts until complete shallowness (tidal features can be observed in the sand quarry at Andornaktálya). It occurs on the surface only in the SW foreland of the Bükk, however, it was exposed by boreholes up to Miskolc. Its age is Egerian (upper two thirds of the Chattian).

The formation of the *Szécsény Schlieren Formation* ($^{s}Ol_2$-Me) started at the very beginning of the Oligocene (Egerian) and continued at the beginning of the Miocene (Eggenburgian) as well. It is composed of deep sublittoral – shallow bathyal, open marine, normal saline, non-stratified, grey, fish scale, fine sandy – clayey aleurite with tiny micas in places. Its homogeneity is caused by bioturbation. Its underlying sediment is Kiscell Clay in the vicinity of Bükkszék-Fedémes-Pétervására where it occurs also on the surface, its transition is continuous. In the above area its overlying formation is Pétervására Sandstone with which its higher levels are interfingered and also form heteropic facies. This formation composes the hills in the vicinity of Ózd and in the surroundings of Borsodnádasd. N and E of Ózd it is underlain by the Palaeozoic – Mesozoic basement rocks.

The development of the basins surrounding the Bükk transformed significantly in the Miocene. In the East Borsod Basin N, NE of the Bükk and also in the West Borsod Basin NE of the mountains a Miocene coal bearing series was formed. West of the Bükk, beyond the Darnó Line the landscape is dominated by Lower Miocene sandstone hills. In the Bükkalja the complete Oligocene series is followed by the "classical" three tuff horizons of the Miocene and the sediments of the Pannonian inland sea reach to the foot of the mountains. In the upper zone of these sediments towards the Great Hungarian Plain lignite seams in great thickness are known and exploited in mines.

In the western part of the South Bükk the material of *Bélapátfalva Travertine Formation* (^{be}Me-o) precipitated out of the water of springs at the time of the Miocene can be identified in several places. The rock material of the former forráskúpok is covered by the Badenian-Sarmatian Felnémet Rhyolitic Tuff at one site. Based on its fossil content, its age is Late Badenian therefore recently, the formation has been considered of Karpatian-Badenian age instead of Early Miocene.

In our area the typical sediment of the Paratethys, the *Pétervására Sandstone Formation* (^{p}Mer-e) developed only in the North Hungarian Palaeogene Basin, W of the Darnó Line, lying on Szécsény Schlieren. It forms a significant part of the surface from the surroundings of Domaháza-Hangony-Ózd to the region of Ivád-Pétervására-Fedémes-Bükkszenterzsébet-Tarnalelesz-Borsodnádasd. The formation is composed of cyclic, cross-bedded or bedded, normal saline, littoral-sublittoral shallow marine, nearshore formation, mica containing, glauconitic sandstone. Glauconite is frequently allochthonous and washed into nodes. Concretions protruding because of their hardness are typical ("loafs"). The majority of the sand grains constituting the formation are quartz with marl or limonite as matrix. The age of the formation is **Egerian – Early Miocene** (Eggenburgian).

The rhyolitic tuff lying on Pétervására Sandstone with a discordance in the vicinity of Istenmezeje–Pétervására is identified as *Istenmezeje Rhyolitic Tuff Formation* (^{i}Me). It is a gravel containing, bentonitic, pumiceous rhyolitic tuff, composed, in its upper part, of laminated tufite, which was reworked in water. Its age is **Lower Miocene** (Eggenburgian).

There are basins containing Miocene coal seams in the northern foreland of the Bükk. Based on their geology and the conditions of the resources, two basins are separated (East and West Borsod basins), which have different structural conditions as well. The two basins are separated by the Darnó Line (Uppony–Rudabánya Line). The basins extend over the Sajó River, the northern border of the Geopark. The river is not only a geographical but a geological border as well regarding the coal bearing series, and it is also important from resource geological point of view, however, its exact role has not been cleared yet. In the area of the Geopark, the West Borsod Basin extends over the vicinity of Egerbakta-Szarvaskő-Borsodnádasd-Ózd while the East Borsod Basin is found in the surroundings of Kazincbarcika-Miskolc.

The deep basement in the East Borsod Basin is provided by Palaeozoic-Mesozoic rocks of the Uppony and Bükk mountains together with Oligocene Kiscell Clay and Eger Formation. The Lower Miocene (Eggenburgian) *Felsőnyárád Formation* (^{f}Mer-e) occurs as the marginal cycle-closing covering series or the heteropic facies of the latter. It is composed of sandy-pelitic sediments with occasional occurrences of coal seams. Its lower parts indicate fresh water – brackish water conditions while its upper section is shallow marine. It was formed primarily in the area of the Darnó Zone. It overlies Palaeozoic–Mesozoic basement rocks in the northern part of the East Borsod Basin and Oligocene sediments elsewhere. It is known on the surface only on the E, SE side of the Lazbérc reservoir lake and around Hársas-bérc, NW of Diósgyőr. Its most typical series was exposed by coal exploring boreholes. The red, non-stratified, unsorted, aleuritic clay with rock fragments overlying Triassic carbonates or Upper Eocene limestone abundant in the southern unit of the Bükk Mountains, outside the basin is called *Vincepál Member* ($^{f}_{v}$Mer-e). Fragments can be either angular or rounded locally. Their material is dominantly dolomite, quartz and flint. In the area above Kács and Cserépfalu siliceous brecciated version of the series is known, the matrix of which is associated with the operation of hot springs rich in silica acid.

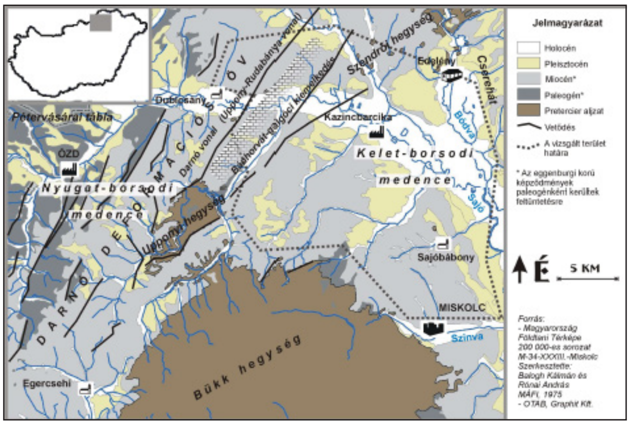
Onto the largely unknown deep basement Szécsény Schlieren and then Pétervására Sandstone (with intermittent Kiscell Clay in places) lies in the West Borsod Basin.

Terrestrial variegated clay occurring in the underlying series indicates a rapid regression at the end of the Eggenburgian (Zagyvapálfalva Formation – "lower variegated clay"). Regression in the Lower Miocene reached its peak at the time of the formation of *Gyulakeszi Rhyolitic Tuff Formation* (^{g}Mo). The first formation of the Ottnangian stage can be found all over the area of the Geopark except for the Bükk and Uppony Mountains. It forms a key horizon in both the East and West Borsod Coal Basin. The Lower – Middle Miocene coal bearing series can be found above it. The formation is composed mainly of fallen, ignimbrite (flood tuff), reworked or phreatomagmatic rhyolitic tuffs. Outside the basin area the ratio of strongly welded flood tuffs (ignimbrites) is higher on the surface in the vicinity of Kisgyőr (*Kisgyőr Ignimbrite Member* – $^{g}_{k}$Mo). Its rocks are especially acid, rhyolitic in character. Based on its chemical character, the primary magma was probably of mantle origin and calc-alkaline type.

Volcanic activity intensified in the Bükkalja in the Miocene produced three well-identified tuff horizons. Cellars and dwellings were excavated into the easy-to-carve rhyolitic tuff. The premises excavated in Pocem at Noszvaj are used and formed by the local artist colony.

Salgótarján Brown Coal Formation (stMo-k) develops above the tuff composed of swamp, brackish water, marine sand, aleurite, clay and brown coal strata. The base formation of the coal seams in the West Borsod Basin is the occasionally variegated, fluvial-swampy *Nógrádmegyer Member* ($^{st}_{n}$Mo – "*upper variegated clay*"). The number of coal seams worth mining is five in the east basin, while in the west basin it is three. The age of the coal bearing series in the west basin is Ottnangian–Karpatian while in the east basin the age of the upper part of the formation is Early Badenian.

The overlying formations of the coal bearing series in the West Borsod Basin are the Egyházasgerge Formation and/or the Garáb Schlieren Formation ("Karpatian schlieren"). These are overlain by the Borsodbóta Formation in which intercalations of the Badenian *Borsodbalaton Rhyodacitic Tuff* (^{bb}Mb$_{1}$) can be found. The covering formation in the East Borsod Basin is the Borsodbóta Formation overlain by the Borsodbalaton Rhyodacitic Tuff.



A general outline of the West and East Borsod basins with the major structural elements of the Darnó Zone (Ádám 2006c)

The name of *Egyházasgerge Formation* (^{e}Mk) used during the coal exploration of the early 20th century was "chlamys bearing sandstone" or "smaller pectin sandstone" after its characteristic fossils. The formation is composed of shoreline – coastal plain, frequently cross-bedded sand and sandstone starting with a basal conglomerate, gravel in places. In the West Borsod Basin, the abrasional coastal, transgressional member composed of local limestone and dolomite gravel at the base of the sand, sandstone is identified as *Égeralja Gravel Member* ($^{e}_{e}$Mk). The matrix of the gravel is sand at the bottom and then fines into aleurite and clay upwards. The stratotype outcrop of the member is the gravel quarry between Dédestapolcsány and Nekézseny, however, another outcrop worth studying is the Határtető quarry at Nagyvisnyó where the rocks of the member are exposed as the cover of the exposed series. The formation can be found on the surface from Sirok to Uppony along the strike of the Darnó Zone while extensive patches of the formation can also be found in the vicinity of Varbó and Miskolc. Its age is Karpatian.

Garáb Schlieren Formation (^{g}Mk) called "Karpatian schlieren" formerly was deposited in pelagic conditions far from the coast, and is composed of a cyclic alternation of sand, mica containing sand, aleurite, clay, clay marl beds. It develops from the Egyházasgerge Formation with a transition in certain places. Its occurrence on the surface follows the "strike" of the Egyházasgerge Formation within the Darnó Zone.

Early Badenian – Late Sarmatian aged pyroclasts in the hills in the western foreland of the Bükk and between the Mátra and the Bükk are classified into the *Felnémet Rhyolitic Tuff Formation* (^{f}Mb-s). It is predominantly reworked rhyolitic tuff alternating with sediments (tuffitic horizon – ^{f}Mb-s^{tu}) but fallen and welded, zeolitised (ignimbrite – ^{f}Mb-s^{i}) versions also occur. Other versions, strongly saturated with siliceous solutions (silicified – ^{f}Mb-s^{q}) occur above the marine sand of Salgótarján Brown Coal Formation around the lakes at Egerbakta, and finely stratified lacustrine limnoquartzite (limnoquartzite – ^{f}Mb-s^{q}) occur in the upland of Berva-bérc. Zeolitised, welded tuffs with accretionary lapillae in the vicinity of Pazsag–Nagy-ökrös and Nagymező in the Bükk are also classified into this formation.

The rocks of the *Dubicsány Andesite Formation* (^{du}Mb-s) composed mainly of neutral volcanic material occur in the northern foreland of the Bükk. The formation is constituted by andesitic agglomerate tuff and tufite, pyroxene andesite lava blocks several cubic kilometre in size, lava breccia and veins. In its rhyolitic tuff, tuffite layers Sarmatian plant remnants also occur. Palaeozoic or Oligocene–Miocene xenoliths are frequent in the agglomerate. Clay, sand, gravel, acid tuff, tuffite layers can also be found, not too frequently, in the formation. Its age is late Badenian – Sarmatian.

In the vicinity of Sirok-Tarnaszentária-Verpelét, extended patches of volcanic formations of the Mátra also occur on the surface. In the surroundings of Sajóbábony and Sajóvelezd some occurrences of *Galgavölgy Rhyolitic Tuff Formation* (^{gv}Ms) ("upper rhyolitic tuff) are also known.

Badenian and younger sediments occur only locally on the surface. Pannonian sediments are typically associated with the southern margin of the foot of the mountains and occur mostly as covered with Quaternary formations, except for the vicinity of Egerszalók-Egerszólát-Demjén-Nagytálya where they occur on the surface as well.

From Bekölce to Sajóvelezd the surface occurrence of the *Baden Clay Formation* (bMb1) follows the strike the Darnó Zone. It was deposited in an open marine basin and composed dominantly of clay, clay marl. Its layers are rich in thin shelled molluscs and foraminifers.

The reef formation of the Badenian stage, *Lajta Limestone Formation* (^{l}Mb) occurs on the surface in small erosional patches near Szilvásvárad and Balaton. The facies of the formation is archipelago with reefs, shallow marine reef. It is composed of lithothamnium containing limestone, calcareous sand with molluscs (calcarenite), mollusc containing limestone. Its macrofauna and benthos foraminifera fauna are very rich.

Kozárd Formation (^{k}Ms) of the Sarmatian stage occurs on the surface along the arc of Felsőtárkány-Egerbakta-Egerbocs. Its composition is extremely diverse sublittoral-littoral, brackish water clay – clay marl with molluscs, sand, tuffaceous sand, loose sandstone, tuffaceous bentonite, calcareous marl, calcareous sandstone. In the associated lagoon facies version diatomaceous, alginitic, bentonitic formations are frequent.

Sajóvölgy Formation (svMb-Pa1) forms the surface of the foothills SE of Tardona, however, it occurs in patches of variable size around Bükkszentmáron, Bükkmogyorósd, Lénárddaróc and the SE part of Miskolc. It is composed mostly of fluvial, lacustrine, or inland sea sand, clay marly aleurite, diatomite, limnoopalite, alternation of polymict gravel-conglomerate with reworked rhyolitic tuff and tuffite layers.

Some patches of *Borsod Gravel Formation* (^{bo}Pa$_{1-2}$) is found in the surroundings of Nagybarca and Sajóvelezd. It is composed of basin margin, alluvial fan-like coarse gravel, sandy gravel series that contains a few metres thick variegated clay and gravelly clay interbeddings.

Pannonian formations developed after the complete separation of the Pannonian Lake from the Paratethys are found along the edge of the Cserhát-Mátra-Bükkalja foothills and the edge of the basin of the Great Hungarian Plain. The time of their formation is thought to be around between 12 and 5 million years ago. The base layers transgrading onto various members of the Miocene tuff formations in Bükkalja are composed of tuffitic sand and clay layers containing the reworked material of their underlying rocks. The majority of the Lower Pannonian series are composed of yellow sand, loose sandstone, yellow and grey clay, calcareous clay, clay marl.

Upper Pannonian basin sediments are composed of the alternation of lacustrine and fluvial facies greenish and grey clay, clay marl, greyish and yellow sand, sandstone with the dominance of sandy layers. This series contains the frequently several metres thick earthy-woody brown coal seams (lignite seams). The uppermost Pannonian sediment series is classified into three formations: Zagyva Formation, Nagyalföld Variegated Clay formation and Bükkalja Lignite Formation. B*ükkalja Lignite Formation* (^{b}Pa$_{2}$) is composed predominantly of grey, blueish grey and variegated clay, with sand and lignite interbeddings. The thickness of the lignite seams could reach 10–15 m. Sixteen "ancient pine" trunk remnants of 4–6 metres sitting on the excavated lignite seam were recovered from the lignite mine in Bükkábrány in 2007. Four of them are preserved in the Herman Ottó Museum in Miskolc and five of them are on display at the geological exhibition site of the BNPI at Ipolytarnócóc.

Bükkalja Lignite Formation with fossilised swamp cypress

The filling of the basin of the Great Hungarian Plain continued in the Pleistocene as well. Large amount of gravelly debris were transported and extensive fans were built by rivers and streams arriving from the surrounding mountains with increased discharge during the interglacial periods. Gravel of the alluvial fan of Eger–Laskó and Sajó–Hernád are mined in the Bükkalja. Mining is most significant at Nyékládháza. *Nyékládháza Gravel Formation* is composed dominantly of fluvial gravel, sandy gravel, gravelly sand and sand layers and lenses. Its thickness increases from 2–5 m to 40–50 m towards the inside of the basin. Clay layers and lenses with variable thickness interbed in the coarse-grained clastic formation.

Strong winds transported the finer material (aleurite – silt) from the fluvial sediments and deposited these in the form of loess, frequently in great thickness in the drier periods of the Ice Age. Loess occurs in the area of the Geopark at Verpelét, Feldebrő, Kápolna, Kerecsend.

The precipitation of the dissolved lime material of karst springs resulted in the formation of travertine (^{f}Qp-h (f)) around the springs and in the bed of the rivers from the Late Pleistocene. Travertines below Vízfő at Mónosbél, travertines of the Castle of Eger and that of Tetemvár are produced by warm springs. Warm springs at Eger shifted to the valley floor during the Holocene and occur today in the water of Bárány Swimming Bath, in the water of a spring in one of the pools of the bath and in that of other medical springs (Török Spring, Tükör Spring). The most significant travertine deposits can be found at Fátyol Falls in Szalajka Valley, in Szinva River and also in Garadna and Bán valleys.

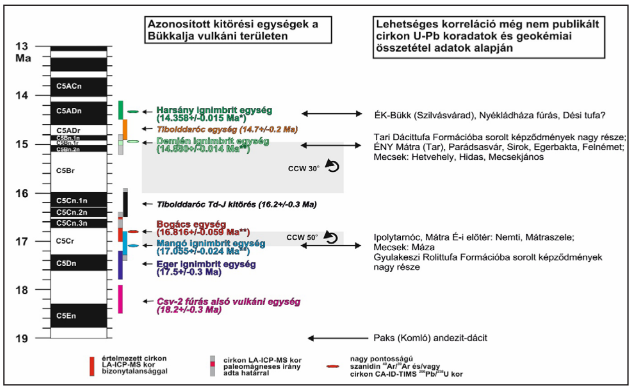
The enormous travertine dome formed out of the water of warm springs at Vízfő of Mónosbél was mined in the 1950s. Today the water of the springs supply drinking water for the inhabitants of the surrounding villages.

III Bükkalja

The geological evolution of the Bükkalja was different from that of the basins surrounding the Bükk. The first volcanic eruptions took place 19–20 million years ago. The scattered explosions were followed by a more intense volcanic activity 19 million years ago producing andesite-dacite volcanoes. These volcanoes cannot be found on the surface today because they were covered by the sediments of later subsidence and filling. However, this volcanic activity heated the crust and enabled the formation of extended reservoirs formed by silica rich magmas. Basaltic magmas stuck at the boundary of the crust and the mantle, crystallisation and partial melting of the crust produced melts with andesite-dacite composition. These melts with small density intruded in shallow depths of the crust and formed magma reservoirs growing in size over a few hundred thousand years (Likács et al., 2015; 2018). Crystallisation of andesite-dacite magmas finally produced a rhyolitic melt with a high silica content.

The rhyolitic explosions took place over 4 million years and brought more than 4,000 cubic kilometres of volcanic material to the surface. Considering this, the volcanism was the largest in last 20 million years of Europe! Its formations are found mostly below the surface, covered with young sediments, however, in the foreland of the Bükk, in the area of Bükkalja, the material of almost all major eruptions are excavated. This unique volcanic heritage is an outstanding natural value even in European terms.

The time of volcanic eruptions could be reconstructed on the basis of isotopic analysis of the tiny crystal of zircon in the formations of the volcanic activity shedding new light on the image formed previously (Figure 2). The first volcanic eruptions occurred 18 million years ago, and after a minor pause, the large eruptions started 17.5 million years ago. Eight eruption events have been reconstructed so far, three of which (Mangó, Demjén and Harsány ignimbrit eruptions 17.05, 14.88 and 14.36 million years ago respectively) were so large that volcanic ash fell in the inner areas of Europe, even in a distance of 1000 km.



Time of formation of rhyolitic volcanic formations in the Bükkalja, the time of volcanic eruptions was determined based on uranium-lead isotopic age determination of zircon (Lukács et al., 2015; 2018; Harangi and Lukács, 2019)

Explosive eruptions were probably accompanied with caldera collapse events, i.e. after the release of the large amount of magma rising to the surface, the top of the magma reservoir collapsed. These caldera structures can no longer be found, presumably they are under the surface, covered with young sediments. Debris and gases exploded to the surface along circular cracks and fissures, representing the upper, foamed part of the magma body, had such a large mass that they collapsed immediately under their own weight and spread sideways on the surface, in the form of so-called pyroclastic flows. These formations are ignimbrites of varied appearance. The remnants of the volcanic material, which were freed from their weight, rose high, up to 20-30 km, and this volcanic ash material was swept by the winds that prevailed at the time, largely in a westerly direction.

The most preserved formation of the rhyolitic volcanic activity is the ignimbrite of pumiceous pyroclastic flows. They filled valleys, sometimes in tens, and more than 100 metres thickness, and also formed an extensive plateau. In the area of Bükkalja, a very diverse form of ignimbrites can be studied, which further increases the geological natural value of the area can be found. Freshly preserved ignimbrite formations in such wealth, cannot be found in many places on Earth especially not in such a small space!

Pumiceous pyroclastic flows were occasionally made up of high-temperature, large-scale volcanic material. During their deposition pumices and small shards of rock glass were squeezed and burnt, which is called welding. In the course of this, elongated obsidian-like material, called fiamme, was formed. Different degrees of ignimbrite welding can be observed in Bükkalja, i.e. this area is an open volcanic natural laboratory (Figure 3)! Explosion material composed of non-welded pumice, tiny rock glass fragments and crystals in the largest mass, however, almost all eruption units also have ignimbrites welded to varying degrees. The most welded rocks resemble lava rocks therefore it is no surprise that earlier geological exploration described these rocks as lava rocks. The volcanological occurrence of ignimbrites clearly suggests that the major volcanic eruptions happened near the Bükkalja!

The volcanic eruptions over 4 million years took place in the key-period of the formation of the Pannonian Basin. The crust of the Earth under our region was significantly thinned in this time period. This rifting and crustal thinning are reflected by the chemical composition of magmas producing the ignimbrites, i.e. a continuous change can be detected in this (Lukács et al., 2018). The above volcanic formations therefore are important witnesses of a plate tectonic event that formed our region!

After the volcanic activity, presumably an extensive ignimbrite plateau was formed into which rivers cut forming deep valleys. The romantic gorge of Felső-szoros at Cserépváralja, which is a strictly protected area of Bükk National Park was cut in such an ignimbrite plateau.

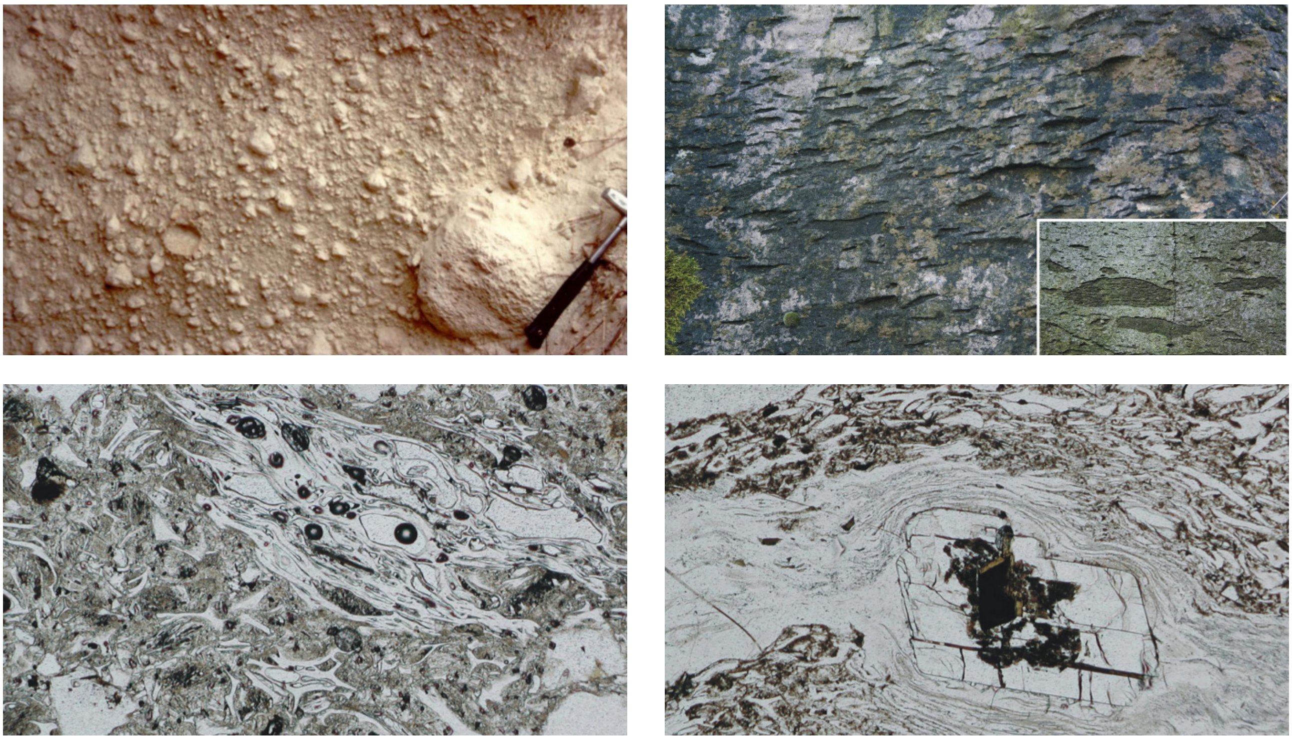


Figure 3 – Non-welded ignimbrite containing large pumice and welded ignimbrite with fiamme content and their microscopic images.

Specific natural values of the Bükkalja are "**beehive**" stones that are also interesting cultural historical values. The material of these rock towers, cliffs is mainly *rhyolitic tuff.* The most typical groups of these tuff cones, rock towers emerging from the surroundings can be found in the vicinity of Eger (*Nyerges-hegy, Mész-tető, Cakó-tető*), around Szomolya (*Vén-hegy–Kaptár-rét*) and Cserépváralja (Great and Small cones at *Mangó-tető, Csordás Valley, Furgál Valley, Kő Valley, Nagybába-szék, Köves-lápa*).

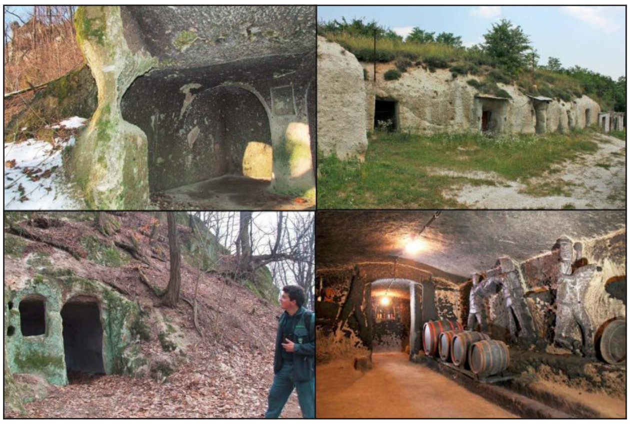
Specific types of natural cliffs carved by humans are the so-called "beehive" stones the highest number of which can be found in the Bükkalja, which forms part of the Geopark. Considering the Bükkalja, 72 beehive stones are known at 38 sites and a total of 473 niches can be counted on the cliffs. The stones can be found in several major groups between Vár Hill at Sirok and Kecske-kő at Kács: the most typical ones can be found in groups at Szomolya (Vén-hegy–Kaptár-rét) and Cserépváralja (Mangó-tető – Great Cone, Furgál Valley, Csordás Valley), and also in the vicinity of Eger (Nyerges-hegy, Mész-tető, Cakó-tető).

Several theories and ideas were developed regarding the function of niches. According to *Gyula Bartalos*, the first scientist exploring the topic, beehive stones were tombs and the shrines for the ashes of dead people were placed into them. Gáspár Klein, chief archivist in Borsod county believed that the niches were sites of *fetish* where *sacrifice* could be made. Already Bartalos mentioned in 1891 the currently most widely known and accepted idea published in the Archaeological Bulletin – highlighting his doubts as well – that the people who constructed the niches kept bees. Andor Saád together with József Korek, an archaeologist made excavations in the early 1960s in the foreland of a couple of beehive stones in Cserépváralja and Szomolya. Findings recovered by archaeological excavations from the 11–14th century provided no evidence of neither of the theories mentioned above. Thus beehive stones hold on to their secret even today.

Due to the petrographic character of the Bükkalja, *working with stones* (carving, cutting and quarrying), vernacular application of stones has a rich tradition in the settlements of this region associated primarily with resistant but easy-to-carve volcanic rocks, rhyolitic and dacitic tuff (ignimbrite). Quarrying building stones and using them in vernacular architecture, stone carving and recessing rooms in rocks has longest history here in the Carpathian Basin. Bükkalja is a traditional area of stone building, apart from ecclesiastical and noble architecture stone has been present in peasant architecture as well for centuries. In the vernacular architecture of the region, stone (rock) appears in two ways: in buildings with standing walls (houses, hutches, stables) and in cave dwellings, cellars and other rooms with economic purposes carved in rocks.

Beehive rocks with starry sky

The most important cultural historical values of stone culture in Bükkalja apart from dwelling places carved in rocks, stone dwellings/cellar houses are other stone rooms "carved in stone" associated with traditional land use and farming methods: mementos of extensive cattle raising, shepherding, stone stables, stone barns, shepherd accommodation on the one hand, and on the other hand the cellar holes, tithe cellars, shelters of vineyards and wine production. Such objects can be found in most of the settlements of Bükkalja.



This complex natural – landscape management – cultural system typical for the region and having historical roots and living traditions deservedly received the title Hungaricum due to its unique character.

B Geomorphology

I Uppony Ridge

Uppony Ridge is the northernmost part of Bükk Region, which can be clearly separated from the Bükk Mountains in the closer sense. It extends to the valley of Hódos Stream to the west and to that of the Hangony Stream to the north-west and continues to the Sajó Valley to the north. It is separated from the Bükk by the valleys of Szilvás and Bán streams. Before the formation of the latter valley system it was together with Bükkhát the northern pediment of the Bükk. This is suggested by the flat ridges of Uppony Ridge that have the same elevation a.s.l. as that of Bükkhát and also by the Middle Miocene gravel layers of Bükkian origin occurring between Nagyvisnyó and Nekézseny, sometimes in great thickness.

Although the majority of its surface is made of also Middle – Upper Miocene sediments (clay, sand, gravel) and andesitic tuff its rock composition and thus its geomorphology are different from the Bükkhát.

Its most markedly separated part is the Uppony Mountains extending along the left side of the valley of Bán Stream from Nagyvisnyó to Bánhorváti. Its mountainous character is the result of the uplifted blocks of its Palaeozoic and Mesozoic rocks south-west of the reservoir at Lázbérc mostly along fault planes and to thick andesite agglomerate formations lying on the Palaeozoic-Mesozoic rocks to the north-east. The south-western limb with a height of 438 m is composed of rocks older than those of the Bükk. Lower Carboniferous shale, sandstone, diabase tuff and semi-crystalline limestone prevail. Schist and sandstone hardened by quartz veins decorate the left side of Rágyincs Valley with spectacular crests and towers. Limestones are exposed by the nice epigenetic valley of Csernely Stream, the valley of Bán Stream controlled by fault planes and the elbow-like Uppony Pass. The majority of the latter is occupied currently by the Lázbérc Reservoir. On the right side of the gorge mouth of Csernely Stream caves famous for palaeontological findings (stone holes of Uppony I and II). The Cretaceous Nekézseny Sandstone to the south of the Lower Carboniferous formations is a specific geological rarity as rocks of this age occur nowhere else on the surface in the Hungarian part of Mátraerdő.

Landforms produced by derasion and landslides are as frequent as in the Bükkhát. The most recent and instructive example of the latter is the basin of Lake Arló blocked by masses slid down from Csahó Hill into Szohony Valley in 1927. Slope movement here was caused by mining therefore it was of artificial origin.

II Bükk

Movements determining the structure of the mountains occurred in at least two phases between the *Late Jurassic* and *Early Eocene*. As a result, the Bükk was transformed into a *folded, nappe mountain* composed of oblique folds, folds overturned mostly towards south and imbrication. Its clays were compressed into schists and its sands cemented into sandstone.

The lithospheric plate of the Bükk was located in a hot and wet environment between the *Late Jurassic* and *Late Eocene* thus surface development was controlled by weathering and the rivers and also by *karstification* in limestone areas. The mountains was transformed into a wide, flat peneplain the *open mixed karst* of which cone and tower karsts dissected. From the *Late Eocene* to the end of *Oligocene* terrestrial surface development was characteristic for longer time periods than marine development over the majority of the Early-Middle Eocene peneplain of the Bükk.

The lithospheric plate of the mountains arrived close to its current neighbourhood around 25 – 30 million years ago, at the end of the *Oligocene*. Since marine sediments formed at the end of the Early Miocene lay on the older formations with a hiatus everywhere it seems clear that the Bükk was in terrestrial conditions in the first half of the Early Miocene and therefore its partly covered karstic block was almost completely exhumed from its Early Tertiary cover. Its limestone areas karstified again although no karst forms with proved ages of Early Miocene are known in the mountains.

The dissection of the peneplain of the Bükk was slowed down by intense volcanic activity occurring in the vicinity of the Bükk from the end of the Early Miocene. This volcanic activity produced – in several phases – a large volume of loose and more or less welded rhyolite-rhyodacite ignimbrite cover over the entire mountains. The mountains started to subside in the Ottnangian and Karpatian stages of the Miocene, its margins were dissected by faults and sea covered it completely for a short period of time. Surface development overall was controlled by alternating terrestrial and marine littoral processes.

Remnants of abrasion platforms indicated by abrasion gravel with pholas on the edge of the present day Tárkány Basin in the northern margin and in the south-west of the mountains indicate heights of 300-500 metres.

By the middle of the *Badenian* stage of the Miocene, the sea had pulled down from the slowly rising mountains, and on its return it had covered only its rims. During the *Sarmatian* stage, due to the gradual uplift, terrestrial exogenous forces already exposed the basement rocks from the shallow marine – volcanic sediments of the Central Miocene. In other words, the continuous karstification of the Bükk in the Neogene–Pleistocene, in parallel with the development of its water network today, could have begun in the *Late Sarmatian*.

At the end of the *Miocene*, in the last third of the *Early Pannonian*, the mountains subsided again, and its southern, eastern and north-eastern margins – along with the

Bükk plateau at dawn

subsided Great Hungarian Plain and the Sajó Trench – were flooded by the advancing *Pannonian Sea*. Due to the decrease in height and then the drying of the climate to semi-desert, the thinning of the Miocene sediment cover of the Bükk slowed. The sea receded by the Late Pannonian, and the mostly intermittent watercourses of the mountains running almost radially, but mainly towards east, north-east and south-west started to carve–build wide pediments in the margins of the Bükk.

The formation of the pediment in semi-desert environment from the *Late Pannonian* to the second half of the *Pliocene* – accompanied by another strong uplift – was interrupted by a more moisture and cooler climate, the return of forests and the renewal and growth of permanent watercourses. *At the end of the Pliocene*, around 2.5-3 million years ago the Bükk must have been a mountain with around 370 – 620 m a.s.l. covered by deciduous forests of a diverse composition with more warm-loving species than today. The fundamental parts of the Bükk, Bükk Plateau, South and North Bükk may have started to be separated from each other. Limestone was exposed to the surface in an increasing grade in the highest peaks and the valley heads and valley floors at highest altitude. Present day dolines were sinkholes supplying water for the older spring caves near the mountain top (Pongor-lyuk, Körös-kő, Pes-kő, Sima-kő, Balla, Vidróczky, Szeleta caves). Springs of the latter and the streams of the covered karsts still occupying large areas formed the valley network that was later inherited onto the extended limestone surfaces of the Bükk Plateau and the South-eastern Bükk.

During the *Quaternary*, in addition to repeated climate change, the Bükk was again characterised by alternating stages of uplift and subsidence. The cooling and slow drying at the beginning of the Ice Age Pleistocene was accompanied by the significant uplift of the mountains. As a result of the increase in the depth of the karst water level, about 2 million years ago, the watercourses of the valleys inherited onto the limestone surfaces of the Bükk Plateau and south-eastern Bükk. After this therefore the interior of the limestone masses, and with the transfer of the location of their swallow funnels to the valley head, the prolongation and reproduction of dry, multi-row valleys began for most of the year. Thus, the surface water network linking the Bükk Plateau and its lower neighbourhood was gradually eliminated.

Both surface and subsurface karstification of limestone peaks are significant. Most frequent are the karren fields, which occur most spectacularly on the slopes of *Istállós-kő, Őr-kő, Tar-kő, Cserepes-kő, Örvény-kő, Pes-kő, Küllő Hill and Körös Hill, and Fekete-Sár-bérc*. The much rarer near-top avens are the oldest karst landforms of the Bükk. They are the remnants of at least Late Pliocene or older sinkhole caves, which lost their discharge area and funnel (*Kálmán-rét, Kis-Kőhát, Lyukas-gerinc, Mélysár-bérc Aven*).

At the back of a high number of the peaks independent, sole dolines can be found near the top similarly to the avens above, and independent of valley doline rows. These "hanging dolines" are probably widened remnants of Late Pliocene sinkholes. They are located 30–70 m high above the valley doline rows, their diameter is 80–200 m. Their depth is small and their floor is almost flat. Most spectacular of them is Tányéros-teber in the north-east vicinity of Istállós-kő.

In the inner peaks cave-sized holes can be found on the sides of Őr-kő (880 m), Mély-Sár-bérc (921 m), Kőris-hegy (944 m), Fekete-Sár-bérc (930 m) and the Ördög-kút-tető (496 m). Kőris-lyuk (Kőrös Cave) among them has the highest altitude (930 m) of spring caves in Hungary, which is worth special attention for its first room with a cracked roof, age and location as well.

South and North Bükk

The W-E extent of the **South Bükk** connected to the southern end of Bükk Plateau from Laskó Valley to the Szinva Valley in Miskolc is 36 km while its N-S extent is 4–13 km. Its altitude ranges between 300 m and 700 m a.s.l. West of the Hór Valley – Hosszú Valley – Három-kőalja line – in the South-western Bükk – mostly non-karstic rocks, east of this line – in the South-eastern Bükk – mostly limestone can be found, however, these are not so dominant as in the two plateaus.

Most of the non-karstic rocks of the **South-western Bükk** are Early Jurassic slate, siliceous slate, basalt (diabase) and gabbro of similar age. From under the shingle-like imbrication of the slates small, island-like limestone patches are exposed. Considering landforms, it hardly differs from the non-karstic mountains in Hungary. The deep valleys mostly with permanent watercourses concentrate in the *Tárkány Basin*. Most of its surface is characterized by 4–7 km long N-S striking major valleys and almost parallel intervalley ridges. Tops breaking the general slopes of these ridges are constituted by rocks more resistant than their surroundings. The majority of the major valleys and many side valleys have to cut through resistant rocks where they form gorges. Regarding cuttings in basalt-gabbro, that of Eger Stream with "pillow lavas" at Szarvaskő and also the gorge of Gilitka Stream (Rocska Valley) flowing into Eger Stream from the left are the most spectacular. Berva Valley, Mész Valley, Lök Valley cut Upper Triassic limestone patches of various sizes. The natural state of these gorges probably of cave origin was preserved only occasionally due to quarrying activities. Since the majority of the South-western Bükk is composed of Upper Triassic limestone covered by slate strongly fractured along thrust lines, it is an extended, hidden, not önálló karst as a whole proved by, for example, the Agyagpala Aven at Nádas-bérc starting in the slate. Partly exhumed karst with doline rows and blind valleys can be found in the Upper Triassic limestone mass of Berva – Cseres-bérc.

In the already mentioned small limestone outcrops, only karren belts were formed. In the sides of the gorges running through them a number of short but palaeontologically important caves were formed (Suba-lyuk, Berva, Lök-völgy caves). The solution hornyolta cliffs of Ódor-vár hide the destructed holes of Lakó Cave renowned due to its old age (Günz-Mindel interglaciation) and Hajnóczy Cave with similar age hiding animal remnants. Warm water springs of Mónosbél Vízfő of the spring in the western margin of Bél-kő produced the largest travertine accumulation of the mountains.

The South-eastern Bükk is characterized by alternating karstic and non-karstic belts. Therefore, and because most watercourses starting from non-karstic areas run towards the limestone areas and leave the mountains through them, its open mixed not separate karst character is much more pronounced than that of the Bükk Plateau.

Its greatest continuous karst area is a 21 km long and 3–8 km wide Middle Triassic ("Répáshuta") limestone belt. Its western half if the Limestone Ridges of Répáshuta, which is bounded by slate zones from both the north and the south. The largest sinkholes in the rim of the karst (Pénz-pataki, Diós-pataki sinkholes) with blind valleys and losing streams are supplied with water of streams arriving from the north. Regarding the caves of peaks of the ridge where rich fossils can be found are Balla Cave and Pongor-lyuk.

The eastern half of the limestone belt, the Kisgyőr-Tapolca Limestone Ridge – with its valleys with sinkhole doline rows, tops with hanging dolines, the doline fields of Lófő-tisztás and the uvala of Dorongos – resembles the Bükk Plateau. Different landscapes only occur along the deep, steep-sided gorges of streams arriving from non-karstic surroundings (Csókás Valley, Tatár-árok). It is relatively poor of extended karst holes (Nagy-Kőmázsa Sinkhole Cave, Galuzsnyatető Aven). Its only major spring cave is the Miskolctapolca Cave at its southeastern end with partly thermal water origin.

(Source: www.hellomiskolc.hu)

The western part of the North Bükk is composed of Upper Carboniferous shale-sandstone formations with limestone lenses to which Permian variegated slates, sandstone and limestone stripes and Triassic limestone and dolomite ribbons, and shale patches are connected. Parallel deep and relatively wide valleys and ridges between them with limestone cliffs – although shorter – resemble the South-western Bükk. In its eastern half, Upper Carboniferous – Permian sediments are much rarer, the diversity of Triassic formations, however, is great (limestone, shale, dolomite, andesite, basalt).

Due to its composition and smaller size, the North Bükk is poor in karst landforms. Contributing to the overall image its limestone areas have sharp cliff (Éleskővár, Dédesvár, Kisvár, Kapu-bérc, Vásárhely, Odvas Stone, Buzgó Stone), tower-like promontories with earthworks (Kelemen széke, Gerenna-vár), bed steps and karren fields on slopes have greatest role.

III Bükkalja

Bükkalja is the largest, most uniform pediment extending from the valley of Tarna to that of Hejő and Szinva in the Mátraerdő. Its W–E "width" is almost 40 km while its N–S "length" is 10–15 km. It is connected to the South Bükk via a narrow, occasionally interrupted Palaeogene sediment belt (Upper Eocene limestone, marl, Oligocene clay, sandy clay). Its southern third sloping down to the Heves-Borsod-Mezőség is composed on Upper Miocene – Early Pannonian marine sand-clay covered by loess in places. Its central zone is composed of loose or more or less welded rhyolitic-rhyodacitic tuffs (ignimbrite) and their reworked material. In the western and southern vicinity of the Bükk, volcanoes occasionally operated by enormous side explosions. Dust settled from their glowing cloud in the form of liquid drops. Finally, these were hardened to form "ignimbrites", which are hard like lava rocks. More welded and less welded tuffs and ignimbrites (reoignimbrites) alternate with each other in south-west, west and north-east, east belts. While its rock composition is characterized by west-east zonation, it is dissected by north-south zonation, and an of N-S striking valleys, and ridges. Its main valleys run from the South Bükk or its southern edge. Parallel side valleys bend either east or west before the hard ignimbrite belts turning towards the main valleys. Therefore, south of these belts the degree of dissection of the pediment remnants, i.e. the inter-valley ridges is significantly smaller than between them or north of them. Apart from the Tárkány Basin stretching into the South-western Bükk, the formation of the Cserépfalu and Kisgyőr basins is also the result of the valley concentrating effect of the ignimbrite belts.

Inter-valley ridges – corresponding to the welded ignimbrite belts – have steep bed steps towards the inside of the mountain enhanced by erosional differences. South of these the gently slopes are interrupted by short, wide and flat derasion valleys or short wadis at the most. These wide ridges, wavy at places due to landslides are the best grape and fruit producing regions of Bükkalja.

The main valleys running from north to south cut through the hard ignimbrite belts in their way mostly via narrow gorges. One of the most spectacular of these is the Felső Gorge at Cserépváralja with columnar rhyolite ignimbrite. The characteristic beehive stones of the Bükkalja were formed on the southern-western slopes of the ridges between the side valleys formed in the loose, less welded tuffs.

Karst hydrogeology conditions of the Bükk

Water bodies

Based on the EU Water Framework Directive, "porous and mountainous water bodies", "shallow porous and mountainous water bodies", two "cold karst water bodies" and "warm water bodies" were determined in the Bükk and in the environment of the Bükk (Bükk Region, Bükk vicinity).

Considering the 185 underground water bodies in Hungary identified based on the EU Water Framework Directive, 14 are cold karstic. Their total area is 9,240 km^2, which is around 10% of the area of Hungary. In the Bükk 2 cold karstic (k.2.1. and k.2.3.) water bodies have been identified – somewhat incomprehensibly dividing the united cold water part of the Bükk Karst – the total area of which is 824 km^2. This includes Triassic, Jurassic, Eocene, Pleistocene and Holocene limestone, calcareous dolomite and dolomite.

The above value covers non-karstic areas as well as karstic ones. The area of the surface of the karstified, open karst rocks is 207 km^2. The movement of cold karst water takes place in a karstified unit the delineation of which is much more difficult due to the diverse geological and tectonic conditions. Based on the difference of 21.8 m between maximum and minimum of the karst water monitoring well Nv-17 between 1993 and 2019, the change of the water level is accompanied by the movement of 43,000,000 m^3 water body taking into account 0.0075 free void volume. (The average annual precipitation is 154,000,000 m^3 out of which 56,000,000 m^3 reaches down to the karst water level considering an infiltration of 36% and this amount is divided into reservoirs and release and extraction.)

Regarding the maximum value of 550 m a.s.l. for the karst water level, and the – estimated – value of 300 m a.s.l. of the isotherm 30°C, the volume of the cold karst water below the temperature of 30°C is 250,000,000 m^3.

Out of the 185 Hungarian underground water body, 15 are thermal karsts. Their total area is 22300 km^2, which is around 24% of the area of Hungary. (Together with the ~10% cold karst water areas around 1/3 of the area of Hungary can be used for karst water extraction.) The area of the thermal karst water body of the Bükk delineated in the Bükk Region is 4,286 km^2, which is the second largest in Hungary. (Around a quarter of this water body can be really regarded as closely related to the cold karst water of the Bükk.) Rocks of the thermal karst include Triassic and Eocene limestone, calcareous marl, calcareous dolomite and dolomite.

The warm and hot volume karst reservoir of the Bükk water body belonging to the Bükk Region can be estimated to 500,000,000 m^3.

It is difficult to estimate the lower boundary of the thermal karst but the deepest well so far has reached the depth of -2,144 m a.s.l. drilling through 516 m of karstified limestone as well. (Thermal water exploring boreholes exposed 855 m of karstified limestone at Miskolctapolca, and 1,161 m of variously karstified calcareous marl, dolomite and limestone at Eger.)

Cold and hot (thermal) karsts form a united system at the level of water bodies, however, certain partial catchment areas can be separated occasionally with more detailed analysis.

Precipitation conditions

Precipitation conditions in the Bükk Plateau can be characterised by detections at Jávorkút. (The maximum, mean and minimum of precipitation at Jávorkút in calendar years between 1960 and 2018 were 1496 mm, 841 mm and 469 mm, respectively.) Of course these values decrease significantly towards the margins of the mountains down to the level of 550–600 mm. Around 35–45% of the precipitation infiltrates into the subsurface forming karstic lithoclases, holes and caves.

Soil conditions

Only a few dm of rendzina soils can be found on the open karst. The hydraulic conductivity of this is 10^{-3} – 10^{-5} m/s and this determines the extent of infiltration into the karst and the infiltrating water takes up the majority of the carbon dioxide required for karstic solution in this zone. (Precipitation water arriving as streams accumulates in non-karst surfaces.)

Water conductivity and storage conditions of the rocks constituting the Bükk

Middle and Upper Triassic platform limestones are excellent in karstification and hydraulic conductivity (Fehérkő, Bükkfennsík, Kisfennsík, Berva Limestone) just as the Eocene Szépvölgy Limestone. Karst landforms (dolines) are abundant in these formations and the most significant caves, cave systems formed in them and cold springs with huge discharge in major valleys and cold and warm springs in the margins are supplied from them.

Upper Permian Nagyvisnyó Limestone and Middle Triassic Hámor Dolomite are moderately karstic, moderately pervious but good aquifer. The Lower Triassic Gerennavár Limestone and Jurassic Bükkzsérc Limestone are slightly better pervious but less good aquifer.

Moderately-poorly karstic and pervious is the Upper Triassic siliceous Felsőtárkány Limestone with marl interbeddings.

Slates of the Ablakoskővölgy, Vesszős and Mónosbél formations containing also limestone interbeddings are of mixed characteristics. Basically they are aquiclude, however, the interbedded layers, lenses are occasionally strongly karstic, supply springs with small discharge, however, their reservoir role is subordinate.

The rocks of the Carboniferous Szilvásvárad, Upper Permian Szentlélek, Jurassic Lökvölgy, Vaskapu and Rocskavölgy Formations can be considered aquiclude. The rocks with pervious lithoclases of the Middle Triassic Szentistvánhegy Metaandesite, Upper Triassic Bagolyhegy Metarhyolite, Szinva and Létrás Metabasalt, Jurassic Szarvaskő Basalt, Tardos Gabbro, Bányahegy and Csipkéstető Radiolarite are parent rocks of springs with small discharge.

Considering covering rocks, marl, clay, rhyolitic and dacitic tuff formations are aquiclude, however, sand, gravel formations have good aquifer properties. (They can be found mostly in the margin of the mountains and in the foreland.) The alluvial fillings of the alluvial fillings of valleys with permanent watercourses are reservoirs. Pleistocene, Holocene travertines are also excellent aquifers, but clayey doline fillings with depths occasionally of several 10 metres and the filling of buried karst adits.

Open sinkholes, dolines

In the protective area of the springs of Miskolc Waterworks around 1150 sinkholes and dolines were identified and recorded on a contour map with the scale of 1:10000. This represents around half of the karstic area of the Bükk. Together with small dolines at least 4000-5000 dolines could be in the mountains. These are local catchment areas as well, their water, however, is sent into the karst in the form of areal infiltration along the boundary of the sediment and the limestone although more concentrated swallow within the doline occurs frequently. In the dolines, 25 exploration boreholes identified 2–51 m thick loess, loess containing limestone or shale fragments, red clay, red clay with shale fragments, Miocene and Triassic volcanites as well. However, such continuous covers can be found along the adit of the Menecske Doline, in the monitoring well of the Balla Valley near Répáshuta, and an adit of 56 m at Kopasz-rét Cave.

According to the official website of Hungarian state nature protection 91 caves are registered in the Bükk as sinkhole caves.

Springs

In nature protection a spring is the natural outlet of subsurface water if its discharge exceeds 5 litres / minute permanently, even if it dries up occasionally. The number of surveyed and recorded springs over the area of Bükk National Park exceeds one thousand. Due to the geological, tectonic, morphologic conditions their discharge and duration are extremely variable from complete drying to over 240000 m3/day.

Springs can be (generally are) classified according to several aspects. Some of these aspects include:

Temperature:

- cold (up to 10°C), e.g. Szinva, Garadna springs,
- warm (10–25°C), e.g. Tavi Spring, springs at Kács,
- hot (25–37°C), e.g. Termál Spring at Miskolctapolca.

Time of their activity:

- permanent, e.g. Eszperantó, Szalajka springs
- temporary, e.g. Imó, Vörös-kő springs

Catchment area and the level of outlet:

- descending, e.g. Jávor-kút, Létrás springs
- ascending, e.g. Termál Spring at Miskolctapolca, springs of Bárány Swimming Bath at Eger

Characteristics for the classification are not always clear therefore the classification of springs is often difficult. Sometimes their other names (e.g. debris, layer, fissure, dammed, fault, flood, escaping, floor springs) may help.

Surface river network

Surface water is subordinate in the centre of the Bükk, mainly due to the periodical character, significant undulation of the discharge of springs, their utilisation for the waterworks and significant infiltration in limestone areas.

Streams flowing out of marginal springs towards the north are collected by Bán Stream transporting their water into the Lázbérc reservoir, from where it gets into the Sajó River and eventually into the Tisza River. Tardona Stream ends in a fishing lake while the water of Harica and Bábony streams gets also into the Sajó River.

Garadna Stream flowing from the central Bükk (and drying out very rarely) flows into the smaller Szinva Stream below Hámor Lake at Lillafüred and continues with the Szinva Stream into the Sajó.

Hejő Stream flowing from Miskolctapolca gets down to the Tisza River along its crooked course.

Csincse Stream flowing from the edge of the South Bükk taking the water of Kács, Sály, Hór, Ostoros and Lator streams arrives into Tisza Lake (Kisköre Reservoir) via the Eger-Rima system.

Water correlations

Since the major springs in the Bükk are involved in the drinking water supply system therefore the survey of the catchment areas was necessary due to drinking water safety. This survey was performed with the help of traceable material (salt, spores of lycopodium, fluorescein). As a result, the place of the springs involved in the waterworks system is known accurately but anthropogenic pollution could cause water quality problems.

Thermal karst water

The exploration of the thermal karst of the Bükk known for centuries due to warm and hot water springs started in 1870 by boreholes in Eger and still goes on in the Bükk Region. A new borehole was drilled in Eger in 1926 followed by another borehole at Mezőkövesd where a void hydrocarbon exploring borehole produced thermal karst water in 1939. After World War II thermal karst water wells, occasionally more than one, were drilled at Miskolc (1953), Bogács (1959), Sajóhídvég and Egerszalók (1961) and at Andornaktálya (1962). Most recently thermal karst wells were drilled at Demjén (2006), Arnót (2008) and Mályi (2010), the latter was aimed to contribute to the district heating of Miskolc. Currently 50 thermal karst wells are in operation in the Bükk Region (mostly production wells but 3 of them are re-injection and 3 are monitoring wells) with various intensity and water temperature ranging from 16°C to 98°C, the deepest of them is 2.3 km deep.

Categorizing the water extracted from the thermal karst according to its temperature the official categories applied in Hungary – according to which water with temperatures above 30°C are considered thermal water – were modified so as water with temperatures between 16°C and 25°C, 25°C and 37°C, and over 37°C was categorised warm-lukewarm, warm and hot respectively.

Regarding the bottom temperature of wells, 105°C is the highest. The geothermal gradient shows excellent correlation with the exposition depth, however, this correlation is closer in Miskolc than in Eger.

Application of water

The cold karst water of the Bükk is used as drinking water and sanitary water by the waterworks. Thermal water is utilised mostly by baths, however, a significant part of the heat obtained by cooling the thermal water is utilised for heating as well. Medical utilisation (Egerszalók, Mezőkövesd Zsóry) is also significant. Water extraction (Mályi) and re-injection (Kistokaj) with heating purposes provides more than 50% of the energy demand of district heating in Miskolc.

Caves in the Bükk Mountains

According to the official webpage of the Hungarian State Nature Protection, there are 1148 caves in the Bükk, which means a quarter of the caves in Hungary. Due to their size, beauty and scientific value 52 of the caves are strictly protected. Out of the 311 caves under special protection in Hungary 127 are found in the Bükk. The high number of caves, however, means that their size is relatively small. The total length of passages of the caves longer than 200 m is around 35000 m while the total length of the passages of all caves is 52000 m.

Around 1/3 of the caves longer than 200 m and deeper than 50 m in Hungary can be found in the Bükk. Out of the 15 longest caves in Hungary 4 can be found in the mountains (longest of them is the 8700 m long István-lápa Cave, which is 5th in the national ranking). Out of the 15 deepest caves in Hungary 7 can be found in the Bükk including the 1st Bányász Cave with a depth of 275 m and the 2nd István-lápa Cave (254 m).

Interestingly, the caves with openings at the highest altitude above sea level in Hungary can be found in the Bükk. One of them is strictly protected and is also the cave deeper than 100 m with opening at the highest altitude, namely Kis-kőhát Aven with a depth of 117 m the entrance of which can be found at an altitude of 915 m a.s.l.

With the connection of caves, a continuous cave system is formed by each of the Szepes-Láner cave system, the Bolhás-Jávorkút cave system and the Szivárvány-Sebes cave system. In the latter case, the first transient cave system of the Bükk – from the sinkhole to the spring – was explored by connecting the Sebes and Szivárvány caves.

In the Bükk Mountains, some of the many caves were suitable for welcoming visitors. Utilising these conditions 4 caves were equipped for tourism in the 20th century, thus four of Hungary's 11 caves opened for tourism – Anna travertine, Diósgyőr-tapolca, Miskolctapolca Tavas (commonly known as „Cave Bath") and Szent István Cave – are found here. The caves that can be visited in clothes have between 60000 and 70000 guests a year, and hundreds of thousands of visitors take a dip in the Thermal and Cave Baths every year.

The formation of caves is based on a very complex geological structure. The first period of karstification was in the Eocene, under tropical climate. With the rise of the mountains beginning at the end of the Miocene, the currently ongoing karstification began. The beginning of the formation of the currently active water-driving cavities was in the middle of the Pleistocene, and their development is still ongoing today.

The currently operating sinkholes swallow water solely from non-karstic areas. No permanent watercourses can be found in karst areas, because water coming from the impervious rocks to the karst surface will eventually be swallowed. Most of the caves in the Bükk are partially filled with sediment.

Listing and description of geological sites within the aUGGp

The following 40 geosites out of the 356 geosites surveyed in the Bükk-Region Geopark are the basis of the evaluation:

	Name of geosite	Settlement	Importance			
			research	education	presentation	tourism
1	Lignite mine, fossil forest	Bükkábrány	X	X	X	
2	Most significant sinkhole caves of the Bükk, Pénz-patak Sinkhole Cave	Répáshuta	X	X	X	X
3	Karst fields of the Bükk Plateau uvala of Nagymező	Szilvásvárad	X	X	X	X
4	Karst landforms of Little Plateau, Udvar-kő	Parasznya	X	X	X	X
5	Anna Travertine Cave	Miskolc, Lillafüred	X	X	X	X
6	Bél-kő and abbey church	Bélapátfalva	X	X	X	X
7	Earthworks at Bükkalja Latorvár-tető	Sály	X	X	X	X
8	Stones of the Bükk, Cserepes-kő	Szilvásvárad	X	X	X	X
9	Damasa Gorge	Bánhorváti	X	X	X	X
10	Dolomite quarry (T-84 key section)	Felsőtárkány	X	X	X	X
11	Travertine, "Salt Dome"	Egerszalók				X
12	Fehérkő Limestone Formation	Miskolc, Lillafüred	X	X	X	X
13	Hór Valley quarry (T-69 key section) and Suba-lyuk Cave	Cserépfalu	X	X	X	X
14	Temporary karst springs, Imó-kő Spring	Felsőtárkány	X	X	X	X
15	Karst ravines, destruction caves: Szarvaskút-Csúnya Valley	Répáshuta	X	X	X	X
16	Kő Valley, Felső-szoros	Cserépváralja	X	X	X	X
17	Mész Hill, Nyerges	Eger	X	X	X	X
18	Cave Bath at Miskolctapolca	Miskolc				X
19	Nagy Hill railway cut (K-10 key section)	Nekézseny	X	X	X	X
20	Nagy-kő	Bükkszenterzsébet	X	X	X	X
21	Ördögtorony and Mész-tető earthworks	Cserépfalu	X	X	X	X
22	Caves in the Bükk inhabited by caveman: Szeleta Cave	Miskolc, Hámor	X	X	X	X
23	Szalajka Valley, Fátyol Waterfall	Szilvásvárad		X	X	X
24	Vár Hill, gorge and Tóbérc quarry	Szarvaskő	X	X	X	X
25	Beehive stones at Szomolya (M-40 key section)	Szomolya	X	X	X	X
26	Tatár-árok, Nagy-sánc	Bükkszentlászló	X	X	X	X
27	Vár Hill, Törökasztal and Bálványkövek	Sirok	X	X	X	X
28	Verebce study trail, Verebce-tető	Nagyvisnyó	X	X	X	X
29	Most significant caves of Bükk Mountains: Bányász Cave	Miskolc	X			
30	Adit caves, avens: Kis-kőhát Aven	Nagyvisnyó	X			
31	Permian-Triassic boundary at Bálvány North (P-03=T70) key section	Nagyvisnyó	X			
32	Bánya Hill J-47 key section	Répáshuta	X	X	X	
33	Key sections along the road leading to the Bükk Plateau Rákmara (Pz-25 key section)	Szilvásvárad	X	X		
34	Oligocene outcrops around Eger: road cut at Kis-Eged (Ol-03 key section)	Eger	X	X		
35	Lök Valley 2 (J-48) key section	Felsőtárkány	X	X	X	
36	Mihalovits Quarry (P-02 key section)	Nagyvisnyó	X	X	X	
37	Síkfőkút quarry (Ol-11 key section)	Noszvaj	X	X	X	
38	Strázsa Hill quarry (Pz-39 key section)	Nekézseny	X	X	X	
39	Szent István Cave	Miskolc, Lillafüred	X	X	X	
40	Geological and Industrial Historical values of the Uppony Mountains: Dedevár Limestone Formation	Dédestapolcsány	X	X	X	

international importance

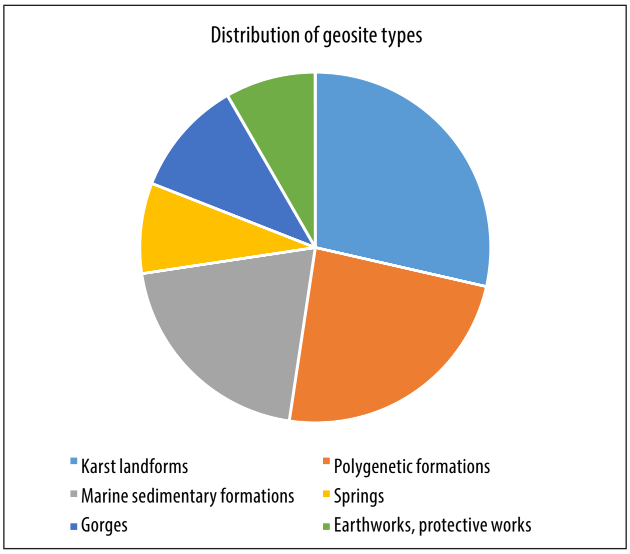
regional importance

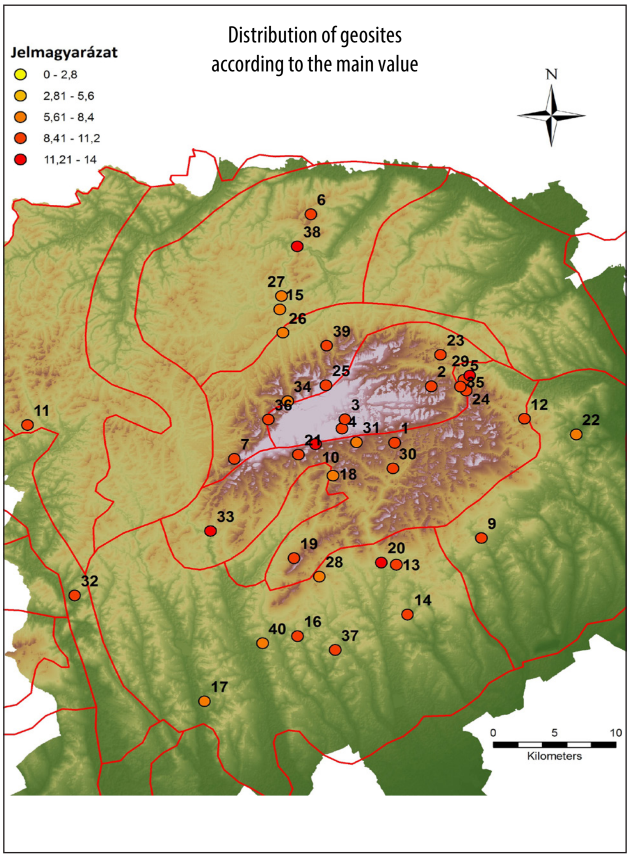
Details on the interest of these sites in terms of their international, regional, national or local value (for example scientific, educational, aesthetic)

In terms of uniqueness (rarity), we have classified five geosites as of outstanding importance at international (continental) level and another 16 values regionally (Carpathian Basin and its surroundings) at international level. This shows that half of the geosites selected for the geopark concept are also unique in international comparison, while another 40% are nationally unique.

The five values with outstanding rarity include the Anna travertine cave, the Permian-Triassic boundary section on the side of the Bálvány, the Miocene swamp cypress remains of Bükkábrány, the oceanic pillow lava of Vár Hill at Szarvaskő and its geomorphological environment, and representatives of a value type: the caves of caveman in the Bükk. These are completely different according to their place in geotourism. While the boundary section of Bálvány can only be studied in small groups as part of a professional visit, the swamp cypress fossil remnants can only be seen in collections, Anna Cave is part of a fully equipped, well-functioning visitor centre, Szarvaskő can be considered an ecotourism centre, and the caves of caveman in the Bükk can be visited on the basis of a variety of approaches and presentations throughout the Central Bükk.

Based on the diversity of geological heritage types, for about a quarter of them, the material, for more than a third of them the form, in the case of 10%, the process of formation and for another quarter of them, the complex unit of the three factors are the primary geotourism value. The 40 priority geosites and the landscape value directly associated with them, the unique landscape value according to the individual landscape value cadastre standard, can be classified into 13 types. Among them, unsurprisingly, different karst forms make up a quarter of geosites (24%). This type of value, as seen from the survey, is the most diverse and the largest number of people on the Bükk Plateau. The next most common category is represented by polygenetic formations (usually geosite and geomorphosite, with additional cultural value several times) (20%), which belong to here, on the one hand, based on their regional extent (Little and Big Plateaus, Uppony Mountains, Hór Valley, Bükk stones, etc.), mainly due to karst, frost shattering and fluvial surface formation. Others were classified in this group because of their special role in the landscape (e.g. beehive stones, Mész Hill, Eger, caves of caveman, etc.). The next most significant group of values is presented by marine sedimentary formations (17%). Frequencies over 5% can be attributed to springs (7%) so typical in karst mountains, gorges formed on diverse rock material (9%) and earthworks and protective works proving humans' early landscape-forming role (7%). The geodiversity of the area supports the geopark concept reflecting the above.





The scientific awareness of the selected geosites, thanks to the conscious marking, is high, at least one scientific journal article, in most cases internationally referenced, describes them among other studies. The possibility of interpretation according to geotourism interest is always available with at least a specialist guide, however, the main characteristics of the values are recognisable and the natural processes associated with them can be understood often without it as well with good guidance (45%). Their current state and vulnerability make geotourism possible in most cases.

Much of the geological heritage is already used in the different fields of education (at least in printed or online curriculum, via study trail presentation) and its condition makes it suitable for future geotourism. Outstanding educational and scientific values include complex polygenetic values, Vár Hill and its surroundings in Szarvaskő, caves of caveman, Anna Cave, and three further complex geosites: the beehive stones of Szomolya, the rock material and the landforms of Hór Valley with Subalyuk Cave, Bél-kő, the Abbey of Bélháromkút and its geoenvironment, and the swamp-cypress remains of Bükkábrány. Karst forms are very diverse regarding their educational and scientific value. In addition to active cave passages that are difficult to reach and interpret, and can be presented only in educational resources, and also in addition to karst landforms with complex genetics (e.g. collapse caves, karst gorges) that can be presented only by specialist guides, well-recognisable karst landforms are included. Due to the various geological formations and earthworks have on average moderately good educational and scientific importance partly due to the lack of background knowledge in the society in this respect and partly due to the more difficult recognition of visible traces. Landforms of external forces (mass movements, valley cutting) and springs show value better than moderate.

From this point of view, Bükk Plateau emerges among the landscapes. Here, the average educational and scientific role of geosites is good, four of which can be classified as excellent: caves of caveman, Anna Cave, Bél-kő and its surroundings, and the range of "Stones". Next in the ranking are landscape fragments of the Eger-Bükkalja, especially the beehive stones of Szomolya and the travertine hill at Egerszalók. Vár Hill of Sirok and its surroundings have similarly good conditions.

Current potential pressure on the geological sites regarding their preservation and proper maintenance

Around two third of the values involved in the detailed study are hardly or not damaged at all and the vulnerability of around the same number of values is small.

Around a quarter of the designated sites of the Geopark are not vulnerable and do not require maintenance. These include natural rock walls, large and deep caves, avens, sinkhole caves that can only be visited by cave scientists. Intervention and activity at these sites shall be less frequent than 10 years and only if necessary, by removing vegetation which threatens the state of the rock or interferes with its visibility and also by removing rock debris that may present the risk of accidents.

Vegetation, rock debris and loose rocks disturbing or hindering visibility, presenting the risk of accidents must be removed from rock walls or outcrops along major roads more often, every 6-10 years. Prehistoric earthworks are primarily threatened by abundant vegetation and advancing scrubs, therefore their condition should be also reviewed every 6-10 years and carry out the necessary maintenance work. Around another quarter of the designated geosites are classified in this category.

In the case of artificial excavations – roadcuts, mining walls – the rocks of which are more prone to weathering, more frequent maintenance is needed with a period of 2-5 years according to their actual condition. This is the frequency of cleaning the locations of the most visited geosites, where the traces of human presence – waste, deliberate vandalism – must be removed in the first place. This category also includes about a quarter of the sites.

In the case of beehive stones with rocks prone to stronger weathering, maintenance must be carried out annually. Here, shrubs and saplings that have settled into the cracks of the rocks stretching them must be removed, or loosened blocks of stone must be reinforced or removed.

In the tourist caves with high number of visitors (Anna travertine cave) and the cave bath of Miskolctapolca, maintenance work must be carried out several times a year as necessary. In the latter case, this is done by the operator Miskolc Waterworks. Fossil tree trunks found in the lignite mine of Bükkábrány, now placed on exhibition under special circumstances at the BNPI Ipolytarnóc Fossils Nature Reserve and at the Pannon Sea Museum in Miskolc, also require several reviews each year.

The necessary inspections are carried out by the geological experts and conservation guards of the Bükk National Park Directorate. The smaller work required on a regular basis is covered by the budget of the Directorate, and the larger maintenance work required every 5-10 years is financed by tenders.

Several interventions have been carried out in recent years to prevent natural processes and damage caused by visitors. The caves, which are strictly protected or endangered, managed by the Directorate, have been locked to prevent partly contamination, the inflow of debris and partly illegal intrusion.

Bálvány North key section of international importance has been roofed to reduce weather damage.

Beehive stones at Szomolya is a site of exhibition presenting complex geological and cultural historical values. Traffic on the rhyolitic tuff rock prone to weathering is dangerous in wet weather, and a large number of visitors have caused significant trampling damage. In order to prevent this a walking platform was established in 2019, which allows the safe visiting of beehive stones without damaging them.

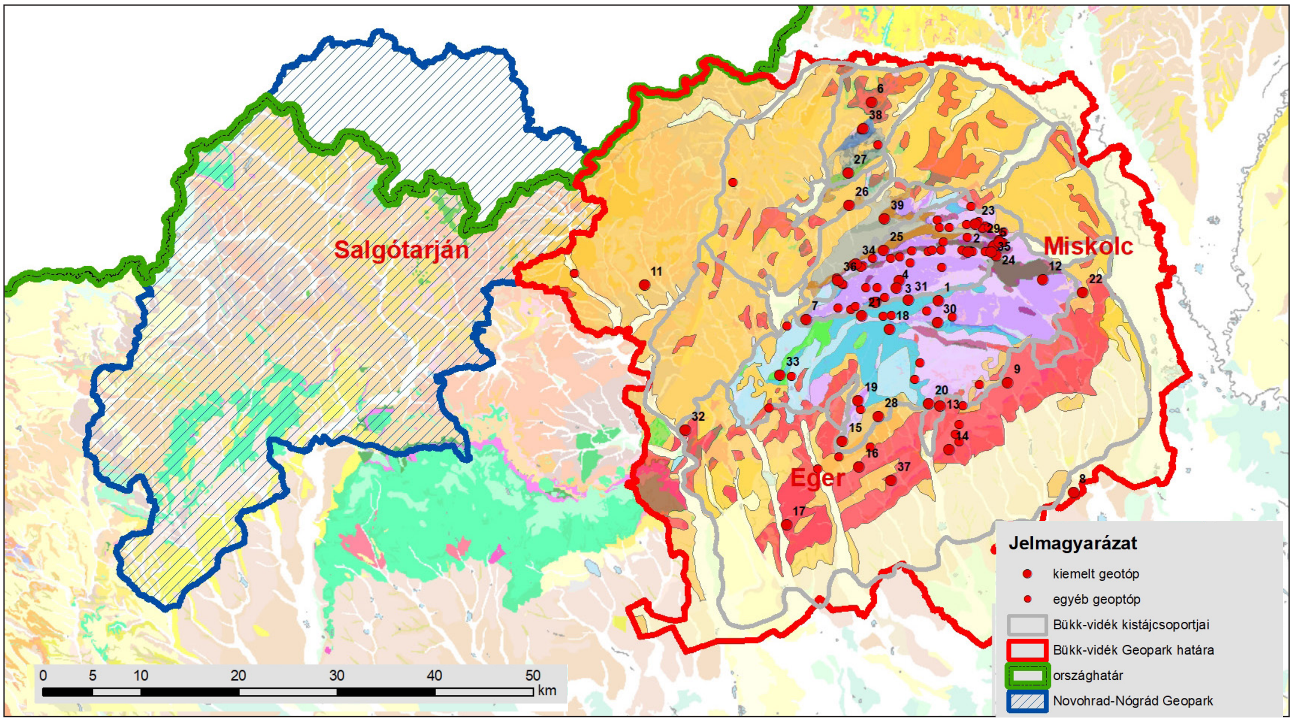
Current status in terms of protection of geological sites within the aUGGp

Geosites located in the nationally protected natural areas of the Bükk Region (Bükk National Park, Uppony Landscape Protection Area, Tarna Region Landscape Protection Area, Szomolya Beehive Stones Nature Reserve) are protected according to the level of protection. All caves and springs the water flow of which permanently exceeds 5 l per minute are protected by law in Hungary. Geological key sections and beehive stones outside protected areas have been given individual legal protection under the title natural monument. Some geosites, e.g. Mész Hill and Nyerges in Eger, the Noah's vineyard at Istenmezeje are under local protection. The salt hill of the thermal bath at Egerszalók and the cave bath at Miskolctapolca are not protected by nature protection, their preservation, however, is guaranteed by their use in tourism.

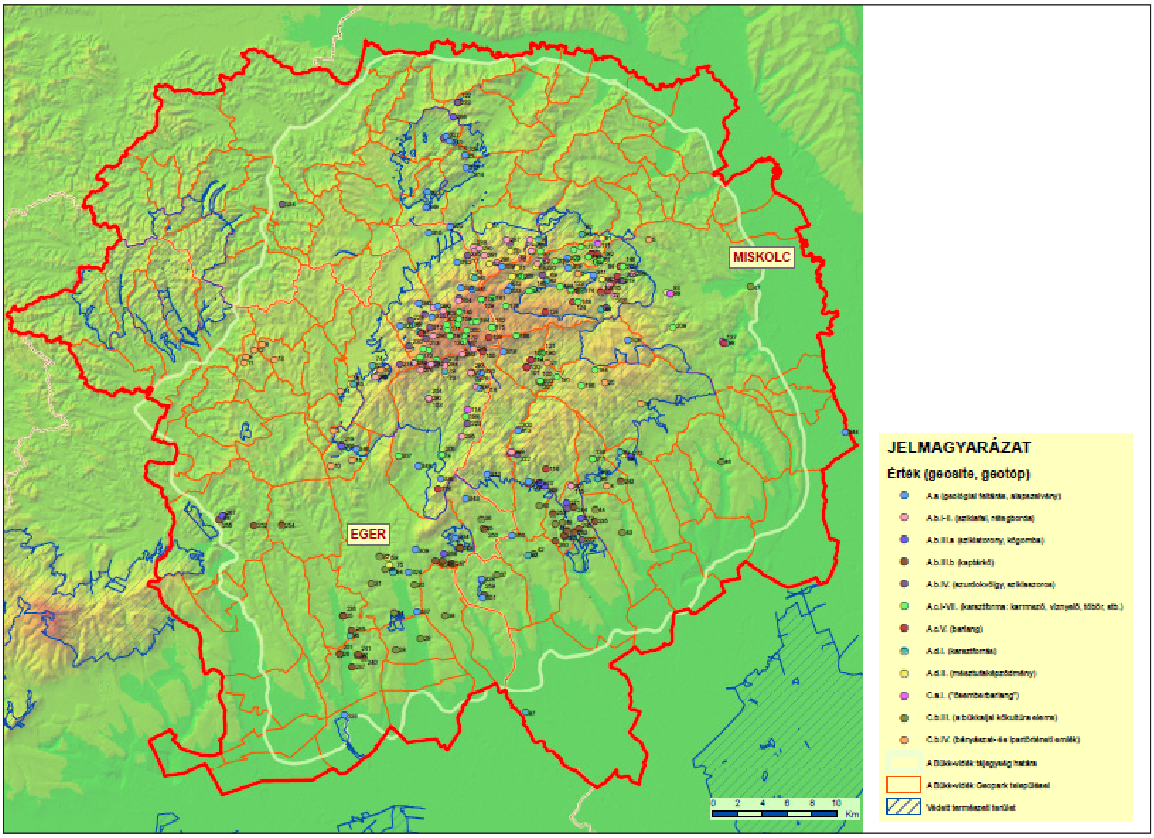
E. 1.2 Boundaries

The planned Geopark covers the central part of the mesoregion of Bükk Region; its boundaries are set by the borders of the 109 municipalities belonging to this region.

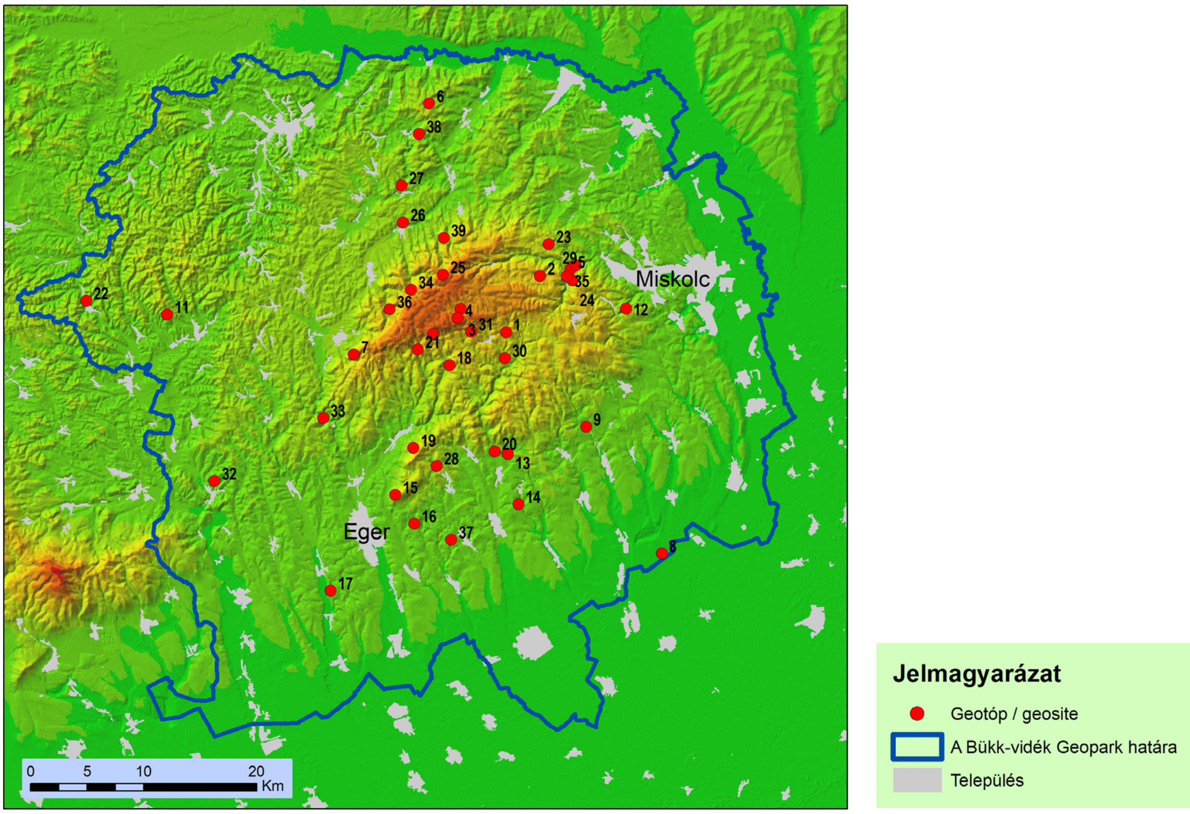
A total area of 2817 km2 of the Bükk-Region Geopark (BvGP), under the organisational system of the Bükk National Park Directorate (BNPI), includes the Bükk National Park in the Bükk Region, as well as the Lázbérc Landscape Protection Area and part of the Tarna Region Landscape Protection Area (together with six nature reserves of national importance). The planned boundary of the aspirant Bükk Geopark is directly in contact with the Novohrad-Nógrád UNESCO Global Geopark in the NW. Although the dominant geological



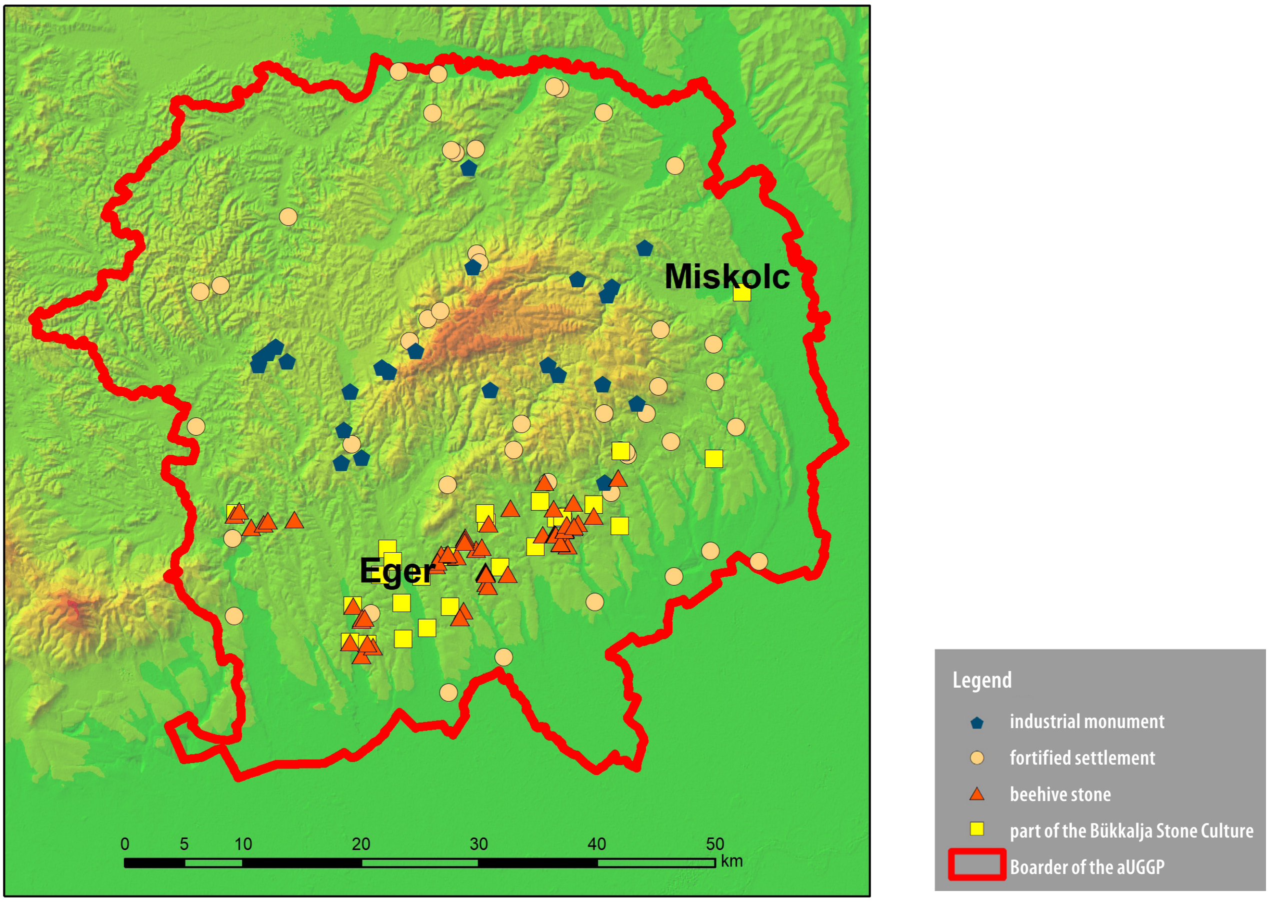
Boarders of Novohrad-Nograd UGGP (blue line) and Aspiring Bükk-Region Geopark (red line) formation on the surface of the involved areas -- Lower Miocene Pétervására Sandstone Formation -- can be found in both parts, but on the eastern side, the geomorphology of Bükk-Region Geopark shows a more homogeneous image, with shallow sea sediments not being crosscut by dominant basalt rocks. The two geoparks are separated from each other in landscapes and difference in surface geological structures can also be detected, and settlements along the border of them belong to different counties. Therefore, delineation is clear from a geological, landscape and administrative point of view.



In total 356 geosites were identified in the area of the aspirant Bükk-Region Geopark 40 out of which were selected



Location of the selected 40 geosites and the settlements



E.1.3 Visibility

Information related to the Geopark – publications and leaflets – is placed in municipalities in the Bükk Region, in schools at municipalities, tourist information points, as well as in partner institutions, primary and secondary schools, the universities of Miskolc and Eger and in museums.

The planned Geopark has its own website, kaptarkovek.bnpi.hu/hu/a-bukk-videk-geopark/

Information panels at the geosites are uniform and have the logo of the Geopark on them.

Currently, information is available in Hungarian and in English.

BNPI has involved a number of ex lege protected and natural monument sites and objects in the network of geotopes and geosites – thanks to several tender development programmes:

- In the framework of the project entitled "Beehive stones" information panels for 30 beehive stones, field infrastructure at 4 locations, and the construction of a platform and resting place at the Szomolya Beehive Stones Nature Reserve;

- Information panels for 30 geological key sections in the framework of the tender entitled "Documents of Millions of Years";

- Establishment of two study trails and 30 information panels in the framework of the development entitled "Rehabilitation of earthworks";

- Information boards containing the image of Bükk-Region Geopark draw attention to the values of nearly 100 geotopes – significantly improving the visibility and appearance of the Geopark, enriching the geotourism offer.

Particularly associated with the current project the Bükk National Park Directorate published scientific educational publications focusing on the values of the Bükk-Region Geopark. Among them geotouristic maps and atlases worth noting:

Bükk-Region Geopark. Geotouristic map, BNPI, Eger, 2018;

Bükkalja. Geotouristic map, BNPI, Eger, 2018;

Szomolya Beehive Stones Nature Reserve (leporello with maps);

Beehive stone repository. Geotouristic Atlas of Bükkalja (1:80,000). BNPI, 2018;

Witnesses of millions of years. Atlas of the geological values of Bükk Region (1:80,000). BNPI, 2018;

Ancient ramparts, medieval castles. Atlas of the cultural historical values of Bükk Region (1:80,000). BNPI, 2018;

E.1.4 Facilities and infrastructure

The Geopark and its services are partly presented via printed publications and partly via the webpage and social media (facebook, instagram).

Bükk-Region Geopark plans to provide visitors with a wide range of services. In our educational programme special attention is paid to kindergarten, primary and secondary school age groups, the values of the area are presented in the framework of lectures or field programmes. We regularly advertise geo-tours to present less known places. Tourist service providers, tourist associations are contacted and our programmes are offered through them. In cooperation with the Eszterházy Károly University in Eger and the county friends of nature associations, the guides of special geological and cultural history tours will be given a training. According to our plans, the tours recommended by us can only be guided by those who have certificates issued here.

E.1.5 Information, education and research

We inform the wider public about the operation, programmes and activities of the Geopark through written and electronic media. We inform media professionals about major events by press reception, otherwise electronically.

In order to introduce the Bükk-Region Geopark several publications and maps have been made. A separate brochure was prepared describing the geological key sections, the beehive stones and the cultural monuments in the area: prehistoric settlements and castles, as well as the medieval castles. Each publication has a detailed map with the location of the objects described. A special publication was prepared to present the most important geosites of Bükk-Region Geopark.

In recent years, the Geopark logo has also been displayed on the information boards placed by BNPI in the sites of the geological and cultural values, emphasizing that the site is a valuable part of the Geopark.

In cooperation with the Bükk National Park Directorate, educational activities are currently underway at the forest school of the Directorate. This includes a description of the geological and geomorphological values of the area.

- The management of the geopark intends to expand educational activities in co-operation with the educational institutions of the region in the future. Training interested teachers to integrate the geological and cultural historical values of the Bükk Region into education, according to the needs of different age groups is also planned.
- We are implementing scientific cooperation with universities in the region, we are already working actively with Eszterházy Károly University to establish the Geopark.
- We have several years of professional co-operation and contact with the Hungarian Geopark Committee, Pro Geo organisation and we have also concluded a co-operation agreement with the Faculty of Earth Science and Engineering, University of Miskolc.
- We also have a living relationship with the museums of Eger, Gyöngyös and Miskolc, which we plan to expand further.

E.2 Other heritage

E.2.1 Natural heritage

I Flora

The area of the Bükk-Region Geopark is not in line with an area delineated with natural landscape boundaries. In addition to the Bükk Region (as a mesoregion) forming the „core" of the area, several contacting microregions are also part of the planned area. Among the microregions forming part of the Great Hungarian Plain are the Gyöngyös and Heves plains, Borsod-Mezőség and the Sajó-Hernád plain. To the west and north, both the Mátra (through the Eastern Mátraalja, South Mátra and the High Mátra microregions) and the microregions of the North Hungarian Basins are involved (Pétervására Hills, Ózd-Egercsehi Basin, Upper Tarna Hills, Tarna Valley, Sajó Valley). One of the most typical specifics of the area is the significant forest cover, which is more than three times the forest cover of Hungary (21%). Considering the central part of the Bükk, this value is above 90%. This fact greatly determines the nature of the wildlife of the area.

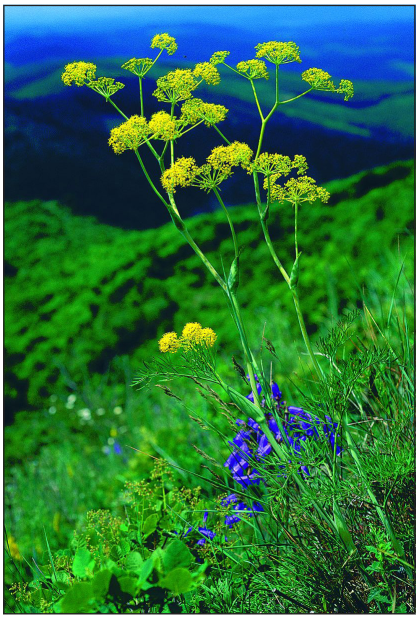
In addition to the southern margins – which are part of the Great Hungarian Plain – the planned area belongs to the flora district of Borsodense, of the North Hungarian Range (Matricum) flora region of the Pannonian flora province including the Bükk Mountains according to the Hungarian floristic-plant geography classification. The western and northern hills and mountainous parts of the area (Mátra, Pétervására Hills) form part of the Agriense flora district, while those that are part of the Great Hungarian Plain belong to the Crisicum flora district.

The flora of the Bükk Mountains is considered very rich, even in Hungarian terms. In the flora work of András Vojtkó 1,320 vascular plant species were discussed. The number of species occurring in the delineated area of the Geopark is much higher, as in the periphery areas not part of the Bükk Mountains (like Borsod-Mezőség, Pétervására Hills, Sajó and Tarna valleys) also contain habitat types (like areas with alkaline soil, sand puszta, floodplain meadows, watercourses, backwaters) that do not occur in the Bükk. The total number of species for the site (including species of anthropogenic habitats) is estimated at 1800–1900 species. The floristic richness of the area is also shown by the occurrence of 26 strictly protected and 364 protected plant species.

Floristically, it is particularly interesting that in the area of the Bükk Mountains dealpine-glacial and sub-Mediterranean interglacial species can also be found, as well as cold-continental species, and its endemic and sub-endemic plants are also famous. *Ferula sadleriana* living on Bél-kő and *Calamintha thymifilia*, which has Mediterranean relations can be considered pre- or interglacial relict species (and also endemic). Some European smoketree (*Cotinus coggygria*) occurrences are also believed to be relict-like.

It is likely that some notable dealpine species of the Bükk, such as the victory onion (*Allium victorialis*), Alpine rock-cress (*Arabis alpina*), *Calamagrostis varia*, Alpine clematis (*Clematis alpina*), *Dianthus plumarius subsp. praecox*, *Hieracium bupleuroides subsp. tatrae*, stone bramble (*Rubus saxatilis*), (*Sesleria varia*), common yew (*Taxus baccata*), Teleki flower (*Telekia speciosa*), Alpine yellow violet (*Viola biflora*) appeared here during the Ice Age. The occurrence of the Baltic acidophilic *Armeria elongata* further expands the range of rarities in the Bükk. The development of the characteristic flora of the mountains was the result of the possibilities of diverse local habitats that are hardly present in other parts of the North Hungarian Range. It was partly the diversity of the bedrock (limestone, dolomite, shale, rhyolite, basalt, porphyry), and partly the alternation of soil types formed on them contributed to the formation of the flora, and the survival or further spread of certain relicts. Habitats with extreme microclimate associated with the relief conditions (dolines, steep-sided valleys, rock cliffs, rocky tops and ridges) also allowed species to survive even after changes in the macroclimate.

The variety and richness of the plant cover of the area have been shaped by a number of factors, in which the landforms of the area, climatic conditions, base



Ferula sadleriana (József Sulyok)

Calamintha thymifolia (József Sulyok)

Dianthus plumarius subsp. praecox (Csaba Baráz)

Alpine yellow violet

Teleki flower

rocks and soil types and the history of vegetation development with past and present land use play a decisive role. These factors are further influenced by mesoclimatic and biogeographical differences between certain parts of the Bükk. Thus, for example, the effect of the Pontic-continental climate is strongest in south-eastern Bükk, while the sub-Mediterranean effect is strongest in the Bükk, even though xerotherm associations are typical for both areas. Similarly, there are significant differences, for example, in the northern vegetation of the north-western slopes of the Bükk Plateau and the Ómassa cauldron.

The most important relict preserving places in the Bükk include: Bélkő, the north-western steep slopes of Bükk Plateau, Garadna Valley, Szinva Valley, Tatárárok, lower sections of Flór Valley, Csákpilis, Örvénykő – Oszra-tető range, Szarvaskő. Some of the smaller relict preserving places include: Csókás Valley, Balla Valley – Csúnya Valley. The vicinity of Dédes – Bugókő, Őrkő – Háromkő range.

Significant flora accumulation places where greater number of species occur due to periphery location include: Bélkő, Nagy-Eged, Ásottfa-tető, Szarvaskő, Berva-bérc, exit of Hór Valley, Nagy-Kőmázsa, Őrkő – Háromkő range.

II Fauna

According to animal geography, the hills and mountains of the area are classified as the North Hungarian Range (Eumatricum) faunal sub-district of the Middle Danube faunal district, while the lowland peripheral areas are part of the Eupannonicum faunal sub-district of the Pannonicum faunal district.

The diverse natural conditions that create vegetation are, of course, also decisive for the fauna. Consequently, the Bükk Mountains and their surroundings are a collection point of collection for a wide variety of fauna elements from an animal geography point of view. Endemic species that live only in the Bükk, such as the cave-dwelling Gebhardt's Ground Beetle (*Duvalius gebhardti*) and the *Entephria cyanata gerennae*, are very valuable. The number of animal species in the Bükk Mountains only is estimated by the simplest calculations to be around 22,000. Since the delineated area also contains a number of habitat types that do not occur in the Bükk Mountains – in the narrow sense – or are very rare, this figure may exceed 25,000. As far as we know, we have data on the presence of 101 strictly protected and 503 protected animal species (including migrating species and those using the area periodically in addition to breeding flocks. This summary cannot cover all groups of organisms and habitat types, therefore only the most specific elements have now been highlighted. *Bythinella pannonica* loves the cold and clean water of karst springs, while in

Predatory bush cricket

Carpathian blue slug (Roland Farkas)

Theodoxus prevostianus

brown bear

wolf

eastern imperial eagle (András Kovács)

Erannis ankeraria (Tamás Korompai)

the lukewarm karst springs of the South Bükk lives the *Theodoxus prevostianus*. The majority of the bat population of Hungary can be found in the caves of the Bükk (the common bent-wing bat /*Miniopterus schreibersii*/ and the Mediterranean horseshoe bat /*Rhinolophus euryale*/ can only reproduce in caves), but there is also a significant number of forest-dwelling bats. The wealth of species and rare species elsewhere are the result of large, old forest blocks and hundreds of caves. Gorge forests, typical mainly of the northern part of the mountains, are home to many valuable northern and high mountain elements. The Eastern Carpathian endemic Carpathian blue slug (*Bielzia coerulans*) and the Mountain whorl snail (*Vertigo alpestris*) are typical. Forest puddles and springs provide breeding sites for many amphibian species, the occurrence of the Alpine newt (*Triturus alpestris*) out of which, indicates relations to high mountains. Reptiles are essentially attached to dry habitats, and in the southern sunny slopes sand lizard and European green lizard (*Lacerta agilis, L. viridis*) are met frequently. In the clearings of warm-loving oaks, and when they are turned up into trees, sunbathing Aesculapian snakes (*Elaphe longissima*) can also be observed. Burrow-dwelling bird species are bound to old forests rich in old and dead trees. White-backed woodpecker (*Dendrocopos leucotos*), red-breasted flycatcher (*Ficedula parva*) and Ural owl (*Strix uralensis*). The bird of prey fauna of the area is also very valuable. Stable, traditional nesting sites are available for the strictly protected eastern imperial eagle (*Aquila heliaca*), lesser spotted eagle (*A. pomarina*), European honey buzzard (*Pernis apivorus*) and peregrine falcon (*Falco peregrinus*). It provides habitat for the specific endemic karst animals of dolines in the Bükk Plateau providing a living space for a specific karst fauna. These associations show Carpathian characteristics. Typical species are the endemic northern brown argus (*Plebeius artaxerxes issekutzi*) and the mountain Alcon blue (*Maculinea rebeli*). In the bushes, warm oaks and dry grasslands of the mountains, warm fauna elements, including the predatory bush cricket (*Saga pedo*), *Paracaloptenus caloptenoides*, *Rileyiana fovea*, *Erannis ankeraria*, Hungarian metallic wood-boring beetle (*Anthaxia hungarica*) are important. In recent decades, the resettleing of large predators can also be observed, with the detection of wolves (*Canis lupus*), Eurasian lynx (*Lynx lynx*) and brown bears (*Ursus arctos*) again appearing in the area. The typical mammalian species of the foothills and lowland areas is the European ground squirrel (*Spermophilus citellus*), the herds of which was locally strengthened after a strong suppression in recent decades.

E.2.2 Cultural heritage

In relation to the geopark, the cultural and landscape historical values are presented that are related to rocks, geographical features, geomorphological forms, i.e. they have geographical determination. Such interdisciplinary elements and attractions: caves of caveman, prehistoric fortified settlements and medieval castles, objects of Bükkalja stone culture and mines of mineral resources, industrial facilities, ancient routes, which are now relics of industrial and transport history.

Ancient cultures in the Bükk Region – Old Stone Age

Szeleta Cave, Szeleta Culture (Szeletian)

Following the revising excavations carried out since 1999, a novel picture of the stratigraphy of the cave and the reassessment of the archaeological material of previous excavations has been established: in the 2nd layer of the cave, the Taubachian and Bábonyian cultures precede Szeletian. In the 3rd layer, in addition to Szeletian, two specific Middle Old Stone Age findings occur, which live through in layers 4-5-6-6/a as well. According to the traditional view, in the so-called early and advanced level findings with leaf tools showing development in the direction of the Gravettian culture, the epi-Szeletian of the early and developed levels containing Gravettian elements can advance becoming complete in layers 6-6/. In the 3rd layer, in addition to the findings of the leaf tool and two Middle Palaeolithic cultures, even Bükki-Aurinacian I. is also represented. Age: 46,000-22,000 years BP.

And from the Istállós-kő Cave near Szilvásvárad, bone and stone tools made by the people of the Aurignacian culture, which lived here for some 20,000 years from 44,000 years ago – spear heads, arrowheads, and a flute made from the bone of a young cave bear, one of the most valuable artifacts of Hungarian palaeoarchaeology – have been recovered.

In the upper Palaeolithic (35,000 to 10,000 years before today), modern man, Homo sapiens lived also in Europe, replacing Neanderthals. The period between 40,000 and 30,000 years ago is also called the transition of Middle and Upper Palaeolithic, when the two races lived side by side in many parts of Europe. In the Bükk Mountains, this is confirmed by the same layer of leaf-shaped spearheads of Neanderthals and the polished bone tip of modern man in both the Szeleta and Istállós-kő caves. There are only a few examples of such concurrency in Europe. These are represented by the occipital bone revealed in the Görömböly-Tapolca cliff hole, which was dated to 30,300 years ago by radiocarbon measurements.

Already during the excavations of 1906, typical Neolithic ceramic findings were recovered first in Kecske-lyuk and Büdös-pest in Forrás Valley, and then in the Szeleta of Hámor, which Lajos Bella identified as a separate culture. The people of Bükk culture (16th to 19th centuries BC) lived in small family houses with wooden structures, and traces of its settlements were found on the higher slopes of the mountains as well as in the valleys of smaller streams and larger rivers. One of the special features of the culture is that caves were used as both residential and burial sites (Kő-lyuk II or Hillebrand Jenő Cave).

Fortified settlements – Bronze Age and Iron Age

The first classical period of prehistoric „castles" in the area of the Geopark was the *early* and *middle Bronze Age*. The people of the early Bronze Age *Hatvan culture* (2000–1750 BC) and the middle Bronze Age Füzesabony culture (1750–1350 BC) settled mostly in the hilly regions in the edge of the Bükk. The fortification typical of them was a small castle next to a large „open settlement" (0.02-0.08 ha). The protected area surrounded mostly with only a ditch, may have been the property of the leading layer: it probably served both separation from their own people and protection against hostile neighbouring peoples and distant cultures. Earthworks from the first half of the Bronze Age in Bükkalja: *Maklár – Baglyas Mound, Novaj – Halom, Tard – Tatárdomb*.

The second great period of prehistoric fortified settlements began in the late Bronze Age. The settlements of *Kyjatice culture* (from the 12th century BC to the 8th – 7th century BC, until the break-in of the „Pre-Scythians") are large and truly impressive in appearance, mainly on mountaintops of great relative height inside the mountains: *Bükkszentlászló – Nagysánc, Miskolctapolca – Vár Hill, Bükkaranyos – Földvár, Cserépfalu – Mész-tető, Sály – Latorvár-tető, Felsőtárkány – Vár Hill.*

Castles, monasteries, old roads – the Middle Ages

In the area of the geopark, in the Bükk Region, the towers, walls and ramparts of 16 medieval strongholds can be found. The wall ring of the wide-footed earthworks of Sály (the castle of Örsur, also mentioned by Anonymus) and that of Vár Hill in Felsőtárkány mark the beginnings, as does the most well-known and more well-preserved fortress of the mountains, the Castle of Diósgyőr.

On the ancient estates of the Örsur clan, on the hill towering above the medieval settlement of Váralja, we find the residential tower of the branch of Váralja, the Latorvár, and on the Vár Hill of Kács (Tibolddaróc) the castle of the Daróc branch can be found. These small feudal castles, built in the early 19th century, were actually made up of a single residential tower surrounded by a combination of a rampart and a ditch. Odor Castle of Cserépfalu, Kecske-kő Castle, Éleskő Castle at Szilvásvárad and the castle of Gerennavár, as well as Dédes Castle at Dédestapolcsány are clearly stone castles built after the Mongol Invasion: serving passive protection, in a place that is difficult to reach, at an invulnerable height, away from the settlements.

According to tradition, king Louis the Great built a hunting castle on the rocky peak of Gerennavár.

During the Middle Ages, several monastic orders were established in the Bükk, some orders built not one monastery. The Benedictines had monasteries at Görömbölytapolca and Kács. The Abbey of the *Order of Cistercians at Háromkút* (Bélapátfalva) was founded by Kilit II, Bishop of Eger in 1232. The monastery church under Bél-kő still stands today and is one of the most beautiful Romanesque architectural monuments in Hungary. The Karthauzians had a monastery in the Barát Valley, north-east of Felsőtarkány. The only Hungarian-founded order, the Order of Saint Paul, settled in three places deep in the Bükk Mountains covered with ancient forest: in the vicinity of Dédes (in Szentlélek), in Diósgyőr and Felnémet (in Almár). The Pauline monastery at Szentlélek is the only medieval monument of the Bükk Plateau.

Ancient roads

From the Middle Ages, two significant roads led north-south across the Bükk Plateau. The so-called *Road of the King* starting from Eger, from the Tárkány Basin led through Egres Valley and Vörös-kő Valley to the Bükk Plateau through Toldi-kapu on the ridge of Kecskor. According to tradition, The Road of the King led to the hunting castle called Louis the Great called Gerennavár. Another of the most notable roads of the Bükk is the *Turkish way*, which can still be followed today. It turned to the Bikk-bérc at Tiba Fountain, and then it led from Várkút under the Vár Hill to Kőkapu along Csipkéskút, Táskás Ridge, Keskeny-Bükk. From there it led to Bánkút across Bánya Hill through the saddle of Kis-Kőhát and Nagy-mező. And from there down the Ördögcsúszda through huge Bronze Age ramparts of Verepce, passing by Vásárhely-parlag to the Dédes Castle.

Forestry and industry – Modern Period

Humans have been walking the forests of the Bükk Region since the Old Stone Age: at the beginning humans were just collecting and hunting in them, but since the Neolithic the forests have been transformed via a more complex use. In the interior areas of the Carpathian Basin there were so-called „visited forests", which were created as a result of the relatively harmonious „coexisting" of human and nature – the primary purpose of which until the modern period was not to meet the need for wood (firewood, building wood, etc.), but to obtain food, various benefits, livestock farming, grazing.

The ownership and use of forests in the Bükk show a very diverse picture. Around 1000, King St. Stephen appointed the Diocese of Eger and ensured the protection of ecclesiastical property, such as forests. The Cistercian Abbey at Bélháromkút and the Benedictine Abbey of Tapolca founded in the 13th century received property from the above ecclesiastical estate. The Archdiocese of Eger, for example, had 13,401 acres of forest in the vicinity of Felsőtárkány and Felnémet, from the 19th century, but the Main Chapter of Eger also owned a significant forest estate. Article I of 1514 declared the nearly 100,000-acre lordship of Diósgyőr as one of the Crown Estate, which our kings repeatedly pawned and rented out. From its last beneficiary, the Chapter of Eger, it was finally redeemed by the Szepes Chamber in 1755, thus leaving nearly 50,000 acres of forest land in treasury property up to this day.

The end of free forest use can first be inferred from Werbőczy's laws: bondsmen are forbidden to cut the forest and can only receive building and firewood according to their needs based on the right for woods, for which service had to be made. Furthermore, forest owners took a tenth of the acorned pigs and people had to pay for grazing, burning lime and coal.

The beginnings of the so-called regular forestry for timber production dates back to the mid-18th century, when the approach to farming of the chamber changed fundamentally, as the development of an industry based on the use of wood became increasingly important. Due to the increasing demand for timber, the examination of the chamber forests and the regulation of logging were ordered in 1766. According to the specifications of Article XXXI of 1879, the operation plans of the treasury forests were renewed and the first operation plan of the church forests and the entail was composed, which specified the maintenance of the forests as well.

Until the 18th century, only shepherds, pigmen, hunters, loggers, lime kilners and forest product gatherers were who trailed the interior of the mountains. In the early 1700s, however, the industrial exploitation of the mineral resources and forests of the region began. The wood demand of forest glasshouses (the first lordship glasshouse started operation between 1712 and 1720 in the forest estate of the Crown Lordship of Diósgyőr, Répáshuta – 1766, Gyertyán Valley – 1834), iron smelters and hammer mills, the paper mill of Szinva Valley (1782) was covered by the huge forests.

The renaissance of the *iron industry* in the region began in the second half of the 18th century. Henrik Fazola explored the Bükk and Mátra regions at his own expense between 1768 and 1769. He found high-quality iron ore in the vicinity of Uppony in 1769 and, based on the raw material extracted from the opened Péter mine, he built the blast furnace at Ómassa and hammer mills No 1 and 2 at Hámor from September 1771 to the end of 1772, where iron smelting began in the same year.

Iron smelting

Count Adam Keglevich established an iron hammer mill at Szilvásvárad in 1792, and then he set up a smelting furnace based on the iron ore of Mária mine at Bélapátfalva and St. Anne Mine in the Gilitka Valley explored between 1801 and 1803. The iron smelter lasted until 1848, and the operation of the iron hammer mill lasted until the early 1870s.

However, the choice of the location of the blast furnace at Ómassa proved unfortunate: it was built too close to the stream, and the wet soil hindered production. As early as 1777, it was planned to move the smelter, but this did not happen until 1813, when the ancient smelter, still visible as an industrial monument, was built at Újmassa. The factory proved viable and until 1868 they worked with only charcoal. The plant then moved to Diósgyőr under the management of the Hungarian state, and through state orders it became one of the largest heavy industrial factories in Hungary in the 19th and 20th centuries.

For the smelter installed at Ómassa by Henrik Fazola and his son Frigyes, and then for the blast furnace at Újmassa, the raw material for iron production was supplied from outside the mountains in a significant amount, from the hydrothermal-metasomatic ore of the Upponyi Mountains.

Iron manganese ore in the sandstone and slate series of Uppony Mountains was exposed by more than 20 shafts and adits, as well as tens of open-pit mines. The total known length of the cuts explored so far (Lower and Upper Mihály Shaft, Lower and Upper Rigós Shaft, Henrik Shaft, Frederick Shaft, Zsófia Shaft, Lajos Shaft, Bóti Valley Shaft, Malomgát Shaft) is nearly 600 metres.

As a result of forest management booming at the turn of the 19th and 20th centuries, narrow gauge railway lines were constructed. At the initiative of landowner Gábor Wessely, the idea of a narrow gauge rail for exploring the almost impenetrable forests of the Bükk Plateau and extracting trees was born in 1908. The narrow gauge train of *Szalajka Valley – Tótfalu Valley*, connecting to the Eger–Szilvásvárad–Putnok MÁV (Hungarian Railway) line, was already in operation in 1910. The track branching out of the Szalajka Valley line reached its end point at an altitude of 600 m a.s.l. in Kukucsó Valley via the single track reversal turn at the peak. It was connected with the Bükk Plateau light rail (*Káposztáskert-lápa – Őserdő main line*) constructed in the meantime by a double track cable car railway. The branch line to Bánkút was constructed around 1930. The steel rail track to Csalános in Huta Meadow was in operation until the 1960s, while the ancient forest track ceased to exist as early as the 1940s.

Fazola Gate (Péter Gervai)

The first line of the Garadna-Szinva narrow gauge rail (Szinva Valley Forest Railway, later Lillafüred State Forest Railway), the Miskolc-Fáskert-Garadna section was built in 1919–1920 to ensure the industrial wood needs of the post-Trianon country. With the construction of the branch lines (e.g. Miskolc-Mahóca line to the northern foot of Örvény-kő, along around 19 kilometres), the extension of the main line and some other branch lines for logging increased the length of the railway network until 1947. The **narrow gauge railway network around Felsőtárkány** was created in World War I: in order to meet the increased wood demand, the horse-tow track was built in the Hideg-kút Valley in the Archdiocese Lordship Forest of Eger in 1915. Following this, branch lines (Vörös-kő Valley, Kós Valley, Mellér Valley, Barát Valley, Vár Hill dolomite quarry, etc.) were built one after the other. Nowadays only the 5 km section between Felsőtárkány and Stimecz house (State Forest Railway of Felsőtárkány), which serves tourism only reminds of the once extended narrow gauge rail network.

Stone culture of Bükkalja

Due to the petrographic character of the Bükkalja, *working with stones*, vernacular application of stones has a rich tradition in the settlements of this region associated primarily with resistant but easy-to-carve volcanic rocks, rhyolitic and dacitic tuff (ignimbrite). Quarrying building stones and using them in vernacular architecture, stone carving and recessing rooms in rocks has longest history here in the Carpathian Basin. Bükkalja is a traditional area of stone building, apart from ecclesiastical and noble architecture stone has been present in peasant architecture as well for centuries. In the vernacular architecture of the region, stone appears in two ways: in buildings with standing walls (houses, hutches, stables) and in cave dwellings, cellars and other rooms with economic purposes carved in rocks.

The most important cultural historical values of stone culture in Bükkalja apart from dwelling places carved in rocks, stone dwellings/cellar houses, are other stone rooms “carved in stone” associated with traditional land use and farming methods: mementos of extensive cattle raising, shepherding, stone stables, stone barns, shepherd accommodation on the one hand, and on the other hand the cellar holes, tithe cellars, shelters of vineyards and wine production. Such objects can be found in most of the settlements of Bükkalja.

Beehive stones and the stone culture of Bükkalja reflect the special relationship between landscape and humans living in it. This complex natural – landscape management – cultural system typical for the region and having historical roots and living traditions deservedly received – in the course of the meeting of the Hungarian *Hungarikum Committee on 17th June 2016* – the title **Hungarikum** due to its unique character.

E.2.3 Intangible heritage

Various industrial activities had decisive roles in shaping the area of the Bükk-Region Geopark.

The life of Bükkszentkereszt (formerly Újhuta), Bükkszentlászó (formerly Óhuta, not an independent settlement, now part of Miskolc) and Répáshuta is closely intertwined with the appearance of industry. All three municipalities were founded as a result of industry appearing in the area. The word "huta" in the (former) names of the settlements comes from the German word Hütte, which means furnace in which industrial activity was carried out. Industrial activity means the production of glass for the three municipalities. Workers were mainly deployed to the area from what is now Slovakia in the 18th century. The descendants are still proud of their Slovakian roots today, indicating their origin with bilingual village name plates both in Répáshuta and Bükkszentkereszt. Especially older people often speak a mixed language, Slovak and Hungarian words and grammatical rules often mix. Slovak origins also appear in gastronomy, and the food called sztrapacska is offered with a good heart in the restaurants. The school teaches Slovak language and traditionalist groups cultivate ethnographic traditions.

Areas shaped by industry can also be found in the Szinva and Garadna valleys near Miskolc. Iron smelting appearing in the valley is also responsible for the image of Hámor Lake and the two settlements, Lower and Upper Hámor. The roots of metallurgy in the area date back to the 18th century. Henrik Fazola, a locksmith from Eger, built an ironwork in today's Miskolc-Ómassa, based on the mines and extensive woodlands of the region. His son, Frigyes, following in his father's footsteps, continued the craft of metallurgy, building a dam in the confluence of the Szinva and Garadna streams, thus forming the image of Lake Hámor known today. Following in his father's footsteps, he built a more modern iron smelter at Újmassa. The so-called Ancient Smelter is the oldest industrial monument in the area, with only three similar industrial monuments in Europe.

The Fazola Festival held in spring every year by the Metallurgical Museum of the Hungarian Technical and Transport Museum commemorates the Fazola family and their heritage. In addition to guided museum tours, there are countless programmes, material science and mining playhouses, folk art exhibitions, museum pedagogical activities.

The water of Szinva, which crosses Miskolc, was not only used for iron smelting. As early as the 14th century, written documents record that watermills were operating along the water of the stream. The mills are no longer visible, but they can be found in one of the most well-known urban legends. The legend of Molnár Rock (Miller Rock) in the Hámor Valley is known to all inhabitants of Miskolc. As a memento of a sad tragedy, a wooden cross can still be seen on the cliff above the Hámor Valley. Several versions of the legend are known. According to one version, the young miller fell in love with the wife of the master miller inexorably, but his love was not returned, so he threw himself from the cliff above the mill into the depths. Another version of the story says that the master miller's daughter and the miller fell in love, but the strict father did not allow them to belong to each other, so they fell into the depths hugging each other in grief.

Intangible heritage associated with viticulture and winery

The area is defined by two wine regions, the Bükkalja and the Eger Wine Region. Both were already famous wine producing regions in the Middle Ages. In addition to the built values associated with wine, we also need to highlight the intangible heritage associated with wine, which has been left to us partly in legends and tales (such as the history of the name Bikavér in Eger) and partly in traditions – which are mainly related to the methods of winemaking and the harvest programmes in which the area still abounds today. Nowadays, both wine regions have wine festivals that attract hundreds of people, which further capture the knowledge that is still alive.

There were once thousands of cellars in Miskolc. Some of these were not only used to store the wines produced in Bükkalja, but since the city was an important part of the transport route, the mainly Greek and Jewish traders also stored here some of the Tokaj and Eger wines to be transported to Poland and Russia. These merchants lived in closed communities, and their descendants in the region continue to inherit their traditions.

Ethnographic traditions – Palóc, Matyó people

According to some, the descendants of Kabars, according to others, descendants of the Cumans, and again according to other ethnographers, descendants of Avars, Székelys and/or the ancient Hungarians are the Palóc people living in the basins north of Mátra and the central part of the Bükk Region, in the Nógrád Basin and in the valley of Ipoly, whose traditions, which still live to this day, typically determine the intellectual heritage of the Bükk Region.

In addition to the unmistakable palóc dialect, they are characterised by palóc folk costumes and folk religiosity. The Palóc people are Roman Catholic, and Eger and Egerszalók have been pilgrimage places in the geopark since Baroque times. Perhaps nowhere is there as zealous a pilgrim tradition even today as there is among Palóc people. The church is not only regarded as an architectural work, not only as a place of the liturgy, but the church was the residence of the deity itself, and of the patron saints. Church tools were considered healing. Folk religiosity involved the residential and economic buildings of the village as well, as at the time of their completion the priest, the farmer or housekeeper sanctified them.

In many places, the family life of Palóc people is still based on the old patriarchal order. The family is headed by the farmer and the housekeeper. Both positions are occupied by the oldest male and female members of the family (or the troops). The Palóc boy when marries, takes the new daughter-in-law home to his parents' house. As a result of this custom, many Palóc fathers lived together his three or four married sons and their children.

A western and an eastern group can be distinguished among Palóc people based on their costumes, customs and dances (according to several ethnographers, a group of central Palóc should also be separated). The reason for the differences is that the central and eastern groups were not impacted significantly from abroad compared to the western group. The eastern and central groups live in the area of the Bükk-Region Geopark. In addition, the Barkó people live in the vicinity of Ózd, who some say can be considered an independent group of Hungarian people, but based on their customs and dances, it is more likely that they are a side branch of the Palóc people.

One group of Palóc is the Matyó, who now live in Mezőkövesd, Szentistván and Tard. They lived before in a more extended area than today. These populous settlements can be classified into a common group in terms of dialect, costume, custom and character. Their name is given after King Matthias, who gave them more freedom and even issued and signed a document for them in Mezőkövesd, that is why they were named „the sons of Matthias" and finally "Matyós". Although those living in Tard consider themselves descendants of some Tatars left behind from the Mongol Invasion, and this is made credible by the Tatar mound above the village, still they can be grouped together with those living in Mezőkövesd and Szentistván.

The Matyó folk art – the embroidery culture of a traditional community – was added to the representative list of the intangible cultural heritage of humankind at the 7th meeting of UNESCO Intergovernmental Committee for Intangible Cultural Heritage in December 2012.

Matyó folk art is characterized by floral, space-filling embroidery from the late 19th century, which is applied on textiles with utility and decorative function. The floral patterns, especially the motif called „Matyó rose", also play a major role in other handicrafts, especially furniture painting, which is becoming an independent folk art branch. Typical matyó-style embroidery is one of the main components of attire reflecting the civil influence, which is now worn in traditionalist occasions and to represent the matyó community. Examples of such events include Easter watering, the Matyó wedding party and the local church-ale, which are also outstanding opportunities for strengthening identity, making the heritage visible and raising awareness of its importance. The folk art and attire of the Matyó ethnographic group is characteristic, it has become nationally known and even world famous over time.

Literature heritage

In addition to the fairy tales and legends of the Bükk since the conquest, over the past centuries it has captured the imaginations of poets and writers, and many outstanding works have been created regarding the area in Hungarian literature, as well as many eminent authors originated from the Bükk or lived there. To give just a few examples, the battle of the Castle in the city of Eger in 1552 was sung by Sebestyén Tinódi Lantos. More than 200 years ago, Sámuel Szrógh, a lawyer, archivist and writer, took the possessions of Miskolc into verses, highlighting the wine culture of Avas Hill, which is also of significant importance for the geopark. In the first half of the 19th century, Sándor Petőfi visited the region several times, singing the beauties of Bükk in his poems (e.g. Twilight) in addition to his Travel Diaries. Later, the poet József Lévay lived in Miskolc, who had many poems about the city and its surroundings. Mihály Tompa, who also lived in the area, wrote poems about the then much more living legends of the region in the second half of the 19th century. At the end of the century, one of Pál Gyulai's poems triggered the Wild Pigeon trial, the other character of which was Ottó Herman, also from Miskolc. Among the greats of the 20th century, it should be pointed out, in addition to the poetry of Lőrinc Szabó, related to Miskolc, that one of the most beautiful love poems in Hungarian literature, the Ode of Attila József, was also born in Lillafüred.

In addition to the poems, Hungarian literature owes the Bükk for short stories and novels as well. After the fall of the War of Independence in 1849, Mór Jókai hid himself in Tardona, where several of his works were born, showing the beauties of the Bükk (e.g. his novel The Levi of Barátfalva). The favourite place of Zsigmond Móricz was the cellar row in Avas at Miskolc, where the most famous people of Hungarian public life at the time also visited at the end of the 19th century and early 20th century. As a result, Bükk and Miskolc also turn up in the literary works of Móricz. Margit Kaffka, one of the most important female writers of the first half of the 20th century, lived in Miskolc, and in her novel Anthill she built on her experiences here. Bükk also inspired the book called Lutra of István Fekete, the popular children's book writer. Stars of Eger, the novel of Géza Gárdonyi is also well-known not only in Hungary, but also abroad, commemorating the siege of Eger in 1552.

The literary heritage associated with the region is now partly included in the primary and secondary school curriculum, and partly occurs in local curricula, especially in secondary education in Miskolc.

E.2.4 Involvement in topics related to climate change and natural hazards

The Bükk-Region Geopark is relatively protected from the effects of climate change and natural disasters in the Carpathian Basin. Nevertheless, adverse weather changes and their consequences have an impact here as well. In the last 10-15 years, average annual temperatures increased, winters got milder than before, and summers became hotter. Mild winter weather is regularly interrupted by some extremely cold days or weeks occasionally with temperatures between -15 and -20 °C. There has been a significant reduction in the number of days of snow cover, as well as the amount of snow that has fallen. This reduces the supply of karst water. In recent years, winter has returned several times for a couple of days in spring, March and April with temperatures below -10 °C, sometimes with strong winds and snow. These phenomena caused significant damage to forests, with breaks caused by wind. Mild winters have recently been followed by a short spring, it is not uncommon for the weather to be summary as early as May. Summer is mostly hot and dry, daily temperature maximums of more than 30 °C are not rare. Rainfall is low in spring and summer, with several weeks without rain. Rare summer rains are often very heavy, causing flooding, agricultural damage. In 2010, more than 1000 mm of precipitation fell in two days in the Bükk Mountains, suddenly significantly raising the karst water level, causing flooding, for example, in Szent István Cave.

Overall, the average annual temperature increases with high temperature extremes. The amount of annual precipitation decreases, but its intensity increases. The effects of climate change are manifested in the state of forests, the decrease in karst water levels, and in that springs become periodical or disappear.

In order to reduce adverse climatic effects, replacing fossil fuels is also being encouraged in the region. Coal-fired power plants have been shut down or switched, and the lignite-based power plant in the geopark area and lignite mining are planned to be terminated and replaced by using solar power.

E.3 Management

The decision making organisation of the Bükk-Region Geopark is the Bükk National Park Directorate, its decision making person is the director of the Bükk National Park Directorate.

Geopark working group:

Bükk-Region Geopark is operated within the Directorate in which experts working in different units also take part. The head of the group is the head of the Ecotouristic Department within the Directorate

Permanent member of the working group

- Director
- General vice-director
- Economic vice-director
- Head of the Ecotourism and Environment Department
- Specialist officer Secretary of the Environmental Education Group (geography – drawing teacher, geographer)
- Head of the Geology and Landscape Protection Group (geologist)
- Representative of Novohrad-Nógrád Geopark in BNPI (geologist)
- Geologist head of the Foundation of Nature Protection, Culture and Ecotourism in the Bükk

The work of the working group is helped by the nature protection guard.

The working group consists of 3 geologists, 1 geographer/teacher, 1 biologist–biology-geography teacher, one regional and urban development manager / tourism and marketing as well as commercial, tourism and finance expert. For the preparation of professional decision-making, external experts such as colleagues of the Eszterházy Károly University, University of Miskolc, University of Debrecen or the Herman Ottó Museum will be involved in the work of the working group, as well as, the staff of the Hungarian Tourism Agency and the Centre for Development of Active and Ecotourism as necessary.

The Bükk Region Geopark's work organization also employs a geologist and a geography teachers. Thanks to their work, they have professionally thoroughly prepared the operation of the geopark, and they can also provide the professional-administrative background for the operation.

They also play an important role in the creation of the basic conditions of the field infrastructure and creation of publications, maps and professional materials related to the geopark, as well as in the line of disseminating education plan and informing the interested public.

The professional background of colleagues in the managementwork organization in a few sentences:

Sándor Holló (geologist): He holds a degree in mining engineering (mining geologist engineer) . He has decades of experience in geological nature conservation and geological dissemination at the Bükk National Park Directorate. For more than 16 years, he has been leading the work of the Department of Landscape and Geological Values. He took part in several tenders aiming at the preservation of geological values, which can be found in the area of the national parks's operation area. In connection with these, he is the author and editor of several publications and field information boards presenting the geological and cultural-historical values of the Bükk-region Geopark (mainly about earth castles).

Éva Gasztonyi (geologist): Graduated as a geologist, civil engineer, decades of experience in geological demonstration, coordinated the survey and protection of geological landscape values at the national park, played an important role in the preparation of the Bükk Region Geopark submission documentation. He took part in the creation of several geological demonstration sites and geological study trails, and in the preparation of excursion guides. Chairman of the Board of Bükk Nature, Culture and Ecotourism Foundation.

Imre Szarvas (geologist): Imre Szarvas is the leader of one of the world-famous geological demonstration sites in the national park. He has great merits in the presentation, research and dissemination of Miocene prehistoric animal traces. He is the organizer and operator of many successful programs related to geology to the general public. The exhibition center under his leadership receives tens of thousands of visitors a year, which is also one of the most popular fossil remains in Hungary.

Csaba Baráz (geologist): Researcher-interpreter with a degree in geography and minerals, and has a number of publications in national and foreign journals. He has been the editor of educational and professional publications, and has been engaged in environmental education and presentation for almost four decades. He plays a prominent role in the creation of the professional publications of the Geopark of the Bükk Region, and he works in order to present and preserve the key geotopes (hive stones) of the geopark.

Richárd Novák (geographer): Geography teacher, geographer. He supplemented his studies at the Faculty of Geology of the University of New Lisbon with part-time studies of dinosaur footprints. For many years, he has been participating in environmental education programs related to geography and geology, and in conducting educational guides. As the leader of the Geopark Group, he coordinates the work of the Aspirant Bükk-Region Geopark.

Management tasks related to the geopark include the following areas: professional, financial and administrative

Professional tasks:

-Coordination of research projects ,Coordination of professional projects ,Contact with national and international organizations , Compilation, coordination and proofreading of the UNESCO Global Geopark submission material, Creation and placement of field demonstration infrastructure (installation of information boards, study trails, etc.), Compilation and editing of professional, educational and tourist materials related to the geopark, Preparation, monitoring and evaluation of the Geopark ecotourism, dissemination and education developments ,Preparation of publications (geopark information materials, map, professional materials), Management of online media interfaces, uploading content and coordinating geopark communication , Complex uniform presentation of Geopark values on offline and online interfaces, Compilation of an information program package for accommodation providers to transfer knowledge about the Geopark ,Coordinating and conducting Geopark tour guide training ,In connection with local producers and their products: Establishment of a common platform of producers and service providers operating in the field of geopark, development into a unified network,Collecting and mapping international good practices in Geopark

Financial tasks: Financial tender planning, payment schedule, budget balance, contract preparation, accounting

Administrative tasks: Preparation of reports, accounts, administration (file management)

The role and presence of women in the work organization of the geopark is at least as important as that of men. The table above shows that half of the colleagues in the management organization are women. A key priority for us is the balance of women and men in our organization. In addition to the geological experts presented in the above point, the member of the work organization is Miss Zsófia Domán, who deals with tourism tasks related to the geopark. In addition to the professional staff, the work of the management organization is also supported by financial and administrative staff, most of whom are women. Based on our cooperation agreements, we maintain professional relations with several nearby institutions (museums, higher education institutions, tourism organizations, associations, foundations). The colleagues working there - among whom there are also a large number of women - help the work of the Aspirant Geopark with their valuable professional experience, and as external employees they also participate in the meetings of the geopark working group. The specific employment categories are: staff, contracted colleagues, volunteers.

Most relevant geopark staff are the following:

N°	name	employment	function	skill	% time	Gender
1.	Kálmánné Rónai	permanent	national park directorate's director	management, economy	10%	F
2.	Tünde Hegyi	permanent	financial director	economy	10%	F
3.	György Dudás	permanent	ecologist	environmental	10%	M
4.	Kornélia Szádeczky	permanent	tourism organiser	ecotourism	20%	F
5.	Sándor Holló	permanent	geologist	geology	20%	M
6.	Csaba Baráz	permanent	field responsible	geomorphology, geology	20%	M
7.	Éva Gasztonyi	temporary	part of the geopark adviser group	geography, geology	20%	F
8.	Richárd Novák	permanent	geopark group head	geography, geology, management	40%	M
9.	Imre Szarvas	permanent	field expert in geology	geology, geomorphology	30%	M
10.	Zsófia Domán	permanent	geopark group asistant	online marketing, website development, administration	30%	F
11.	Attila Kozma	permanent	film expert	filmmaking ,editing	10%	M
12.	László Sütő	voluntary	professional consultant	geoscience and tourism expert	10%	M
13.	Ranger service (5 persons)	permanent	field expert, environmental education	ecology, geology	10%	M

Geopark Working Organisation (Geopark Group)

The Bükk-Region Geopark Group operates within the Ecotourism and Environmental Education Department of BNPI. The Geopark Group is managed by the head of the Group. The staff of the group includes colleagues with the qualification as geographer/pedagogue and historian/industrial heritage manager, with a male-to-female ratio of 50-50%. The tasks of the Geopark Group include:

- international and national mailing related to the geopark, keeping contact.
- Hungarian and foreign language communication and carrying out monitoring
- working out and realising regional development plan (e.g. preparation of contracts, agreements) in the geopark.

The financing of the Bükk-Region Geopark is included in the budget of the Bükk National Park Directorate, in a separate budget section, which includes the wages of the staff, as well as the communication, travel, programme organisation and other expenses incurred. Developments will be implemented by the Directorate from tender sources.

Expenses of Bükk National Park Directorate, as a working organisation – related to the geopark (in thousand HUF)

Name	2017-2019	2020-2021	2022-2023
Wages with contributions	18 000	21 000	22000
Additional fees for internal and external members of the working group	1 600	1 700	1800
Marketing costs	1 000	2 000	2 000
Protection of springs, spring bogs (189 sites)		300 000	
Rocks with niches, beehive stones (21 sites)		180 000	
Earthworks, landscape and cultural values (7 sites)		180 000	
Documents of millions of years – key section outcrops (17 sites)		180 000	
Dripstones and bats (38 caves)		380 000	
Bábakalács Forest School, exhibition, renovation, energetic development		18 000	
Exhibition accommodation, forest school renovation (Borostyán, Rejtek)	56 000	76 000	
Astronomical Observatory in the Bükk, astrotouristic visitor centre			990 000
Szeleta Park visitor centre			1 400 000
Development of a property at Szilvásvárad into an exhibition site			150 000
Improvement of the accessibility of geotopes in the Geopark, geotouristic thematic trails, establishment of Bélkő clay quarry study trail, look-out point			350 000
Protection and long-term preservation of the lukewarm spring of Theodoxus prevostianus at Kács			120 000
Total	76 600	1 338 700	3 035 800

The Bükk National Park Directorate, as a working organisation, can earn income from its activities, like adult education, guided tours, organisation of educational programmes. Apart from the above, non-material contributions can also be expected by cooperating municipalities and organisations, even by renting out or handing over free of charge. By participating together in certain tenders our common goals could be achieved.

E.4 Overlapping

Matyó folk art, in particular Matyó embroidery, was added to the representative list of the intangible cultural heritage of humankind in December 2012. Matyóland is the settlements of Mezőkövesd, Tard and Szentistván, at the meeting of the Bükk Region and the Great Hungarian Plain, where the Matyó people live. Although their embroidery has been added to the list of intangible heritage, their traditions are much wider than that. Typical matyó-style embroidery is one of the main components of the costume reflecting the civil influence, which nowadays is worn in traditionalist events and to represent the Matyó community, but Matyó furniture painting, wedding customs, Easter Matyó and other folk customs still serve as a living heritage, which are also presented to the general public at their events.

The Bükk-Region Geopark, which covers a significantly larger geographical area than Matyóland, considers the presentation of the wide cultural and intellectual heritage in its area to be an important objective. In addition to geological conditions, intangible heritage is also presented in its programmes, as well as how geological values have affected the lives of people living in the region in past centuries.

The management of the Bükk-Region Geopark also offers local products with Matyó embroidery, and geopark management is in contact with local crafters in Matyóföld.

In the educational materials on the geopark for local schoolchildren, Matyó folk art will also be presented.

The survival and making known of the Matyó heritage is ensured by the Matyó Museum in Mezőkövesd and by local non-governmental organisations and institutions established for the preservation of folk art. The Matyó Folk Art Association, which also includes the Borsóka (Small Peas) Embroidery Group, which pass on the knowledge of embroidery and motif drawing, organises handcrafted demonstrations, exhibitions and other demonstration programmes from time to time – these programmes are also included in the offer of the Bükk-Region Geopark.

E.5 Educational Activities

Education-training is an essential part of geopark work. Cooperation with schools is essential to move forward, as future generations will acquire their ties to the area in schools.

Bükk-Region Geopark is present at all levels of education.

Geopark in university training

A cooperation agreement was concluded between the Geopark and the Faculty of Science, Eszterházy Károly University, in the framework of which students study the geological values of the Bükk via research projects.

Pilot projects in the Geopark for secondary school students

At secondary school level, the pilot project will be developed and implemented together with Eventus Vocational School in Eger, where students will be able to learn about the geological values of the Bükk several times a year in an ascendant system (starting with grade 9 in 2019) via professional supervision by the management of Bükk-Region Geopark. During the one-day and several-day training projects, several geosites are presented in a complex way – not only the geological values, but also the cultural heritage, traditions and historical links associated with them.

The agreement with Eventus school is a pilot project – the aim is to develop a geopark–school package together with the teachers that can be adopted into the curriculum of other secondary schools of the geopark.

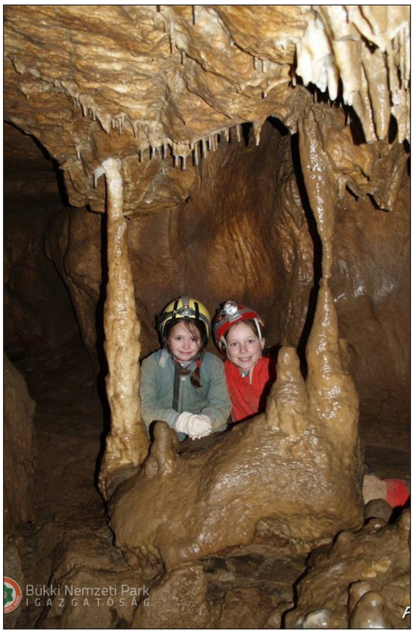
Bükk Region geoschool programme

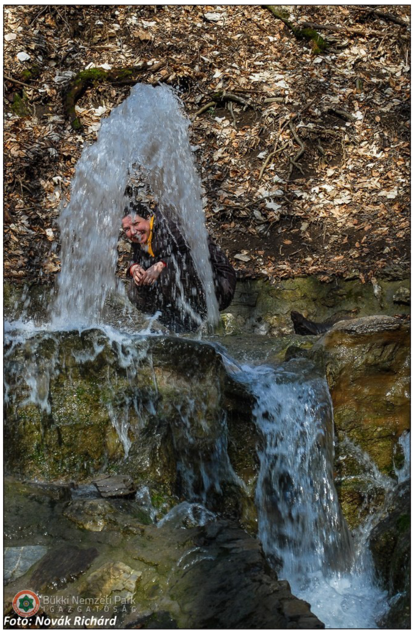
At primary school level, the aim is to implement further training programmes at the Bábakalács forest school of the Bükk National Park Directorate at Felsőtárkány for primary school teachers, which provides methodological guidance for teachers of schools in the geopark to teach geovalues in schools.

In parallel with the courses, we plan to create geo-schools at primary school level, which aims to provide professional support to schools who incorporate geotopes and their associated cultural, historical and built heritage into the curriculum for at least 3 subjects, helping to shape local identity. Geopark schools are selected after a trial period by an expert jury and the schools are awarded the title Bükk-Region Geopark School. This will enable the involvement of the widest possible range of students in the region in the work of the Geopark.

Professional work planned by the Geopark in relation to the schools of the Geopark are the following:

- complex development of teaching material for classes at higher grades;
- methodology guide for teachers;
- creating playful task sheets, exercise books separately for children studying in the area of the Geopark and also for children arriving in the area for a trip;
- composing educational adventure packages.





Bükk Region geo-kindergarten

In the geo- kindergarten programme in the Bükk Region, the learning of geological values begins already in preschool. For kindergartens to be included in the programme, we collect the geo-tales of the region, through which the smallest ones can learn about geological values. Special methodological training for kindergarten teachers related to the programme is organised with field programmes. For the related geo-kindergarten, the book of geo-tales will be provided free of charge, provided that the kindergarten includes cooperation with the Bükk-Region Geopark in its pedagogical programme.

The start of the geo-kindergarten programme is planned in 2021.

Adult education

Two modules will be developed in the framework of adult education. The first was launched as a pilot project in 2018, with the second project starting in the year 2020.

- **geotour guide training –** this is to provide tour guides with appropriate knowledge in the geopark area
- **teacher's training** – the aim is to present geopark values to teachers working in the region from time to time during training in order to start and succeed the above programmes.

However, the environment of the forest school offers excellent opportunities for geological-geographical dissemination. The three-circuit nature trail network, the nearby stone park and the institution's tools and equipment provide a good basis for the creation of a new module. The aspirant Bükk-Region Geopark wants to become a member of the UNESCO Global Geopark network, so it was necessary to create a module that provides knowledge of Geoparks and also helps children gain field knowledge using experiential educational methods. It is important to emphasize that the overall perception of geological and geographical values is much less popular than other living natural values (plants, animals). Success also depends largely on the type of value presented and the nature of its ability to be involved in educational and pedagogical work. In this case, there are several locations and tools available to get students interested and make the learning process adventurous.

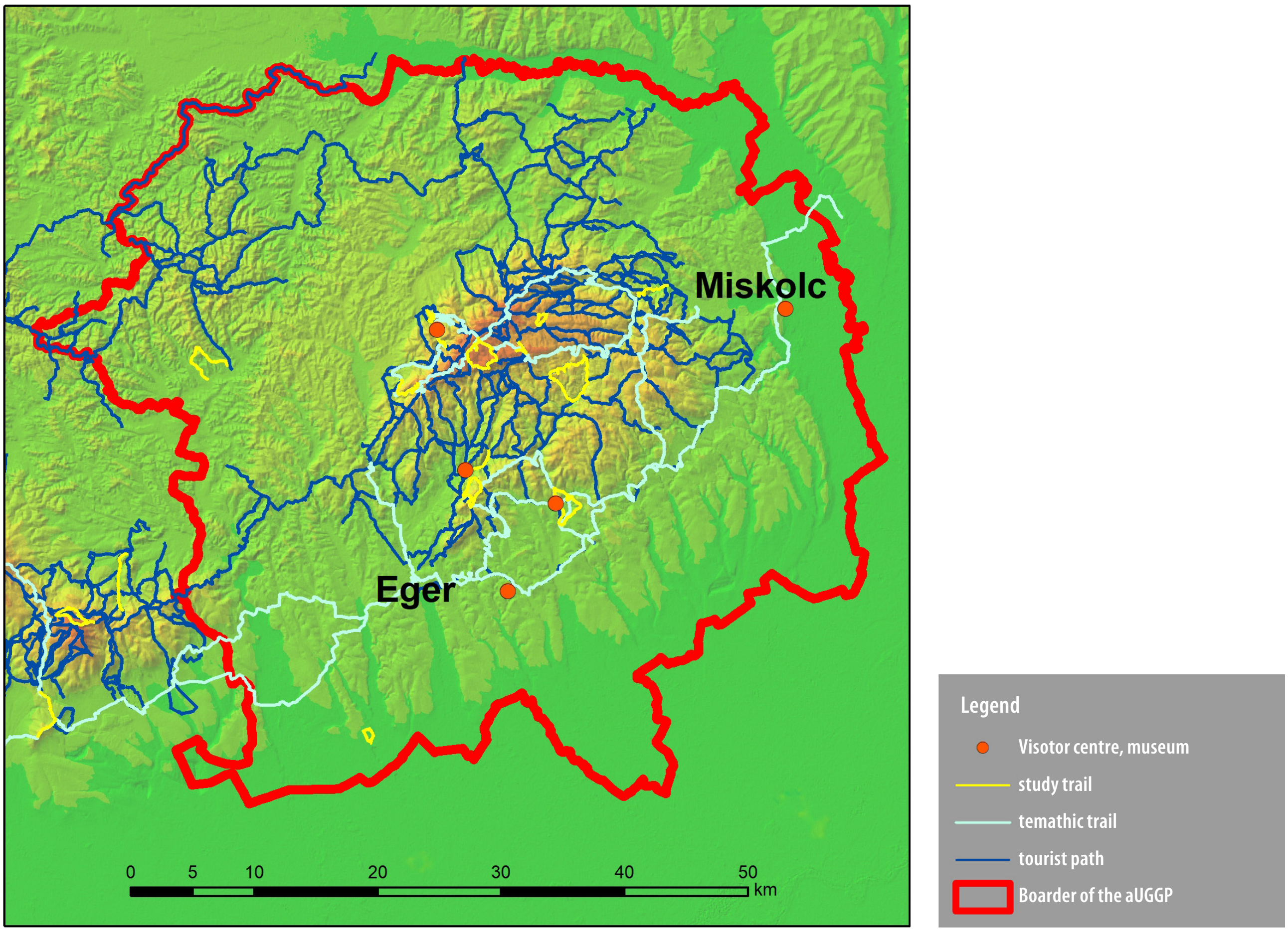
For more than 10 years, our forest school in Felsőtárkny has been one of the focal points of our environmental education activities.

E.6 Geotourism

The Bükk-Region Geopark includes three major tourist destinations: Eger and its surroundings, Miskolc and its surroundings, as well as Szilvásvárad and its surroundings. The geopark management organisation carried out several primary and secondary research on tourism opportunities in the area including geotourism in 2019 and 2020. The survey analysed visitor traffic statistics of the Central Statistical Office, and in 2019 a national survey of nearly 1,000 people mainly surveyed demand for geotourism demonstration sites, and in 2020 it also examined the needs for geotouristic offerings and satisfaction with current services based on a national sample of 270 people in the course of a primary research.

The primary attraction of the area for foreign guests is mainly the spas (Eger, Egerszalók, Demjén, Mezőkő, Miskolctapolca, etc.), while for Hungarian guests, baths and the built and cultural heritage together. The Hungarian guest group mostly comes from Budapest and the agglomeration of the capital, as well as from the Great Hungarian Plain. Basically, the interest of the guests arriving at the Geopark is different from that of those who choose Eger or Miskolc. While for the latter the main attractions are the baths and the complex tourist offers of the metropolitan area (city tours), the main motivation for those arriving at the geopark is hiking, and they are attracted by the quiet environment and, in addition, by heritage tourist offers (museums, castles, halls).

Apart from the target areas with significant guest traffic, other areas of the Bükk has low-attendance. Although pensions and guesthouses can be found scattered in the area and some restaurants await guests, guest traffic, which is largely focused



on settlements, is not yet able to keep tourist revenues at a level that will have a long-term population retaining effect for the local population, while local work is only offered by forestry and agriculture in addition to tourism in the area. Apart from the municipalities responsible for the region, the management of the geopark and the Bükk National Park Directorate are responsible for addressing this problem.

Several programmes have been launched related to a number of tourist developments in the Bükk area. The development programme affects the municipalities of Lillafüred, Bükkszentlászló, Bükkszentkereszt, Répáshuta and Felsőtárkány. The development programme includes the design of the Astronomical Observatory in the Bükk, the implementation of ecotourism accommodation developments, and, together with geopark management in Bükkszentkereszt, the development of the Bükk-Region Geopark Centre and Pension, which acts as a complex geotourism programme centre from October 2019. As a result of the complex development, the Bükk National Park Directorate and geopark management can directly provide employment for about 30 local residents, while the project also has an additional employment-incentive role through cooperation with local supplier partners. As an indicator, the National Park Directorate has calculated an increase of around 45,000 visitors from 2022 in the relevant action area, which does not yet affect environmental sustainability, but significantly increases the economic sustainability of the area.

Network development in geotourism

This work will involve geo-guides whose training is undertaken by the Bükk-Region Geopark, the primary purpose of which is to know the local conditions and offer geotours locally, within a radius of up to 30 km.

Geotourism network development includes thematic tours that were announced by the geopark in Lillafüred in 2020, involving several local tourism providers. These thematic tours are available as a guaranteed programme based on pre-registration. Two types of programmes have been announced: 1) tours to Szeleta cave, presentation of Szeleta culture, 2) Lillafüred and its surroundings showcasing cultural and cultural history values with gastroshow and/or cave tour.

Hiking trail and study trail network

The National Blue Trail, the most visited hiking trail of Hungary goes through the Bükk-Region Geopark. Marked hiking trails expose all over the area, offering hiking opportunities that suits pedestrians and cyclists alike. The Bükk National Park Directorate, as well as the Forestry in the area, have a significant network of study trails in the geopark. One of the important tasks of the geopark is to display these hiking trails on digital platforms (mobile application, outdoor designers).

Currently, bicycle trails are only available in a small number of places – together with local authorities, development associations, the Bükk National Park Directorate and the Forestry, it is necessary to define the development of the cycle trail network and find the resources to develop an attractive mountain bike trail network, into which geotopes can be channeled.

The 21 study trails established and maintained by BNPI in the planned area of the Bükk-Region Geopark are interpretive field demonstration sites that encourage independent knowledge and knowledge acquisition, which also serves tourism. The study trails planned in 2007 on the basis of the methodological guide issued by the BNPI are mostly of the complex environmental knowledge type on the basis of the knowledge material presented. The aim of these is to present the landscape and the natural and anthropogenic landscape elements as versatile as possible – i.e. each study trail has a station providing earth science knowledge. Among the thematic nature trails there are some particularly earth-science-related types, such as the Szarvaskő Geological Study Trail or the Beehive Stone Study Trail at Szomolya.

1. Bélapátfalva – Bél-kő study trail
2. Bélapátfalva – Kelemen széke study trail
3. Bükk Plateau – Jávorkút study trail
4. Bükk Plateau – Kis-kőhát–Nagy-mező study trail
5. Bükk Plateau – Olasz-kapu study trail
6. Bükkszenterzsébet–Tarnalelesz – Nagy-kő study trail
7. Cserépfalu – Ördögtorony study trail
8. Eger – Mész-hegy–Nyerges-tető study trail
9. Egerbakta – Baktató study trail
10. Felsőtárkány – Barát-rét study trail
11. Felsőtárkány – Kő-köz study trail
12. Felsőtárkány – Tamás-kút study trail
13. Felsőtárkány – Vár-hegy study trail
14. Miskolc–Lillafüred – Szinva study trail
15. Nagyvisnyó – Verebce-tető study trail
16. Rejtek small circle (forest school study trail)
17. Rejtek study trail
18. Szarvaskő – Geological study trail
19. Szilvásvárad – Millenium study trail (and look out tower)
20. Szilvásvárad – Szalajka Valley exhibition trail
21. Szomolya – Beehive Stone study trail

The most important geotope of geopark in the Bükk Region is the **Szomolya Beehive Stones nature reserve** and the **Beehive Stone study trail**. During 2018 and 2019, there was a conservation development with visitor management and geotourism implications: the built walking platforms are essentially designed to eliminate trampling erosion, protect vulnerable rhyolitic tuff rocks, while at the same time facilitating visits and providing information, presentation and experience. The visitor counter at the field showroom in BNPI's nature reserve and asset management began its „service" at Easter 2019, providing exact data on the tourist traffic of the free-to-visit site. In 2019 (April to December), the total number of visitors was 11,439 (number of days queried: 258). In one year (until April 2020, a total of 14,387 visitors (based on the 261-day query: 14,346 people) were registered by the access control system.

Among the programmes and events related to earth science values, which are now becoming regular and also have geotourism implications, BNPI organises the following: in addition to the tours, specialisations related to the *„Geotope Day"*, guided tours (Hór Valley, Bél-kő, Bükkalja beehive stones), the most significant conservation and geotourism event is the annual *„Transbükk Crossing"*; *„Beehive Stone Day"* is a complex event in Szomolya related to the stone culture of Bükkalja and the beehive stones, which serves to organize local communities, but also to experience guests and tourists from further afield.

In the design area of the Bükk-Region Geopark, three exhibition places, museums and visitor centres have been set up for earth science values in recent years. The exhibition and exhibition site of the Herman Ottó Museum in Miskolc, **Pannon Sea Museum, Suba-lyuk Museum and Visitor Centre** maintained by the Municipality of Cserépfalu (which shows prehistoric anthropological and archaeological finds from the Suba-lyuk Cave in the Hór Valley and the stone culture of Bükkalja), the exhibition entitled „**Karst and its wildlife**" in the Western Gate Visitor Centre of the Bükk National Park Directorate.

Among the NGOs, it is necessary to highlight the **Kaptárkő** (**Beehive**) **Nature and Cultural Association** of Eger and the **Holocene Nature Conservation Association** of Miskolc, who have been active in the field of value protection, dissemination and geotourism in earth sciences for more than a decade: the establishment of nature trails (Holocene Association: Cserépfalu – Ördögtorony study trail; Beehive Stone Association: Eger – Mész Hill – Nyerges-tető study trail), publications, organization of programmes (e.g. Stone culture of Bükkalja, Kaptárkő performance tour, etc.) and the conduct of actions are linked to the two organizations. Thanks to the initiative of the Beehive Stone Association, the „Beehive Stones and The Stone Culture of Bükkalja" was added to the collection of Hungarikums. The members of the **Bükkalja Stone Road Tourism Cluster Association** are active in the sustainable and competitive tourism of the area.

Since 2008, the „**Geotope Day**" initiative was launched in Cserépfalu as an accompanying event for the Less Nándor Memorial Tour, which has since become a national series of events: the annual geotourism event (Geotope day tours in several locations across the country) embraced and coordinated by the **Hungarian Geological Society** aims to promote earth sciences values through active knowledge acquisition.

There are still many initiatives to raise knowledge about earth sciences and increase geotourism potential.

The northern Hungarian section of the „**Pannonian Volcano Path**" initiated by the Commission of Volcano Geoheritage and Volcanic Protected Landscapes of the International Volcanology Society (IAVCEI) and worked out and developed by the **Volcanological Research Group of MTA-ELTE** runs through the area of the Bükk-Region Geopark. This thematic road covers existing earth science sites (such as the Szomolya Beehive Stones nature reserve and study trail), but also tries to include new geotourism sites in the volcanic geotope network.

Geotourism potential of Bükk-Region Geopark

The geological (geological, geographical) protection of values in addition to the legal protection of geoheritage and the conservation management activities of the Bükk National Park Directorate (research, assessment, preservation, preservation of values – instituting) is a very important activity in the presentation of geotopes (interpretation) – as well as its sustainable exploitation, i.e. its attraction to geotourism, its development into a tourist attraction, an „attraction", a „tourist product" (innovation).

The presentation of the geological (geological, geographical) heritage is linked to the occurrences, properties and surface appearances of rocks – such sites are called geotopics by the earth science literature. The Bükk Mountains and its surrounding geotopes are essentially natural formations (geographical phenomena, surface forms), sometimes artificial excavations, anthropogenic landscape elements (quarries, mines, beehive stones, objects of quarry culture). The tourist exploitation of these earth science values begins with the presentation of each geotope. Development of geosites („geosite"), the creation of nature trails in the geopark design area of the Bükk Region – in the Bükk National Park, in lázbérci and tarna countryside landscape protection districts and nature reserves – it has a long history of presentation, awareness-spreading, education and ecotourism activities related to the basic tasks of the Bükk National Park Directorate (BNPI), the area's conservation management manager.

The development of nature trails, field show sites (including geotopes) is not based on a separated presentation of point developments, but is the result of strategic planning: the networking was based on the interwork reconciliation material „Holiday tourism and education presentation" prepared in 2006-2007 for the conservation management plan of the Bükk National Park (created by Izra Bt.). Strategic planning was aided by a map annex to the tourist and environmental presentation plan of the Bükk National Park, which displays the main entry points of the national park

- (the 9 touristic gates)
- other points of entry (11 sites)
- visitor flow corridors (7 zones)
- main tourism-recreation destinations, 10 pieces
- demonstration (C) zones, training and visitor centres, study trails, „tourist" caves, other showrooms and current and/or potential conflicts (Map Annex 1).

The design of the geotourism display (the development of geotopes as a tourist attraction) is fundamentally influenced by the dense tourist trail network of the area (especially the Bükk Mountains).

Future aims related to tourism

Creation of a Bükk Region GEO-KULT ticket group

The mentioned research projects have shown that geotourism and heritage tourism are equally important for guests arriving in the area for geotourism goals, and when assembling their programmes, they prefer heritage tourism values (museums, castles, castles) in addition to hiking.

Bükk Region Geo-Accommodation programme

The aim is to include accommodation in the area of the geopark in the geotouristic offers.

Bükk Region Geo-Cuisine programme

In addition to presenting the use of local raw materials, the aim of the programme, based on UNESCO's Geofood Programme for Global Geoparks, is to further capture the local traditional gastronomic heritage.

Bükk wine-cellar-vineyard tours as a geotouristic programme

The geopark features the famous Eger wine region and the once famous Bükkalja Wine Region. It is the winery of the latter that starts the wine speciality, which aims primarily at the common representation of the Bükkalja wine region – but in addition to the presentation of the wine region, the features of the geopark also occur.

Geopark Partner attractions

The aim is to promote the Geopark's offer with as many attractions as possible in the Geopark area. Museums and other attractions involved agree to display the Geopark logo on their website and to incorporate Geopark communication into their communication.

Trends in demand	Advantage/disadvantage for the planned development	*Development strategy*
Demand trends related to foreign visitors		
Priority for safe destinations	+	Improving marketing (informing)
Geosites less known and visited by foreigners	-	Improving marketing (informing)
Main countries of origin for North Hungary: Poland, Slovakia, Ukraine, Romania	+	Multilingual services
Demand trends related to domestic visitors		
Domestic visitors arrive from Budapest and its vicinity and from North Hungary	+	Effective outreach to the target group via new service packages developed specifically for the clearly identified target group
Domestic visitors are mostly new visitors, the number of visitors returning within 1-2 years is small	-	With temporary offers renewed in every 2-3 years the activity of returning visitors can be increased. In order to reach to the expanded visitors in the geographically identified target areas new marketing measures are required.
Short trips (1–3 days) + low willingness to spend	+	Expanding services and activities + expanding target market segment
Demand trends related to accommodation and accommodation packages		
Small municipalities in the area of the Geopark are dominated by private accommodation		Quality development is required
Strong seasonality	-	With forward planning (geotours, professional programmes of the geopark, events) seasonality can be reduced
Trends according to experience promises		
Most typical aims include health tourism hiking in nature, leisure activities	+	Strengthening the offer of leisure activities
Increasing interest in gastroculture	+	Increasing the availability of local base material and local recipes in the offer of the restaurants
Decreasing interest in museum services -	-	Increasing interactivity, interpretation – experience-orientation

Tasks of the geopark management related to geotourism

development of tourism products and services in groups and networks – e.g. continuous development of SMART applications, development of family-friendly programmes, etc.;

preparation of the receiving areas (language competences at all levels, local image building, community development);

rethinking sales channels, developing new channels, as it is clear that it is not possible to build on existing systems in the long-term, they are transformed

E. 7 Sustainable development and partnerships

E.7. 1 Sustainable development policy

The work and all activities of the Bükk-Region Geopark must be able to contribute to the presentation of the region's unique cultural values – geological values built heritage and local products in particular. In product development and communication, care should be taken to make sure that these values are emphasized and that these values are the focus when determining developments.

Contribution to the development of local communities and shaping their identity

In the area of the geopark, serious attitude shaping work is still needed among the local population, tourism service providers and NGOs, it is necessary to present local values, to organise community programmes that help to increase identity. Geopark presents the unique values of the area to the local population by presenting geotopes and organising open days.

Tourism providers also need to organise programmes to get to know each other and the region – even in the form of study tours. A very important task of geopark management is to develop a community view aimed at the tourism service providers in the geopark area wanting to recommend each other, to participate in the development of common products and joint packages – and more importantly, that all tourist operators, including municipalities, tourist service providers and attractions, can and want to recommend the geopark. Without it, geopark management will never be successful, but this can only be achieved with very close cooperation.

In order to strengthen identity, it is also important to organise local product programmes and to help with economic cooperation.

Contribution to local social and environmental responsibility

Environmental sustainability is always the basis for social sustainability. Where the latter is not aspired to by the community as a whole, social sustainability cannot be expected in the long term, since the environment fundamentally affects people's relationship with the area.

Geopark management needs to support all programmes related to landscape conservation and the preservation of the built heritage. At the same time, it is necessary to build on the increasing environmental awareness of visitors, which is why it is necessary to pay particular attention to the use of environmentally conscious, environmentally friendly tools in the design of the programmes, and to draw the attention of visitors to the need to be able to act together for natural and social sustainability by geopark management, service providers, the public and the visitors arriving here.

Contribution to environmental sustainability is best via environmentally conscious means such as the use of recycled paper in communication, natural raw materials when packaging souvenirs, etc., which visitors are also reminded of. At the same time, with the objectives set out in pricing and communication, according to which visitors themselves contribute by paying for the ticket to make the geopark offer available and enjoyable to future generations. In addition, it is highly important that the geopark prioritises digital communication platforms rather than paper-based platforms in order to reduce the ecological footprint of its work.

E.7.2 Partnerships

Keeping contact with partners and locals

Civil organisations

The management of the Geopart cooperates with civil organisations according to the specifications of cooperation agreements.

Tasks identified together with civil organisations are presented in detail in the following:

Hiking organisations – our priority partners are organisations that help us organize quality geotours and provide programmes. In the course of the cooperation, we provide geopark training for their tour guides, while they provide information materials and tour guide training modules for our geotourism guides. They also have a role to play in maintaining and painting hiking trails and creating common activities.

Tourism and cycling associations – The geopark organisation helps geo- and ecotourism marketing activities and the promotion of individual civil programmes, the associations will be responsible for local programme organisation.

Cultural preservation societies and cultural associations – the geopark organisation strives to work with organisations the primary purpose of which is to preserve tradition and nurture culture. In the geopark offer, they provide the cultural programme offer. Other cultural associations expect primarily advertisement from the geopark, and the geopark labour organisation asks them to widen the programme offer.

Other associations – there are NGOs in the geopark area the activities of which do not belong directly to the geopark's scope of operation professionally, but at the same time NGOs have a very important role to play in the operation of the geopark. Examples include industrial heritage organisations or the Rotary Club, which also provide important programmes for visitors. Their involvement as partners in the geopark work is a very important task.

National NGOs the activists of which operate in and around the city – the Mary's Path Association is a fine example, as its activists constantly organize pilgrimages related to Mary's Path in the geopark area, carry out signal painting, etc. The geopark organisation has a duty to help and strengthen these organizations within its own work.

Wine associations and wine clubs – in the Eger and Bükkala wine regions there are several wine associations that combine wine and geotourism elements in their offer. Some of these help to widen the geopark offer by organising various wine programmes. The geopark organisation provides their own tools to promote them to the service providers of the region and to visitors.

Local governments

Bükk-Region Geopark regulates cooperation agreements with municipalities. The aim is to make municipalities feel directly the results of geopark work, especially through the revenues of local entrepreneurs and the expansion of their opportunities. It is clear that the geopark alone cannot solve the social and economic problems of the region, but works to help and promote SMEs, can contribute, in particular, to retaining the population of smaller settlements and to increasing their economic opportunities.

The aim is to develop programmes to support promotion with larger city governments in particular, and we try to demonstrate in joint consultations, in closer cooperation with smaller municipalities, how municipalities can make good use of geopark connections in their own work.

Service providers in tourism

The management of the Bükk-Region Geopark works together with TDM organisations and other tourism organisations in the region, as well as directly with tourist service providers to develop and sell geotourism programmes in a form detailed in the Tourism chapter.

Cooperation in education

In addition to the two higher education institutions in the region, the University of Miskolc and the Eszterházy University in Eger, the management organisation of the Bükk-Region Geopark works together with the University of Debrecen and Szent István University in Gödöllő. The management of the Bükk-Region Geopark maintains contact with secondary and primary schools of the region via forest schools and other programmes, as presented in the Education chapter.

Cooperation with scientific collections

The management of the Bükk-Region Geopark has a lively relationship with the Herman Ottó Museum in Miskolc, which mainly helps the geopark's work in Miskolc and around Miskolc in the field of research and the presentation of values.

In relation to the caves of caveman, we work closely together with the Suba-lyuk Cave Visitor Centre and the Orbán House in Szilvásvárad, organizing joint geo-tours with them.

International relations

Cooperation with the Novohrad-Nógrád Geopark

The aim of a close cooperation with Novohrad-Nógrád Geopark is not only to delimit the area but also to develop a professional cooperation, and it resulted in the technical preparation of joint geotourism programmes in 2019. These programmes are scheduled to start in the summer of 2020 after the necessary contracts have been concluded.

Joining the GEOTUR Erasmus+ project

An important point in the life of the Bükk-Region Geopark for international cooperation is that the textbook presenting geotourism case studies to be developed in the GEOTUR programme financed by erasmus+ could include the Lillafüred Geopark Open Day at Lillafüred of the Bükk-Region Geopark, for which we thank hereby the partners participating in the programme.

E.7.3 Full and effective participation of local communities and indigenous peoples

1 Involvement of inhabitants

Contact with local inhabitants has been a priority for Bükk-Region Geopark since the start.

- It has developed a newsletter system for tourist service providers and municipalities, which gives us the opportunity to draw the attention of our partners to geopark values in a targeted way.
- As part of the sample programme presented in the Geotourism chapter, we are continuously consulting tourist service providers, municipalities and local producers living study area. We present good practices to them in the form of workshops and create common communication platforms aimed at boosting the local economy.
- We have planned scientific educational presentations for 2020 for the population of the geopark on the cultural and industrial history values of the geopark, which will be made available in the form of a webinar due to the coronavirus.
- Geopark values are presented to the local population in geopark open days, and we also contact the local population in the form of personal information at geotours and scientific educational lectures and settlements.

2 Actual examples

The first landscape walk organised by the Bükk-Region Geopark and the Bükk National Park Directorate in the autumn of 2018 for which people mostly from Eger and its surroundings registered.

Hundreds of people were interested in the programmes of the Geopark Open Day in Lillafürd on 6th April 2019. Inhabitants of Miskolc received discounted access to the caves, as well as a film screening presenting the values of the geopark and a tasting of local products. During the day-long programme, visitors were also first to try the 360-degree virtual walk of the two caves in the BNPI app GUIDE@HAND.

There was also considerable interest for the Szomolya Beehive Stone Day in 2019, where again mostly local inhabitants were involved and informed.

During the year, additional geotours were launched to promote geopark values as widely as possible.

In the spring of 2019, we presented the Bükk-Region Geopark on the Tourism Cluster Day organised by the Eszterházy University, where we presented geopark plans to tourist service providers in Eger and its vicinity with geopark brochures and personal information.

In February 2020, the Bükk-Region Geopark was introduced in the Green Tent of the Miskolc Aspic Festival in the framework of a performance and games promoting the geopark, reaching hundreds of people from and around Miskolc.

The Szalajka Valley Information House and the information point at Szent István Cave were also important platforms for personal information throughout the year, where colleagues reached thousands of people.

3 Communication platforms

The website of the Bükk-Region Geopark targets two groups: on professional pages geopark values are presented to interested professionals, while geopark values are displayed, as well as the related (geo)tourist offers and package offers in three languages on the webpage for the general public starting at the end of May 2020.

From the beginning of 2019, The Bükk-Region Geopark's Facebook and Instagram pages provide interesting professional and public information on the area of the geopark. Geotopes, tour and organised programme offers are presented, as well as interesting articles and posts from the past of the region.

The Twitter page of the Bükk-Region Geopark is a platform for social media communication in English, its aim is to reach interested non-Hungarian people, which is important not only at international level, but also because many non-Hungarian-speaking residents live in our major cities as well thanks to the management of major foreign companies. They largely use Twitter and LinkedIn, and because they employ thousands of people, we can use Twitter to involve people working for them in geopark programmes.

At our partners and in the showrooms and accommodation run by the Bükk National Park Directorate, a wide range of information about the geopark can be obtained, and the information is supported by a publication package published by the Bükk National Park Directorate.

The nice little symbol of the Bükk-Region Geopark is Bükk Elfin, an alder cone bodied figure with an acorn cap, who primarily helps communicate programmes for children. The advantage is that with a little dexterity anyone can make it, thus everyone can have their own Bükk Elfin, the size of which fits in a Bükk acorn.

The 360° virtual cave tour in Szent István and Anna caves available in GUIDE@HAND app. and on webpages as well is useful in environmental education, which teachers like to use to prepare school class trips and analyse what they see.

SWOT analysis

SWOT analysis of Bükk-Region Geopark

Strength	Weaknesses
Quality accommodation and gastronomy offer in several points of the geopark. Easy access (easy to reach from several directions on motorways). A multitude of geological interests of international importance that make the site unique. A wide range of offerings is available in one place. The existence of a complex programme offering, which can already be sold directly. A suite of services that build on multiple target groups. Experiences provided by the geopark are innovative, unique, natural, complete and complementary to the current offer. Favourable natural conditions. With the presence of the Bükk National Park Directorate nature protection and ecotourism professionalism is in the right hands. Close relationship of scientific research groups and cultural institutions with the Bükk National Park Directorate.	Limited resources are available for marketing. There is little cooperation with municipalities and tourist service providers to exploit the potential of tourism. Regional businesses are often unable to see their own interests and engage in the process of tourism development and tourism marketing (lack of cooperation).
Opportunities	**Threats**
Increase in tourist demand (both domestic and foreign areas of origin). Interest in natural and environmental values is growing. Active tourism is able to reach ever wider crowds, while at the same time the destinations providing unique offerings are being valued. Cross-border cooperation and infrastructure improvements will make the region more accessible and better equipped with infrastructure.	Lack of qualified labour. Due to the quality development of dominant tourist regions this area falls back in the competition. Tourist demand decreases. Negative change in the geopolitical situation.

E.8 Networking

1 Cooperation with universities via particular field programmes

Bükk-Region Geopark concluded a cooperation agreement with Eszterházy Károly University in 2018 in the framework of Szomolya Beehive Stone Day in order to mutually assist natural science research. A similar agreement was later concluded also with the University of Miskolc.

At the beginning of 2019, joint thinking was launched between the various departments of Eszterházy University and the University of Miskolc and BNPI in order to develop and implement the geotourism programme of Bükk-Region Geopark. It is very important for the working organisation that students studying at universities in North Hungary are familiar with the eco- and geotouristic offer of the region, as well as teachers and students to be involved in geopark-related regional development work, which is why, on several occasions during the year, we have shown students in field programmes how to create a geopark the meaning of which is different from geological, conservational, regional development and tourism point of view, touristically in practice – i.e. how tourist product development and branding starts based on geological values in a product-based tourist destination. In connection with this, tourism students of Eszterházy University have been given the development of geotourism products as a project task in the framework of the Tourism Product Development course for the 2nd year.

In the meantime, consultation with the staff of the Faculty of Science, Eszterházy University was launched, in particular on the development of a joint geotourism training package. The plan is to start geotourism training in the form of training packages at different levels, organised by the University and BNPI. The Bükk National Park Directorate submitted a Slovak-Hungarian INTERREG tender for the development of the training package and the implementation of the training courses.

Cooperation with research groups

Through the decision-making organisation of the Bükk-Region Geopark, it is in professional cooperation with the Mining and Geological Survey of Hungary and the ProGEO Department of Earth Science Nature Protection. We also concluded a research cooperation agreement with the Herman Ottó Museum in Miskolc, the Castle Museum of Eger and the Miskolc Cultural Centre Ltd., which controls the research of the Diósgyőr Castle.

2 Civil organisations

Bükk-Region Geopark has established close cooperation with civil organisations operating in the region in several fields. Particular examples are the following:

- Among the NGOs, it is necessary to highlight the Kaptárkő (Beehive) Nature and Cultural Association of Eger and the Holocene Nature Conservation Association of Miskolc, who have been active in the field of value protection, dissemination and geotourism in earth sciences for more than a decade: the establishment of nature trails (Holocene Association: Cserépfalu – Ördögtorony study trail; Kaptárkő Association: Eger – Mész-hegy–Nyerges-tető study trail), publications, organisation of programmes (e.g. KőkulTúra in Bükkalja, Kaptárkő endurance hike, etc.) and their implementation are associated with the two organisations. Thanks to the initiative of the Kaptárkő Association, the „Beehive Stones and The Stone Culture of Bükkalja" was added to the collection of Hungarikums. The members of the Bükkalja Stone Road Tourism Cluster Association are active in the sustainable and competitive tourism of the area.
- Research and monitoring: The Bükk Foundation for Nature Conservation, Culture and Ecotourism has been assisting geopark with geotourism and thematic cave tours for years. The Foundation has been actively involved in the preparation of the professional work of the Bükk-Region Geopark, in the preparation of the necessary surveys and studies, in the maintenance and monitoring tasks related to geosites and in the implementation of educational programmes. In addition, it helps to raise the awareness of the Geopark in the Bükk Region with scientific educational lectures.
- Geopark tour guide training: In cooperation with the Kaptárkő (Beehive) Nature Conservation and Cultural Association, we were training tour guides in 2018, paying special attention to geological values. Discussions with the Borsod and Heves touring associations are ongoing. They have a great deal of experience in

the management of hiking trails and have a great view of active touring associations in the county. With this in mind, we count on them both in the conduct of the training and in the contact with the tour organisations.

- Events and shaping attitudes: The working relationship with the Green Contact Association, based in Miskolc, was close before. At the Aspic Festival in Miskolc in February 2020, upon the invitation of the association, we were able to present the values of the Bükk-Region Geopark. The aim is to continue to appear at joint events, especially in and around Miskolc, promoting the area.
- Local products: In February 2020, the Bükk-Region Geopark was introduced to local winemakers as part of a workshop in Miskolc. An important element of cooperation with them is the promotion of local products. The aim of the winemakers is to present the wine of Bükk, in the marketing of which the Bükk-Region Geopark would like to participate. Bükk Region wines will be offered in geo-accommodations, and cellar tours will add colour to the geotourism offer.

Relationship with foresters

The Bükk-Region Geopark has a lively working relationship with forestry organisations in the area. The cooperation with Északerdő cInc. includes the presentation of the ecotourism attractions of the forestry and the development of joint programmes, while forestry agreed to include the geotourism offer of the geopark in its own offerings.

3 International relations

Cooperation with the Novohrad-Nógrád Geopark

The aim of a close cooperation with Novohrad-Nógrád Geopark is not only to delimit the area but also to develop a professional cooperation, and it resulted in the technical preparation of joint geotourism programmes in 2019. These programmes are scheduled to start in the summer of 2020 after the necessary contracts have been concluded.

Joining the GEOTUR Erasmus+ project

An important point in the life of the Bükk-Region Geopark for international cooperation is that the textbook presenting geotourism case studies to be developed in the GEOTUR programme financed by erasmus+ could include the Lillafüred Geopark Open Day at Lillafüred of the Bükk-Region Geopark, for which we thank hereby the partners participating in the programme.

Active contact with other international geoparks

We have active relationship with the Ries Aspirant Geopark (DE) and Kielce UNESCO Geopark (PL). The head of the Geopark working group concluded a study trip to Ries Geopark in 2019 in the course of which professional discussions and co-thinking was started apart from field studies.

Since the foundation of the geopark in the summer of 2017, we have been in active contact with Novohrad-Nógrád Geopark. We had several joint product development and communication programmes in recent years, e.g. the joint introduction of the two geoparks in the Ipolytarnóc Fossils nature reserve. Currently, we have several international proposals under consideration aimed at developing joint geotourism product development and joint educational packages.

Colleagues of the Bükk-Region Geopark participated At the 8th International UNESCO Global Geopark Congress in the Adamello Brenta UNESCO Global Geopark in the autumn of 2018, where our colleagues presented the Bükk-Region Geopark with a poster.

In 2020, thanks to the Novohrad-Nógrád Geopark, a case study of the Bükk-Region Geopark was included in the methodology publication of geotur erasmus+ programme, making our offer part of an international geotourism-related educational material.

The head and one of the colleagues of the working group of the Bükk-Region Geopark and one of the external experts of the working group attended the Oxford Geoheritage international virtual conference on 25-29 May 2020. Our expert gave a presentation on the geosite rating system of the Bükk-Region Geopark.

E.9 Selling of geological material

Bükk National Park Directorate will not participate directly in the sale of geological objects such as fossils, minerals, polished rocks and ornamental rocks of the type normally found in so-called “rockshops” within the UNESCO Global Geopark (regardless of their origin) and will actively discourage unsustainable trade in geological materials as a whole. Trade of geological materials based on such a system may be tolerated in exceptional circumstances, provided it is clearly and publicly explained, justified and monitored as the best option for the Global Geopark in relation to local circumstances. Such circumstances will be subject to approval by the UNESCO Global Geoparks Council on a case by case basis.

F INTEREST AND ARGUMENTS FOR BECOMING A UNESCO GLOBAL GEOPARK

Character of the Bükk-Region Geopark

The earth sciences character of the Bükk-Region Geopark is divided into four characteristic parts that make it special at both national and international level:

A – Basic features of the earth sciences (geological, geomorphological) character

The folded – overturned folded-imbricated – thrusted (overthrust folded) structure of the Bükk Mountains (and the neighbouring Uppony Mountains), the core, centre of the Bükk-Region Geopark formed in the course of orogenesis in the Cretaceous period.

B – Basic features of the geomorphological character

The richness of the Bükk Mountains in karst features and karst forms. The specific and unique image of the Bükk is determined by the Triassic white and light grey limestone formations: areas composed by these have the abundant karst landforms of the mountains and store the waters entering the karst. The richest area of the Bükk in karst landforms is the Big Plateau composed of white limestone (Bükkfennsík Limestone Formation) formed in the Triassic period, but a rich ensemble of karst features (karren fields, dolines, sinkholes, karst ravines, travertine formations and caves) can be found in the limestone areas of the Little Plateau, North and South Bükk as well. The Bükk is the richest area of Hungary in caves.

C – Hydrogeologic characteristics of the Bükk Mountains

The vast karst water treasure of the Bükk Mountains is the continuous karst hydrodynamic system of the karst mountains and carbonate rocks subsided and mostly covered by impervious rocks in their foreland. The supply area of karst water is delineated by the karst rocks of the mountains on the surface, where water supply and infiltration takes place. The second unit is the transitional zone: this is where the mixing of cold karst water poor in mineral salts flowing from the mountains, and the warm or hot waters rich in mineral salts flowing from the depths below basin sediments. The medicinal springs of Eger, for example, were formed in this zone as well. Here, thermal karst waters rise to the surface in springs through clastic sedimentary rocks from horsts made up of carbonate rocks uplifted along faults and bounded by impervious layers. The third unit of the karst hydrodynamic system is the zone of karst thermal waters. Waters moving along the fracture systems of the covered, subsided carbonate rocks are heated by high temperatures in the depths, and their dissolved salt content increases: this is where the medicinally significant and valuable thermal karst waters form.

D – Cultural historical values with geological and geographical relations

With regard to the geopark, the cultural and landscape historical elements are highlighted that are associated with the rocks, geological features and landforms of the Bükk Region, i.e. they have geographical determination. Such interdisciplinary elements and attractions: the „caveman caves", prehistoric fortified settlements and medieval castles, objects of the stone culture of the Bükkalja (rooms carved into stone and the beehive stones are now members of the Hungarikum Collection), and iron and brown coal mines established on the basis of mineral raw materials, industrial facilities, which are now monuments of mining and industrial history.

Objectives of the operation of Bükk-Region Geopark:- values added, goals to be achieved:

- Conservation and sustainable use of the earth sciences, natural and cultural heritage
- Establishment of exhibition sites, infrastructure of international quality and level
- Organisation and accomplishment of professional meetings, conferences, workshops
- Development of the local economy based on local strengths, keeping income locally
- Development and support of geotourism, presentation, education and promotion
- Raising the awareness of the importance of landscape and geological values, sustainable rural development
- Supporting attachment to the place of residence, increasing local employment, improving the life standard of the inhabitants
- To contribute to the increase of the number of guest nights in the area
- Development of the value-based thinking of visitors via presenting the significance of the geological heritage, its conservation, and best practices
- Development of infrastructure supporting conservation with active involvement of local communities
- Expansion of the utilisation of local services and accommodation
- Definition of the geotourism offer, product development, establishment and maintenance of infrastructural background
- Establishment of meaningful collaborations based on general consensus