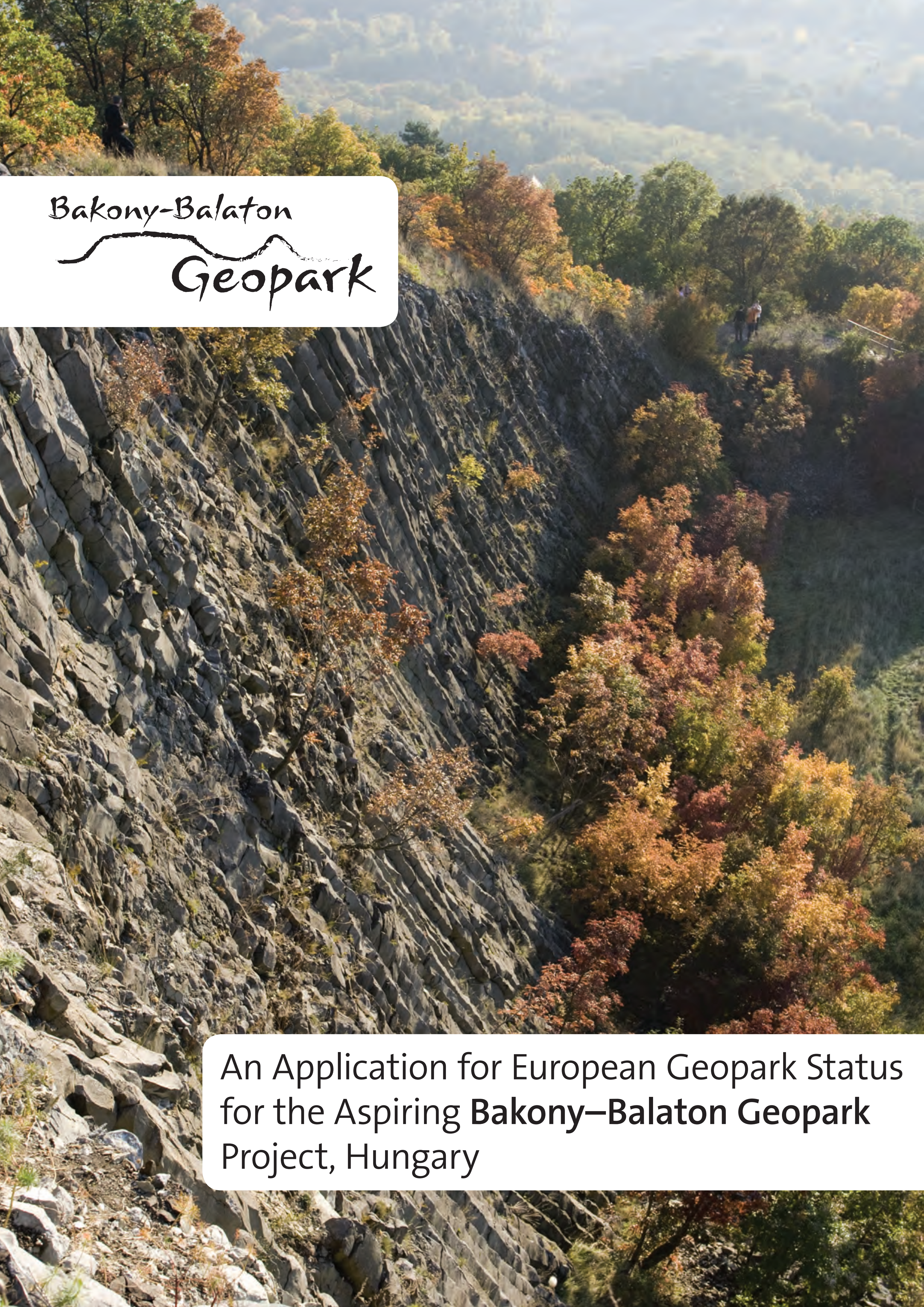

Bakony-Balaton Geopark

An Application for European Geopark Status for the Aspiring **Bakony–Balaton Geopark** Project, Hungary

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BALATON-FELVIDÉKI NEMZETI PARK

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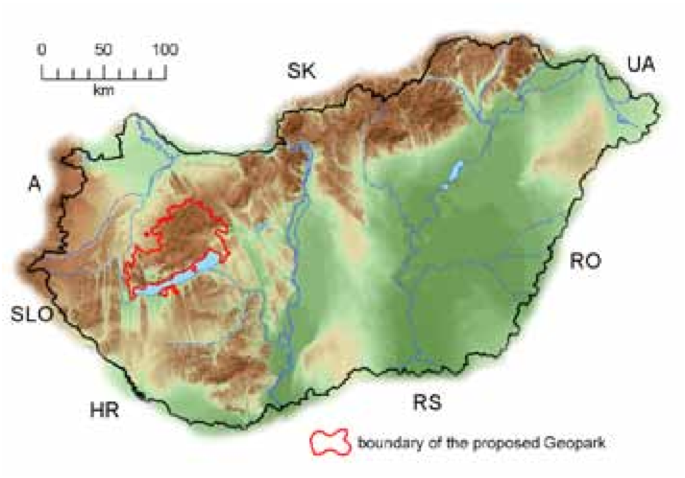
For reason of simplification, Bakony–Balaton Geopark (or BBGp) is used in this application dossier in the meaning “The candidate, Bakony–Balaton Geopark, being proposed for nomination as a European Geopark”.

Body text is set in Monotype Janson® which is the name given to an old-style serif typeface named for Dutch punch-cutter and printer Anton Janson. Research in the 1970s and early 1980s, however, concluded that the typeface was the work of a Hungarian punch-cutter named **Miklós (Nicholas) Tótfalusi Kis** (1650–1702). He travelled to Amsterdam in 1680 to apprentice under Dirk Voskens and cut several typeface while working under him, producing a roman text face c. 1685 upon which present-day Janson is based. For more info (in English) please visit: http://web.archive.org/web/200101060425/http://web.idirect.com/~nfhome/kis.htm



A. Identification of the Area

A.1. Name of the proposed Geopark

Bakony–Balaton Geopark

(please note: there is an en dash [–] *character between the two geographical names, and not a* hyphen [-])

A.2. Surface area, physical and human geography characteristics of the proposed Geopark

Administrative data

The total administrative area of the Geopark is 3 578 km^2 but this also includes the area of Lake Balaton. The total *land area* — territory of the proposed Geopark — is *3 140* km^2 . It comprises the administrative areas of *151 settlements* (in 15 micro-regions, 9 of them are covered partially). There are 19 counties in Hungary, the area of the Geopark covers four ones: 134 settlements belong to Veszprém County, 13 to Zala County, 2 to Győr–Moson–Sopron County and also 2 to Somogy County.

Administrative map of the proposed Geopark (red: geopark boundary, white: boundaries of Micro-regions, gray: boundaries of municipalities)

Regions

The proposed Geopark is situated in the central part of the Hungarian *Transdanubia,* in the north-western part of the *Carpathian Basin* of Central Europe — encircled by young folded mountain ranges. Its more than 3 100 km^2 area is located at the boundary of *4 major geographic regions,* therefore it is characterised by a great variety of geological, topographic, climatic and hydrological features and a great biodiversity. On the North the *Transdanubian Range,* on the South the *Transdanubian Hills,* on the East the *Great Hungarian Plain,* whereas on the West the *Little Hungarian Plain* extends into its area. These areas surround the *Lake Balaton.* The predominant part of the Geopark belongs to the so-called *'Bakonyvidék',* which comprises the following terrains: *North Bakony* (consisting of the so-called 'High Bakony' and the 'East Bakony'), *South Bakony, Balaton Uplands* and *Keszthely Mountains.* The *Tapolca Basin* is situated between the three latter regions.

Rising to 709 m a.s.l., the *Kőris-hegy* is the highest point in the Bakony Mountains and in the area of the Geopark, whereas the water level of the Lake Balaton (104 m a.s.l.) represents the lowest area of the Geopark. The High Bakony is made up of 500–600-m-high blocks of a diameter of some km. These blocks are separated by basins of the similar size. Hills made up of hard rocks (limestone, dolomite) are covered with deciduous forests, whereas the internal basins (of an altitude of 300–400 m a.s.l.

One of the many gorges in Bakony Mts

and filled with loose sediments) are used for agricultural purposes. The landscape is dissected by picturesque gorges of the creeks. The karst plateau (450–500 m a.s.l.) of the East Bakony, which is covered merely by patches of vegetation, gradually descends north-eastward (to an altitude of 250 m). Hundreds of *sink-holes, dolines* and *caves* can be found in it, and *deep, rocky valleys* have been incised into its rim. The Bakony is divided into a northern and a southern part by the *Veszprém–Devecser trough.* The international main road E66 runs in this tectonic depression of an altitude of 200–300 m; this territory is mainly under agricultural use. The two highest peaks of the South Bakony — i.e. the *Kab-hegy* (599 m a.s.l.) and the *Agár-tető* (511 m a.s.l.) — are of basalt-volcanic origin. The rest of the area is built up of limestone and dolomite forming 400–500-m-high blocks separated by internal and marginal basins. The neighbouring Balaton Uplands area on the South is characterised by a strike of NE–SW direction. Its mountain ranges are dissected into some-km-wide blocks of a height of 300–400 m, which encircle smaller or larger basins. Towards the NE this area is joined by the *Veszprém Plateau,* and the predominantly carbonate rocks of Triassic age descend under the young deposits of the *Várpalota Basin.* W of the Balaton Uplands half a dozen of *volcanic remnant hills* rise 300–400 m a.s.l. above the floor of the Tapolca Basin characterised by an altitude of 150–200 m a.s.l.. Among these hills the best-known is the 437-m-high *Badacsony.* The south-western area is dominated by the plateau of the Keszthely Mountains reaching an altitude of about 400 m and made up of dolomite. The surface covered with forests is strongly dissected by valleys and descends gradually towards

Sunset at Lake Balaton. The volcanic remnant hills of Tapolca Basin can be seen in the background the *Lake Hévíz*. The limestone block of the *Sümeg* fortress rises on the western rim of the Geopark. The plain of the *Marcal Basin*—which belongs to the Little Hungarian Plain—is located north of it. The solitary *Somló* hill (432 m a.s.l.) rises above the surrounding area of an altitude of 150 m a.s.l. This extinct volcano is regarded as a particular wine-growing region. The Fortress Hill at *Fonyód* and the diatreme remnant at *Balatonboglár* also belong to the basalt-capped volcanic remnant hills. In the South, the 77 km-long Lake Balaton is bordered by the slopes of the *Somogy Hills* which are dissected by smaller and larger *swamps*. The depth of the 5–10 km wide Lake Balaton—which is suitable for swimming and sailing—does not exceed some metres in the sub-basins. The swamp area of the *Kis-Balaton* ('Small Balaton') is a large *bird reserve*. The thousand-year-old abbey of the *Tihany Peninsula*, which extends into the lake, was built on the calcareous-siliceous sediments of volcanic thermal springs. The southern shoreline of the Lake Balaton is the remnant of a former sand spit, whereas the northern shoreline is dissected by several small bays. On the East the swelling waves formed spectacular bluffs in the *Pannonian* (upper Miocene) *sediments* of the *Mezőföld* area.

The gorge of Cuha creek in High Bakony

Climate

In accordance with the diverse geographical conditions of the different regions, the Geopark is the scene of the *mixture of different climatic impacts*. *Continental* climate characteristic of the most part of the Carpathian Basin and characterised by dry and warm summers and cold winters, occurs in alternating intensity. It is modified by *Atlantic* air masses coming from the NW and resulting in humid and cool summers and mild winters, and by the *Mediterranean* effect arriving from the SW, from the Adriatic Sea. The two latter are manifested in more rain in winter and dry, hot weather in summer.

Another factor—similar to the so-called 'foehn wind' of the Alpine region—has a strong influence on the climate of the Bakony region. The north-western slopes of the Bakony Mountains—which are situated at right angles to the route of the Atlantic cyclones—receive a relatively great amount of precipitation from the moist air masses, whereas the south-eastern side is characterised by a drier weather. Clear weather occurs mainly in the Balaton Uplands, which manages an annual average total of over 2000 hours of sunshine.

The *mean annual temperature*—which depends on altitude and location—varies from 8 °C to 10 °C over the area of the Geopark. Local climate is modified by relief, exposition and vegetation cover. *Annual average precipitation* is 800 mms on the western side (over the highest areas it may reach 1000 mms), whereas along the shoreline of the Lake Balaton and in the East Bakony is much less than 700 mms. The *natural vegetation cover* reflects climatic differences. The *forest* vegetation at higher altitudes of the Geopark (i.e. above 400 m a.s.l.) is characterised by beech forests, whereas in the lower zone oak forests are typical. Due to the sub-Mediterranean climate, on the southern slopes and on the carbonate bedrocks of the Balaton Uplands *karst scrubs* have developed. The gently sloping sunny areas, called 'Lake Balaton Riviera', have been famous of their *viticulture* for 2000 years. The south-eastern areas with thin soil cover and the lack of trees are characterised by dolomite rock *grassland* habitats. The diverse flora provides habitats for a fauna abounding in rare species.

Hydrography

The hydrological conditions of the Geopark area are basically determined by the distribution of precipitation and the geological build-up. Since the mountains are made up predominantly of limestone and dolomite, the *rate of infiltration is high;* water soaking into the ground increases the amount of *karst water*. Water rises up to the surface in *karst springs* and *karst swamps* near the bottom of the basins and in the marginal zone of the mountains. A part of the karst water descends into great depths and warms up, and some thousand years later it rises up to the surface in the form of *thermal water* (Lake Hévíz, 38 °C) or *lukewarm spring* (Lake Cave of Tapolca, 20 °C). In earlier periods of the Earth's history thermal water activity was much stronger (as it is proved by the presence of thermal water caves, spring cavities and special sediments).

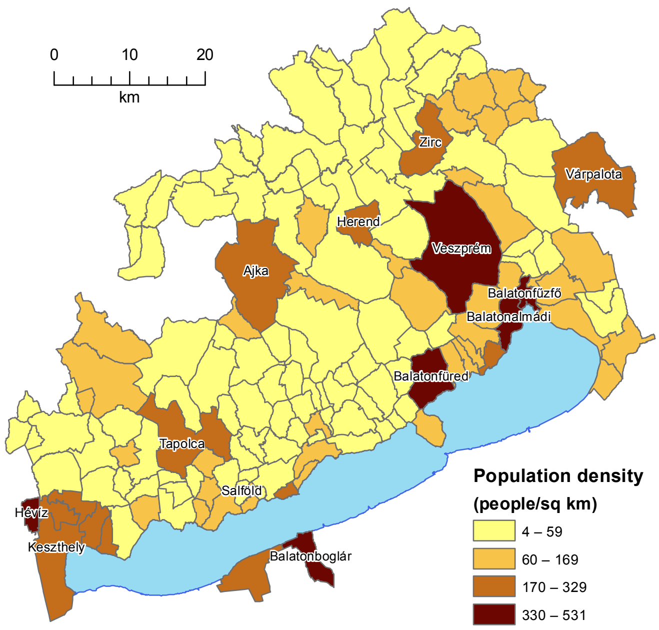
In spite of the features characteristic of a karst terrain, the Geopark is rich in *small watercourses*. Due to the impermeable rocks, in many places water rises up to the surface or the valleys have been incised down to the karst water table. Due to the *uplifted, island-like character* of the area, brooks that originate here, run towards every point of the compass. The *hydrographic centre* of the North Bakony can be found in the vicinity of *Zirc*. The *Cuha* creek runs northward into the Danube, the *Gerence* runs towards the Northwest, whereas the *Gaja* runs eastward into the *Mór Trough*. Some temporary brooks run southward. The watershed of the Veszprém–Devecser trough stretches in the vicinity of *Herend*. The *Séd*, which is one of the largest creeks of the Bakony Mountains, runs towards the East from here. The *Torna* creek drains water away into the river Marcal. The *Vázsonyi-séd* collects water from the South Bakony, and joins the *Eger-víz*, which drains water into the Lake Balaton through the Tapolca Basin.

Due to tectonic reasons the *Balaton Uplands* can be considered as an *independent hydrologic unit*. It is characterised by relatively high-yield, *vauclusian springs* (which are, for the most part, captured for drinking purposes); their water directly runs into the Lake Balaton after flowing through short, high-gradient valleys (the local name for these creeks is "séd") . The lake is mainly fed by the river *Zala* flowing from the west. It is drained artificially by the *Sió Channel*.

There are *only few natural lakes* in the area of the Geopark. The Lake Hévíz, which has positive curative effects, is well-known all over the world. The *Lake Kornyi* and the dozen ponds and small lakes on the top of the volcanic hills are worth mentioning. In many places creeks were impounded and small fish ponds came into being.

Human geography characteristics (population)

According to the statistics of July 2011, 330 000 people live in the *151 settlements* of the geopark, which amounts to 3.3% of Hungary's population of 9 967 000. *Salföld* has the smallest population (only 44 people): one of the most beautiful villages of the Káli Basin – and perhaps of the entire Geopark – could be a typical example of the villages with an *aging popula-*



tion, becoming *depopulated*. However, in this case the renovated, thatched cottages mainly function as *holiday houses of urban intellectuals* (a Hungarian peculiarity is that even this village has its own local government and mayor…). As the other extremity concerning the number of inhabitants, there is a *county seat* as well within the Geopark: *Veszprém* town is worth mentioning because of its 64 000 inhabitants, comprehensive services, export oriented industry and rich geological heritage.
There is *a high number of tiny villages on the area:* less than 1 000 people live in 90 villages. Not more than 11 settlements each give home to more than 5 000 people, and only 6 towns have more than 10 000 inhabitants.
The *average population density in Hungary* is 116 people/km^2. This average in the Geopark is obviously *lower* (80 people/km^2) because of the many tiny villages and the *sparsely populated areas* in the medium-height mountain range. It is to be noted that as the administrative areas of some settlements are extended also to Lake Balaton, the calculation of the population density took *only the terrestrial parts* for its basis (because the water surface can be reckoned as unpopulated). The *most sparsely populated areas can be found in the High Bakony* (4–6 people/km^2), but there are many areas where population density is not more than 10–15 people/km^2 (e.g. in the Káli Basin), which lie only a few kilometres away from the shore of Lake Balaton. Only 3 of the 10 most populated (272–531 people/km^2) administrative areas of settlement are located not on the shore of the Balaton (Ajka, Hévíz, Veszprém). For more information on human geography, please refer to Chapter D.1.

A.3. Organization in charge and management structure

The *Balaton Uplands National Park Directorate* (official name in Hungarian: *Balaton-felvidéki Nemzeti Park Igazgatóság)* started the preparation of the Bakony–Balaton Geopark project *in the autumn of 2005.* The proposed Geopark is located *within the Applicant's operational area* of 1 million hectares (such an operational area in the Hungarian official nature conservation includes not only protected areas but the entire region where the Directorate is responsible for the conservation of natural assets). This area has *one of the richest geological heritages in Hungary* and the *tradition of activities concerning geological nature conservation and interpretation* has been present for many decades. The National Park Management's viewpoint has been from the beginning that on such an area it is the Applicant organisation that can *most efficiently accomplish the goals of a Geopark* (doing all this by *significantly widening its sphere of activities, performing new functions,* etc.). The Applicant nourishes a traditionally *good relationship with civil organisations* and — as one of the tools of *sustainable regional development* – operates its visitor centre and all but one of its exhibition sites in *cooperation with local entrepreneurs.* In the Applicant's opinion these facts provide an adequate ground for the Bakony–Balaton Geopark to be shifted from an initiative to a real Geopark of full value.
The Applicant has a *well defined organisational structure* with *defined hierarchy,* and *well defined tasks* for the individual employees. Additionally, each year a *well defined work plan* is prepared for the Directorate, including the most important tasks, deadlines and people in charge. The directorate's *Rules of Organisation and Operation* is being reviewed, partly in order to insert the possibility to designate Working Groups that include employees from different departures. The *Geopark Team* is already set up and works for the geopark project and *this team will be transformed into the Geopark Working Group* in accordance with the new Rules of Organisation and Operation, *shortly after the time when the application is — hopefully — declared to be successful by the EGN.* The *composition* of the Geopark Team: one *coordinator (geoscientist),* one *specialist of regional development and tourism,* one *specialist of education* and one *specialist of financial issues.* The members carry out other tasks as well. Although not permanent members of the Geopark Team, the *Ranger Service* support actively and continuously the Geopark project by their expertise and local knowledge concerning the huge area of the Geopark.
The involvement of other stakeholders in the management structure of the future geopark will be ensured by the *Geopark Commission,* the *Geopark Partner Labelling System* and the *cooperation agreements* concluded between the Applicant and the stakeholders.

The headquarters of the Applicant in the village of Csopak

The members of the above mentioned Geopark Team and Geopark Working Group are and will be employed directly by the Applicant. The Geopark Commission will be made up of the Geopark Working Group, the *director of the Applicant* and the *heads of three Multi Purpose Micro-Regional Associations* among the fifteen Associations that work within the area of the proposed geopark. These Associations have *all signed the enclosed Cooperation Agreement* (see Annex 4), thus have become Geopark Partners. The designation of the three Micro-Regional Association members of the Geopark Commission changes *in a rotating way. Two sessions* of the Commission take place *annually.* During the late autumn session the *report of the actual year's achievements, the action plan and budget of the next year* (both documents prepared by the Working Group) are approved and strategic questions are discussed by the Commission. During the late spring session an interim report prepared by the Geopark Group and plans for the next year are discussed.

A.4. Application contact person

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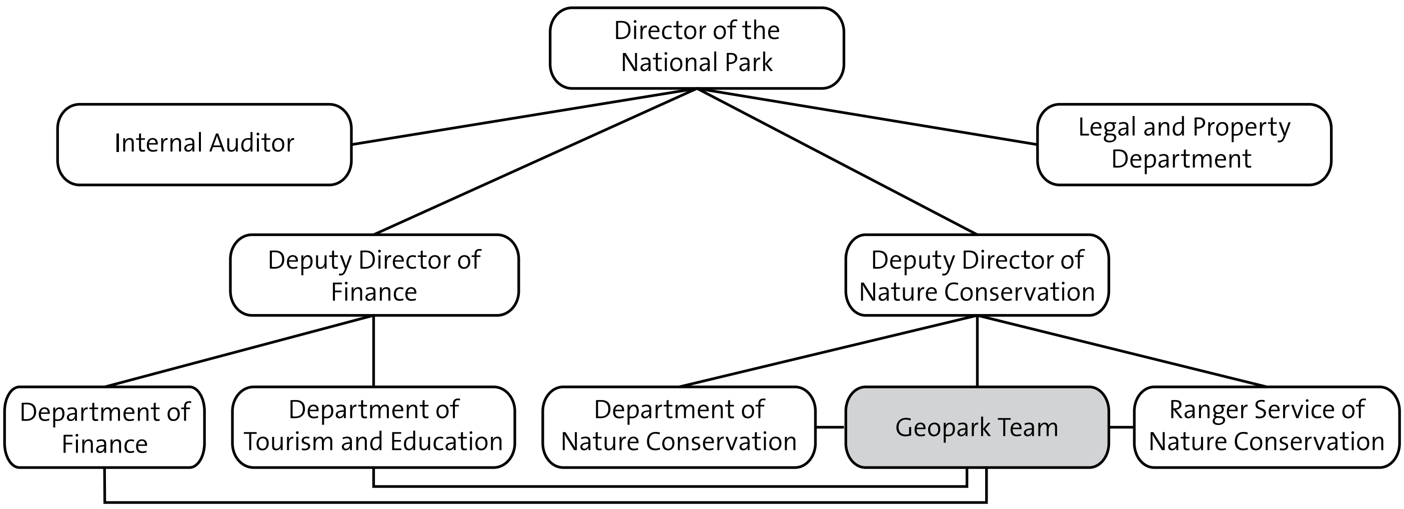
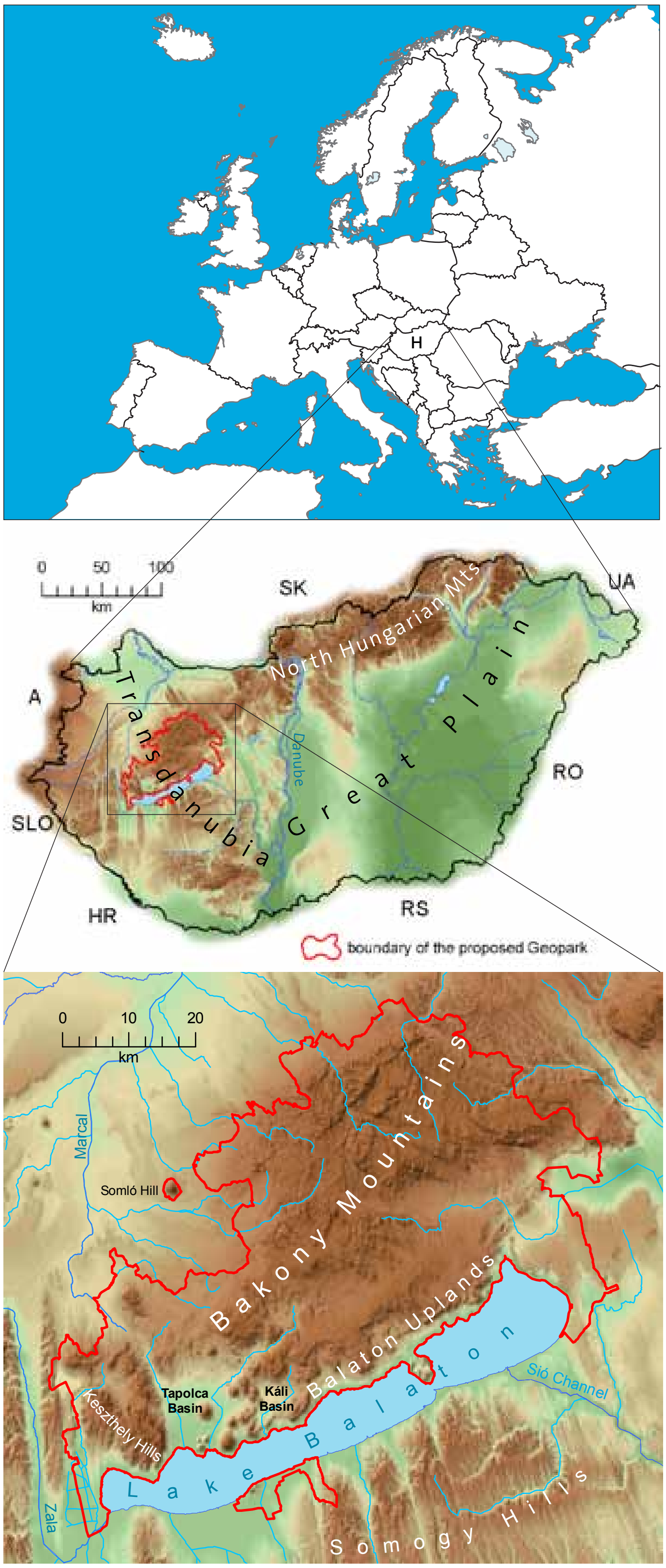


Organogram of the proposed Bakony–Balaton Geopark

B. Geological Heritage

Bakony–Balaton Geopark: land of the calmed-down volcanoes and dinosaurs *(a preface in 150 words...)*

The proposed Geopark area is a geological–geomorphologic mosaic on 3100 km^2 in West Hungary comprising 171 different formations: Ordovician metamorphites, Permian sandstone, Alpine Triassic carbonate succession near Central Europe's largest, shallow-water lake, the Lake Balaton; Ammonite-rich Jurassic and new dinosaur genera-bearing Cretaceous above bauxitic tropical tower karst, Eocene large foraminifers and Miocene mollusc fauna with several hundred genera in the Bakony Mountains. The former Lake Pannon's diverse endemic mollusc fauna is unique in limnic facies in the Earth's history. Silicified sandstone cemented into 'seas of stones' around the Káli Basin; outstanding remnant hills of one of the "densest" volcanic fields in Europe (Mio-/Pliocene) that formed a dramatic landscape; almost 700 caves in gorges and on karst plateaus; hundreds of sinkholes; a 9-km-long thermal-water maze under a town and more than 1600 clear-water springs—these are all under the nature conservation supervision of a National Park Directorate: the Geopark candidate.



B.1. Location

The proposed Bakony–Balaton Geopark is located in Eastern Central Europe, in the central part of Western Hungary (Transdanubia). The Geopark can be reached by car within 1.5 hours from the Hungarian capital (Budapest), from Slovakia, Austria, Slovenia and Croatia. For more location details please refer to Chapter A.2., under Regions.

Extent of the proposed Geopark in geographic coordinates:

N 47° 24' 36,35" on the North
N 46° 40' 18,14" on the South
E 17° 08' 11,67" on the West
E 18° 15' 41,80" on the East

B.2. General geological description

History of Geological Recognition

From a geological point of view the Bakony is one of the areas of the Transdanubian Range that have been studied *for the longest time and in the most detailed way.* The first geological observations—written in the first half of the 19^{th} century—can be found in travel reports. The first scholarly but sporadic observations were made by the French Beudant (1822), the Austrian Zepharovich (1856) and the Hungarian Flóris Rómer (1860). In the course of the investigations the next milestone was the *geological surveying of the territory* of the Austro-Hungarian Monarchy. The geological mapping of the Bakony was carried out in 1860–61 by the geologists of the Geological Institute of Vienna. Hauer and his colleagues identified and distinguished the major lithostratigraphic units and pointed out their close relationship to the Alpine realm (Hauer 1870).

After the founding of the *Geological Institute of Budapest* (1869), geological research work of the Hungarian territories got under way. One of the first target areas of a more detailed geological mapping was the Bakony area, in which János Böckh (1872, 1873, 1874) and Károly Hofmann (1875–78) played an outstanding role. The most significant milestone in the research of the Balaton Uplands (which form the southern wing of the Bakony Mountains) was the publishing of the *'Balaton monograph'*. Lajos Lóczy sen. published his epoch-making work, i.e. *"Geological Formations of the surroundings of the Lake Balaton and their setting in the different areas"* in 1913. A detailed geological map on a scale of 1: 75 000 was also compiled (Lóczy 1920). In the geological appendix of the volume a detailed description of the geology of the surroundings of Veszprém was provided by Dezső Laczkó (1911), and a summary of the basalts of the Balaton region was given by István Vitális (1911). In the palaeontological appendix issued in four volumes, the most famous scientists of Central Europe gave an overview of the knowledge that had been gained about the fossil record of the Balaton Uplands, until that time. Many fossils have been described from the Balaton Uplands and this is reflected by the names of some of them (for example *Hungarites, Balatonites, Arpadites* etc.)

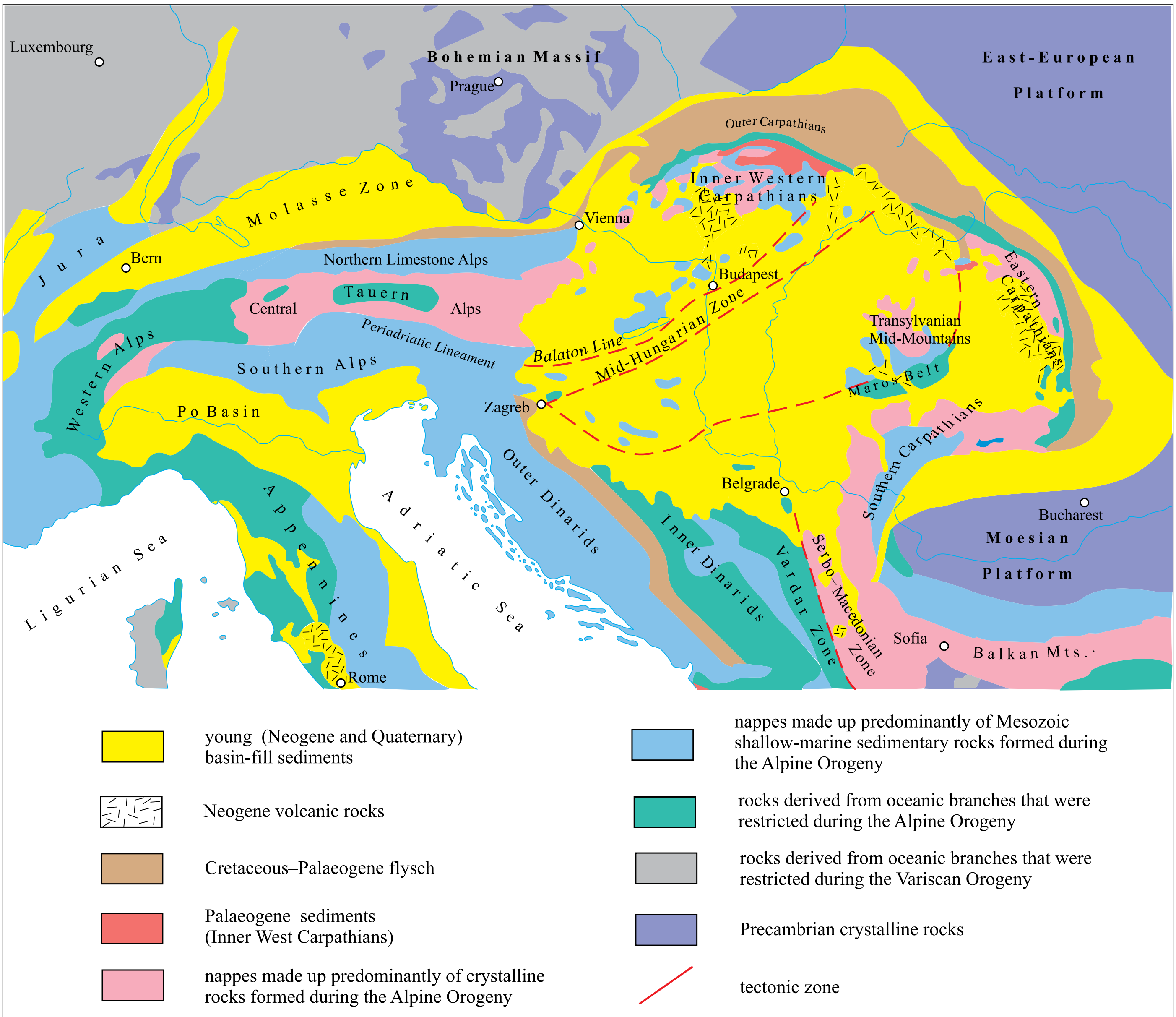
After the First World War an intense raw material research commenced in the area of the Transdanubian Range. It resulted also in the compilation of a *detailed geological map* of the Bakony Mountains (Telegdi Roth 1934). After the Second World War the progress of geological knowledge was also in close connection with the research of raw materials (predominantly coal and bauxite), resulting in the publishing of new maps, among others a map representing the area of the North Bakony (Noszky in Barnabás et al. 1957). From the middle of the 1960s until the end of the 1970s the *engineering geological mapping of the shoreline areas* of the Lake Balaton (Boros et al. 1985) and the *systematic geological mapping* of the Bakony Mountains (Császár et al. 1981, Gyalog, Császár 1990, Bence et al. 1990) were performed. The latest geological mapping of the Balaton Uplands on a scale of 1:10 000 started in 1982. It was carried out in

Geological map of the Balaton Uplands by S. Beudant (1822)

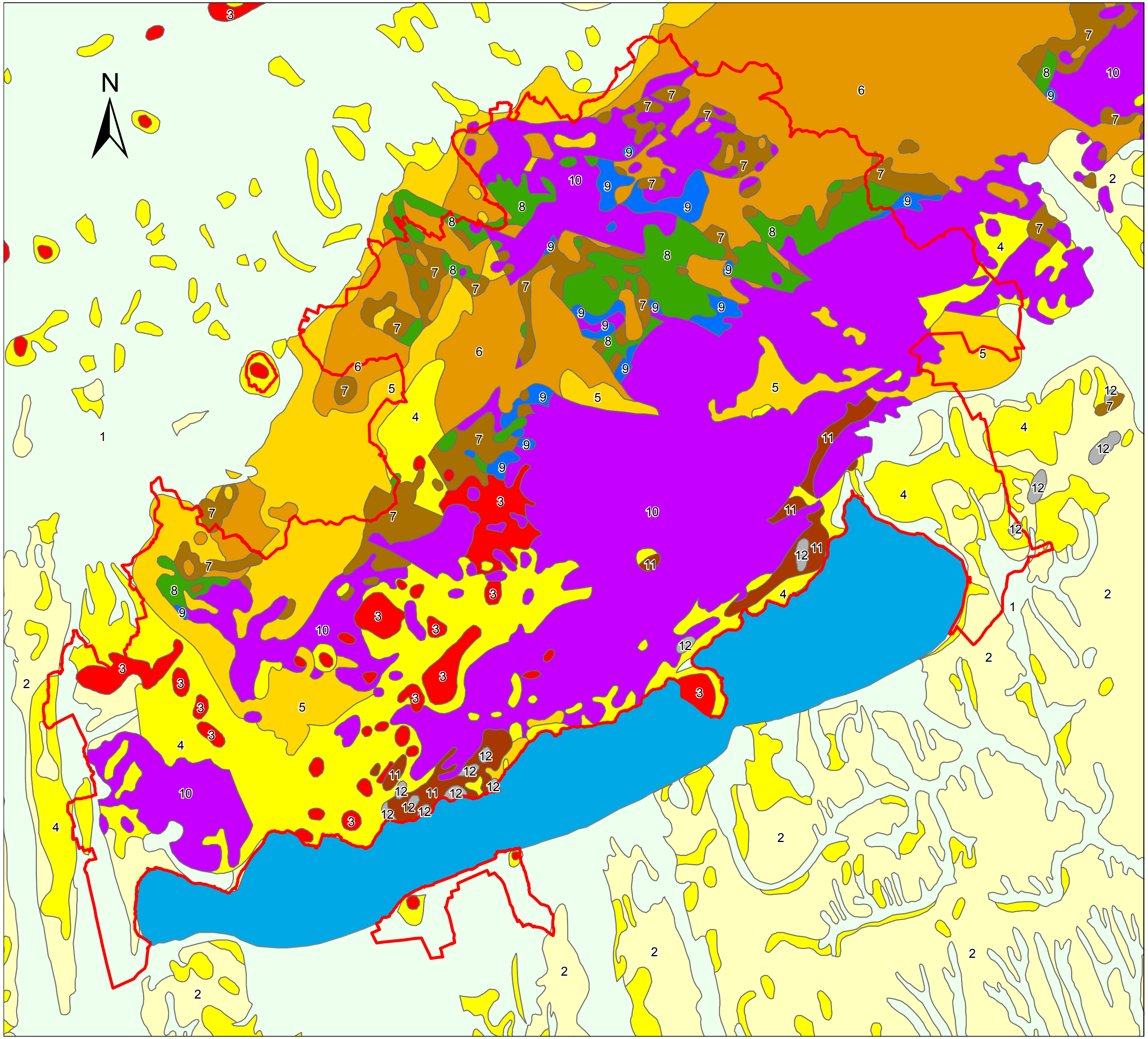
the frame of the regional mapping programme of the *Geological Institute of Hungary*. As a result of the work a *regional geological map* on a scale of 1:50 000 and an *explanatory book of the geological map* were published (Budai, Csillag 1998; Budai et al. 1999a, 1999b).
The general description of the geological build-up of the Bakony Mountains can be found in several handbooks, which give comprehensive summaries about the geology of Hungary (Juhász 1983, Trunkó 1996, Haas ed. 2001, Budai, Gyalog eds. 2009).)
At the beginning the geomorphologic investigations of the area were closely associated with geological surveying. Jenő Cholnoky was a prominent scientist of the first half of the last century. Landscape studies—organized by the *Geographical Research Institute* and led by Márton Pécsi—started in the 1960s in the Bakony Mountains. The results of the geomorphologic studies were summarized in *a landscape monograph in two volumes* (Ádám–Marosi–Szilárd 1987–88). Additionally, *numerous publications are available* which deal mainly with the question of volcanic remnant hills and karst phenomena. Nowadays cadastral survey of protected caves, sink-holes and springs is being carried out.

Geological build-up

The area of the Geopark is made up of sedimentary rocks of different geological ages, which have been formed within approximately *300 million years*. The areal extent of magmatic rocks is subordinate, metamorphic rocks can be found only in small patches on the surface. The bulk of the mountains are built up of *shallow-marine carbonates (limestone and dolomite) of Triassic age* with a thickness ranging from 2.5 km to 3 km. The geological build-up of the Bakony (and of the entire Transdanubian Range) is significantly different from the surrounding areas (i.e. the basement of the Little Plain and the area located S of the Lake Balaton. Based on geological data derived from surficial observations and from boreholes, and according to palaeogeographic and tectonic interpretations of these data, the Transdanubian Range has been shifted to its current place from its probable *original position in the Alps as a result of large-scale movements.* According to the currently-accepted tectonic models, the *Bakony Mountains belong to the East Alpine Nappe System,* and are situated in the highest position, above the nappes that form the basement of the Sopron Mountains and the Little Plain.
From a geological point of view, in the SE the Bakony area is bordered by the tectonic zone of the Balaton Line, whereas from a geomorphologic point of view it is bordered by the northern rim of the basin of



Geological setting of the Carpathian Basin within the Alpine Mountain System (after Haas et al. in Mészáros, Schweitzer eds. 2002)



Simplified geological map of the proposed Bakony–Balaton Geopark

	1	Quaternary fluvial sand, clay, limnic ooze, paludal clay, peat; slope sediments
	2	Pleistocene loess with palaeosols
	3	Pliocene basalt, pyroclastics
	4	Upper Miocene sediments of the Lake Pannon: silt, sand, clay, abrasional gravel, travertine, siliceous sandstone
	5	Miocene marine clay, clay marl, sandstone, gravel; shallow-marine biogenic limestone
	6	Oligocene fluvial variegated clay, sand, gravel
	7	Eocene pelagic marl; shallow-marine foraminiferal limestone, brown coal
	8	Cretaceous shallow-marine crinoidal and bivalve-bearing limestones; pelagic marl, clay marl; platform and reef carbonates, bauxite, brown coal
	9	Jurassic limestones of deeper-marine facies (ammonitico rosso), cherty limestone, radiolarite, manganese ore
	10	Triassic shallow-marine marl, dolomite; limestones and marls of basin facies, cherty limestone; platform Main Dolomite and Dachstein Limestone
	11	Permian alluvial red sandstone, siltstone, conglomerate
	12	Ordovician–Silurian quartz phyllite, slate, metabasalt, metarhyolite

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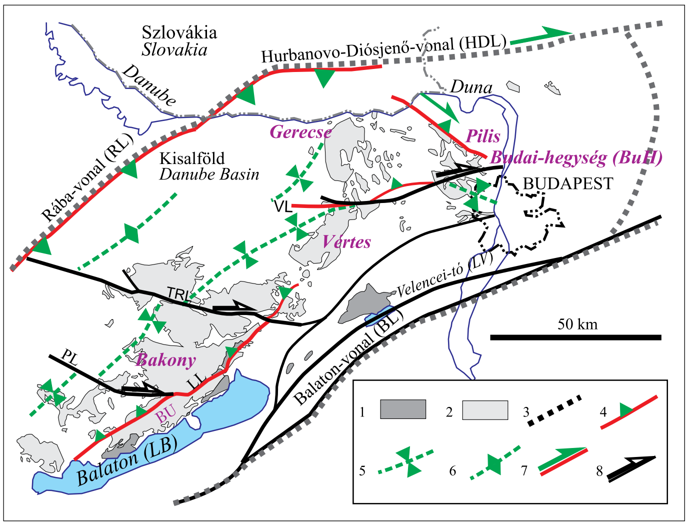


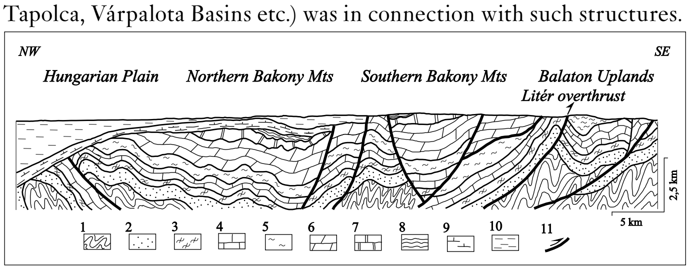
Simplified geological map of the Transdanubian Range Structural Unit with the surficial extent of Palaeozoic and Mesozoic formations (after Balla, Dudko, Tari, Fodor). Legend: 1. Palaeozoic formations; 2. Mesozoic formations; 3. Boundaries of the Transdanubian Range Unit; 4. Mesozoic overthrust; 5. Cretaceous syncline; 6. Cretaceous anticline; 7. Cretaceous lateral fault; 8. Cenozoic lateral fault. LL – Litér Line; PL – Padragkút Line; TRL – Telegdi Roth Line; VL – Vértessomló Line; BH – Balaton Uplands

the Lake Balaton. In the NE — towards the Vértes Mountains — it is bordered by a more peculiar tectonic structure, i.e. the Mór Trough.

The structure of the Bakony Mountains is determined by a syncline of a SW–NE axis. Its south-eastern and north-western limbs are made up of the oldest (Palaeozoic–Triassic) sequences, whereas towards the axial zone of the syncline increasingly younger (Jurassic–Cretaceous–Palaeogene) formations can be observed. The *Balaton Uplands* and the *Veszprém Plateau* form the south-eastern limb of the syncline, where Palaeozoic and older Triassic rocks can be traced on the surface. Beds preferentially dip north-westward and their general strike is approximately similar to that of the axial direction of the syncline. This general tectonic structure is complicated by *longitudinal (SW–NE) compression structures of different amplitudes, folds and reverse faults.* The most significant one is the *Litér overthrust,* which determines the structure of the Balaton Uplands and the Veszprém Plateau and along which the Permo-Triassic sequences are repeated within two slivers thrust over each other. The *tectonic boundary of the Balaton Uplands and the South Bakony* (in the strict sense) is determined by an *overthrust line,* the so-called *Veszprém Fault.*

Besides the longitudinal compressional tectonic structures *transverse ones* (of NW–SE and WNW–ESE directions) *are also of determining significance.* These structures in the sliver located S of the Litér Fault Line are mostly of compressional character. *Anticlines, synclines and overthrusts* (e.g. the horse-tail structure at Dörgicse), which can be observed in the central part of the Balaton Uplands, belong to these structures. A large-scale anticline structure can also be outlined within the sliver situated N of the Litér Fault Line, in the vicinity of Hidegkút and Tótvázsony. This structure is accompanied by a disintegrated syncline structure along the northern margin of the Pécsely–Balatonszőlős Basin.

Transverse tectonic structures include dextral strike-slip faults with amplitudes of several km (Telegdi-Roth Line, Herend–Márkó Line, Úrkút–Padragkút Line) and the curving faults which turn from an approximately N–S direction into NE–SW direction. These faults delineate the margins of the Csehbánya Basin and the Ajka–Nyirád Basin. The formation of the *Miocene basins* of the Bakony Mountains (Várvölgy, Tapolca, Várpalota Basins etc.) was in connection with such structures.



Simplified geological cross section of the Bakony Mts (Trunkó et al.). Legend: 1. Early Palaeozoic basement; 2. Upper Permian sandstone; 3. Lower Triassic formations; 4. Middle Triassic carbonates; 5. Upper Triassic marls; 6. Upper Triassic dolomites; 7. Dachstein Limestone; 8. Jurassic formations; 9. Cretaceous formations; 10. Tertiary formations; 11. Reverse faults

Geological History

Based on the geological setting and tectonic characteristics, the geological history of the Geopark can be divided into the following periods.

Pre-alpine history

The *oldest formations* of the Bakony Mountains are represented mainly by *marine clastic sediments,* which were deposited during the *Early Palaeozoic* (approximately 500–360 million years ago) and subsequently, during the Variscan orogeny, underwent *metamorphism.* The grey, anchimetamorphic slate and metaaleurolite, which make up the succession, crop out at two places in the Balaton Uplands (at Alsóörs and Révfülöp), whereas slightly East of the Lake Balaton the pre-existing rocks underwent stronger metamorphism *(Balatonfőkajár Quartz Phyllite).* Based on palaeontological data the deposition of the succession of originally deep-sea environment commenced at the beginning of the Ordovician and took place until the middle of the Devonian. It was interrupted twice by significant volcanic events, which resulted in the formation of the Lower Ordovician *Alsóörs Metarhyolite* and the Silurian *Révfülöp Metaandesite* and *Litér Metabasalt.*

In the middle period of the Devonian clastic sedimentation was replaced by *carbonate sedimentation* in the pelagic basin. The red, nodular *Kékkút Limestone,* which was exposed by boreholes, yielded characteristic fossils (conodonts and tentaculites). Younger marine sediments of Palaeozoic age are unknown in the Balaton Uplands.

Variscan orogeny took place in the early period of the Late Palaeozoic, during the Carboniferous. It resulted in the folding and transformation (metamorphism) of sedimentary rocks dating from earlier times. These processes took place about 325–310 million years ago.

Alpine history

Continental and shallow-marine sedimentation during the Late Permian

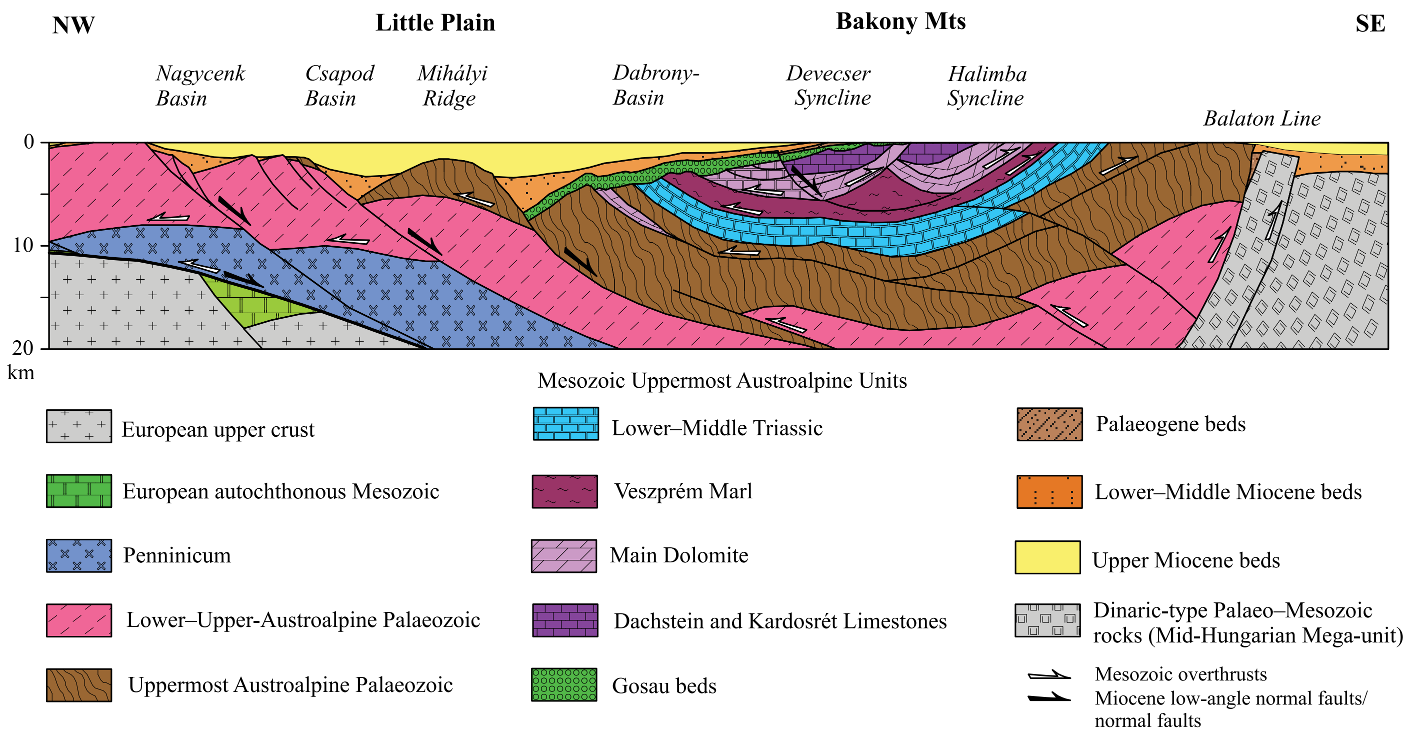
In the final period of the Palaeozoic, approximately 300–250 million years ago, denudation of the mountains (which had been folded and uplifted during the Variscan orogeny) and the *deposition of the eroded debris* took place. The closure of the earlier oceans, which had existed between the ancient continents, led to the formation of a supercontinent (Pangea) in the Permian. One of the most characteristic formations of this period is represented by a succession cropping out in certain areas of the Balaton Uplands and in the Veszprém Plateau. It is made up of *red sandstone, pebbly sandstone, conglomerate* and *siltstone* and characterised by a thickness of several hundred metres. Based on the study of sporomorphs belonging to one-time plants and derived from the *Balaton-felvidék (Balaton Uplands) Sandstone,* a fluvial and limnic (i.e. continental) depositional environment can be reconstructed for the end of the Palaeozoic. The red, purplish-red colour which is characteristic of the succession indicates that these beds were deposited in an oxidative sedimentary environment under semiarid conditions. Fossils of the rock are unique; besides the plant remains a foot print of an *ancient reptile* is known from the Pálköve quarry.

Shallow-marine siliciclastic–carbonate ramp in the Early Triassic

The alluvial plain of a large areal extent, which came into being by the end of the Palaeozoic, was inundated by the sea at the beginning of the Mesozoic, about 250 million years ago. The deposition of fine-grained siliciclasts and carbonates started in the area of the shallow-marine shelf. In the south-western part of the Balaton Uplands the succession is represented by the light-grey, sandy *Köveskál Dolomite,* whereas NE of the Tihany Peninsula it is made up of the grey *Arács Marl.*

Deposition of the red sandstone *(Zánka Sandstone)* in the middle of the Early Triassic indicates the increase of terrigenous influx (i.e. the increase of denudation of the continental terrain around the sea). The sandstone is overlain by the gypsum-bearing beds of the *Hidegkút Dolomite,* which indicate the temporary shallowing of the sedimentary basin and the development of restricted, periodically hypersaline lagoons.

The sea-level rise, which took place in the second half of the Early Triassic, resulted in the development of an open shelf basin. Besides the fossils of ammonites, skeletal fragments of gastropods, bivalves and crinoids are frequent in the lower section of the *Csopak Marl.*



Tectonic setting and geological build-up of the Austroalpine nappes (after Tari & Horváth 2010)

Formation and development of shallow-marine carbonate platforms in the Middle and Late Triassic

After the infilling of the Early Triassic basin — at the beginning of the Middle Triassic (about 240 million years ago) — a tidal flat of a large areal extent came into being. Sedimentation started in a dry and warm climate under desert conditions, in a hypersaline, shallow-marine lagoon, which temporarily dried up *(Aszófő Dolomite)*.

Subsequently, the relative sea-level rise resulted in the development of an inner shelf lagoon-system, which was temporarily restricted from the open sea. The lower section of the dark-grey, bituminous *Iszkahegy Limestone* of laminated structure was deposited in a poorly-ventilated seafloor. Due to the gradual shallowing of the sea, a gently-sloping, well-lit shallow-marine ramp developed, where carbonate sedimentation continued *(Megyehegy Dolomite)*.

By the middle of the Triassic (approximately 235 million years ago) the undisturbed development of the sedimentary basin was stopped by a sudden, drastic geological event. This period of the geological history is called ‘Pelsonian' all over the world, after the Latin name of the Lake Balaton (i.e. Lacus Pelso). Dilatational tectonic movements resulted in the disintegration of the previous uniform basin floor; different parts of the dissected area were characterised by different sedimentation patterns. In the area of the uplifted blocks shallow-marine carbonate sedimentation continued until the end of the Anisian Age. The sedimentary environment was similar to that of the Bahama Bank, i.e. carbonate sedimentation took place on submarine ridges in a shallow-marine, intertidal environment *(Tagyon Limestone)*.

Simultaneously, in the down-faulted depressions between the submarine ridges (island platforms) narrow and deep basins were formed, in which ammonitic, bituminous limestone developed. The massive occurrence of the fossils of shallow-marine organisms (crinoids and brachiopods) in certain horizons of the *Felsőörs Limestone* indicates that from time to time a significant amount of sediments was re-deposited from the submarine ridges into the basin.

Probably as a result of the former tectonic movements *tuff explosions* of the submarine volcanism, which took place at the Anisian/Ladinian boundary (about 233 million years ago), were particularly intensive at the end of the Anisian *(Vászoly Beds)*. The coeval sea level rise manifested in the ”drowning” of the shallow-marine platforms. During the Triassic the deepest basin was formed by this time. It is indicated by the ammonitic, nodular and cherty *Nemesvámos Limestone* — which alternates with volcanics — and the thin layers made up of the siliceous skeletons of protozoan organisms (radiolarians) which are called radiolarites.

At the beginning of the Late Triassic the shallow-marine platforms of the Balaton-felvidék significantly expanded replacing the basin areas, in which the accumulation of calcareous mud took place, which had been redeposited from the platforms. This resulted in the formation of a popular building stone of the Balaton Uplands region: the light-grey, thick-bedded *Füred Limestone,* which contains chert lenses and stringers, and the *Berekhegy Limestone* which occurs on the Veszprém Plateau.

During the Carnian the predominant part of the Balaton Uplands was occupied by a basin, which was encircled by carbonate platforms. This basin was filled up with terrigenous siliciclasts (clay and silt) derived from distant continental terrains *(Veszprém Marl)*. The marl sequence is divided by the nodular, cherty Nosztor Limestone of a thickness of 10 m to 20 m. A similar basin existed in the area of the North Bakony, whereas the Veszprém Plateau and the East Bakony were dominated by platforms.

By the end of the Carnian Age the terrigenous influx resulted in the gradual filling up of the basin. Coevally, its areal extent decreased between the platforms. This led to the formation of a poorly-ventilated, hypersaline lagoon which was followed by the development of a normal shallow-marine environment *(Sándorhegy Limestone)* after a temporary sea level rise.

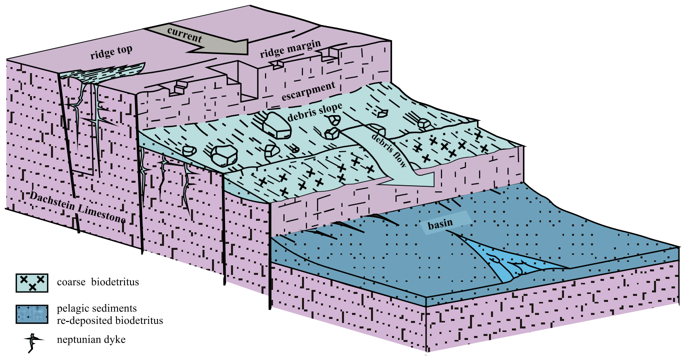
The Carnian basins were separated from each other by submarine ridges and platforms on which the sedimentation of shallow-marine carbonates took place. The *Ederics Limestone* (characterised by sponges and other reef organisms) and the *Sédvölgy Dolomite* were deposited. Carnian platforms of large areal extent can be traced SW of the Balaton Uplands (in the Keszthely Mountains) and NE of it (over the Veszprém Plateau).

By the end of the Carnian Age (approximately 220 million years ago) basins were completely filled up, and the progradation of the surrounding platforms resulted in the development of an uninterrupted and relatively flat terrain (i. e. a uniform platform). Carbonate sedimentation took place on a shallow-marine undersea ridge, which was similar to the present-day Bahama Platform but was significantly larger than this one. Initially carbonates were deposited under a dry climate and subsequently under a humid and warm climate. The approximately 1.5 km-thick Main Dolomite and the 200–500 m-thick *Dachstein Limestone* — which make up the predominant part of the Bakony Mountains — are the touchable evidences of this type of sedimentation.

As a result of tectonic movements during the Norian, about 210 million years ago, the Late Triassic platform was dissected resulting in the formation of smaller and larger, semi-restricted basins. In their poorly-ventilated sea floor organic-rich, laminated, cherty dolomite *(Rezi Dolomite)* and marl *(Kössen Marl)* were deposited in the area of the Keszthely Mountains and in the South Bakony.

Formation of submarine highs and basins in the Early Jurassic

As a result of the *opening of the Neotethys Ocean,* tectonic segmentation of the Late Triassic platforms significantly intensified at the beginning of the Jurassic. In certain uplifted areas of the Bakony Mountains carbonate platform evolution continued in the Hettangian *(Kardosrét Limestone),* but in later periods of the Early Jurassic the intensified tectonic subsidence led to the drowning of the platforms. In the area of the earlier



Sedimentary model of the Transdanubian Range in the Early Jurassic (Galácz, in *Haas* ed. 2001)

platforms submarine highs were formed, which were characterised by temporary carbonate sedimentation. For the most part, the surfaces of the downfaulted blocks were inhabited by rich, shallow-marine biotas, in which brachiopods and crinoids dominated *(Hierlatz Limestone).* Red, thick-bedded limestone *(Pisznice Limestone)* was deposited in the deeper sea basins; locally with chert intercalations, which are derived from the skeletons of siliceous sponges *(Isztimér Limestone).* The deep basins between submarine ridges were also characterised by low sedimentation rates and the deposition of nodular, ammonitic limestone and clayey limestone *(Tűzkövesárok Limestone, Kisgerecse Marl).* In many cases *planktonic bivalves* occur in large numbers in these types of sediments *(Tölgyhát Limestone, Eplény Limestone).* Manganese ore deposits accumulated in the close vicinity of the submarine ridges *(Úrkút Manganese Ore)* indicating a global anoxic event in the area of the Jurassic basins of the Bakony Mountains.

Deepening and filling up of the basin in the Middle and Late Jurassic

The Jurassic basin of the Bakony area may have reached its maximum depth during the middle of the period (about 170–160 million years ago) when the extensive proliferation of radiolarians (planktonic protozoans with siliceous skeletons) resulted in the formation of siliceous marl *(Lókút Radiolarite).* Subsequently, in the Late Jurassic, due to the resuming of tectonic mobility the *sea basin gradually became shallower;* nevertheless, open-marine carbonate sedimentation continued in the area of the Bakony. In the early period of the Late Jurassic red, *ammonitic limestone*—containing planktonic crinoids in rock-forming quantity—was deposited *(Pálihálás Limestone),* whereas at the end of the Jurassic a white, laminated, cherty limestone *(Mogyorósdomb Limestone)* was formed; this rock is made up of the skeletons of planktonic unicellular organisms.

Evolution of the sea basins in the Early Cretaceous

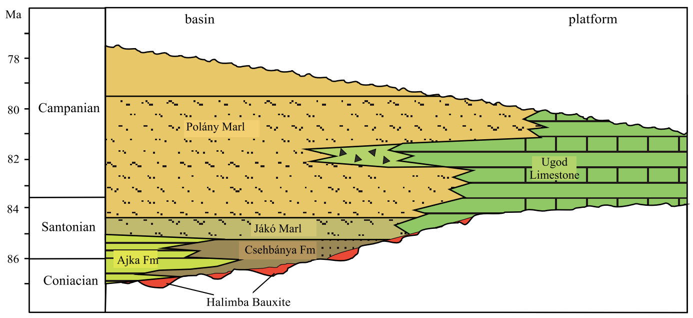
In the south-western areas of the Bakony Mountains the sedimentation of open-marine carbonates of *Maiolica facies*—which started in the Late Jurassic—continued in the early period of the Cretaceous, whereas in the North Bakony the so-called *Szentivánhegy Limestone* was formed. This rock is yellowish-white or light red and locally, contains *belemnite guards* and *brachiopod shells* in large quantities. In the later period of the Early Cretaceous an increased influx of fine terrigenous material occurred in the area of the South Bakony *(Sümeg Marl).* Coevally, in the North Bakony the shallow-marine crinoidal–brachiopod-rich *Borzavár Limestone* was formed.

Orogeny and denudation in the middle of the Cretaceous

The closure of the several Tethyan oceanic branches led to orogenic movements in the Alpidic region. Due to compressional tectonic movements a large area of the Bakony was exposed at the surface during the Aptian Age which resulted in the denudation of the previously formed rocks. As a result of the late Aptian transgression, crinoidal limestone *(Tata Limestone)* was formed all over the area. This event was followed by a much stronger uplifting and denudation in the Albian Age *("Austrian Orogenic Phase").* The compression (which accompanied the orogeny) led to the formation of the syncline structure of the Bakony and the longitudinal reverse faults and folds characteristic of the limbs of the syncline. In the middle period of the Cretaceous the sea invaded the basin of the Bakony area again. The coastal areas were characterised by *brackish-water* environments *(Tés Clay Marl),* whereas in the shallow-marine areas carbonate sedimentary environments came into being characterised by patch reefs which were inhabited by large-size bivalves and gastropods *(Zirc Limestone).* Due to the further sea level rise an open basin developed in which carbonate–siliciclastic sedimentation took place *(Pénzeskút Marl)* at the beginning of the Cenomanian Age, approximately 100 million years ago.

Formation of shallow-marine ridges and basins in the Late Cretaceous

In the early phase of the Cretaceous the Bakony area became a *continental terrain* again. Intense *tropical karstification* commenced and *bauxite* was formed under a warm and humid climate *(Halimba Bauxite).* In certain parts of the surface fluvial sediments were deposited, in which fossiliferous beds—rich in fossil *reptile* bones—can be found *(Csehbánya Beds).* In other areas swamps came into being, and coal deposits began to form *(Ajka Coal).* Subsequently, due to the gradual sea level rise, a shallow-marine environment evolved and this was followed by the development



Theoretical profile of the Late Cretaceous formations in the Bakony Mts (*Haas* ed. 2001)

of a *much deeper, open sea basin* in the area of the Bakony syncline; carbonate sedimentation and the deposition of fine siliciclastic material started about 85 million years ago *(Jákó Marl* and *Polány Marl).* Coevally, reefs were formed on the shallow-marine ridges which dissected the sea basins. These reefs *(Ugod Limestone)* were made up of *large-size bivalve molluscs* attached to the hard ground (hippurite rudists).

Denudation at the beginning of the Palaeogene and transgression in the middle Eocene

Compared to their earlier positions, the arrangement of continents and oceans significantly changed during the Cenozoic. The convergence of Africa towards Europe led to the gradual *closure of the Tethys Ocean* and the *orogenic folding of the Alpidic chains.* At the beginning of the Palaeogene (i.e. in the Palaeocene and in the early Eocene) there was a pause in sedimentation in the Bakony syncline, which had been formed in the Middle Cretaceous. This period was characterised by a *warm and humid climate* under which tropical karstification took place. Over the limbs of the Bakony syncline a several-hundred-metre-thick succession was eroded and in many places of the Bakony Mountains *karst bauxite* was formed.

Due to the transgression from the SW, the area of the *Bakony was invaded by the sea* in the middle of the Eocene, about 50 million years ago. Successions deposited in the coastal marshes comprise coal seams which are overlain by marine sediments of the inundating sea *(Csernye Marl).* Subsequently, the pelagic areas were characterised by the deposition of marl *(Csolnok Marl* and *Padrag Marl),* whereas in the uplifted areas shallow-marine carbonate sedimentation took place *(Szőc Limestone).* Eocene sediments are usually rich in fossils; beside bivalves and gastropods large foraminifers (among others nummulites) occur in rock-forming quantities.

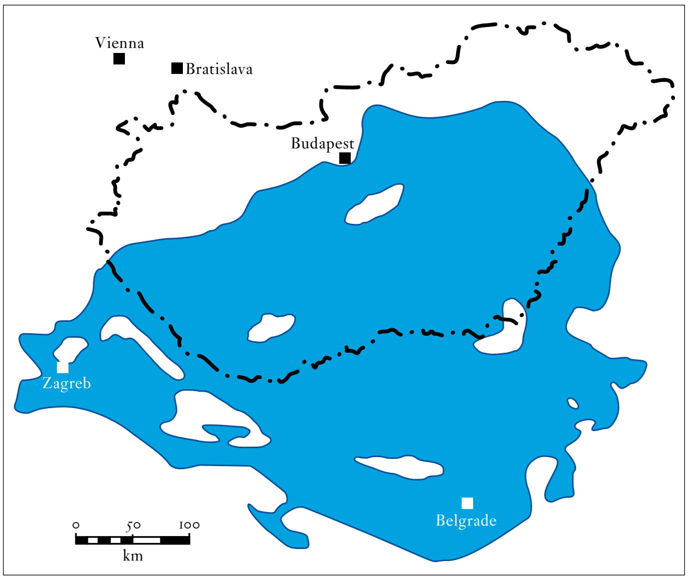
Denudation in the Oligocene and transgression in the early and middle Miocene

The Alpine orogeny was manifested in the closure of the seaways between the branches of the one-time Tethys and the world seas. In this period, the area of the Transdanubian Range belonged to the *Paratethys Sea*. During the Oligocene, as a result of the orogenic movements of the Alps, a series of basins of approximately E–W direction developed in Central and East Europe. These basins stretched from the northern foreland of the Alps towards the present Aral Lake. This series of basins were temporarily invaded by the sea or became flat plains due to fluvial deposition.

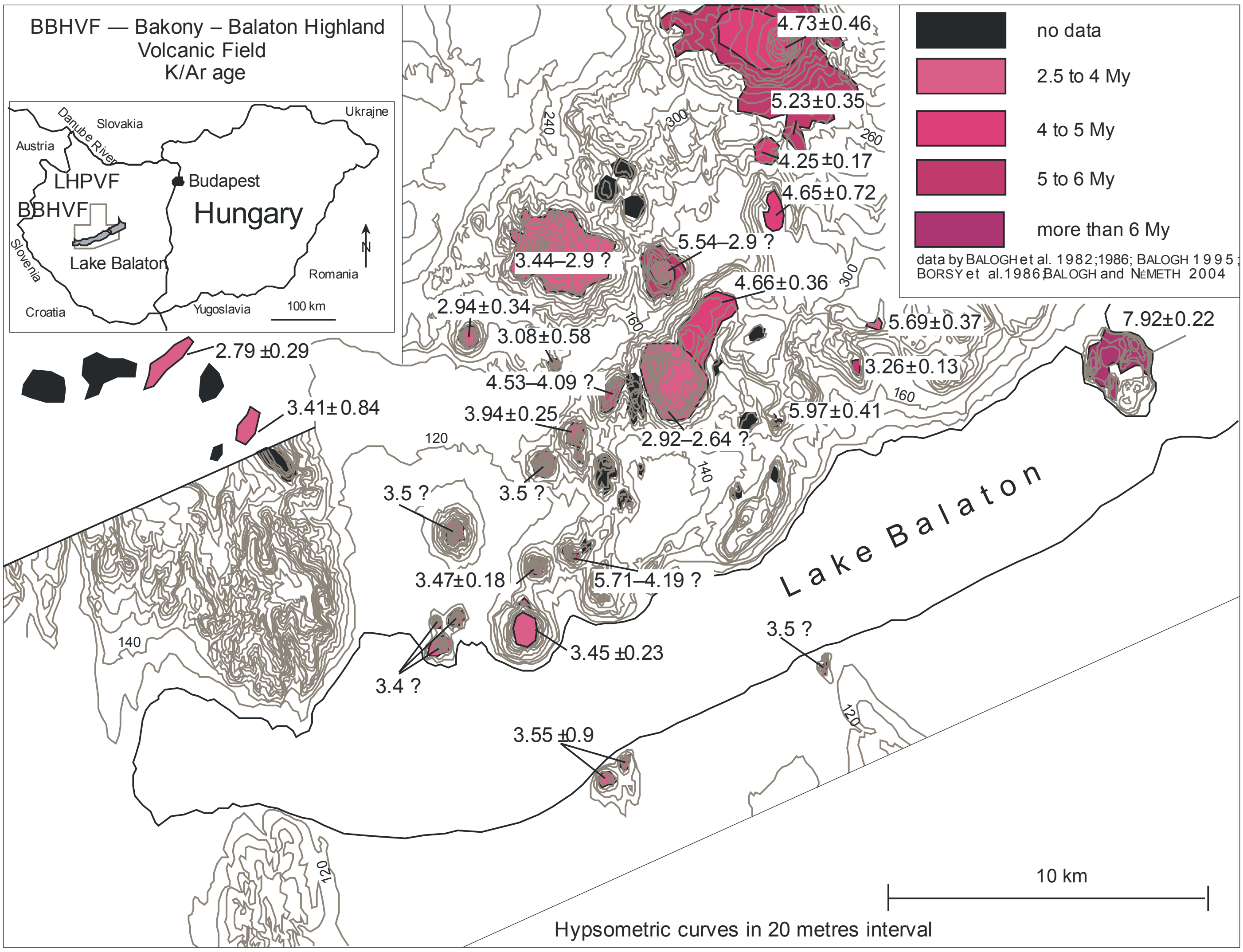
During the Oligocene and the early Miocene the Bakony area was a continental terrain, on which a clastic succession of a considerable thickness was deposited by rivers *(Csatka Formation)*. In a later period of the Miocene the sea invaded the basins which had been opened as a result of lateral tectonic displacements. Clastic and calcareous sedimentation took place in them. In the Várpalota Basin and the Herend Basin coal-bearing sequences were deposited in the middle of the Miocene *(Hidas Brown Coal)*. Middle Miocene shallow-marine limestones, which were formed 15–12 million years ago, are represented by the largest areal extent in the area of the Bakony Mountains and the Balaton Uplands. The *Lajta Limestone* of Badenian Age and the *Tinnye Limestone* of Sarmatian Age were deposited in a shallow-marine, reef archipelago environment, which was inhabited by a biota made up predominantly of bivalves, gastropods and protozoans (foraminifers).

The development of the Pannonian Inland Sea and the basalt volcanic activity in the late Miocene

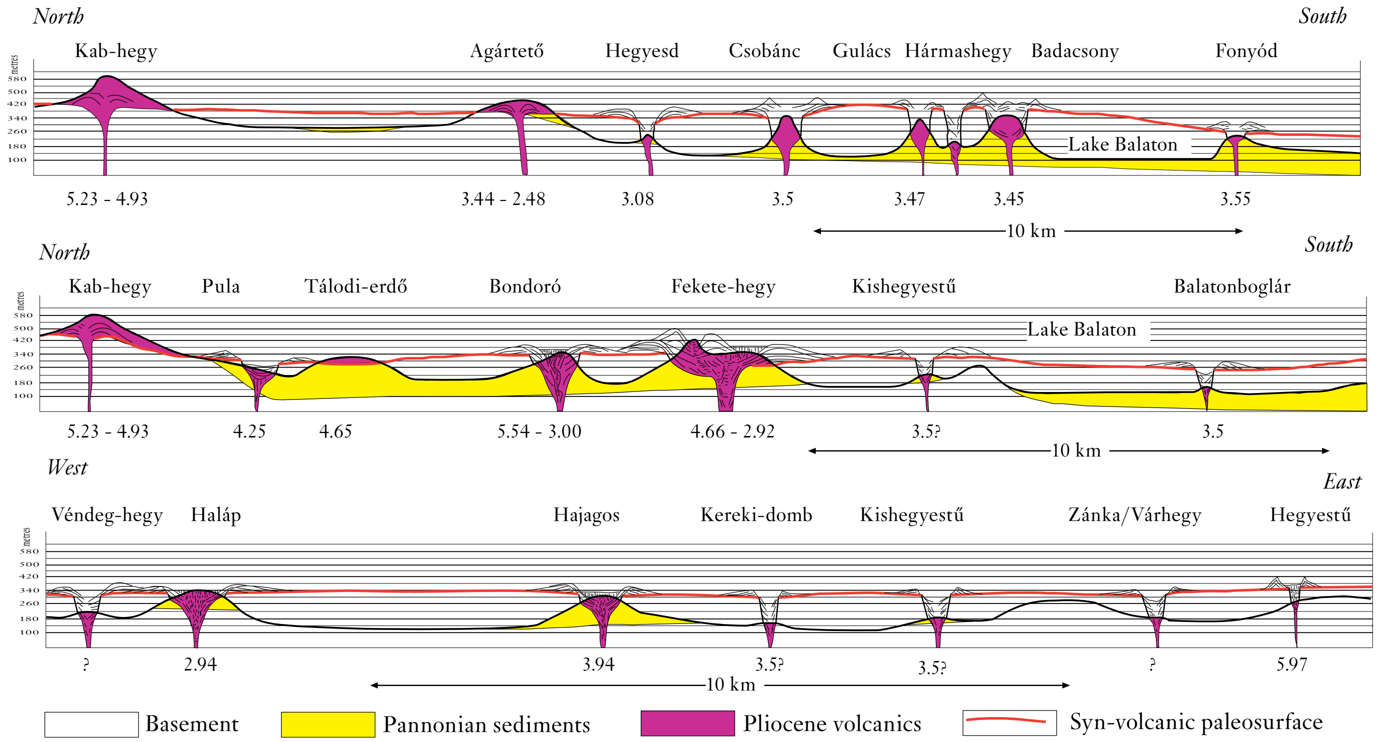
At the beginning of the late Miocene (approximately 11.3 million years ago) an *inland sea* came into being, which was separated from the other basins of the Paratethys Sea. It became diluted by the rivers running into it and, by the end of the Miocene, it was filled up with sediments transported by streams. The *Lake Pannonian* of a huge areal extent occupied the predominant part of the Carpathian Basin, and throughout 4–4.5 million years it covered the prevailing part of the Transdanubian Range and encircled its higher areas which rose above the water surface. Its characteristic sediments are wide-spread in the Balaton Uplands, in the Keszthely Mountains and in the Bakony Mountains, as well. On the southern slopes of the hills rising above the *'Balaton Riviera'* as well as along the hillside of the Keszthely Mountains the abrasional *Diás Gravel* can be traced; it outlines the wave-agitated shoreline of the lake. The type area of the sand and gravel deposits *(Kálla Gravel)*—which were transported by creeks and rivers running down from the increasingly elevating Bakony Mountains and spread over certain areas of the



Extent of the Lake Pannonian 9 million years ago



K/Ar age distribution map of the Bakony–Balaton Highland Volcanic Fields (after Balogh et al., Borsy et al., and Balogh & Németh)



Reconstruction of syn-volcanic (Pliocene) paleosurfaces (Németh K.)

Balaton Uplands—is the Káli Basin. In the internal parts of the Lake Pannonian basin and in the inlets fine-grained sand, silt and later clay and carbonaceous clay were deposited *(Somló* and *Tihany beds)*. In the calm water of the restricted basins separated from the lake by the ranges of the Balaton Uplands and the Bakony Mountains, lake marl was also formed *(Kapolcs Limestone, Nagyvázsony Limestone)*. Among *endemic molluscs* the most frequent bivalves of the Pannonian sediments are represented by the bivalve species of Congeria and Lymnocardium genera and a gastropod species which belong to the Melanopsis genus.

The last phase of the Alpine orogeny—in connection with the upwarping of the mantle, along faults within the crust—molten *basaltic lava* rose up to the surface and the development of *one of the most crowded volcano field* in Europe: almost *50 volcanoes erupted* in the area of the Balaton Uplands, in the northern foreland of the Keszthely Mountains and in the South Bakony, as well as along the rim of the Little Plain. The initial phase of the intense basaltic volcanism provided a small amount of pyroclastics and lava during the late Miocene. *Phreatomagmatic explosions* started at this time (approximately 8 million years ago) in the area of the Tihany Peninsula (the explosive nature is due to the hot magma with water or sediments of high water content). Subsequently, the predominant part of the volcanoes in the Balaton Uplands were characterised by a calmer activity producing *lava fountains* and *cinder cones*, nevertheless, the activity that produced lava flows was the most common one.

Volcanism in the Pliocene, continental sedimentation and denudation during the Pliocene and the Quaternary

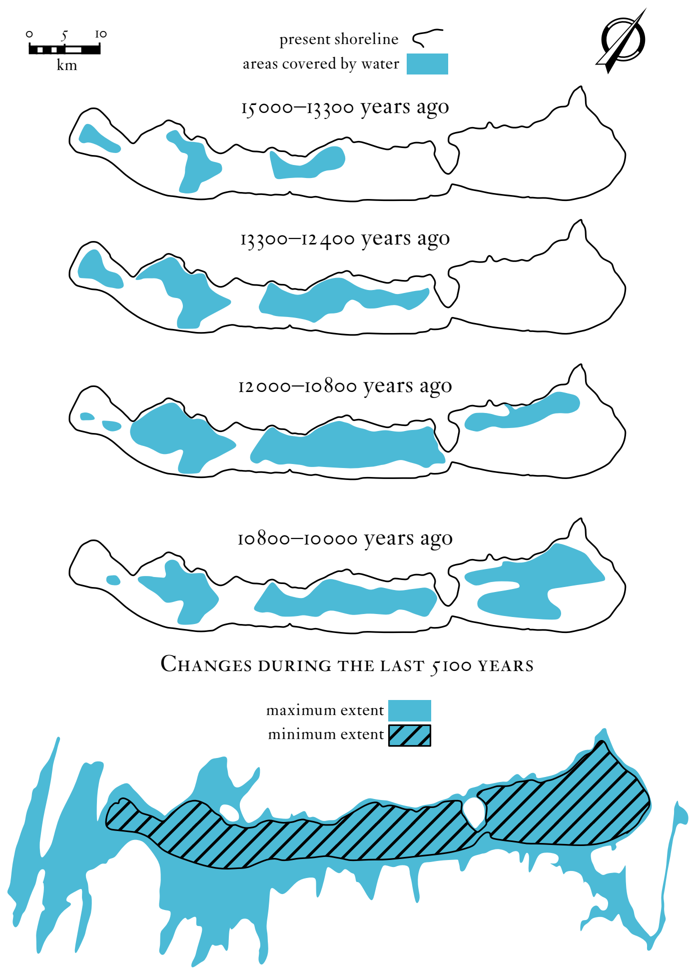
After the termination of the Pannonian sedimentary cycle the present relief of the Bakony Mountains began to form at the end of the Miocene. Earlier subsidence was replaced by *uplift* in a significant part of the area (hitherto the average value of the uplift amounts several hundred metres). This process manifested in the erosion of the previously deposited sediments. The evolution of the present network of *watercourses* and the development of the large *gorges* may have been started at this time.

Phreatomagmatic explosive volcanic activity started in the Tapolca Basin and Káli Basin over the Pliocene erosional surface. Extensive *lava fields* developed in the areas of the *Kab Hill* and the *Agár-tető*. In the lakes which came into being inside the tuff rings of the volcanoes, volcaniclastic deposits accumulated, or—under favourable conditions—thick, *lacustrine successions* were formed. The high organic matter content of the layers has been transformed into oil shale. Meanwhile denudation processes took place, thus erosional surfaces and different levels of the Pannonian sedimentary sequence have been overlain by the volcanic formations. In the northern areas of the Keszthely Mountains a significant part of the magma was trapped at shallow depths under the surface in the Pannonian strata.

Post-volcanic activity resulted in the formation of the well-known *geyserites* in Tihany. *Thermal springs* reached the surface along volcano-tectonic fractures. Carbonates and dolomitic sediments were precipitated from their water which was rich in dissolved substances. The subsequently precipitating silica saturated the lacustrine sediments. The formation of the *Lóczy Cave* (Balatonfüred) is also in connection with thermal water activity.

Strong *climatic fluctuations* during the Pleistocene created variable landforms and peculiar sediments. Due to frost disintegration, mainly slope debris accumulated on retrograding hillsides in the dry and cold periods (periglacial). In areas exposed to strong winds polished rock surfaces and faceted pebbles (ventifacts) were formed. During interglacial periods watercourses—fed by the abundant rainfall—carried a significant amount of *loose sediments* away. This led to the formation of the *basalt-capped volcanic remnant hills* in the Tapolca Basin, in the northern areas of the Keszthely Mountains and at the margin of the Little Hungarian Plain. A considerable amount of *debris* has accumulated in the piedmont areas, and in the mouth of the valleys large *alluvial fans* were formed. Warm climate was favourable for weathering processes and the formation of *red clays,* which have been preserved mostly in buried soil sections or in the form of cave deposits. During the last cold period (Würmian) the terrain was covered by a *loess* sheet. It is derived from aeolian dust and locally its thickness reaches 10–15 m. The increased rainfall during the Holocene favoured fluvial erosion; water courses incised gullies into the loose sedimentary surfaces and the alluvial fans have been disintegrated.

The evolution of *Balaton basin* (that is covered with water) took place in several phases. At the beginning of the Pleistocene (about 2 million years ago) small rivers and brooks running down from the Balaton Uplands towards the S could directly reach the depressions of the *Sárvíz* or the *Kapos*. The gradual deepening—resulted by multiple faulting of the Balaton basin—can be explained partly by tectonic movements (i.e. uplift of the surrounding area and the subsidence of the basin along faults respectively) and partly by the devastating effect (deflation) of the strong winds which were characteristic of the cold periods of the Pleistocene. The lake appeared at the end of this long process of several thousand years, approximately 15 000 years ago, in the so-called postglacial period of the late Pleistocene. At the beginning numerous shallow lakes—separated from each other —developed independently. As climate became more humid the water level increased. Ramparts



Development of the Lake Balaton (Cserny, T.)

which surrounded the small lakes were washed away by the waves, and *about 5000 years ago an uninterrupted water surface came into being.* The lake's present-day water level of 104 m a.s.l. has not been constant throughout historical times. Compared to its present-day position, the water surface — reaching a level of 112–113 m a.s.l. — occupied a much larger area in certain periods characterised by abundant precipitation. The areas of the Tapolca Basin and the *Nagyberek* were also covered by the water of the lake; the hills of Szigliget, Tihany and the hills of Fonyód were islands rising above the water. However, in warm and dry periods the lake shrunk and certain sub-basins became swamps or temporarily completely dried up. Due to human impact of modern history — as a result of artificial drainage — the western part of the lake became a swamp and the Kis-Balaton ('Small Balaton') has been formed.

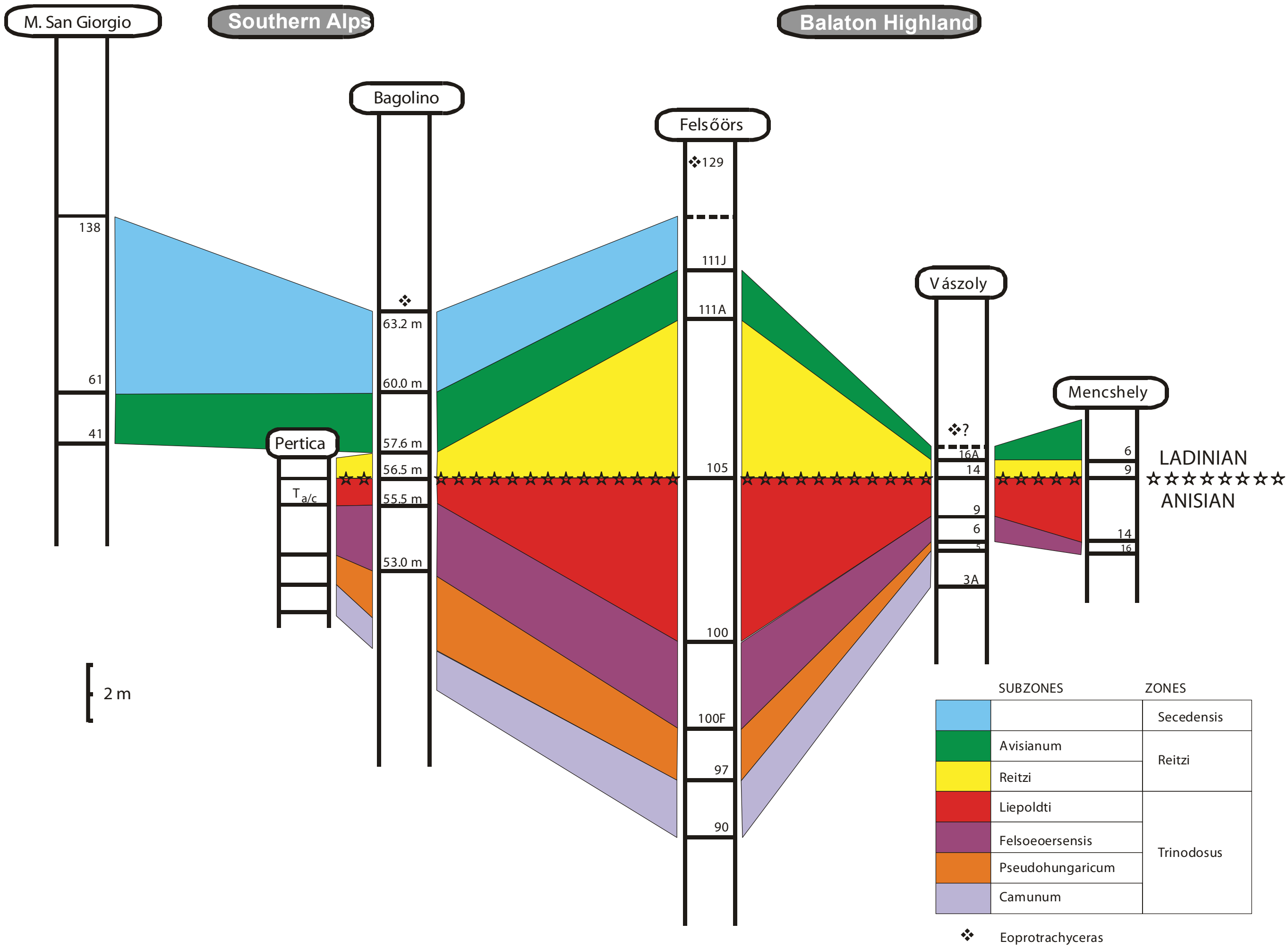
The significance of the Geopark and its most outstanding values

Due to the exceptionally favourable coincidence of the events in geological history, the Bakony–Balaton Geopark possesses peculiar local conditions. The rocks, fossils and geomorphology of the area (covering a square of side length 80 km) reflect the effects of geological processes of *almost 500 million years* from the Ordovician up to now, represented by more than a hundred excellent outcrops. Its outstanding geodiversity Europe-wide is due to the prevailing morphotectonic situation of the Bakony area — representing a *nappe of the Alps,* which had broken off and drifted to its present-day position. While the surface gradually rises from the Lake Balaton towards the NW, the deep structure forms a syncline. Consequently, due to the erosion, the Palaeozoic rocks (which make up the basement) are exposed on the south-eastern wing, in the vicinity of the lake. On the other hand, towards the axis of the syncline, the entire Triassic sequence crops out to the surface and on the ranges of the Bakony Mountains Jurassic and Cretaceous rock types of a great variety are exposed. This some-km-thick Mesozoic succession (including almost 50 formations) is overlain by Tertiary (mainly Eocene, Oligocene and Miocene) sediments in patches. The area has been eroded during the recurring erosional phases and the basement formations became visible on the surface; at the same time, locally, the cover beds have been preserved. Along the axis of the syncline (NE–SW), in the line of strike, a shift in facies of the one-time neighbouring areas can be observed within the rock types of the different geological ages. The fairly complex palaeogeographic setting has become even more difficult due to the impact of different tectonic movements. This peculiar geological and morphological build-up made the Bakony area *a giant geological puzzle.* The area of excellent conditions has been already studied for half a century by the participants of numerous international conferences on stratigraphy and palaeogeography. The area represents *one of the most exhaustively elaborated and well-published areas in Europe.* Among others, the *Anisian/Ladinian boundary at Felsőörs* is internationally noted; moreover, fifty further (mainly Triassic and Jurassic) key sections are regarded as references to the geological history of the Tethys.

The geology of the area became more diverse: the central part of the Bakony Mountains and the higher parts of the Balaton Uplands rose above the *Pannonian Inland Sea* of the late Miocene, forming islands with broken shorelines. Besides the diverse abrasional formations and morphology (Keszthely Mountains), the sediments of the filling inland sea of a decreasing salinity can be found at several places (Tihany, Balatonkenese, Fonyód). They are characterised by a definitely *endemic mollusc fauna.* Their preservation (a lucky coincidence again) is due to the final *basalt volcanism of the Pannonian Basin in the Miocene and Pliocene,* which resulted in the activity of about *50 volcanoes* in this area. The solidified lava cap protected the underlying Pannonian sediments from the erosion. As a result of phreatomagmatic eruptions *exceptional volcaniclastic successions* were formed (Káli Basin, Tapolca Basin and Tihany Peninsula); their scientific elaboration has still been carried out by international cooperation. Participants of the *Second International Maar Conference* organized under the sponsorship of the *IAVCEI (International Association of Volcanology and Chemistry of the Earth's Interior)* in the autumn of 2004 in Hungary also visited the area. In the Tihany Peninsula the *post-volcanic thermal water activity* has created geomorphologic values of European significance: almost one hundred spring cones rise in the area, and even spring caves have been preserved in some of them. Considering the rich geological heritage this was the *first announced landscape-protection area of Hungary in 1952.* The unique nature of the area (and National Park) has been acknowledged by the *European Diploma* of Protected Areas, which was granted by the Council of Europe to the area in 2003. The famous *"seas of stones"* of the Káli Basin has been sculptured by cementation processes due to subsurface waters and later erosion. Apart from this there is only one area in Europe with such exceptional features. The rock surfaces of the large blocks are pitted by small depressions, the so-called "gnammas" ('gnamma holes').

Vertical tectonic movements which intensified in the Pleistocene enriched the geological scenery. Spectacular *gorges* have been incised into the surface between the rapidly emerging blocks (Bakonybél, Balatonfüred, Csesznek, Veszprém), most of the extinct volcanoes became *volcanic remnant hills* (Badacsony, Szent György Hill). The panorama from the Szépkilátó at Balatongyörök provides a spectacular view of these hills. On their hillsides rows of gigantic (30–50 m high) basalt organ pipes (with a diameter of 1–2 m) can be traced over several hundred metres. Rocks underwent weathering-out by frost erosion in the Ice Age and *bizarre cliffs, concave rock walls* and *hogbacks* have been sculptured (Padrag Cliffs, Malom Valley, Tekeres Valley). *Loess* — which was deposited during the Würmian — has not covered the whole area; it has been eroded in the uplifting mountainous region and due to its redeposition it played a role in the evolution of the covered karst landscape (Tés Plateau, High Bakony). A new and determining element of the landscape came into being not more than some thousand years ago: the uninterrupted water surface of the *Lake Balaton.* 20–50-m-high bluffs have been formed in the sandy, Pannonian sediments by the swelling waves. Such features are missing from the shores of any European lakes.

Especially in a morphological and sedimentological point of view, other features of outstanding value in the Geopark are represented by the *palaeokarst* phases which can be traced from the Mesozoic. The process was strongly promoted by the geological build up of the mountains, i.e. the predominance of carbonate rocks. Palaeokarst phenomena can be observed already in the successions of Triassic marine limestones and dolomites (Litér, Sóly). The remarkable, fossil tropical karst features of the Bakony Mountains are in close connection with bauxite sedimentation from the end of the Cretaceous until the Eocene. As a result of the intense dissolution 50 m to 100-m-deep huge *dolines* and *sink-holes* came



Correlation of Felsőörs and other key Anisian/Ladinian boundary sections in the Balaton Highland and Southern Alps (VÖRÖS et al.)

into being about 100 million years ago (Iharkút). In the whole area of the Transdanubian Range the underlying rocks of the bauxite (which are predominantly made up of Triassic dolomite) are characterised by karstified surfaces, which have been exposed in the course of mining operations. Such a nature conservation area is the pit of an exploited bauxite lens at *Darvastó,* which stretches along 500 m and characterised by shallow dolines. The nature conservation area of the 30-m-deep, precipice-like palaeokarst at *Úrkút* also shows palaeokarst features. Because of its well-preserved one-time relief (due to the hand-held mining) and its peculiar oxidic manganese ore filling the site has gained a world-wide fame. The bottom of the dolines—which have been formed in the pink, Jurassic limestone—can be accessed by stairs. The area is designated as an exhibition site.

In the lower hall of the *Ördög-lik cave* (located near Dudar) the abrasional deposits of the one-time sea shore can be seen, which date back 50 million years. Similar sediments are exposed in a small cave of the *Cuha gorge,* where the karstified Triassic basement is also overlain by nummulitic limestone. Such an exposure in a cave has never been found on Earth.

The *Keszthely Mountains* represent an especially interesting *karst terrain.* In the vicinity of Cserszegtomaj and in the area of the Billege Forest near Uzsa cauldron-like dolines—with Miocene kaoline in them — have been exposed and in some cases their depth exceeded 100 m. The labyrinth-like system of passageways of the *Kútbarlang ('Well Cave')* running 50 m beneath the village of Cserszegtomaj, is a unique formation all over the world. The karstic *karrenfeld* of the Triassic dolomite (dissected by shallow dolines) is overlain by Miocene sandstone. Due to the subsequent thermal water activity a cave has developed at the boundary of the formations, thus the *negative image of the karst topography*—characteristic of the end of the Miocene—has been preserved.

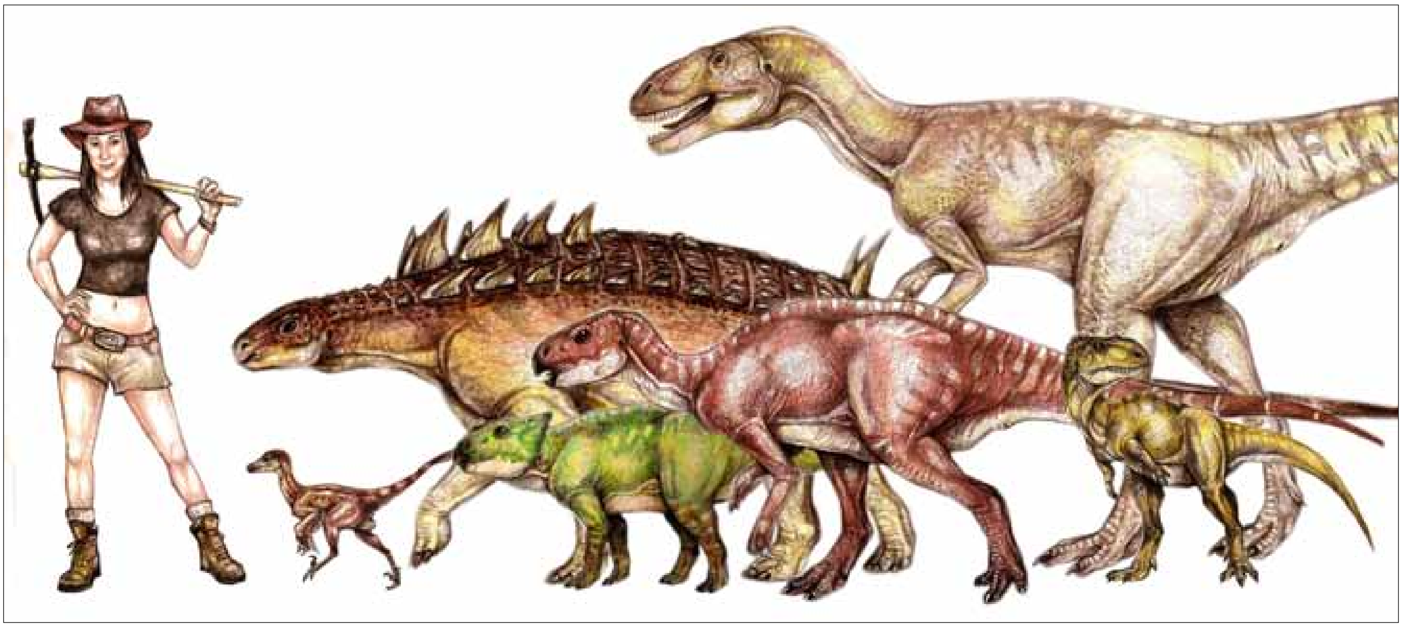
A dolomite terrain stretches between Veszprém and Várpalota and over the area in the vicinity of Ódörögd. It is characterised by old, *exhumed dolines* and *conical features* of a height of some tens of metres (however, their exact age is unknown).

Karst features developed at and under the rim of the basalt lava—which rests on the limestones of the *Kab Hill*—represent a different type of forms belonging to the "basalt karst". An exceptionally spectacular sinkhole is the so-called Macskalik, which is related to rock boundaries.

The more than *700 caves* of the mountains are the touchable evidences of a strong subsurface karstification. Most of them are *senile remnant caves;* nevertheless, some of them contain valuable palaeokarstic fills. Caves developed in *basalt,* as well as in *siliceous sandstone.* Mostly the Keszthely Mountains are characterised by caves, which came into being by the combination of spherical niches formed by *thermal waters.* The strictly protected *Lóczy Cave* with free public access is of the same origin. The *Lake Cave of Tapolca* was also formed by lukewarm waters. Every year more than 100 thousand visitors make boat trips in it under the streets and houses of a town. The neighbouring *'Hospital Cave'* is used in the

One of the most dramatic landscapes of Hungary: volcanic remnant hills in the Tapolca Basin

treatment of respiratory tract infections.
It is worth mentioning the *Csodabogyós Cave,* which was formed along huge *tectonic fissures.* Its upper section is opened for candidates for adventure tours in caving overalls. The several hundred-m-long, narrow passage system of the *Szentgáli-kőlik Cave,* which was formed by vertical fractures in well-bedded *Main Dolomite,* is also accessible to the public. The approximately several hundred young sink-hole caves can be found mainly in the covered karst of the *Tés Plateau.* The karst water system in the Mountains is fed by narrow *shaft caves* (Csengő, Háromkürtő and Jubileumi Shafts) reaching a depth of more than a hundred metres.
The extraordinarily rich palaeontological record, which can be found partly in the collection of the *Bakony Natural History Museum in Zirc* and partly in collections of Budapest, is due to the long geological time and the great variability of facies represented by the rocks of the Geopark. Without claim to completeness only some particular findings and localities are mentioned here. First of all, the *"flat-plate turtle"* (Placochelys) should be mentioned; it was a world sensation at the time of its discovery. Such a fossil reptile has never been discovered earlier. *Placochelys placodonta* was a reptile which possessed an armoured shell and lived in the Late Triassic.
Successions in the Balaton Uplands are extremely rich in different Triassic fossils. Fossils (mainly ammonites, brachiopods and bivalves) — among which numerous finds have been described from this area — have been studied by Hungarian and foreign palaeontologists for a century. Fossils could aid in reconstructing the palaeogeographic relationships between the Bakony and the Alp–Mediterranean area. Ammonites and brachiopods derived from the Bakony Mountains also play a significant role in the international research on Jurassic. Biostratigraphic studies which have been continued at *Lókút* and *Hárskút* (Bakony Mts) promoted the correlation of these sediments with similar formations in Europe. Simultaneously, palaeontologists performed detailed examinations of other groups (brachiopods, bivalves, gastropods, conodonts and radiolarians). There are further 'curiosities' represented by *fish remains* derived from the *manganese-bearing sequence at Úrkút.* Sediments of the Cretaceous Period also yield a rich fossil record; besides ammonites (at Pénzesgyőr) first of all the shallow-marine fauna is worth mentioning. The reef-forming pachiodont bivalves (Hippurites) at Sümeg, reaching a size of 1 m, and the well-known coral "Cyclolites" are not only notable but also very spectacular. A fossil turtle of Late Cretaceous age has also been found here. The *Eocene* subtropical shallow-marine environments of the Bakony area were *extremely rich* in living creatures with calcareous skeleton: bivalves, gastropods, corals, echinoids and the gigantic protozoans, among others the nummulites lived there. Hungarian foraminifer studies are well-known all over the world just like the investigations focused on the very well-preserved *Miocene mollusc fauna of international importance* found in the sand pit at *Várpalota.* It was highly commended also by the participants of the *International Palaeontological Regional Meeting* (1928) held in Hungary (in the town respectively), the *Colloquium on Neogene Stratigraphy* (1969) and the *Neogene Congress* (1975). The locality is a protected area, which has been designated as a geological exhibition site. It yielded *more than 400 bivalve and gastropod species.* Due to its characteristic shape, the bivalve *Congeria ungulacapræ* became famous world-wide among the endemic bivalves of the Pannonian Inland Sea of decreasing salinity. Besides the *"goat hooves" of Tihany* further bivalve and gastropod species can be found in the key section of the Fehér-part; these species can be found exclusively in the Carpathian Basin. Almost the whole skeleton of a *fossil rhino (Stephanorhinus megarhinus)* and fragmentary remains of half a dozen further specimens have been found in the oil shale at *Pula.* These finds are of European importance among the fossil vertebrate remains. Besides leaf impressions this peculiar locality (the laminated sediments of a maar lake) yielded thousands of fossilized *fishes* and some *insect* remains.
Last but not least, from a palaeontological point of view the most valuable site is the *dinosaur locality at Iharkút* (High Bakony), which was discovered a decade ago. Its *international importance* is confirmed by the paper about a new dinosaur species described from here; it was published last year in the journal *Nature.* The Late Cretaceous (85 million years old) sandy-clayey sediments of fluvial–alluvial plain facies are approximately 10 million years older than those of the localities in France and Romania. Thus, fossil vertebrate remains found here are unique all over the world. Based on more than 10 000 isolated bone and tooth remains the presence of 30 (!) vertebrate groups could have been revealed by the ongoing research work, so far. Skeletons of *armoured dinosaurs (Hungarosaurus tormai),* fossil remains of *herbivorous* and *carnivorous dinosaurs, fish, amphibians, turtles,* and the Mosasaur find (of fresh-water habitat), *land lizards, crocodiles* (i.e. the extraordinary, heterodont *Iharkutosuchus makadii),* the jaws of flying reptiles — the pterosaurs *(Bakonydraco galaczi)* and the bones of ancestral-type birds have been collected. Based on the studies of bivalves, gastropods and the plentiful fossil plants (fruits, leaves, flowers and trunks) which were found together with the above-mentioned finds, the entire ecosystem can be reconstructed.
From the geological history of the Geopark Man should not be ignored… Two *flint* and *chert mines* of European significance can be found in the area. People of the *Neolithic Age* mined the excellent Cretaceous chert with the help of tools made of antlers. The radiolarite mine of Jurassic age — which had been extracted for some thousand years — was encircled by 8 settlements of the Bronze Age near *Szentgál.* Stone blades found here are known from archaeological records from areas over the Carpathian Basin. Based on investigations the excellent material has been transported even *to the area of the present-day Benelux states* and to the surroundings of the Baltic Sea. In the neighbouring cave (Szentgáli-kőlik) human skeletons, large urns and a Moon idol have been found dating from the Bronze Age. These finds indicate that this site may have been a cultic burial-ground. Half a dozen of further small caves (for example the Odvaskő Cave, Öreg-Szarvadárok Cave, Csesznek Cave and Nagy-Pénzlik) yielded different remains of the prehistoric man.

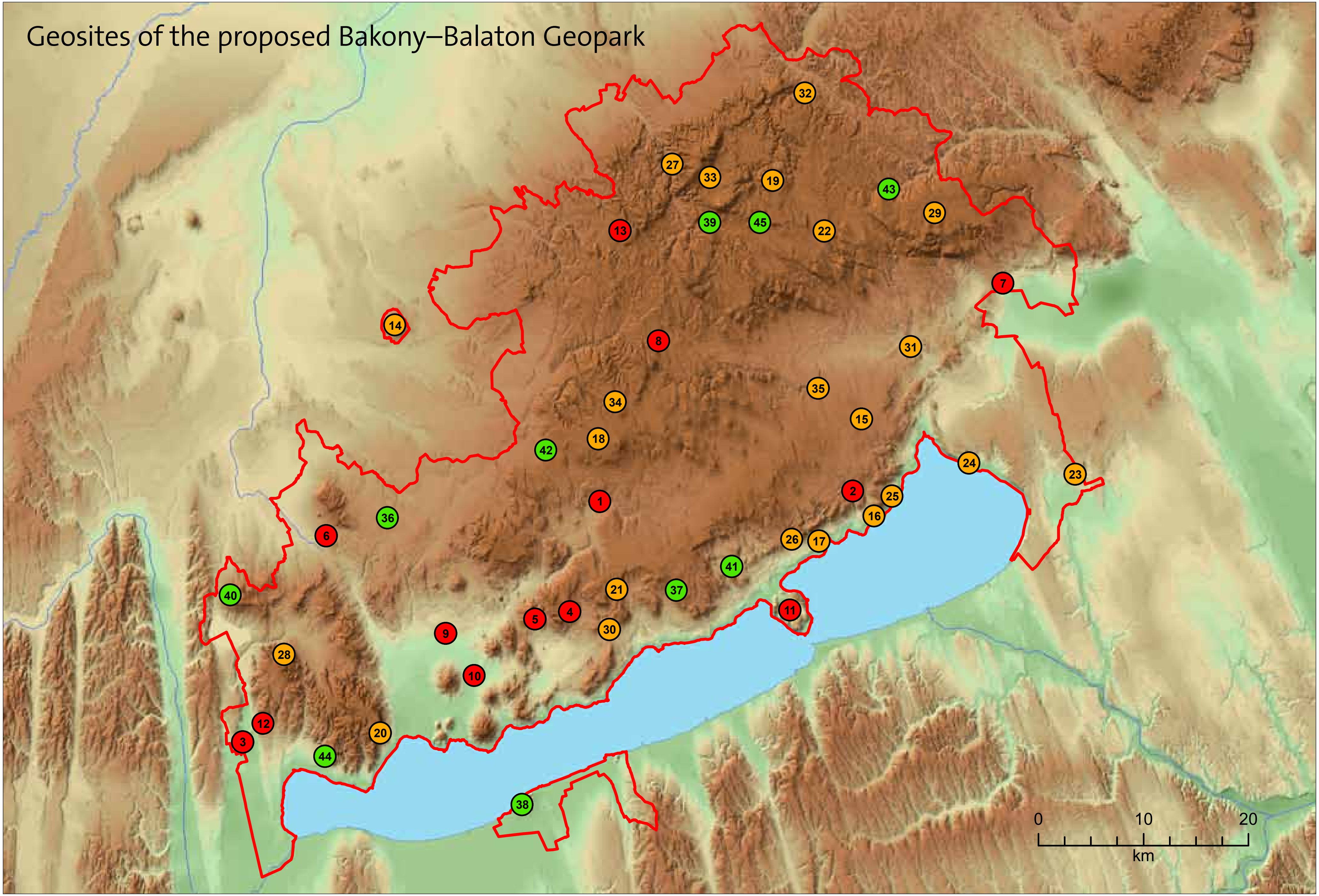


Size-scaled gallery of the six Hungarian dinosaurs discovered in Iharkút. The generally small size of these 85 million years old animals is explained by the isolation of the Hungarian fauna during the Cretaceous (drawing by Tibor Pecsics)

B.3. Listing and description of geological sites, details on the interest of these sites

Id	*Name of the geosite*	*Site type*	*Importance*	*No access*	*Scientific*	*Educational*	*Touristic*
G-01	Volcanoes of the Eger-víz valley	G/N/C	INT		x	x	x
G-02	Felsőörs, Anisian–Ladinian boundary on Forrás Hill	G	INT		x	x	x
G-03	Lake Hévíz	G/N/C	INT		x		x
G-04	Volcanoes of the Kál Basin	G/N/C	INT		x	x	x
G-05	Seas of stones in the Kál Basin	G/N/C	INT		x	x	x
G-06	Sümeg Mogyorós-domb Nature Conservation Area	G/C	INT		x	x	x
G-07	Várpalota Sand Pit Nature Conservation Area	G	INT		x	x	x
G-08	Szentgál, prehistoric chert mines, cave, etc.	G/C	INT		x	x	x
G-09	Lake Cave of Tapolca	G	INT			x	x
G-10	Volcanic remnant hills in the Tapolca Basin	G/N/C	INT		x	x	x
G-11	Tihany Peninsula	G/N/C	INT		x	x	x
G-12	The Kút (Well) Cave in Cserszegtomaj	G	INT	x	x		
G-13	Iharkút Cretaceous dinosaur locality	G	INT	x	x	x	
G-14	Somló Landscape Protection Area	G/N/C	NAT		x	x	x
G-15	Szentkirályszabadja, the Middle Triassic of the „airport quarry”	G	NAT		x	x	
G-16	Alsóörs, key section of the Alsóörs Metarhyolite	G	NAT		x	x	
G-17	Csopak, Permian–Triassic boundary	G	NAT		x	x	
G-18	Kab Hill, Basalt-covered karst	G/N	NAT		x	x	x
G-19	Zirc, road to Borzavár, cross-bedded crinoidal limestone	G	NAT		x	x	
G-20	Csodabogyós Cave	G	NAT		x	x	x
G-21	Balatoncsicsó, the Triassic of the Csukréti ditch	G	NAT		x	x	
G-22	Olaszfalu, Eperjes Hill geological key section	G	NAT		x	x	x
G-23	Balatonfőkajár, quartz phyllite on the Somlyó Hill	G	NAT		x	x	x
G-24	Bluff at the Lake Balaton and Pannonian beds	G/N/C	NAT		x	x	x
G-25	Balatonalmádi, Permian key section of the Lake Köcsi quarry	G	NAT		x	x	x
G-26	Balatonfüred, Koloska Valley and Lóczy Cave	G/N	NAT			x	x
G-27	Bakonyszücs, Odvas-kő and its caves	G/N/C	NAT			x	x
G-28	Key section of the Rezi Dolomite, hydrothermal caves	G/N/C	NAT		x	x	x
G-29	The karst area of the Tés Plateau	G/N/C	NAT			x	x
G-30	Monoszló, the volcanic neck of the Hegyestű, geological demonstration site	G	NAT		x		x
G-31	Hajmáskér, Berek-hegy Limestone	G	NAT		x	x	
G-32	Csesznek, Fortress Hill	G/N/C	NAT			x	x
G-33	Bakonyszücs–Fenyőfő, Százhalom: mound graves, sink-hole, brook meanders	G/N/C	NAT			x	x
G-34	Úrkút Palaeokarst Nature Conservation Area	G	NAT		x	x	x
G-35	Veszprém: meandering gorge in the town	G/C	NAT			x	x
G-36	Darvas-tó Exploited Bauxite Lens Nature Conservation Area	G	REG		x	x	
G-37	Dörgicse, Kő Hill	G/N	REG		x	x	x
G-38	Fonyód, Fortress Hill	G/C	REG		x	x	
G-39	Pénzesgyőr, Kerteskő Gorge	G/N	REG		x	x	x
G-40	„Basalt street”, Kovácsi Hills	G/N	REG			x	x
G-41	Pécsely, quarries on the Meggy Hill	G	REG		x	x	x
G-42	Ajka, Padrag cliffs	G/N	REG			x	x
G-43	Bakonynána, Roman Bath: gorge with waterfall, cave, geological key section	G/N	REG		x	x	x
G-44	The Vadlány-lik (Cave) in Gyenesdiás, key section of the Diás Formation	G	REG		x	x	x
G-45	“Cockpit karst” near Zirc	G/N	REG		x	x	

Legend | ***Site type:*** *G - geological, N - natural, C - cultural/historical*
Importance: *INT - international (red circle on the map), NAT - national (orange circle), REG - regional (green circle)*


Geosites of the proposed Bakony–Balaton Geopark
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Volcanoes of the Eger-víz valley (G-01)

Spindle bomb at the foot of the slope of the Agár-tető crater

The picturesque valley of the *Eger-víz* leads along an extremely diverse volcanic area. The largest volcano of the Bakony–Balaton Uplands Volcanic Field (BBUVF), i.e. the *Kab Hill* rises above its source region. The *Pula maar crater* can be found on its southern slope. The volcanic mass of the *Fekete-hegy* and the maar volcano of the *Bondoró* are divided from one another by the gorge-like section of the valley beneath *Kapolcs*. The valley—which widens below—is bounded by the also volcanic *Sátorma* on the South and by the *Agár-tető* on the North.

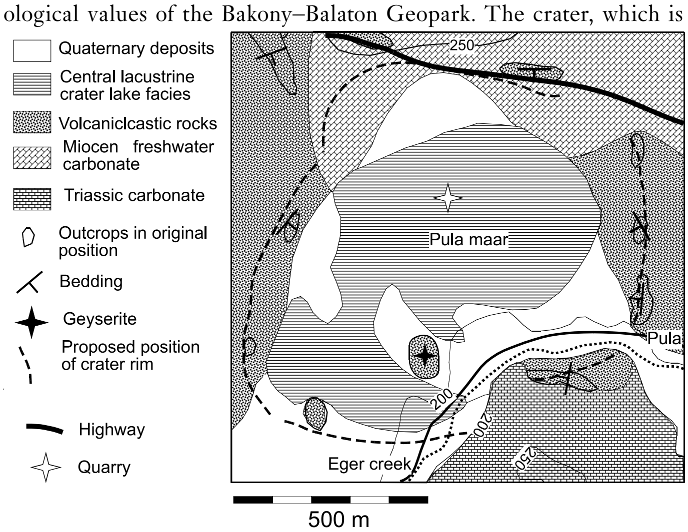
A lot of visitors come to see the spectacular basalt "bastions" of the *Királykő* above Kapolcs. The studied nearby outcrop reveals a considerably varied pyroclastic succession. The youngest maar volcano of the BBUVF, i.e. the 2.3-million-year-old Bondoró, rises opposite to it. The cone, which was built on the lava plateau, was formed due to scoria eruption and lava fountaining activity, resulting in small-volume lava

The columnar jointed basalt outcrops of Királykő, near the village of Kapolcs

flows. Spindle bombs as well as mineral and rock inclusions (olivine, lherzolite) derived from the mantle are frequent.

Agár-tető is a lava plateau of a diameter of 8 km; its activity lasted for a long time (5–2.8 million years ago). The still relatively intact crater rises on its north-western part. On its outer, steep slope and at the foot of the slope small lava flows can be identified.

The *maar* of a diameter of 800 m near Pula is one of the significant geological values of the Bakony–Balaton Geopark. The crater, which is



Simplified geological map of the Pula maar (Németh)

Fossil remains of a Stephanorhinus megarhinus renoceros, exhibited in the Natural History Museum of Bakony, Zirc

thinly covered with young sediments, is *filled with organic-rich lacustrine deposits* of a thickness of a few tens of metres. The oil shale—made up predominantly of *brown algæ,* and described as *alginite*—was penetrated by 40 exploration drillings which helped in the reconstruction of the palaeomorphology of the maar crater. The eruption may have taken place 3.9–4.5 million years ago. Periodically, sand- to pebble-sized *basalt debris* (derived from the tuff ring at the crater rim) spilled into the lake. These layers show spectacular load pressure and slump structures, as well as graded bedding.

A small quarry was opened for the exploitation of alginite; it makes the study of the rich flora and fauna of the succession possible. According to examinations the climate was warmer than it is today and was characterised by 1000 mm annual precipitation and the alternation of dry and wet seasons. The quarry has yielded nearly a dozen, fragmentary fossil remains of *rhinoceros* and an almost intact, 3-metre-sized specimen *(Stephanorhinus megarhinus).* The thousands of *fish remains* found in a bed are also important.

Felsőörs: Anisian–Ladinian boundary on Forrás Hill and the Szent-Kereszt Hill rock rib (G-02)

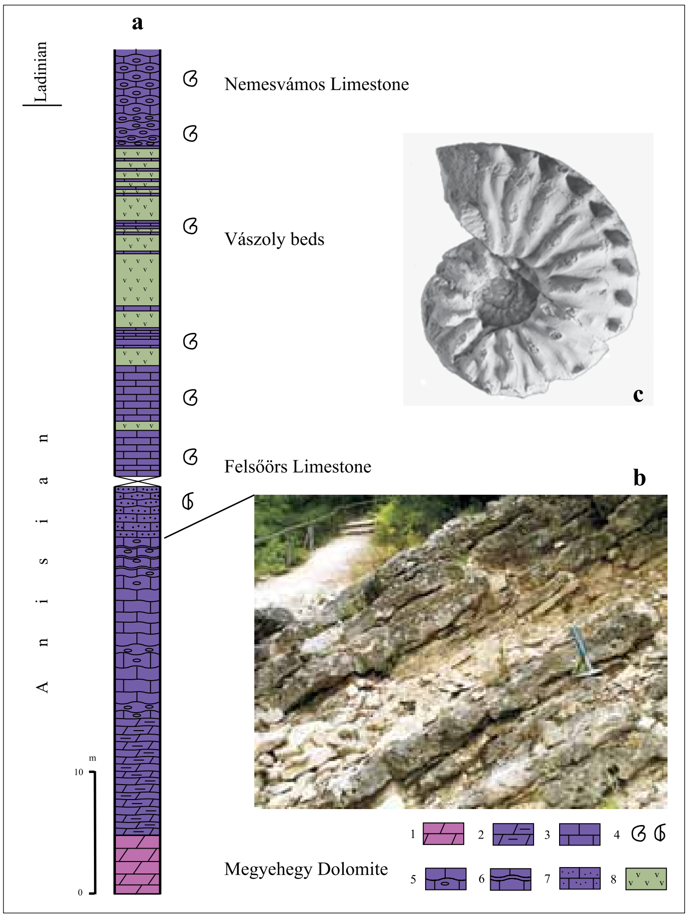
The upper part of the Forrás Hill section, protected by a canopy

The *oldest* and *most well-known* and *world-famous geological key section* in the Balaton Uplands can be found in the northern outskirts of Felsőörs, on the side of the Forrás Hill. The key section, in which a geological nature trail was developed recently, exposes the 242–238-million-year-old *Middle Triassic succession* ranging from the Middle Anisian up to the Middle Ladinian. The main geological events of this period are presented in tables which are set up along the section.

Near the stairs—which to the lower section—the uppermost beds of the *Megyehegy Dolomite* can be studied. It is overlain by a poorly-bedded marly dolomite, which can be seen along the path. The latter is overlain by the *Felsőörs Limestone;* its lower section is made up of thick-bedded limestone comprising chert nodules. Above this, the end of the lower section is made up of marly, poorly-bedded limestone, which contains crinoidal and brachiopod remains.

At the beginning of the upper section, the uppermost, well-bedded, bituminous and ammonite-rich part of the *Felsőörs Limestone* can be seen. The light green tuff layers of the overlying *Vászoly beds* are dissected by yellowish-brown, siliceous limestone layers and lenses. The lower part of the overlying *Nemesvámos Limestone* is made up of light grey, upwards pale red, considerably hard, siliceous, thick-bedded and nodular limestone which contains red chert. According to the studies on ammonites, radiolarians and ostracods, the sediments were formed during the Middle Triassic in an increasingly deepening open sea, where the deposition of carbonate mud was interrupted by submarine tuff explosions of shorter or longer durations.

The international reputation of the Felsőörs section is due to *biostratigraphic studies based on the very detailed, bed-by-bed examinations of different*



The profile of the Middle Triassic geological nature trail on the Forrás Hill in Felsőörs (a), the lower section of the Felsőörs Limestone (b) and a characteristic ammonite from the succession (c): Kellnerites felsoeoersensis (Budai 2006). Legend: 1. thick-bedded dolomite of shallow-marine ramp facies; 2. bituminous dolomite; 3. limestone; 4. ammonite, brachiopod; 5. nodular cherty limestone; 6. nodular limestone with marl intercalations; 7. crinoidal limestone; 8. tuff, tuffite

Rock rib made up of the nearly vertical beds of the Iszkahegy Limestone on the Szent-Kereszt Hill

fossils. With the help of ammonites, radiolarians, conodonts and phyto-spores the boundary between two stages of the Middle Triassic (i.e. Anisian and Ladinian) could be exactly defined. Such a detailed-studied and multilaterally elaborated section is scarcely known in the Alpine region.

On the side of the *Szent-Kereszt Hill* a vertical rock rib extends over the valley. The beds, which are set on their edge due to tectonic movements, belong to the Middle Triassic *Iszkahegy Limestone*. The dark grey rock was formed at the low-energy, poorly-ventilated bottom of a lagoon which was restricted from the open sea.

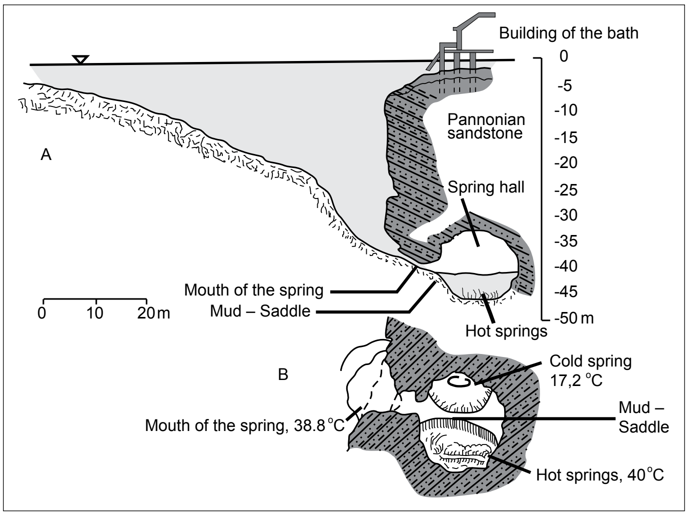
Lake Hévíz (G-03)

Lake Hévíz is *one of the most well-known geosite* of international importance in the Bakony–Balaton Geopark. The extremely large number of visitors is due to its *warm, medicinal water,* which has been utilized for centuries. Despite of its built-up, artificial environment it is a unique natural formation.

Europe's largest warm lake was formed in the so-called Pannonian sandstone *(Somló Formation)* of Late Miocene age, in the fault zone that has formed the edge of the Keszthely Mountains. Its formation is associated with considerably interesting hydrogeological conditions, as the water of the lake is derived from a 17 °C cold spring and a 39 °C hot spring. Water gushes out from the two springs into a spring cave at a depth of 45 m under the water level. Due to the different discharges, the mixing of

these waters produces a 38.8 °C temperature of the emitted water. Although the cold and warm springs are located next to each other, their waters have different flow routes from the infiltration area right here. Cold water travels a relatively short way under the surface. A part of the karst water of the predominantly Upper Triassic dolomite mass of the Keszthely Mountains (which is located E of Lake Hévíz) reaches the surface here. Two-thirds of the area of the mountains belongs to the infiltration area of the lake. Based on studies in connection with the age of the spring water, the cold water travels a few thousand years from the infiltration area to the spring.

Warm water travels a much longer distance as it is indicated by its age of tens of thousands of years; it has warmed up on its way in the subsurface carbonate rocks of the Transdanubian Range. The long, detour flow route of waters infiltrating in the western and south-western parts of the mountains, can be found at a depth of several km and is designated by the flow directions determined by the impermeable Upper Triassic and Cretaceous marls. At the end of this flow route water reaches the surface through the thermal spring of Lake Hévíz.



Section and bird's-eye view of Lake of Hévíz and the its spring cave (Ember)

Volcanoes of the Káli Basin (G-04)

Almost all volcanic formations, forms and phenomena of the Bakony–Balaton Volcanic Field can be found in the relatively small area of the Káli Basin. Due to the various types of erosion, *volcanic structures* represent different erosion stages.

In the deepest part of the basin the remains of small diatremes such as the *Lapos-Hegyes-tű, Kis-Hegyes-tű, Harasztos-hegy* and the *Kereki-domb* can be seen. The material of the latter is made up of *unsorted lapilli tuff* which steeply (>60°) dips eastwards. The unusually steep dip was caused by the collapse of the crater rim which subsided into the deeper zone of the crater.

The small crest of the *Harasztos Hill*—which can be seen a few metres above its surroundings—is built up of coarse-grained, unbedded and unsorted lapilli tuff. The similarly steeply-dipping pyroclastics are penetrated by lava rocks of radial columnar jointing.

The 8–9 km^2 large area of the basalt plateau has developed by the amalgamation of four eruption centres. Its shape—rising up above its sur-

Overview of the Szentbékkálla outcrop exhibiting a phreatomagmatic pyroclastic flow unit (lower part) overlain by dilute base surge deposits

roundings—and its formation is similar to those of the volcanic remnant hills of the Tapolca Basin. The one-time *maar craters* of the volcanic plateau were filled with the basalt of lava ponds and spatter cones. Depressions of an average diameter of 100 m can be found on the plateau. They are shallower than 10 m and characterised by small pools with peculiar living assemblages. The low ridges which divide them are probably the remains of one-time *lava flows*. The rim of the southernmost crater is cut by the *Vaskapu Valley* exposing the cooling structure of the lava flow which piled up in the internal side of the former tuff ring. The final stage of volcanism was characterised by *scoria eruptions*. Its most beautiful example is represented by the

Pyroclastics of the Szentbékkálla outcrop (with peridotite xenoltits and pre-volcanic lithics)

Boncsos-tető, which rises 90 metres above the plateau. The one-time cinder cone is made up of porous, red and grey scoriaceous basalt.
The intact cinder cone of the *Kopácsi Hill* is only 2.61 million years old; a 2-km-long pyroclastic flow of an earlier eruption event may have started from here. Its material, which filled the one-time valley above Szentbékálla, can be well studied in an outcrop, too. Both the central, unbedded facies and the bedded, marginal one can be seen. Locally the gas escape channels are also visible. The periglacial rock-stream on the northern slope of the *Kő Hill* is also notable.

'Seas of stones' in the Káli Basin (G-05)

Near Szentbékkálla the most preserved 'sea of stone' can be seen

One of the targe-sized 'bird baths' (gnamma holes)

The most well-known and most famous geological formations, geomorphologic features of the Káli Basin are represented by the *gigantic boulders and groups of cliffs* which are strongly *cemented by silica*.
The seas of stones were formed by the subsequent cementation of *sand, pebbly sand* and *gravel* beds which had been deposited in the *Lake Pannon*. The *Kálla Formation* is built up of deltaic sediments of rivers coming from the Bakony and deposits of the near-shore currents which moved the deltaic sediments. The gigantic blocks cemented by silica and representing the material of the seas of stones can be found within the sand beds. They became exposed on the surface by the erosion of the overlying, non-cemented layers. The reason why silicification took place, the time when it happened and the formation of the seas of stones have long been debated. On the basis of a new theory the cementation process is similar to that of the Fontainebleau Sandstone in the Paris Basin. According to this they have been formed due to the dissolutional effect of infiltrating water and as a result of precipitation from solutions in the phreatic zone, near the local base level of erosion. Loosing their support, these peculiar-shaped blocks have often been tilted from their original position. One of them "functions" as a balanced rock. The formation of shallow depressions and hollows on the rock surfaces is not clear either. A part of them may have been formed due to the weathering effect of the organic matter (that accumulated in the meteoric water in the hollows) and of lichens and mosses. These water-filled depressions (gnamma holes) are mentioned by their colloquial name i.e. *'bird baths'* in the specialized literature. The bare rock surfaces are locally characterised by corrasional forms, i.e. shallow blowouts and strongly polished and faceted surfaces. Broken and polished quartz pebbles are also characteristic on the surfaces of the conglomerate beds.

"Geological Paradise" in the surroundings of Sümeg (G-06)

Field trip for geologist students at the Mogyorós Hill Nature Censervation Area

Besides its cultural and historical sights (i.e. medieval castle, former Episcopal see, etc.), Sümeg is famous also in a geological point of view. The *Sümeg Mogyorós-domb Nature Conservation Area* reveals several rock types of the Bakony. On the SE the *Dachstein Limestone* and the *Kardosrét Limestone* is found, which represent Late Triassic – Early Jurassic age. Towards the NW they thrust over the Middle Jurassic *Lókút Radiolarite.* It is adjoined by the Upper Jurassic *Pálihálás Limestone* (ammonitico rosso) which is overlain by the key section of the *Mogyorósdomb Limestone* (passing up into the Lower Cretaceous). The younger carbonate rocks of Cretaceous age (i.e. *Tata Limestone, Ugod Limestone)* are revealed by partly still active quarries. On the surface — smoothened by the Eocene and Miocene abrasion — a part of the beds can be found in a vertical position. This made it possible to designate a long geological key section here. The marvellous ancient flint mine was discovered in the course of the preparatory works. The laminated limestone contains chert nodules, which were mined with tools made from deer antlers 5 000 years ago. A part of the prehistoric galleries functions as a geological exhibition site and is *protected by canopies.*

The abandoned *Sintérlap quarry* demonstrates the boundary between the Upper Cretaceous Tata Limestone and the overlying Ugod Limestone also in a key section. The latter locally contains the skeletons of large-sized reef-building bivalves called rudists. The better understanding of geological events is supported by a nature trail.

The neighbouring, reclaimed *Kecskevár quarry* yielded the 30-cm-sized skeleton of a turtle (Senonemys sümegensis) of Late Cretaceous age. Cretaceous limestone is being quarried in the *Gerinci quarry,* as well. In the red clayey filling of the exposed palaeokarstic depressions remains of Tertiary vertebrates have been found.

The *'Fehér-kövek'* above the vineyard is *also a nature conservation area.* The 15–20-metre-high Eocene limestone walls were sculptured by the abrasion of the Lake Pannon. The panorama from their tops provides a marvellous view of the surrounding area.

The Castle Hill of Sümeg

The fantastic world of the Tertiary sea coast is revealed by sediments characterised by conglomerate beds comprising abrasional cliffs. These beds are exposed in a dozen places by the abandoned quarries of the *Rendeki Hill.* The Castle Hill's cone is made up of Cretaceous crinoidal limestone. Its sides were washed by the waves of the one-time Lake Pannon. Fossil cormorant bones — found in the sandy filling sediments of a small cave — are the interesting palaeontological evidence for this.

Várpalota Sand Pit Nature Conservation Area (G-07)

The *Várpalota basin* — located in the south-eastern foreland of the Bakony — is filled with an almost 500-metre-thick, young *Tertiary sedimentary succession,* from which *brown coal* was mined over a long period of time. The *Miocene sand* of high quality, which can be found in the inner part of the town, was produced for decades. After realizing how significant the locality is in a palaeontological point of view, the production was stopped in 1954, and *one of the first nature conservation areas in Hungary was established.* The geological key section, which became an exhibition

The outcrop is protected by a canopy

site for today, is *protected by a wooden canopy* from the weather. The lower few metres of the almost 10-metre-high wall is built up of ochre, fine- and medium-grained *quartz sand* which was mixed with some clay. The shallow-marine sediments were deposited in relatively calmer water than those of the overlying littoral succession. It contains fewer molluscs but more foraminifers than the latter one. Almost 100 species could have been identified among these calcareous protozoans.

The upper section of the wall, comprising the greater, 4–5-metre-thick part of the succession, is made up of well-sorted, medium- and small-grained, cross-bedded sand. It contains calcareous-shelled mol-

Some specimens of the extremly rich fauna (a shark tooth in the middle)

luscs (gastropods and bivalves) in incredibly large quantities; it is no exaggeration to say that there are millions of specimens. Beside the ornamentation sometimes the original colour of the *very well-preserved calcareous shells* can also be seen. Several palaeontologists focused their studies on the determination of the extremely rich fauna. The list includes *more than 400 species;* the most frequent genera among them are the following: Turritella, Pirenella, Natica, Dorsanum, Nassa, Tudicla, Ancilla, Arca, Anomia and Venus. The large specimen number is due to the wave action that washed the shells together. A rich fauna like this and of the same age is known only from Southern France. According to foraminifera dating the succession represents the so-called "Upper Lagenid Zone" of the lower part of the lower Badenian (M4b).

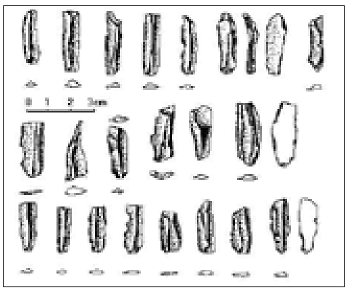
The well-preserved, some-cm-sized fish remains — found in the micro-laminated siltstone (oil shale) of one of the open pit coal mines in Várpalota — are considered as unique and rare palaeontological finds. Together with several ten thousands of other palaeontological materials, these fossils are kept in the Bakony Natural History Museum in Zirc.

Szentgál: chert – Man – cave (G-08)

Near the entrance of the Tűzköves-hegyi Cave ('Cave of Flinty Hill')

One of the largest prehistoric chert mines in Europe is found in the outskirts of *Szentgál* in the Bakony Mountains. The locality — the Middle Jurassic radiolarite beds of which yielded an excellent lithic raw material — was discovered by the primitive man already in the Palaeolithic period. The chipped stone tools that were found in the red ochre mine in *Lovas* (which is several tens of thousands of years old) and in the filling of the *Száraz-Gerence Cave,* had been manufactured at this place.

The heyday of flint mining activity occurred in the Late Neolithic period. A group of the population of the Lengyel culture was specialised for flint mining here. For the protection of the locality they created a ring of settlements around the locality within a radius of 10 km; this is unique in the world. Mining and the stone core manufacturing escalated to industrial proportions. Based on data of archaeological excavations, left-behind chert chips can



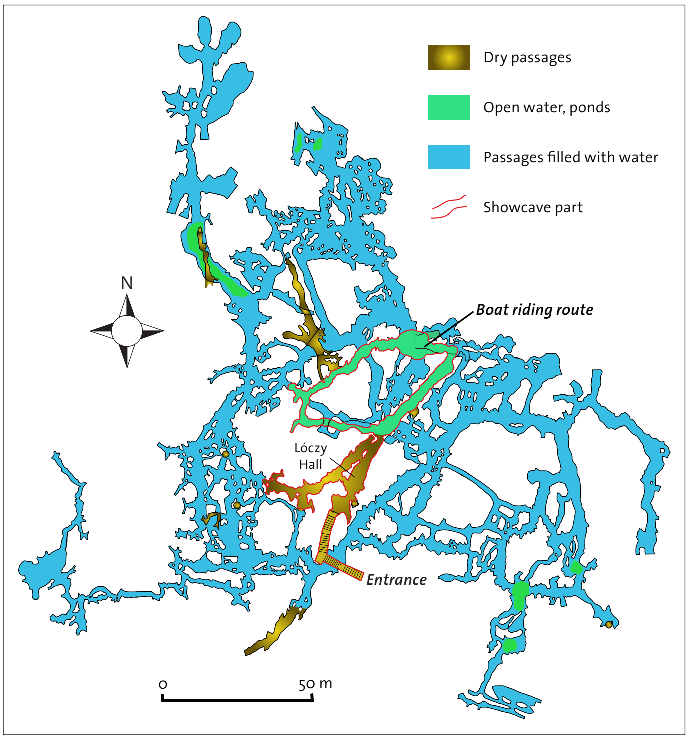
Blades from the Szentgál locality, made of flint

Entrance of the strictly protected Szentgáli-kőlik Cave

be found in considerably large numbers within a one-square-kilometre-area.
They provided with the characteristic, red-coloured stone tools not only the inhabitants of the stone-free regions in Hungary, but (due to more distant trade relationships), chert tools — derived from this locality — appeared in the area of the present Slovakia and Slovenia, moreover, in a site in the Netherlands (!), too.
The *Tűzköves-hegy Cave* was discovered in 1934 in the quarry that had produced the Lower Jurassic limestone of the Tűzköves Hill. Besides the spectacular solution forms in the cave (which is under special protection today), tectonic features are also predominant. In addition to stalactites, the principal value of the cave is the hibernating bat population which is one of the biggest in Hungary.
In the southern outskirts of the settlement a strictly protected cave, i.e. the *Szentgáli-kőlik* can also be found. It is a multi-storeyed labyrinth of intersecting tectonic fissures formed in the Upper Triassic *Main Dolomite*. Its upper section has been made accessible to people taking tours in overalls by the Applicant. The cave — characterised by an interesting geological history — has yielded Copper Age earthenware remains, *Bronze Age urn* fragments, 6 human skulls, human and animal bones and an earthenware moon idol. According to archaeologists the cave may have been a cultic place.

Lake Cave of Tapolca (G-09)

There is a huge (more than 9-km-long) karstic labyrinth hiding beneath the town of *Tapolca*. It consists of several caves. The largest among them is the 3280-m-long Lake Cave of Tapolca, a few-hundred-metre-long section of which has been made accessible to visitors. The facility management and operational running of the cave are provided by the applicant Balaton Uplands National Park Directorate. After a walk along the accessible section, the hundreds of thousands of visitors who pass through here each year can make *boat trips* on the turquoise water along a passage which curves back towards the starting point. The 20 °C karst water keeps the temperature mild and the air humid throughout the whole year.
The cave was discovered in 1903 in the course of digging a well, at a depth of 14 m. Its formation is due to a lucky fact. A part of the meteoric water that infiltrates the karstified limestone and dolomite areas of the Bakony flows towards the marginal basins along the fissure network of the rocks. The other part of the water descends into a depth of several km, warms up and as thermal water it ascends near the surface. The two types of karst waters meet just in the area of Tapolca; the cavern system has been created by the corrosive effect of their mixture. The thermal



Map of the cave system (Zoltán Szabó)

water origin is proved by sphaerical niches which are seen on the wall of the halls and passages.
Due to the small-scale uplift of the area the upper passages and a part of the middle (built) level has become dried up, whereas the deepest passages opening from the rowing section has remained under water. Solution of limestone is a still ongoing process in this zone which is searched by divers. Temporarily, karst water flows here from the neighbouring *Kórház–Berger cave system* through inaccessible passages. After leaving the southern part of the cave it reaches the surface through the springs of the nearby *Malom Lake*.
On the 8-m-high walls of the *Lóczy Hall* (named after the famous Hungarian geologist) the almost horizontal bedding of the 14-million-year-old shallow-marine limestone *(Tinnye Limestone)* can be observed. Halls and sphaerical niches are connected to each other by short passageways. The rowing section is somewhat similar to this; however, the smaller halls (having dome-like, higher ceilings) are connected by low tunnels. Dripstones have not been formed in the cave since water percolation from the surface is hindered by a few-metre-thick clayey zone.
An interesting cave dweller is the Eurasian minnow *(Phoxinus phoxinus)* which feeds on tiny crabs. The not more than 10-centimetre-long fish reach the cave from the Malom Lake through watery passages.

Volcanic remnant hills in the Tapolca Basin (G-10)

The unique landscape diversity of the Tapolca Basin is primarily due to its *basalt volcanic remnant hills*. The low-lying, flat basement is predominantly made up of *Miocene limestone*, which became overlain by the fine sandy *deposits of the Lake Pannon* 10 million years ago. The *alkaline basaltic magma* penetrated the moist sedimentary succession with huge explosions 3–5 million years ago. Dozens of *tuff rings* were formed, and later they were filled with *lava lakes*. In the final stage of volcanism, *cinder cones* were formed. Where the surface was not protected by basalt caps the thick but loose Pannonian sediments have been removed by the erosion that started in the Pliocene. Simultaneously, erosion of tuff rings and, subsequently, of the basalt masses, started. Frost weathering in the Pleistocene intensified the process, and large *scree slopes* came into being. On the sides of the volcanic bodies, which became increasingly weathered out from their surroundings and cracked by cooling, the formation of *basalt organs, rock bastions* and *pinnacles* is an ongoing process.


Basalt 'organ pipes' of the Szent György Hill

Within this general model of formation each volcano has its own evolution and has a variety of geological–geomorphologic character. Some maar volcanoes *(Véndek-hegy, Hegyesd, Szigliget)* have become eroded right to the diatreme, whereas others *(Badacsony, Szt. György Hill)* possess their red cinder cones. In some places *(Gulács, Tóti Hill)* basalt — migrating upwards along cracks — was trapped within the overlying sediments, therefore narrow ridges have been formed.
Traces of different volcanic processes and the peculiar geomorphologic features can be well studied in natural outcrops and in the abandoned quarries. In the contact zone of the Tapolca Basin and the neighbouring Lake Balaton fresh meadows and inlets, changing into *swamps,* came into being. Nevertheless, the northern part of the basin (made up of carbonates) is characterised by dry grasslands and dolomite barrens.
Due to the combination of biodiversity and geodiversity, an incredible range of natural values came into being in the area. All these are demonstrated to the numerous visitors by *nature trails, information booklets* and various publications.

Tihany Peninsula (G-11)


The pyroclastic succession of the former maar at the Monks' cells

The Tihany Peninsula — located on the northern side of the Lake Balaton — is one of the most popular tourist destinations in Hungary. Due to its unique geological–geomorphologic natural values it was declared protected in 1952 as the *first landscape protection area* in Hungary. Since 2003 it has been the holder of the *European Diploma*. Its almost thousand-year-old Benedictine abbey attracts hundreds of thousands of tourists. Most of them walk all over the geological values which can be found along the *Lajos Lóczy Nature Trail.* The new visitor centre of the Applicant, i.e. the 'Lavender House' was opened in 2011; at the same time it is the *Eastren Gate of the Bakony–Balaton Geopark*.
The basement of the peninsula is made up of the thick, sandy, silty sediments of the 10-million-year-old *Lake Pannon*. The fossil shells of the bivalve *Congeria ungulacaprae* have been washed out from the lower beds. There is a few-century-old legend attached to these fossils which have been worn by the waves and resemble goat hooves. The *Tihany Formation,* representing the paludal, closing member of the Pannonian succession, crops out in a natural exposure of the Fehér-part which can be seen from a far distance.
The *first basalt volcano of Transdanubia erupted here 8 million years ago*. The *pyroclastic deposits* in the maar craters of the repeated volcanic activity are represented by very spectacular forms. The most well-know place is the surroundings of the *"Monks' cells"*, where dwellings have been hollowed into the several-ten-metre-high walls by the one-time monks. Impact structures, made by *volcanic bombs* in the pyroclastic beds of variable grain sizes, can also be recognised.
The protruded cliffs of the *Kiserdő-tető* which are exposed to the wind and rain are the striking examples of selective erosion. In the nearby exposure, clasts derived from the basement rocks (i.e. Silurian phyllite, Permian red sandstone, Triassic dolomite and welded clay) and torn up by explosions can be studied. The panorama from the top of the cliffs provides a spectacular view of the bird paradise in the swamp of the Külső Lake.


The thermal spring cone of the Aranyház ('Golden House')

There is a foot path along the western edge of the peninsula beneath the rock wall. This wall is built up of the *calcareous–siliceous sediments of thermal springs,* which overlie the deposits of the former maar lakes consisting of basalt clasts. The several-metre-thick succession — made up of mm-thick laminae — indicates a long-term seasonal rhytmicity of precipitation. While walking along the path tourists may visit a dome-shaped cave, as well; it was formed in the already deposited calcareous material by the dissolution effect of ascending thermal waters.
In the vicinity of the *Lake Belső* (Inner Lake) the field of spring cones which rise above the forest is the evidence of an extremely strong post-volcanic activity. The internal areas of the peninsula can be viewed from the largest cone called *'Aranyház'* ('Golden House'). The hill of the abbey church is of the same origin; a cave (having small halls) has been formed in its calcareous rocks by the dissolution effect of thermal waters.

The Kút (Well) Cave in Cserszegtomaj (G-12)

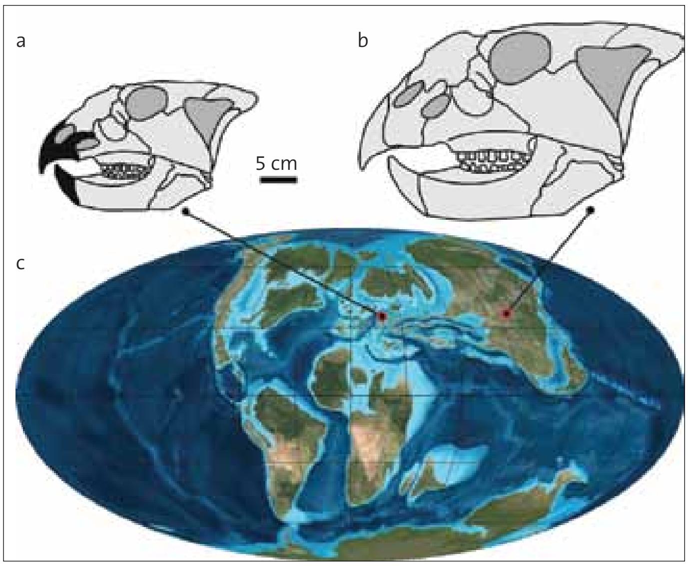
In the neighbourhood of the world-famous medicinal spa Hévíz, an exceptionally unique geological formation is found. The cave was discovered at a depth of 50 m in the course of digging a well at the corner of the Cserszegtomaj cemetery in 1930. Since the 1960s up to now a 3320-metre-long passage has been known, however, according to estimations, the same length is to be surveyed. Nevertheless, this relatively considerable length can be found within an area of a diameter of 120 m and a thickness of 12 m, in which passages form an intricate maze. Their average width rarely reaches 1 m, and their height only locally exceeds the same value. In their points of intersection a few-metre-sized halls are found, from which narrow passages start in several directions, frequently connecting back to the previous parts. The amazing features can be explained by its special speleogenesis, which, at the same time, gives a unique value to this geological formation.
The surface of the Triassic dolomite underwent karstification in the Miocene. Under the subtropical climate, peculiar morphological features — interspersed with crevices and funnel-shaped depressions — came into being. This surface was invaded by the Lake Pannon; subsequently, the deposited sand filled the unevenness of the basement, perfectly representing the former karst surface. Later clayey sediments

were deposited in a thickness of several tens of metres. In the Pliocene, the ascending thermal waters could not reach the surface because of the impermeable Pannonian clay. The trapped hydrothermal solutions have impregnated the Pannonian sand with silica and it has become a hard rock. Calcium carbonate has been dissolved from the underlying Triassic dolomite; therefore its upper part has become friable. The labyrinth-like passage network has been formed in this way along the dolomite/sandstone contact, within a few-metre-thick zone. Thus, the roof is made up of siliceous quartz sandstone, whereas the basement is of friable dolomite. The column-like sandstone features and crests hanging from the ceiling into the caverns represent, in fact, the negative forms of the former karst surface from a bottom view. That's what makes the Cserszegtomaj Kút Cave unique in the world.

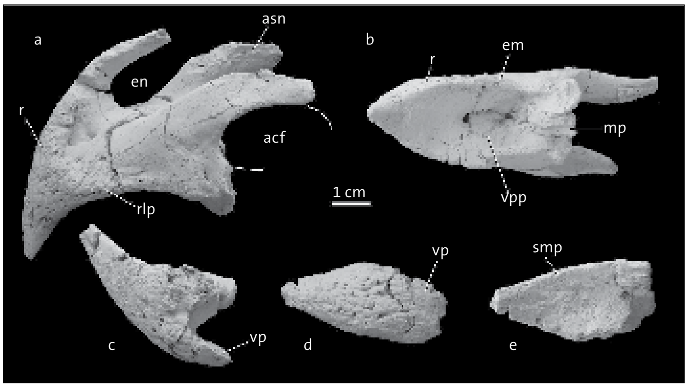
Besides the exceptional morphology of the cave, noteworthy mineral precipitations can be seen. In some halls the walls are ornamented with haematitic coatings with blue and red tints and manganous coatings. In many places gypsum minerals are found; their formation is an ongoing process. Besides the tabular appearance, spirally twisted fibers, i.e. "gypsum flowers" are found. Decay of the pyrite content of deeper-lying rocks may play an important role in their formation. The cave also provides with a palaeontological speciality: locally, on the sandstone walls, impressions of plant stems — with a length of several spans and a width of a few cm — have been preserved.

Iharkút Cretaceous dinosaur locality (G-13)

Until a few years ago, only fragmentary, scattered remains and footprints of vertebrates were known from the territory of Hungary from the Mesozoic Era, which is also called the age of the reptiles. In 2000 the ice was broken: geologist Attila Ősi PhD discovered the first, systematically collectible continental vertebrate locality in the Bakony, in the outskirts of the village of Iharkút. 85-million-year-old Cretaceous sedimentary rocks *(Csehbánya Formation)* — cropping out along the slope of the abandoned bauxite pit — have yielded the *first dinosaur remains in Hungary.* The research work at this site has lead to the discovery of a *worldwide unique* assemblage of fossil remains, in which the number of the predominantly isolated bones and teeth, and the subordinate skeletons, exceeds ten thousand pieces for the moment. On the basis of fossil finds more than *30 different vertebrate species* have been described from *fish* through *amphibians, turtles, lizards, crocodiles, pterosaurs, dinosaurs and birds.* Several species, such as *Hungarosaurus tormai, Bakonydraco galaczi, Ajkaceratops kozmai* and the *Iharkutosuchus makadii* have been known only from the Iharkút fossil site. Besides vertebrate finds an important *mollusc fauna* is also known. Moreover, a greatly rich assemblage of *pollen and plant fossils* (seeds, leaves, flowers, branch/trunk fragments) provides us with a more complete image of the Late Cretaceous ecosystem.



Late Cretaceous palaeogeography and bagaceratopsid skull outlines. a, b, Skull outlines, to scale, for Ajkaceratops kozmai (a) (preserved bones in black, remainder of skull based upon Magnirostris) and the Asian bagaceratopsid Magnirostris (b). Although the exact phylogenetic position of Ajkaceratops is unclear it is probably closely related to the Asian bagaceratopsids Magnirostris and Bagaceratops. c, Late Cretaceous palaeogeographical map showing locations of Ajkaceratops and Asian bagaceratopsids – map courtesy of R. Blakey (Attila Ősi 2010)



Anatomy of Ajkaceratops kozmai gen. et sp. nov. a, b, Holotype MTM V2009.192.1, fused rostral and premaxillae in lateral (a) and ventral (b) views. c–e, Referred material MTM V2009.193.1, predentary in lateral (c), ventral (d) and dorsal (e) views. acf, inferred position of accessory fenestra between the premaxilla and maxilla; asn, articular surface for nasal; em, edentulous margin of premaxilla; en, external naris; mp, fragments of rostral processes of maxillae; r, rostral bone; rlp, lateral process of rostral; smp, sharp margin of predentary; vp, ventral process of predentary; vpp, vaulted premaxillary palate. (Attila Ősi 2010)

Besides the taxonomic and anatomical description of the finds discovered in the course of research works and belonging to new and already well-known groups, the palaeobiology of certain species could have also been studied. Moreover, zoogeographic relations of the Iharkút fauna could be outlined. One of the most well-known animals of the locality is the small, omnivorous Crocodile of a maximum length of 1 m, namely the Iharkutosuchus. The detailed examinations of skull, jaw and tooth remains have pointed out that — unlike the other crocodiles — this species was suitable for transverse jaw movements, and thus, it could efficiently grind food with its flat, multi-cusped grinding teeth.

The remains of *more than 50 specimens of the flying reptile,* i.e. the Bakonydraco galaczi — which has been discovered in Iharkút — indicate that this species was definitely frequent in this *alluvial area* (interspersed with river branches and riparian forests). For today, the description of the newly-found flying reptile remains has already been done. This contributes to the better understanding of this group, which was documented predominantly on the basis of rare and fragmentary finds.

In a faunistic and zoogeographic point of view the Iharkút fossil site is regarded as a *unique locality.* Although, at the family level a significant part of the collected vertebrate remains corresponds with the faunae of several European sites (in Romania, Austria, France and Spain), there are significant differences at the genus or species levels. Moreover, in case of amphibians, a new family of frogs has been revealed.

Many of the discovered species show ancient characters. The armoured dinosaur Hungarosaurus (described from Iharkút) is 30 million years younger, whereas an ancient form of the modern Eusuchia crocodiles, i.e. the Iharkutosuchus is *40 million years younger than their closest relatives.* The relative prevalence of new species and the presence of ancient forms indicate that 85 million years ago, for a shorter or longer time, the present *Bakony was an isolated region* within the European archipelago that existed in the western end of the *Tethys Ocean.* Similarly to finds of other Cretaceous fossil localities in Europe, there are forms among the

Iharkút turtles, crocodiles and Therapod dinosaurs, which had relatives in the southern continents of the Gondwana. These species support the opinion according to which the archipelago of Europe was conquered by groups coming from Africa.

Another unique feature of the site is that it is *a few million years older than the other European continental vertebrate localities of Late Cretaceous age.* It represents a time interval which has been virtually unknown in Europe from the viewpoint of continental vertebrates. Thus, the bone record derived from the fossil site plays an *extraordinarily important role* in the better understanding of Cretaceous zoogeographic relations. Nothing proves this better than the recently found skull remains of *Ajkaceratops,* which are undoubtedly *the first Ceratopsid dinosaur remains in Europe.* This has disproved the earlier hypothesis that this dinosaur group (characterised by horns and frills) lived exclusively in the area of Asia and North America. The remains of Ajkaceratops also show that — probably together with other dinosaur groups — *significant faunal migrations* took place from East to West sometime in the Cretaceous Period. As a result of this, the groups — indicating basically Asian relationships — reached the European archipelago in the western end of the Tethys Ocean.

Somló Landscape Protection Area (G-14)

Vineyards under the basalt outrops

The geological history of the solitary hill (432 m) is similar to those of the other basalt volcanoes in Transdanubia. Its *tuff ring* was formed due to a *phreatomagmatic explosive activity* 3.5 million years ago. The pyroclastic beds — which overlie the Pannonian sediments — were penetrated by magma, and this created fascinating transitions of rocks. In the northern valley of the Somló it can be observed that the adjacent Pannonian clay was "burnt" red by hot, molten rock. A hard, compact rock type of conchoidal fracture came into being which resembles ceramics.

In the second, more pronounced stage of volcanic activity the tuff ring was filled with lava in several phases. The cooling basalt solidified into *thick-bedded, massive blocky* structures. These structures on the cliffs — under the edge of the hilltop — can be seen even from a distance. The Somló is characterised by the so-called "sunburn basalt". Its texture comprises about 1-cm-sized or smaller grains. When struck with the hammer or due to natural exogenic effects (frost, rain, roots) the seemingly solid basalt relatively easily falls apart into small pieces.

In the final stage of volcanic activity the basalt of the cooled lava lake was penetrated by the repeatedly ascending, gas-rich melt, and a 30-metre-high cone of a diameter of a few hundred metres was formed, which is made up of red, porous, scoriaceous lava.

The morphology of the Somló is of a classical volcanic remnant hill from all sides. Its lower part is made up of loose sediments (Pannonian sand, silt, clay and pyroclastics) forming medium-angle slopes. Above these slopes — excellent for viticulture — very steep, in some places vertical basalt walls can be seen; locally their height reaches 50 m. The central cinder cone is situated on the almost flat hilltop (mesa) of a diameter of one kilometre. There is a lookout tower on it.

The integrity of the landscape is disrupted by a curved valley axis on the North. The valley cutting backwards at the bottom of the cauldron (which is likely to be of explosive origin) makes the hilltop accessible, which can be hardly reached by vehicles. These local natural conditions and the strategic importance of the place were realized by the fortress builders. After the 1200s a fairly large fortress was built on the basalt crest of the western side of the cauldron. Near the gate of the fortress — which looks formidable even in its ruined state — the exfoliating basalt bedrock can be seen.

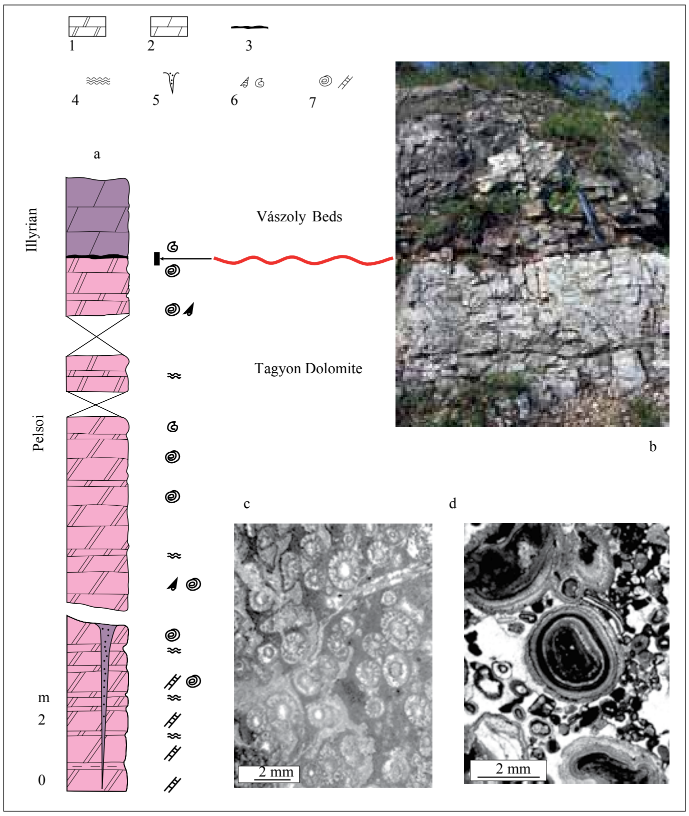
Szentkirályszabadja, the Middle Triassic of the „airport quarry" (G-15)

A hill called *Péter-halma* is located 1.5 km to the North of *Szentkirályszabadja.* There is a disused quarry inside the fence of the former military airport, which exposes the middle section of the Middle Triassic of the Veszprém Plateau as a key section. The profile was presented during several international geological programmes.

In contrast to most parts of the Balaton Uplands — where the middle section of the Anisian stage is represented by the Felsőörs Limestone (deposited in a relatively deep basin of the open shelf) — in this profile the same stratigraphic interval is made up of shallow-marine platform carbonates. The succession of the *Tagyon Dolomite* of cyclic structure is made up of the rhythmic alternation of thick beds deposited in the subtidal zone and laminated beds of the intertidal zone. On the weathered surface of the bedding planes tower-like gastropods, the porous tubes of green algae (Dasycladacea) and coated grains (pisoids) of concentric structure —resembling botryoidal stalactites — can be observed.

The succession exposed in the northern quarry yard is the only profile known, so far, in which the evolution of the Anisian carbonate platform — i.e. subaerial exposure, subsequent karstification and re-flooding — can be well documented on the basis of sedimentological features and the ammonite fauna of the layers. The Middle Anisian (Pelsonian) age of the shallow-marine Tagyon Dolomite is based on *Balatonites balatonicus,* whereas the ammonite assemblage *(Asseretoceras camunum, Lardaroceras krystyni,* "Hungarites" inconstans) of the brownish-grey, reddish-grey, crinoidal, dolomitised layers of the *Vászoly Beds* (overlying with a sharp contact) is indicative of the upper part of the Anisian stage (Illyrian). According to this, the time span of the hiatus between the two formations can be estimated for 1.5 million years. The red clay that covers the surface of the Tagyon Dolomite in a thickness of a few cm is the product of the karstification period that took place between the subaerial exposure and the re-flooding of the platform.

On the basis of the comparison between the Felsőörs and Szentkirályszabadja profiles, it seems to be proved that during the Middle Triassic, in the second half of the Anisian, relatively deep sea basins were formed on the Tethys shelf between the shallow-marine platforms. Disintegration of platforms was resulted by syn-sedimentary exten-



Profile of the Szentkirályszabadja airport quarry (a), the sharp stratigraphic boundary between the Middle Anisian platform carbonate and the Upper Anisian basin facies (b), green algae sections (c) and pisoids in the Tagyon Dolomite (BUDAI 2006). Legend: 1. platform carbonate; 2. carbonate of basin facies; 3. red clay; 4. stromatolite; 5. neptunian dyke; 6. gastropod, ammonite; 7. onkoid, Dasycladacea sional tectonic movements. An evidence for this can be found also in the Szentkirályszabadja quarry. The 1–2-m-thick dikes on the wall of the southern quarry yard, which intersect the succession of the white dolomite and are filled with red, crinoidal, dolomitised limestone, may have been formed in the course of the rifting of the platform margin and the subsequent filling of rifts with marine sediments.

Alsóörs, key section of the Alsóörs Metarhyolite (G-16)

The abandoned quarry located on a plot at 46 Endrődy Street is the protected key section of the *Alsóörs Metarhyolite* of Early Palaeozoic age. This is the only outcrop of this rock type the length of which is about 50 m. The massive rock — which is exposed in a thickness of 1–2 m — was formed by the subsequent *transformation of a deposit of a pyroclastic rock and ignimbrite of rhyolitic composition.* The large-sized crystals, which can at least be seen by the naked eye, are made up of quartz, feldspar and biotite in a matrix consisting predominantly of fine-crystalline quartz. Volcanism took place at the late period of the Ordovician (about 450 million years ago). The acidic volcanic rock was deposited in the sea and this is indicated by its stratigraphic position within the *Lovas Slate* beds. Based on radiometric dating metamorphism of the succession may have taken place during the Variscan orogeny, about 315 and 330 million years ago.

Csopak, Permian–Triassic boundary (G-17)

One of the oldest protected sections in the Balaton Uplands is a railroad cut, which exposes the Permian–Triassic boundary. It is located W of Csopak (where there is the headquarters of the Applicant), on the side of Road No. 71. The succession — remarkable for its variable colours — was exposed approximately a hundred years ago during the construction of the North lake shore railroad. At present it is *one of the most well-known key sections.*

The lower part of the section is made up of the continental, Upper Permian *Balaton-felvidék (Balaton Uplands) Sandstone,* which is represented by purplish-red, cross-bedded sandstone and siltstone beds. The thickness of the beds ranges from 0.2 to 1 m. The grains are made up predominantly of quartz, whereas feldspars, micas and clay minerals are subordinate in quantity.

The Upper Permian sandstone — deposited under semi-arid climate in an alluvial plain environment — is overlain by a Lower Triassic shallow-marine succession which indicates the global sea-level rise that occurred at the Permian-Triassic boundary. The approximately 4-metre-thick, lowermost section of the Triassic succession is made up of grey, dolomitic siltstone and sandstone *(Köveskál Dolomite).* The sandstone is cross-bedded and ripple marks can be seen on the bedding planes. Some beds are characterised by ooids with quartz nuclei. Upwards in the succession the amount of debris gradually decreases, whereas carbonate content increases; sandstone is replaced by yellowish-grey, thin-bedded, porous dolomite. The Lower Triassic succession has yielded few, poorly-preserved fossil bivalves (Claraia) and brachiopods (Lingula). The sparse occurrence of fossils indicates that the colonization of vacant shallow-marine niches did not occur for a long time after the Permo-Triassic mass extinction, which happened about 250 million years ago.

Kab Hill, basalt-covered karst (G-18)

On the *largest and highest* (600 m a.s.l.) *volcano* of the Geopark (i.e. the *Kab Hill)* no tuff ring was formed during the Pliocene; the lava flowed freely down the slopes. The first stage of lava flows (5.23 million years) was followed by a longer pause. The warm and humid climate of that time resulted in the weathering of the basalt and the formation of a several-metre-thick pale red clay. In the second stage of volcanism the clay was mostly covered with the material of the renewed *lava flows,* nevertheless, locally it can be still seen. As a result of the two active stages an almost 20–40 metre-thick lava field came into being predominantly on the north-western and southern slopes of the hill; it is about 40 km^2 in areal extent. In the last stage of volcanic activity (4.73 million years) *red, scoriaceous, vesicular basalt* was formed around the present-day peak.

Lava flows covered the surface which is made up of *Mesozoic* and *Eocene limestones* and underwent karstification until the end of the Tertiary.

Due to the formation of the basalt cover the area suitable for surface karstification decreased, however, at the same time, the intensity of the process increased. The massive basalt and the intercalating clay are impermeable; thus water flowing on the surface and along shallow fissures can reach the edge of the basalt cover. At the rock contact water intensively dissolves the carbonates and creates *sinkholes* within a short time. The most beautiful sinkhole of the mountains, i.e. the still active *Macskalik (see above),* has been formed at such a *basalt/limestone contact.* The *Bújó-lik* is a sinkhole cave of similar appearance.

The area is enriched by another peculiar karst feature. Solitary and interlocking *dolines* and sinkholes were formed *within the basalt cover.* According to a probable theory of their formation the lava flows surrounded the one-time limestone elevations. Karstification started along such an internal contact of rocks and after a while morphological inversion came into being. A probable representative of the subsurface karstification is the *Pula basalt cave;* its development is due to the collapse of the rock into one of the cavities of the underlying limestone. According to another theory it is a collapsed vesicle. The *'Halász Árpád' cave* was also formed in basalt. The cavern — exposed in the course of quarrying — is considered as a lava tunnel. On the western and especially on the southern side of the Kab Hill there are about a dozen *temporary ponds* to be found (see below). Besides the natural karstic depressions there are hundreds of small, doline-like pits in the basalt. They are anthropogeneous forms: traces of the centuries-old basalt quarrying activity.

Zirc, cross-bedded crinoidal limestone near road to Borzavár (G-19)

In the vicinity of Zirc the well-bedded, easily carvable limestone — characterised by coarse-grained stripes — was mined for centuries. This is its only occurrence in the country. The popular building stone can be seen in the walls and fences of several houses in the surrounding area. The disused quarry near the road is a spectacular geological key section. The Lower Cretaceous *crinoidal limestone* is made up of two, similar formations of different ages; there is an about 5 million years hiatus between them. Its lower part is the pale red *Borzavár Limestone* (Valanginian, Hauterivian) comprising also chert nodules. However, the overlying grey (on the surface faded to yellow) — and also crinoidal — limestone belongs to the Aptian *Tata Limestone.*

The approximately 10-metre-thick succession was described in 1875 for the first time, and the latest summary was made in 2003. According to the latter the lower limestone is almost completely made up of the disintegrated, strongly-worn, few-mm-sized fragments of echinoderm skeletons. Locally recognizable remains of crinoidal (e.g. Torinocrynus) ossicles and calices (reaching a size of even 1 cm), moreover, the 1–1.5-cm-sized, club-like spines of echinoids can be observed. Brachiopods (Pygites) and aptychi are relatively frequent; however, ammonites, belemnites, sponge remains and fish teeth have also been found.

The mass of deposits — which is slightly thicker than 15 m and its surficial extent is a few square km — was deposited 130 million years ago within a short time period. The rich assemblage was swept away from a submarine high by strong bottom currents. Billions of *calcitic skeletal remains* were broken into tiny pieces, were deposited in the deeper water and became a well-bedded rock.

The causes of the hiatus spanning a few million years are unknown so far. The material of the upper limestone indicates similar palaeoecological conditions. This laminated, thin-bedded rock is also predominantly made up of the strongly-worn skeletal fragments of echinoids. Calcite grains are mixed with older (mainly Jurassic) limestone clasts. With the exception of some brachiopods and belemnites larger fossils can hardly be found. The cross-bedded limestone is a visibly unique formation of the quarry. The section of a *shaft cave* (see above) is also a curiosity. Its clayey deposits contained the hundred-thousand-year-old remains of tiny land vertebrates.

Balatonederics, Csodabogyós Cave (G-20)

The Csodabogyós Cave, which is located on the top of the steep, rocky slope above *Balatonederics,* is *one of the finest examples of the tectonic caves* in Hungary. Locally it is decorated with *stalactites* and *stalagmites.*

The *strictly protected,* 5.2-km-long and 110-m.deep cave comprises the labyrinth of *halls* and huge *crevices* and *shafts* running parallel and at angles to each other. The width of the passages is usually between 1 m and 4 m, whereas their height ranges from 10 m to 30 m. Some of the spacious crevice shafts — dissected by false floor levels and constrictions — are 40–50 m deep. This unique labyrinth is the network of fissures and crevices which have been formed due to the locally predominant dilatational tectonics. At the same time, traces of strike-slip and reverse faulting can be seen in the form of large slickenslides on certain walls.

The predominant part of the passages has developed in the Upper Triassic *Ederics Limestone.* This special rock type shows the most extensive

occurrence here within the area of the Transdanubian Range; however, its surficial extent is less than half a square kilometre, albeit its thickness is at least 300 m. The unusual three-dimensional shape is due to the fact that the limestone — interfingering with the dolomite — forms a one-time reef.

The light grey or snow-white, small- and coarse-crystalline host rock of thick-bedded or massive appearance represents platform carbonate facies. Its *typical facies* is characterised by *reef-dwellers* and *reef-builders:* the rich, tropical biota is represented by *green algae, foraminifers, calcareous sponges, corals* and *bryozoans* in large quantities.

Another interesting feature of the cave is that it forms a common airflow system with a neighbouring cave. In winter the humid and warm air escapes through its entrance forming a vapour column. The upper, some-hundred-metre-long section of the cave has been opened to the public by the applicant Balaton Uplands National Park Directorate (i.e. the nature conservation management of the area) since 2006: the upper, some-hundred-metre long section of the cave can be explored during tours in "caving overalls" (please note: visitors can not access directly to the dripstones; the man in the photo is a professional caver). In small groups, every year thousands of visitors come to this unique geological formation.

Balatoncsicsó, the Triassic of the Csukréti ditch (G-21)

The Csukréti ditch — in which the *Csorszai Creek* flows — stretches between villages of *Balatoncsicsó* and *Monoszló* near the road that runs through the vineyard. The Upper Triassic (Carnian) *Veszprém Marl* (which is among the thickest formations in the Balaton Uplands) and the intercalating *Nosztor Limestone* are exposed in a few-hundred-metre-long section along the creek bed.

A small waterfall developed on the beds of the Nosztor Limestone in the ditch

The oldest formation which crops out in the creek bed is the Middle Triassic (Ladinian) *Nemesvámos Limestone.* In the course of former examinations some ammonites were found in the red nodular limestone beds. It is overlain by the Upper Triassic (Lower Carnian) *Füred Limestone* which forms a several-metre-high wall on the steep slope, on the downhill side of the opposite located *Kő Hill.* Some metres higher above the thick beds of the Füred Limestone, the thin, laminated–lamellar beds of the grey, dark grey, soft marl–clay marl crop out on the creek bed side; the lower part of the Veszprém Marl is made up of the latter rock. Along a 250-m-long section from here down to the mouth of the left creek branch the succession is fairly poorly exposed. However, in the tributary channel and around the fork the layers can be well followed; their carbonate content gradually increases. The marl–clay marl is overlain by calcareous marl and marly limestone. 70–80 m far from the tributary channel an old road crosses the creek; here crops out the light grey, brownish-grey, thick-bedded *Nosztor Limestone*. It divides the marl sequence and the creek cascades over it like a small waterfall.

The outcrop continues in the upper section of the Veszprém Marl. Over a pretty long distance the creek flows in the same direction as the strike of the beds; thus, in the side of the creek bed, we can follow the some-square-metre-sized bedding planes of the layers over a long distance. Getting closer to the *Kő Hill spring*—which is located at the end of the series of outcrops—the soft marl is substituted by hard calcareous marl of splintery fracture.

Poorly-preserved, fragmentary fossils are frequent in the marl and clay marl beds. The most frequent remains are the few-mm-sized shells with concentric growth rings, which can be found in certain bedding planes in large quantities. Previously these tiny shells were considered as the remains of shelled phyllopods which belong to the genus Estheria. According to other opinions the fossils are the juvenile specimens of the bivalve Halobia, which is frequent in the Upper Triassic. Besides these remains, there are bivalves *(Halobia rugosa, Gonodus astartiformis)* and ammonites *(Neoprotrachyceras baconicum),* which are considered as rare fossils.

The Csukréti Ditch is *the only good outcrop of the thickest formation in the Balaton Uplands,* i.e. the Upper Triassic Veszprém Marl. Data derived from the detailed palaeontological studies and stratigraphic conclusions based on them were demonstrated in the *XXI. European Colloquium on Micropalaeontology* in 1989, in Hungary.

Olaszfalu, Eperjes Hill geological key section (G-22)

The *locally protected area* near Zirc has been studied for a century. The variable successions—with hiatuses—in *three artificial exposures,* developed to form key section, range from the upper Triassic *Dachstein Limestone* up to the Upper Albian *Pénzeskút Marl*. These are overlain by the patches of the Middle Eocene *Szőc Limestone* and the *Csatka Formation* of end-Oligocene age. The *nature trail*—which also presents the living natural values—was created in 2002 on the hillside which formerly was a wooded pasture. An explanatory booklet is also available.

The specific character of the Eperjes Hill was developed after the end-Triassic disintegration of the carbonate platform, at the beginning of the Jurassic. It represents the edge of the one-time submarine high that stretched south-eastward from here. It is cut by a considerable left-lateral strike-slip fault of N–S direction, thus two different facies of the Jurassic system can be studied here.

"Long Ditch"

Its 100-metre-long section exposes the Jurassic (Hettangian–Berriasian) with considerable hiatuses. In the lower third of the profile the fossil-bearing layers of the *Pálihálás Limestone* of ammonitico rosso facies can be seen. They are overlain by the Hierlatz-type, fossil-rich (ammonite-, brachiopod- and crinoid-bearing) Szélhegy Member of the *Szentivánhegy Limestone*. Around a third of the ditch, East of the strike-slip fault, different Jurassic formations can be found. Between the higgledy-piggledy blocks of the *Kardosrét Limestone,* as well as in an overlying position, the reddish, microfossil-rich material of the *Szentivánhegy Limestone* can be observed. This megabreccia of peculiar arrangement may be associated with the collapse of the one-time platform.

"Stripped profile"

The spatial arrangement of the formations can be seen in a large area here. The blocks of the Kardosrét Limestone and the *Hierlatz Limestone* occur only near the northern end of the exposure, whereas in the southern part the Cretaceous *Tata Limestone* overlies the tilted blocks of the *Dachstein Limestone*. The purplish fissure-filling material of unknown age within the huge blocks in the middle section is also remarkable.

In one of the layers of the overlying Szentivánhegy Limestone the alternation of peaks—resembling stromatolites—and narrow troughs can be seen. These beds are especially rich in ammonite casts, aptychi and crinoidal fragments; fossil brachiopods and solitary corals also occur.

"Profile on the hilltop"

The some-metre-high cliff which forms the crest of the hill, and the ditch perpendicular to the latter, expose the bassets of the Cretaceous *Zirc Limestone,* which underwent strong karren formation. The type locality of the lower section of the formation (Eperkéshegy Member) can be studied in the escarpment. The thick-bedded limestone of Urgon facies contains the shells of rudist bivalves in large numbers. In certain beds the bivalves—attached by byssus threads—can be observed even in groups. The beds of the Mesterhajag Member crop out at the upper end of the profile.

At present the Eperjes Hill is one of the best-documented geosites in the Bakony, which has been made comprehensive for the public by exposures, explanatory tables and publications.

Balatonfőkajár, quartz phyllite on the Somlyó Hill (G-23)

The *oldest formation* of Transdanubia, not only the proposed Geopark area—which forms the crystalline basement of the Bakony—crops out to the surface on the Somlyó Hill which is located NE of *Balatonfőkajár*. The *quartz phyllite* and the subordinate *chlorite-sericite phyllite* are exposed in a disused quarry at the south-western foot of the hill. The white quartz veins (see below, in the front of the snail) are very impressive in the grey, greenish-grey, strongly-folded rock. Besides the bi-directional, low-angle schistosity the slightly-metamorphosed rock shows recumbent folds and flattened quartz strips between the foliation planes. Among the rock-forming minerals quartz, feldspars and micas can be identified.

Ordovician–Silurian formations—originally made up of clastic sediments (sand and subordinately clay) and acidic volcanic interbeddings were deposited in the Southern Hemisphere, 450–420 million years ago. Based on radiometric dating on micas their metamorphism of greenschist facies took place during the Variscan orogeny, about 340–320 million years ago. The main direction of the compressional deformation was NNE–SSW and it was in connection with a nappe-forming event of SSW direction. The results of investigations in the quarry and on the succession of the borehole deepened in it were summarized in several monographs. In 2010 volunteers of one of the most active civil partners of the Geopark candidate, namely the Pangea Association, cleaned out the exposure, moreover, an information board has been placed in it.

Bluff at the Lake Balaton and Pannonian beds (G-24)

The eastern shore of the Lake Balaton rises above the lake in the form of a 50-metre-high steep wall. The whitish-yellow shoreline — which can be seen from a distance — was undercut by wave action caused by the water of the lake. The lower clay beds, saturated with water, were affected by slump movements of considerable areal extent. A hundred years ago — due to such a disaster — even the railway track slid into the lake. The margin of the *Mezőföld* of this place is built up of the succession of the one-time *Lake Pannon;* it is composed of Upper Miocene *sand, silt* and *clay.* At Balatonkenese a cyclic sedimentary succession of the *Tihany Formation* can be studied (see above). It represents the near-shore facies of the lake of decreasing salinity. Sediments ranging from wave-base to swamp environments locally yield the remains of fossil bivalves and gastropods. The topmost part of the succession comprises grey, organic-rich clay, i.e. a palaeosol bed.

Some specimens from the rich mollusc fauna of Papvásár Hill (Lajos Katona in press)

In the past centuries cave dwellings *('Tatár hollows')* were hollowed into the bluff by the people who lived here. The panorama from the lookout tower (built on the hilltop) provides a spectacular view of the eastern basin of then Lake Balaton. The former loess-steppe and steppe vegetations have been preserved; a strictly protected botanical value is found among them, i.e. the Crambe tataria which has a spectacular inflorescence.

The neighbouring *Papvásár Hill* vineyard also reveals interesting formations from a geological-morphological point of view. The Pannonian succession of the abandoned sand pit reveals younger beds than those of the Kenese bluff. On the hilltop the freshwater limestone deposits of Pleistocene springs can be found. The weathered-out surfaces of the blocks show spectacular, laminar-nodular carbonate precipitation patterns.

Balatonalmádi, Permian key section of the Köcsi Lake quarry (G-25)

One of the most significant formations of the Balaton Uplands, i.e. the Late Permian *red sandstone* is exposed in a small, disused quarry, which is located behind the children's camp at Káptalanfüred (which belongs to Balatonalmádi).

The *Balaton-felvidék (Balaton Uplands) Sandstone* is divided into three groups; its *lower part* overlies the older, folded Palaeozoic basement with a *coarse-grained, red conglomerate.* The *middle third of the succession* is characterised by the alternation of *red sandstone and siltstone,* whereas in *the upper third* the repeated *coarsening of sediments* occurs with the appearance of conglomerate interbeddings. The coarse-grained sediments which were deposited in one-time riverbeds cyclically alternate with the fine-grained sediments of *alluvial sedimentary environments.*

The *lower section of the succession* — exposed in the quarry near the Köcsi Lake — is represented by a poorly- or slightly-bedded *conglomerate.* It is overlain by *cross-bedded, pebbly sandstone* which indicates north-eastern flow direction. Above the latter, conglomerate and (again) sandstone beds can be seen. Pebbles are made up of *quartzite, metasandstone* and *acidic volcanic rocks* (i.e. dacite) of red or grey colour; grains are cemented together by siliceous-kaolinic cement.

The considerably poor fossil record is represented by petrified tree remains; nevertheless, spores are relatively frequent.

The "new red sandstone" of general areal extent in the area of the one-time Pangea was deposited in semi-arid environment about 250–260 million years ago.

The sandstone of Permian age is the most popular building stone in the vicinity of the Lake Balaton. The soil formed on it yields excellent and characteristic wines.

Balatonfüred, Koloska Valley and Lóczy Cave (G-26)

These formations are among the most popular beauty spots in the vicinity of Balatonfüred. Starting from the Lóczy Cave — which has been made accessible to the public — visitors may get acquainted with these geological values.

The *Koloska Valley* basin of variable width is one of the most beautiful examples of a topography which closely fits the geological build-up. The brook — fed by a *vauclusian spring* of the valley — cuts through the *Péter-hegy* range in a narrow valley. Above the gorge a wide marl basin came into being, in which long, narrow and rocky ridges rise above the surface providing an excellent example of selective erosion. At the Koloska Spring there is a 50-m-high rock wall.

Walking up the valley one can get acquainted with most part of the Middle and Upper Triassic successions of the Balaton Uplands, i.e. from the Anisian dolomite to the *Füred Limestone, Veszprém Marl, Sándorhegy Formation* and the *Main Dolomite.* The geological, botanical and zoological values of the area can be studied along a nature trail.

The *strictly protected Lóczy Cave* (see below) can be found on the outskirts of Balatonfüred which is famous of its spring providing curative acidic water. The 150-m-long, 20-m-deep cave, possessing unique features, has been named after geologist Lajos Lóczy sen. who was the world-famous researcher of the Lake Balaton in the last century. The cavities — which came into being by the solution effect of thermal water in the well-bedded Füred Limestone (quarried for building stone in the area) — have been made accessible to visitors by a local master joiner already in 1933.

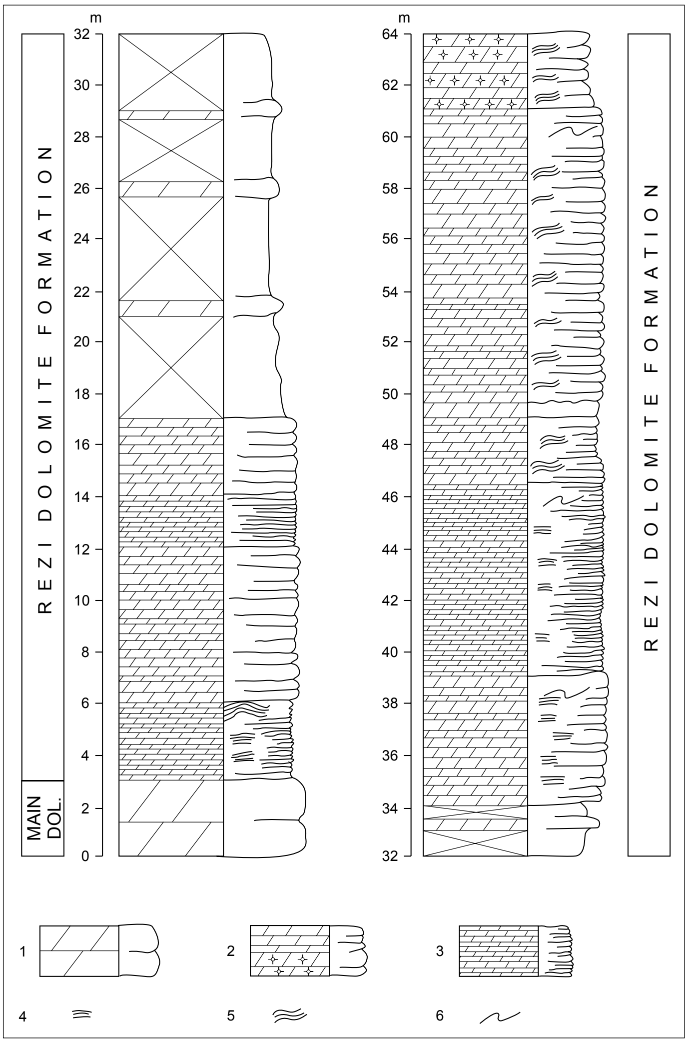
He used his own assets for the purpose. Currently the renovated cave is under the management of the Applicant and is visited by 15 thousand tourists every year. The halls — formed in the tilted limestone beds —, the weathered-out chert nodules, solution pockets, chimneys and the *'Lejtős Passage"* (which was formed in the curved beds of the fold axis), are very spectacular. A nature trail starts from the cave to the lookout tower on the top of the *Tamás Hill.*

Bakonyszücs, Odvas-kő and its caves (G-27)

It is a crag located in one of the tributary valleys of the *Gerence Gorge,* in the foreland of the highest peak (Kőris-hegy, 709 m a.s.l.) of the Bakony. It was named after its caves and caverns. The *Benedictine abbey* of the nearby *Bakonybél* was founded by Saint Stephen the *first king of Hungary, in 1037. The earliest reference* to a cavernous place in Hungarian language is the name *"Oduaskw",* which can be found in the copy dating from 1230 and providing the description of the property which is included in the deed of gift.
The cliff in the *High Bakony Landscape-Protection Area* is part of a *tectonic thrust fault zone;* the beds of the Upper Triassic *Main Dolomite* are almost vertical. During the Pleistocene cavities and caves were formed in the rock. The largest among them is the strictly protected *Odvas-kő Cave* (its length is 30 m, see above). *Archaeological excavations* in the cave-filling sediments have been carried out for more than a hundred years: traces of fireplaces, few remains of earthenware pots and a tooth of the cave bear have been found. On the other hand, the nearby *Odvas-kő cavity* yielded a large number of *bear bones.* The third cavern, i.e. the *Odvas-kő rock shelter* was proved to be barren.
The group of rocks is valuable in a botanical point of view, too. Despite the cool-wet climate of the mountains, the microclimate of the strongly exposed valley side facing to the South — due to the strong sunlight — is very dry and much warmer than that of the surrounding areas. It is well indicated by the island-like appearance of oak trees in the beech forest. Due to the permanent water shortage, the height of the approximately hundred-year-old trees with thick trunks is only 5 m. Next to the spacious entrance of the Odvas-kő Cave — which opens to the NW and descends inward — large icicles and ice columns are formed in winter. The caveman did not settle here permanently — probably due to the unfavourable microclimate. Nevertheless, in the cave-filling sediments of the *Öreg-Szarvadárki Cave,* which is located in the bottom of the valley and is under special protection, a chipped stone tool was found accompanied by the fossil bones of several animals of Pleistocene age.

Key section of the Rezi Dolomite, hydrothermal caves (G-28)

The key section of the Rezi Dolomite is found directly at the foot of the walls of the *Rezi Fortress* which is considered to be a popular beauty spot. The extremely steep path up to the fortress is made up of the series of escarpments of this rock. The *Keszthely Mountains* are built up predominantly of *Upper Triassic rocks.* During the Middle Norian the large carbonate platform of the Tethys Sea was dissected by tectonic movements, and small basins came into being in its area. The Keszthely Mountains was part of such a basin.
Three members can be distinguished within the *Rezi Dolomite.* Its lower part is represented by well-bedded, locally brecciated, frequently laminitic, strongly bituminous dolomite. Locally it is dissected by chert laminae. Its exposure in Vállus yielded a monospecific conodont fauna of high specimen number. The middle member is made up of thick-bedded, porous-cavernous, occasionally brecciated, usually bituminous dolomite containing fossil molluscs and dasycladaceans. The upper part



Key-section of the Rezi Dolomite at the Rezi Castle. LEGEND: *1. Thick-bedded to unbedded dolomite, 2. Thin-bedded dolomite, cavernous, cellular dolomite, 3. Laminated dolomite, 4. Lamination, 5. Folded laminites, 6. Slump*

is built up of bituminous, laminated and subordinately cherty dolomite; the overlying *Kössen Formation* develops from the latter through a 50-m-thick transitional succession.
The profile beneath the Rezi Fortress exposes the lower section of the Rezi Dolomite. The 60-m-thick succession is made up by dolomite characterised by contorted laminae and slumps. The uppermost few metres are built up of very thick-bedded, porous dolomite which belongs to the middle member.
West of the key section, at the end of the protruding rock (that descends from the fortress) a unique feature of thermal water karstification in the Keszthely Mountains can be seen. Due to the solution effect of the warm water — rising up to the surface during the Pleistocene — several caverns and caves came into being in the dolomite; they have been exposed on the surface by the erosion of the hillside. The remnants of linked spherical niches of a diameter of a few metres form a spectacular cave passage near the path. Going further towards the East, the oval-shaped entrance of the *Rezi Cave,* formed by solution processes and situated at the foot of the rock wall, leads into a smaller thermal water labyrinth which comprises several halls. This is the only place which is accessible to tourists to see these peculiar thermal karst forms.

The karst area of the Tés Plateau (G-29)

The central part of the *East Bakony* is made up of a *continuous karst terrain* which is nearly 20 km long and 3–5 km wide, and from the West towards the East its height decreases from 500 m to 300 m a.s.l. Its western half is called *Tés Plateau,* and in the East it is joined by other spectacular karst terrains. The area — which underwent peneplanation — is predominantly made up of Triassic *Main Dolomite* and less *Dachstein Limestone.* These rocks are overlain by the patches of the Oligocene gravel and the Pleistocene loess blankets which represent the relatively thin cover sediments. However, on the north-western part of the area Cretaceous formations crop out at the bottom of the erosional tributary valleys of the Gaja Brook. The Tés Plateau can be described as follows: it is full of holes, since — according to surveys — *more than 150 sinkholes* and *dolines* are deepened into the almost flat surface. Beneath most of the karstic hollows – of a predominant size of about 10 m — inflow caves open. Besides this inclined passage network (formed by the dissolution of rock along the bedding planes) locally, more than 100-metre-deep, *vertical shaft caves* extend down to the karst water level. The strictly protected *Csengő, Bongó* (see on the left), *Háromkürtő* and *Jubileum avens* possess especially spectacular solution forms. At the same time these are huge, vertical natural exposures. Waters infiltrating the surface of the plateau appear partly in the valley system of the *Gaja Brook* and partly on the southern side of the mountains where they feed the mega springs in the vicinity of *Bánta* and *Inota*. The number of caves listed in the cadastre is of the order of hundreds. Their total length exceeds 5 km.

Monoszló, the volcanic neck of the Hegyestű, geological exhibition site (G-30)

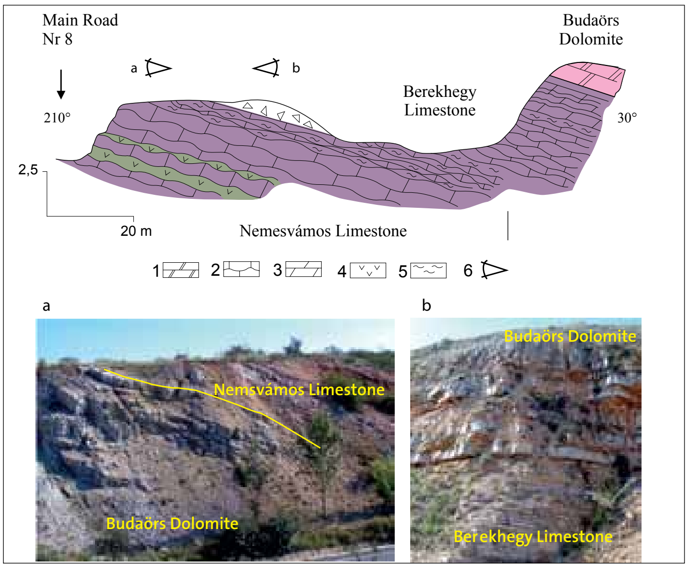
For the moment, the abandoned basalt quarry of the Hegyestű, which is located only a few kilometres from the Lake Balaton, is *one of the most important geological exhibition sites* of the proposed Bakony–Balaton Geopark (see at the bottom of the page). The mining area — developed on the hilltop — is the memory of an *early success of the Hungarian nature conservation,* as the quarry was not opened on the side that is facing the Lake Balaton; therefore the hill — watching from the lake shore — has retained its original, natural shape.

The 336 m peak of the *Hegyestű* rises more than 200 m high above the shore of the Lake Balaton. The *basalt peak* steeply rises above the approximately 300-m-high Triassic surface. In the course of quarrying the peak was almost cut in half, thus the internal structure became visible. The nearly 30-m-high wall of the disused quarry is entirely made up of basalt (more precisely *basanite)* characterised by *columnar jointing,* and this is *one of the most beautiful and spectacular occurrences in Hungary.* Based on the latest $^{40}Ar/^{39}Ar$ dating measurements the melt got cooled on the surface 7.94 million years ago, that is to say not more than 20 thousand years after the first explosions of the intercontinental basalt volcanism in Tihany. The diameter of the vertical columns is 10–45 cm. The upper section of the basalt is characterised by a *vesicular structure* which indicates a *wet environment* during the explosion. The Hegyestű's neck has been formed from the melt that had filled up the vent and crater of the strongly-eroded volcano. On the lower, northern side of the quarry basalt clasts of a vesicular texture can be seen in a *strongly palagonitized matrix.* This *tuff breccia* may have been formed in a high-temperature environment abounding in water, within the surrounding basalt body that is characteristic of the entire quarry.

From the top of the Hegyestű visitors can have a 360-degree panoramic view; the 'Somogy' (Sothern) side of the Lake Balaton, the Balaton Uplands, the Bakony and the Keszthely Mountains are visible from here.

Not only the geological build-up and geological history of the Balaton Uplands, but the flora and fauna and the memories of the former quarrying are illustrated by a small exhibition on the exhibition site, as well. Outdoors, visitors may get acquainted with the *most typical rocks of the Transdanubian area* in the form of multi-ton boulders. At the same time, the Hegyestű may offer space for the *prospective visitor centre of the Bakony–Balaton Geopark.*

Hajmáskér, Berek-hegy Limestone near Main Road No. 8 (G-31)



Geological cross section of the Berek-hegy (Berek Hill) between the Main Road No. 8 and the quarry (after Budai 2006). Legend: 1. thick-bedded dolomite (platform carbonate); nodular limestone (basin facies); 3. dolomitized limestone; 4. volcanic tuff, tuffite; 5. marl; 6. observation point

The *Veszprém Plateau* represents the interfingering area of the pelagic basinal sediments characteristic of the south-western part of the Bakony (Balaton Uplands), and the Middle Triassic shallow-marine sediments of the north-eastern part of the Transdanubian Range. Its most spectacular exposures are found in the road-cuts of the Main Road No. 8. The most detailed-studied profile is the *Berek Hill* road-cut near Hajmáskér and the quarry which is located above it in a stratigraphic point of view.

The succession of the exposure on the southern side of the main road starts with the Upper Anisian *Vászoly beds*. Their nodular limestone of basin facies is overlain by the lower part of the shallow-marine platform carbonates of the *Budaörs Dolomite*. The well-stratified, thick-bedded dolomite is overlain by tuff with a greenish tint. It underwent slight clayification. Upwards red, clayey, nodular limestone beds *(Nemesvámos Limestone)* can be seen, which belong to a younger, i.e. the Ladinian stage of the Middle Triassic. Pelagic bivalves (Daonella) and ammonites (Eoprotrachyceras, Protrachyceras, Arcestes) are relatively frequent in this succession which was deposited in a several-hundred-metre-deep pelagic basin

The succession that overlies the Nemesvámos Limestone and is built up of the cyclic alternation of well-stratified, thin-bedded, light beige limestone and marl is exposed in a small quarry of the Berek Hill. The limestone layers are made up of carbonate debris showing an upward-fining trend within the layers; in the lower part of the beds clasts of a size of 1–2 cm can be observed. This characteristic oriented sorting (gradation) and the fossil assemblages of the carbonate grains indicate that the material of the individual limestone beds is derived from a shallower environment and it was transported into a deeper sea basin. On the limestone bedding-planes tortuous sedimentary structures—indicating wormholes—and scattered ammonite impressions (Celtites) can be observed. Beds of the overlying Budaörs Dolomite indicate that at the end of the Middle Triassic carbonate platforms prograded towards the increasingly shallower sea basins; this was resulted by the global sea-level drop.

The detailed palaeontological and sedimentological studies on the succession of the quarry yielded significant data for the international research on the boundary between the Middle and Upper Triassic and for the development of Triassic sequence stratigraphy in Hungary. The quarry was shown in several *international field conferences.*

Csesznek, Fortress Hill (G-32)

The *medieval fortress,* which attracts several tens of thousands of visitors every year, has been built on the E–W-oriented blade of a *large-scale tectonic overthrust* of Miocene age. On the wall of the gate-bastion (carved into the bedrock) the fault-striated surface of the Middle Eocene limestone and the Upper Triassic *Dachstein Limestone*—which have become "smeared" onto each other—is clearly visible. The combination of the overthrust and the right-lateral strike-slip fault resulted in the formation of the 50-m-long and 10–15-m-high rock wall of the ridge that is located W of the fortress.

Several *caves, solution cavities* and decaying, tube-like *passage-remains* can also be seen in the wall. Their palaeokarstic origin is proved by conglomerate fillings in them.

The *Kőmosó Gorge* (see above), which cuts through the ridge, has been deepened by the brook as a result of *tectonic uplift.* Movements are still going on, and the watercourse flows down over several-metre-high rock steps into the hollowed rock pools forming waterfalls. The gorge is only 200 m long but its depth is 50 m. With its precipitous, rocky walls and bedrock-paved stream-bed it is a spectacular morphologic feature. Caves open on its both sides; one of them has yielded archaeological finds.

Another geological curiosity is the disused quarry designated for parking; its *Eocene limestone* wall reveals an overturned fold.

The strong microclimatic effect of the Castle Hill's sharp crest is well-indicated by its vegetation. Its shaded, cool northern side is covered with beech trees, whereas 20 m away, the treeless rocky grassland of the sunny, southern side is flanked by a Mediterranean-like karst shrubforest. The several-km-long gorges of the *Kő-árok* and the *Ördög-árok* are two popular hiking destinations in the vicinity of Csesznek.

Bakonyszücs–Fenyőfő, Százhalom: mound graves, sinkhole, brook meanders (G-33)

The central mass of the Bakony *(Kőris Hill)* is surrounded by the 5-km-long, epigenetic, strongly meandering valley of the *Száraz-Gerence ("Dry Gerence"),* which is worthy of its name; the lower section of the valley is almost always dry; water rapidly seeps away into the karstified limestone bed. Water is carried by the Ördög-séd only after thaw or heavy rains. The *Száraz-Gerence Cave* (also known as *Pörgöl Cave)* opens in the middle section of the valley, above the vertical rock walls on the right-hand side. Traces indicating temporary human presence have been revealed by the repeated excavations. The uppermost section of the *Ördög-séd* has been formed on the impermeable succession of the Miocene clayey gravel field. The brook which rises at the *Tekeres-kút* has formed very spectacular meanders along its 50-metre wide, terraced valley floor.

The intermittently active *Meander Sinkhole* (see above) can be seen in the East neighbourhood of the watercourse. Holes had developed in the impermeable cover above the locally uplifted limestone basement; therefore a young sinkhole cave was formed.

The Bakony's largest *mound-grave field,* consisting of about 220 mounds, is located on the western side of the brook. The name *(Százhalom = Hundred Mounds)* refers to the area. There are usually 1–2-metre-high mounds, of a diameter of 5–10 metres beneath the old beech trees; there are only a few larger ones among them. On the basis of archaeological investigations the graves with cremation urns—belonging to *Bronze Age people*—can be found in the gently-sloping area. The Road of the Monks passes along the mounds; the monks of the Bakonybél Benedictine Abbey walked along this road to *Pannonhalma* in the Middle Ages.

Úrkút Palaeokarst Nature Conservation Area (G-34)

One of the most famous geological exhibition sites in Hungary can be found in the inner area of *Úrkút* village. Since *it has been declared protected in 1951,* millions of people visited this geological curiosity, which has been made accessible by stairs and provided with nature trail information tables. It can be found along the route of the *'National Blue Trail',* which crosses Hungary in an E–W direction. The demonstration of the geological formation and the better understanding of the processes that acted to create it are supported by an *information booklet.*

The unique, 70-million-year-old natural value owes its existence to the fact that the overlying Eocene limestone has protected it from erosion and at the beginning of the last century the accumulated manganese ore was extracted by hand tools. Therefore, the mineral ore-bearing palaeokarstic land-

forms have been perfectly preserved. In an area of an extent of a few hundreds of metres series of vertical-walled, cauldron-like *dolines* have been dissolved in the *Lower Jurassic limestone.* They are of a diameter of 30 m and of the same depth. The surface of thresholds and highs between the karstic depressions underwent considerable karrentification.
All these took place under the end-Cretaceous tropical climate — similarly to the formation of the footwall of karst bauxites in Hungary. The difference between them is that in Úrkút Jurassic limestone is the rock that underwent karstification and forms were filled with oxidic manganese ore — this gives its uniqueness. The long-term preservation of finer morphologic features (i.e. half-chimneys, solution pockets and shafts and rill channels) exposed on the surface is due to the stability of rock.
In other parts of the protected area other geological curiosities can also be found: e.g. one-time submarine fissure-fillings, striae of strike-slip faults, caverns cut in half by faults and a small *cave.*
Besides geological knowledge dissemination, the very spectacular and unique area well serves education as a location of school excursions and university field exercises. Research on the formation of manganese ore (which has not fully understood yet) attracts a lot of scientific experts to Úrkút.

Veszprém: meandering gorge in the town (G-35)

The administrative centre of Veszprém County (wearing the same name) has been made famous by *Queen Gizella,* the wife of Hungary's first king, since it was the centre of her estates. The monuments of the medieval castle, comprising palaces, commercial houses and churches, provide a picturesque view. The thick walls have been erected on a cliff which rises above the Séd Brook. The long and narrow strath terrace of the *Benedek Hill* (see on the right) protrudes from this cliff. One can look far over the ranges and internal basins of the Bakony from here. This unique view is due to the fact that the ancestor of the *Séd Brook* has incised a 50-m-deep valley into the eroded Triassic dolomite of the Veszprém Plateau. Its bed formed several-metre-wide bends on the former surface (covered with pebbly–clayey sediments). Near the present-day Veszpém such a double S-bend was superimposed on the uplifting dolomite bedrock. During the Pleistocene it deepened its valley in these incised meanders. A few-km-long foot path leads through its gorge-like valley, where water mills used to work.
A further beautiful example of tectonic movements is the road-cut behind the viaduct that bridges the valley, where the overthrust of the Veszprém Marl upon the Main Dolomite can be seen. The steep valley-incisions of the adjacent grassy hillside also indicate fault lines.
Jenő Cholnoky (1870–1950) the native of the town was a world-famous geographer and a participant in the research on the Lake Balaton. Geologist and museum founder monk Dezső Laczkó taught and worked in Veszprém through nearly half a century since 1888. He has found the fossil skull and skeleton remains of *Placochelys placodonta* (flat-plate turtle, see on the left) of Late Triassic age in the quarry of the town.

Darvas-tó Exploited Bauxite Lens Nature Conservation Area (G-36)

Bauxite occurrences in the Transdanubian Range were exploited partly in open-pit mines. Such a *disused bauxite pit* can be found East of Sümeg which is famous of its medieval fortress; later it was *declared a nature conservation area.* The *palaeokarst features* of the underlying Triassic *Main Dolomite* have remained almost intact during the exploitation. Along the bottom of the 500-metre-long open-pit mine the series of large *dolines* and the 10–20-m-high *karstic elevations* and *crests* show the end-Cretaceous morphology. The value of the site is increased by the exposure of the Eocene succession (which directly overlies the bauxite) in the wall of the former mine.
The continental conditions in the Bakony, which started at the end of the Cretaceous Period, lasted for more than 20 million years. It resulted in the denudation of Cretaceous and Jurassic sediments over a large part of the area. Due to the tropical, subtropical climate the exposed Triassic Main Dolomite underwent considerable karstification. Several-metre-deep dolines, of a diameter of sometimes a hundred metres, came into being; they became connected to each other and have formed series of dolines.
45 million years ago, during the Lutetian Age transgression occurred. The palaeoenvironmental changes are indicated by the transgression deposits which overlie the bauxite. The organic-rich, clayey sediments of the lagoon are overlain by a fauna-rich, more calcareous bed and upwards by a shallow-marine, Alveolina-bearing limestone and Miliolina-bearing calcareous marl. The succession is topped by the lower, nodular limestone of the *Szőc Limestone Formation.*
The protected area is *regularly visited for educational purposes by students of higher education* institutes who deal with earth sciences and by excursion groups of other schools.

Dörgicse, Kő Hill (G-37)

The Kő Hill — which is located between *Felsődörgicse* and *Kisdörgicse*, SSE of the high road — is made up of a characteristic formation of the Balaton Uplands, i.e. the Upper Triassic (Carnian) *Füred Limestone.* The path leading to the hill starts at a *Baroque stone bridge* and reaches the marked tourist path after 200 m. The latter leads to the upper yard of the abandoned quarry. In this horizon of the quarry the lower, thick-bedded section of the Füred Limestone was excavated for building stone and for decorative stone. In a south–south-easterly direction the wall of the disused quarry continues in a cliff above which the most beautiful *karrenfeld* (limestone pavement) can be found in an area of a diameter of some hundred metres. The development of the sometimes half-metre-deep grikes — which densely intersect each other — is associated with the tectonic fracture network.
The upper yard of the quarry exposes the upper section of the Füred Limestone which is dissected by marl intercalations and characterised by tabular bedding. Borehole Dörgicse Drt–1 was drilled in this yard in

1985; it penetrated through the succession of the Kő Hill from the Füred Limestone down to the base of the *Tagyon Limestone.*
The hiking trail mark leads from the stone bridge southwards to the some hundred-metre-long antecedent gorge. On the uphill side of the *Kő Valley* (see the photo of the preivous page) the Füred Limestone forms a 10–15-metre-high, near-vertical wall showing the alternation of 1–1.5-metre-thick beds and the well-bedded sections—made up of thinner layers—in the succession of the Füred Limestone. In the slope of the gorge there are about a dozen smaller caves indicating the one-time subsurface karstification.
Among the fossils of the Füred Limestone *protozoans* (foraminifers and radiolarians) are frequent. Thin-shelled bivalves also occur, ammonites are sparse.

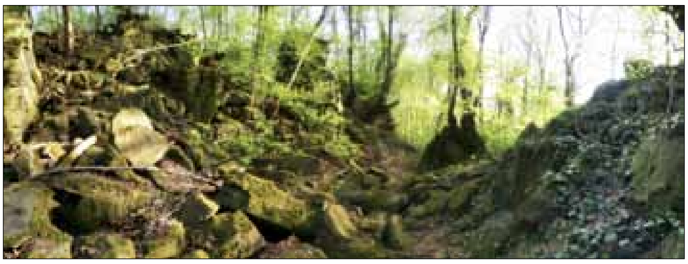
Fonyód, Fortress Hill (G-38)

The most prominent peak in the southern, flat shoreline of the Lake Balaton rises opposite of Badacsony (233 m). Similarly to the *volcanic remnant hills* in the Tapolca Basin it is—together with the neighbouring *Boglár Hill* on the East —of the same origin (erosional volcanic remnants). Based on radiometric dating on basalt blocks which crop out of the soil that covers the hilltop, *the lava solidified 3.5 million years ago.* However, the origin of this basalt is still not clearly understood: according to some opinions, similarly to the other volcanic remnant hills, it was a single eruption centre. Others say that the small amount of lava rocks and the lack of pyroclastics rather refer to the remnant of a lava flow. On the basis of petrographic similarities lava may have come even from the Badacsony.
However, this small basalt cap was enough to protect the underlying Pannonian succession from the erosion (see above). The spectacular clay stringers of the abandoned sand pit in the southern part of the town were deposited in the Lake Pannon. Nevertheless, the real geological (and geomorphologic) peculiarity is the vertical collapse on the northern side of the hill. The wave activity of the Lake Balaton eroded the loose sand beds even 150 years ago; situation has changed only after the construction of the railway line. The sometimes still moving, almost 50-metre-high wall of the coast—which stretches over several hundred metres —exposes the beds of the Tihany Formation. The lower part of the profile exposes coarse-grained, cross-bedded fluvial sand with reworked mollusc shells and clay clasts in it. It is overlain by a succession of cyclic structure made up of beds of coastal facies which are dissected by paludal horizons.
A walkway has been built along the coastal edge of the bluff top. The panorama from here provides probably the most spectacular view of the Lake Balaton. Opposite to this place almost all volcanic remnant hills of the Tapolca Basin can be seen. The Keszthely Mountains rises in the north-west, whereas north-eastwards our gaze wanders even beyond the Tihany Peninsula. One of the historic buildings of the landscaped walkway houses the permanent exhibition which shows the Lake Balaton and its vicinity. The natural history material illustrated with plentiful photos and figures makes visitors acquainted with a great variety of aquatic and terrestrial habitats. Fossils, maps and the rocks in a sand table provide insight into the geological history of the area.

Pénzesgyőr, Kerteskő Gorge (G-39)

The *Gerence Brook*—which flows westwards from the *Pénzesgyőr Basin*—cuts through a few-hundred-metre-long but rather spectacular gorge towards *Bakonybél.* In times past the ancestor of this brook flowed through the Miocene gravel blanket, which overlies the Mesozoic rocks of the area. Due to the Quaternary uplift of the area the bed of the brook was superimposed onto the underlying Cretaceous limestone and meandered its way through this rock, cutting deep into it. The valley is located in the *High Bakony Landscape Protection Area.* It is surrounded by vertical cliffs of a height of several tens of metres. The well-bedded *Lower Cretaceous limestone* is dissected by numerous faults indicating strong tectonic effects. Erosion has widened the vertical cracks into crevices; characteristic rock ribs can be seen on the walls.
The rocks of the southern side of the gorge were uplifted by these tectonic movements, which resulted in the formation of a perched karst water table. The water of the Judit Spring rises up to the surface at the contact of the impermeable Cretaceous clay with the overlying *Zirc Limestone.*
Carbonate precipitation from the karst water resulted in the formation of a series of small *flowstone terraces* along the steep slope; small waterfalls make beautiful additions to the valley-side above the Gerence.
According to tradition, the rock pinnacle of semi-cylindrical shape of the neighbouring *Oltár-kő*—as its name suggests—was a place of sacrifice of the conquering pagan Hungarians.
The *Szömörke Valley* with a special atmosphere represents the lower continuation of the gorge. It leads tourists to Bakonybél. Here goes the tourist path named after a 19th-century famous Hungarian naturalist of the Bakony area (i.e. Flóris Rómer).

„Basalt street", Kovácsi Hills (G-40)



This geosite can be found near *Vindornyaszőlős,* on the western margin of the basalt hills that form the northern part of the *Keszthely Mountains,* in the area of the Balaton Uplands National Park. The alkaline basalt volcanism of the *Kovácsi Hills* is different from the processes common in the area of the Transdanubian Range and in the Little Plain. Most of the 3.4–2.7-million-year-old volcanic bodies have been trapped beneath the surface in a small depth and could not penetrate the entire succession which had been deposited in the Lake Pannon. Basalt became exposed on the surface after the denudation of the Pannonian sequence (which is made up of loose sediments) and in several quarries the network of sills and dykes can still be studied; its best exposure is in the abandoned quarry in Sümegprága.
The exceptionally spectacular Basalt street was formed during the Quaternary in connection with processes that led to the *erosion of the Pannonian succession.* The basalt— overlying the loose Pannonian deposits frequently dissected by impermeable clay layers—is more resistant to all exogenic processes of weathering than the neighbouring beds, therefore it rises above the surrounding area with steep slopes. The slopes are frequently affected by *landslides* occurring along the clayey Pannonian beds; both the sedimentary succession and the basalt are represented in these processes.
The Basalt street represents the largest, long-stretching form of such a type of mass wasting. It borders the edge of the Kovácsi Hills on the West about along a half-a kilometre-long curve. A ditch-like form—which is

wider than 10 m and locally is of a similar depth — came into being due to the displacement of rock masses. It is lined with houses and resembles a street. Its uneven surface is hardly passable due to the huge collapsed and displaced boulders. Displacement resulted in the formation of hardly-accessible crevices in the basalt. Such a pseudo-tectonic cave is the *Vadlány-lik* in Vindornyaszőlős. The unique natural assets are well represented by the *nature trail* that starts in *Vindornyaszőlős*.

Pécsely, quarries on the Meggy Hill (G-41)

The *Meggy Hill* — which is made up of the Upper Triassic (Lower Carnian) *Füred Limestone* —rises in the centre of the *Pécsely Basin*. The crest of the Dobogó Hill of the Middle Carnian *Nosztor Limestone* stretches North of it. The Pécsely Basin is located between the ridges and was formed on the soft layers of the *Veszprém Marl*. The southern rim of the basin is bordered by the Middle Triassic range of the Ágas-magas. This "wavy" surface is an excellent example of the impacts of selective erosion.

The disused quarries of the Meggy Hill can be reached from the main road. The most spectacular wall exposing the upper section of the Füred Limestone can be found at the eastern end of the series of pits. The north-eastward-dipping succession is made up of the rhythmic alternation of 1–2-dm-thick limestone beds and the intercalating thin marl layers. Due to this tabular bedding the rock can be easily quarried, therefore the Füred limestone is one of the most popular pedestals and curb stones in the Balaton Uplands. The light grey limestone is dissected by strips and elongated nodules of dark grey chert. Fine striae can be observed on the limestone escarpments, which indicate horizontal displacement of the beds which had been broken due to tectonic effects. Finding fossil costate bivalves (Halobia) and ammonites *(Trachyceras aon, Dittmarites rueppeli)* on the nodular bedding-planes involves luck. Detailed palaeontological investigations (on radiolarians and conodonts) have proved that the Füred Limestone belongs to the Lower Carnian and its age is about 228 million years old.

Ajka, Padrag cliffs (G-42)

Padragkút is a district of the town Ajka which is known for its former coal mining. The considerably spectacular cliff formation rises above both sides of the dry bed of the nearby ephemeral watercourse. Because of its geomorphologic value, the formation — favoured by the tourists — has received local protection.

It is made up of the well-bedded, Middle Eocene *Szőc Limestone*. It contains the fossils of gigantic protozoans, i.e. nummulites. The most well-known among them is the lentil-like *N. perforatus* and the flat disc-shaped *N. millecaput*. The colloquial name for the latter — due to its coin-like shape — is *Saint Ladislaus's coin;* moreover, a folk legend is attached to it. Besides these fossils, numerous — mostly microscopic — extinct, calcareous unicellular organisms represent the diverse palaeobiota that inhabited the subtropical shallow-marine environment 50 million years ago. Bivalves, gastropods and echinoids belong to the larger fossils; therefore they are less frequent here.

The *Padragi-víz creek* deepened a short, antecedent valley section into the rocks during the Pleistocene. The north-eastern side of the rock mass forms a rock ledge which steeply bends downwards. Above it, the surface water — filtering into it along the bedding planes and fissures — formed some-dm-large cavities and short cave passages by the dissolution of the limestone. The path which leads up to the cliff continues along the forest edge; the panorama from here provides a spectacular view over the plain of the Bakonyalja and the solitary volcanic remnant hill of the Somló. The southern group of the Padrag cliffs rises above the surface on the other side of the valley, forming a vertical rock pillar. The huge rock walls with their weathered, smooth surfaces make interesting impressions. The rock mass with an almost vertical wall on one side is penetrated by several faults, along which narrow fissures have been incised into it. A boulder protruding several metres from the top of the wall is especially spectacular. The surrounding rock mass has already collapsed forming huge stone crests, set on their edge, on the hillside.

Bakonynána, Roman Bath: gorge with waterfall, cave, geological key section (G-43)

The formation of a peculiar name is not related to the Romans; however, archaeologists have found brick remains of this age near the neighbouring village of *Bakonynána*. The most significant watercourse of the East Bakony, i.e. the *Gaja Brook* has formed a 2-km-long, meandering *epigenetic gorge*. The brook, cutting a 50-m-deep valley into the *Cretaceous limestone,* is flanked by rocky sections. Its wildest part is called *'Roman bath';* it is characterised by small waterfalls in the potholes of the rock steps, but during floods awesome swirling water is found here. A graphic description of the cauldron was published in a popular science book already in 1860.

A further natural curiosity is the cave that opens 10 m high above the brook in a well-stratified, thick-bedded limestone. According to the legend, the 12-metre-long hollow was the hiding place of Jóska Sobri, one of the famous outlaws in the Bakony. It is hardly accessible on a narrow rock ledge.

In the romantic part under the waterfall near the *Vadalmás spring,* a small rest area has been established for tourists who often arrive here while hiking along the route of the *'National Blue Trail'*.

In a road-cut on the way to the parking place above the gorge a geological key section has been established. The rock wall exposes the transition of the Cretaceous *Zirc Limestone Formation* to the overlying *Pénzeskút Marl,* which were formed in near-shore environments. The lower succession is made up of greenish-grey, glauconitic, fine-sandy beds containing coalified plant remains, echinoid fragments and worm-tube fillings. The boundary between the two formations has been drawn on the basis of foraminifer investigations. Some of the marly-clayey beds in the upper, few-metre-thick section contain rich macrofauna (Ammonites, Belemnites, Echinoidea). Ammonites derived from the vicinity of Bakonynána have already mentioned in Hauer's 1861 dissertation.

The Vadlány-lik cave in Gyenesdiás, key section of the Diás Formation (G-44)

The small cave — located on the top of the steep, western slope of the hill that rises directly in the outskirts of *Gyenesdiás* — drew the attention of geoscientists (who worked in the area) already long ago. The hill is situated on the southern edge of the *Keszthely Mountains*. Everywhere in its background the *Upper Triassic dolomite* crops out to the surface; however, the hill itself is built up of conglomerate beds which are made up of dolomite breccia and dolomite pebbles. The cave was form in this succession.

The succession which builds up the hill was deposited along the shore of the *Lake Pannon* during the Late Miocene. Its material is derived from the *dolomite debris* that had been transported into the lake shore-zone from the marginal slope of the Keszthely Mountains which stood out like an *island* from the Lake Pannon. The debris has been partly reworked by the wave activity; clasts became medium- to well-rounded pebbles, and were formed into sorted beds. However only a part of the debris could have been reworked by wave action, therefore gravel beds are found only above a few debris beds. In the area of the Transdanubian Range, the name *"Diás Gravel"*, referring to the abrasional gravel, breccia and conglomerate beds of the shore-zone of the Lake Pannon, comes from this locality; this exposure is the key section.

Detailed examinations on the origin of the small cave — located on the hillside, directly beneath the hilltop — have not been carried out, yet. Bulla (1928) mentioned it in his work as an abrasional cave that had been formed on the shore of the Lake Pannon. However, this would mean that an 8-million-year-old surface form has been preserved almost intact, moreover, in a slightly-cemented rock. The path leading to the cave reveals such conglomerate beds which are cemented by sparry calcite. The latter and the harder "rock cap" of the hilltop indicate ascending warm water. Hence, this suggests that the formation of the cave is due to subsequent processes related to ascending warm water.

"Cockpit karst" near Zirc (G-45)

Tourist may find unique, cone-shaped rock features nearly 1 km to the NW of the so-called 'Akli' district of *Zirc*. Walking through the small forest patch of the *Köves Hill,* it is prominent that there are two, approximately 1-kilometre-long, parallel *limestone outcrops*. The distance between them is 50 to 100 metres. Isolated cones and rock crests rise from the almost flat surface. The ground-plan of the limestone protrusions, lining up one after the other, is more or less an elongated ellipse of a diameter of 10–50 m and of a height ranging from 5 to 20 m. Mound-like, elongated forms are seen between the isolated cones. On their steep hillsides, frequently with boulders staggered on them, locally several-metre-high, vertical (subordinately concave) surfaces also occur. Locally they are thick-bedded (0.5–1.5 m), however, the chaotic appearance is more typical; it is interspersed with slip planes (of a size of a few square metres) characterised by striae, reverse fault planes and fault lines. Old linden-trees can often be found on them, enhancing the dark green colour of mosses which cover the light grey rocks.

The material of the cones belongs to the Lower Cretaceous *Zirc Limestone Formation;* it is indicated by the thick-shelled bivalve shells which have been weathered out on the dissolved surfaces. Formerly the rock was named after them: *"Requienia-bearing limestone"*. It is prominent that — with few exceptions — these strange landscape features are predominantly characteristic of this rock type. Similar features can be found only in three sites in the surroundings (i.e. South of *Pálihálás,* on the *Iharos-tető* in Pénzesgyőr and on the *Mester-Hajag* in Hárskút). Such forms are unknown in other karst areas of the country.

The development of the strange rock features have not clearly explained, yet. They may have been formed due to the exhumation and further recent karstification of palaeokarst terrains. The underlying clayey succession *(Tés Clay Marl Formation)* — being impermeable, loose sediment — and tectonic processes (manifested in striae and brecciated-crushed zones) probably played an important role in their formation. Karst water lenses "leaning" on the clayey aquiclude are tapped by small, intermittent karst springs at the foot of the limestone outcrops. Precipitation of calcareous tufa from the water of the small brooks occurs, coating the pieces of wood lying in the bed. Such a precipitation can be seen at the western end of the area, where a periodic waterfall has developed, which flow down over a few-metre-high scarp.

C. Geoconservation

C.1. Current or potential pressure on the proposed Geopark

Centres of heavy industry and mining also operated on the area before 1990. The overwhelming majority of these activities ceased to exist, leaving significant unemployment in the affected region. Nowadays only two, low capacity underground mines of bauxite and manganese ore operate within the Geopark area. Naturally, the industrial demands are still supplied with small clay, gravel, basalt, bauxite, dolomite and limestone open cast mines. The relationship between the Applicant and the mining companies is usually fair, but obviously there are situations when the interests of nature conservation confront with that of the for-profit companies. For example in October 2011– on the basis of our notification – the Authority on Mining limited the operation of a limestone quarry in the Bakony Mts because a cave was found during quarrying. A few years ago we successfully prevented the enlargement of a sand pit, because it would have endangered the geological heritage of the Sea of Stones at Salföld in Káli Basin. With the cooperation of the inhabitants of nearby villages, we have also prevented the reopening of a limestone quarry, because the transport would have been possible only across the national park area.

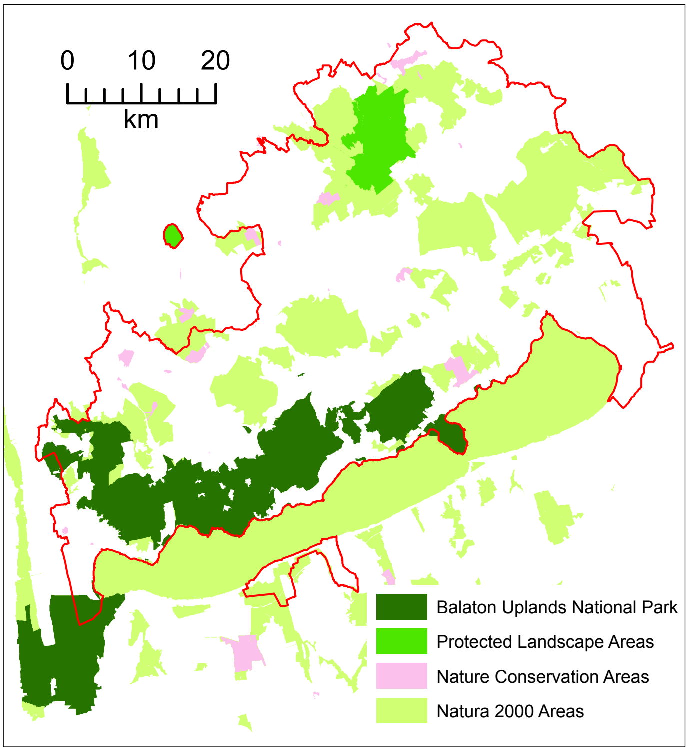
A positive example is the mainly rehabilitated open cast bauxite mine of Iharkút where the first late Cretaceous dinosaur remains in Hungary were found, bearing international significance. What is more, the mining company has supported research up to the present. Another example to follow is the case of Úrkút Palaeokarst Nature Conservation Area, where the clearing of the geosite, the establishment of the stairway and of the nature trail was financed by the local manganese ore mining company (the construction works, the creation of the guide booklet and the nature trail was implemented by one of our Geopark Partners, the Pangea Association).

Several geosites can be found along popular hiking routes (e.g. 'National Blue Trail', which traverses Hungary in a western–eastern direction), thus at some sites obviously a seasonal load can be observed (tread on rocky grasses, etc.). Luckily, less and less vandalism and rubbish have been observed lately. Although the magnitude of fossil collecting is not significant, unfortunately also foreign collectors appear in the Bakony Mts at some places of occurrence rich in ammonita, and some of the fossils can be found at fossil fairs abroad. A solution also for this problem may be to declare these geosites (most of them are geological key sections) protected as natural monuments, because this way the Ranger Service can take steps by referring to a rule, if needed. We also emphasize the safeguarding of the biotic and abiotic natural assets during our geotour guide training course. Instead of further details, we quote a relevant article from the cooperation agreement concluded with the geotour guides:

„The geotour guide during the excursions interprets and makes our geological heritage, biotic natural assets and cultural values known with optional tools of communication. Collecting the entities of any species, disturbing, damaging their habitat and collecting minerals, fossils is forbidden for the geotour guide as well as for the participants."

C.2. Current status in terms of protection of geological sites

Hungarian heritage conservation consists of three levels. The EU level is represented by the Special Areas of Nature Conservation of the Natura 2000 Network in the Geopark, protected according to Community legislation. The legislation at national level is in the form of Nature Conservation Acts. The Act on Nature Conservation No LIII. of 1996 protects Natural Areas (National Parks, Protected Landscape Areas, Nature Conservation Areas) and Natural Assets (Natural Monuments, caves, springs, sinkholes, fens, kurgans and earthworks). The Act on Cultural Heritage No LXIV. of 2001 protects Cultural Monuments and Archaeological Sites. The 23. § (2) section of the Act on Nature Conservation grants an 'ex lege' protection to all Natural Assets, except Natural Monuments. The European Diploma-holding Tihany Peninsula (included in National Park) was granted special protection at national level. The sites of local interest (e.g. Olaszfalu, Woodpasture Nature Conservation Area including Eperjes Hill geosite) are protected by municipality decrees.



Among the above mentioned 'ex lege' protected natural assets, the proposed Geopark area comprises 690 caves, 1607 springs and 529 sinkholes. Altogether 24 of the 45 geosites listed and described in Chapter B.3. are located on protected natural areas of national interest (National Park, Protected Landscape Area, Nature Conservation Area) and/or the geosite itself is under 'ex lege' protection (caves). 15 geosites can be found on the Natura 2000 Network's Special Areas of Conservation (SACs) of Community importance (out of which 7 geosites are located otherwise on non-protected areas). The total number of geosites that are neither 'ex lege' protected, nor are on protected area or on SAC is 13.

The proposed Geopark covers one of the most geodiverse regions of Hungary. This is also proved by the fact that most of the Hungarian geological key sections (125 out of 494) is located in the Applicant's operational area, preceding the operational areas of the other nine National Park Directorates. According to the present database kept by the Hungarian Commission on Stratigraphy, 116 of them are located within the Geopark. Among these 32 are on protected natural areas of national interest (National Park, Protected Landscape Area, Nature Conservation Area): in these cases we can speak of nature protection. Granting protection to the key sections that are not on protected areas is under preparation and is expected to be accomplished within a few years.

The unique volcanic remnant hills of the Tapolca Basin and the 'seas of stones' of the Káli Basin are strictly protected areas of the Balaton Uplands National Park, thus it is impossible to quarry there also from a legal point of view. A great success of Hungarian nature conservation was when in the 1960's the basalt quarry of Badacsony was stopped (the disused quarry has become a habitat of strictly protected birds of prey). One of the Applicant's most emblematic geological exhibition sites (Monoszló, Hegyestű) is also located in a disused basalt quarry which is also a strictly protected area of the National Park.

C.3. Data on the management and maintenance of these sites

Several geosites of the proposed Geopark, located on protected areas are in the property management of the Applicant. According to the management plan of the Directorate and, if needed, on the proposal of the Geopark Team, these sites are regularly managed and maintained by the Ranger Service. Appropriate human resources and equipment are also available at each of the geographical units of the Geopark (machinery, powerful bush cutters and clearing saws, etc.). Two workshops are also operated by the Applicant within the proposed Geopark (Tihany Peninsula, Káli Basin) where a great number of preparation work can be done: e.g. the making of the supporters of nature trail information panels and balustrades.

According to the Cooperation Agreement concluded by the Applicant and the Micro-Regions, the involved Micro-regional Associations undertake that they promote the participation of the involved settlements in the clearing of geological key sections with the help of public work projects of the settlements, especially where the real estate concerned is managed by the local government. They also promote the maintenance of the geological heritage and the accompanying infrastructure (e.g. nature trail, resting area, information boards, hiking marks). There are places where a nature trail had been created not by the Applicant but some other organisation (e.g. the local government). According to necessity, the renovation of these nature trails, the clearing of the excavations is part of our plans.

The experiences of the Applicant are positive also in those cases when the geosite can be found on a privately owned property. The owners have never banned management activities on the site – on the contrary, they are rather proud of having a geosite located on their land, and they have even helped our work in everything they could.

One of the tasks of the Applicant's Ranger Service is involving public workers in the works of nature conservation management. After consultation with the Geopark Team, several geosites are the locations of such work repeatedly. This summer e.g. the clearing of bushes at a karrenfeld near the village of Dörgicse was carried out and will be from now on, annually. Management of the seas of stones in Káli Basin is done several times a year. Civil organisations cooperating with us, our Geopark Partners have also done such work at a number of sites (cleaning of the Sand Pit of Várpalota NCA, clearing of bushes in the quartz phyllite quarry on Somlyó Hill near Balatonfőkajár, where the oldest rock type of the Geopark is uncovered (on the next page the working team of the *Pangea Association* can be seen), cleaning of rubbish a Bakonyian sinkhole, etc.), and these works are carried out by them each year where needed. Some geosites are visited by the member of the Geopark Team or Ranger Service almost every week, but naturally there are also remote sites that we can reach only in a few months' frequency. During the nature conservation rehabilitation of disused quarries we develop rock surfaces and slopes that are properly stabile and secure.

The project of the Applicant financed by the EU's Environment and Energy Operational Programme will have accomplished cave reconstructions, clearings of seas of stones and nature conservation rehabilitation of a disused quarry by February 2013. Our geotour guides play an important role also in giving us notification about damage or other events concerning the geosites. We have received a notification e.g. about a minor rock-fall at a geosite. The agreement with the Micro-Regions also includes reference to such notifications. The required maintenance works have been done at some geosites (e.g. building supporting pillars under the basalt pyroclastic beds situated above the Monks' Cells in Tihany or establishing a protective roof above the excavation of the Sand Pit of Várpalota NCA). The latter area is fenced in order to protect the exceedingly rich fossil locality, and visitors are allowed to enter the area only if accompanied by our trained geotour guide. The establishment of the protective roof placed on the area of the Mogyorós Hill of Sümeg NCA was financed by the Geological Institute of Hungary, many decades ago (this area is also fenced).

C.4. Listing and description of non-geological sites and how they are integrated into the proposed Geopark

Cultural heritage

The geological values testifying to the power of nature: grim cliffs and hot springs, volcanoes and basalt columns show only one face of the proposed geopark. The landscape has been shaped for five thousand years not only by nature but also by culture – and its historical layers outcrop unexpectedly just as the geological phenomena. The presence of man, using and ceaselessly redefining the land has created a region so rich in cultural monuments that it has rightly evoked and kept the attention of tourism and has given work to the museums of high standard: the Balatoni Museum in Keszthely, the Laczkó Dezső Museum in Veszprém and several smaller collections and country houses. This time only some connections and details can be mentioned from the richness represented by the area of the proposed geopark, as a cultural landscape, a historical landscape and a sacral landscape in Central Europe.

The history of the proposed area can be divided into three eras from the viewpoint of land use: the era preceding the expansion of the Roman Empire (before the 1st C.), the Middle Ages and the Early Modern Period (until the end of the 17th C.) and the period from the Ottoman-Turk conquest to present day. A common feature of all the three eras is that important commercial routes crossed the area, serving the transport of universal cultural goods – such as the Neolithic achievements or the Roman pottery – and also of specific products to the northern and southern and to the eastern and western parts of Europe. However, in terms of the system of nature's goods that can be exploited, the proposed area of the geopark itself can be divided into several units of economic geography. Two of these are particularly interesting because of their influence on culture: the environs of Lake Balaton, rich in fish and shoreline plants and Bakony Hills, rich in timber and minerals.

Although man appeared on the area about 70–80 thousand years ago already, *(continued on page 40)*

A traditional cottage in Tihany, made of the local basalt lapilli tuff

Archaeological sites (compiled by Judit Regenye archaeologist)

Id	*Settlement, site*	*Period*	*Access*	*Utilisation*	*Importance*
A-01	Bakonybél, burial mounds	Bronze	yes	S	LOC
A-02	Bakonyszücs, burial mounds	Bronze	yes	S/T	NAT
A-03	Balatonfőkajár, settlement	Roman	no	S	LOC
A-04	Balatonfüred, villa	Roman	no	S/T	REG
A-05	Balatonfüred, cemetery	Migration	yes	S/E	LOC
A-06	Balatonfüzfő, Avar cemetery	Migration	yes	S/E	LOC
A-07	Balatonfüzfő, potter settlement	Roman	yes	E	REG
A-08	Balatonszőlős, Avar findings	Migration	no	S	REG
A-09	Balatonudvari, cemetery	Migration	no	S/E	NAT
A-10	Balatonvilágos, potter settlement	Roman	no	S	LOC
A-11	Farkasgyepű, burial mounds	Bronze	yes	S/T	LOC
A-12	Gyulafirátót, villa	Roman	yes	S/T	LOC
A-13	Inota, burial mounds	Roman	yes	S/T	NAT
A-14	Kékkút, Paleochristian basilica	Roman	no	S/E	REG
A-15	Keszthely, fortification	Roman	yes	S/T	INT
A-16	Királyszentistván, cemetery	Bronze	no	S	LOC
A-17	Lesencetomaj, cemetery of the Keszthely culture	Migration	yes	T	LOC
A-18	Lovas, paint-quarry	Palaeolithic	yes	S/E/T	INT
A-19	Mencshely, industrial community	Neolithic	no	S	INT
A-20	Nemesvámos, villa	Roman	yes	S/E/T	INT
A-21	Nemesvámos, grave	Roman	yes	S/E/T	NAT
A-22	Öskű, dam	Roman	yes	S/T	NAT

Utilisation: S: Scientific E: Educational T: Touristic

Id	Settlement, site	Period	Access	Utilisation	Importance
A-23	Paloznak, villa	Roman	no	S	LOC
A-24	Somló, metalwork centre	Bronze Iron	yes	S/E/T	INT
A-25	Sümeg, flint quarry, chieftain centre?	Bronze	no	S/E/T	NAT
A-26	Szentgál, stone quarry	Neolithic	no	S/E/T	INT
A-27	Szentkirályszabadja, villa and dam	Roman	yes	S/E/T	NAT
A-28	Tapolca, urn cemetery	Iron	no	S	LOC
A-29	Tihany, earthworks, settlement	Iron	yes	S/E/T	INT
A-30	Tihany, settlement; Starcevo culture	Neolithic	no	S/E	INT
A-31	Uzsabánya, settlement, chieftain centre	Bronze	no	S/E/T	NAT
A-32	Várpalota, Langobard cemetery	Migration	yes	S/E	LOC
A-33	Várpalota, Avar cemetery	Migration	no	S	LOC
A-34	Várpalota, Cemetery	Migration	no	S	LOC
A-35	Veszprém, encrusted pottery	Bronze	no	S	LOC
A-36	Veszprém, Avar cemetery	Migration	no	S	LOC
A-37	Veszprém, Avar cemetery, goldsmith's workshop	Migration	no	S	NAT
A-38	Veszprém, Lengyel chieftain centre	Neolithic	yes	S/E	NAT

Sites of religious architecture (compiled by Veronika Schleicher ethnographer)

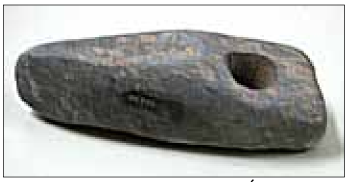
Id	Settlement, site	Period	Access	Utilisation	Importance
R-01	Aszófő, Kövesd church ruin	13th C.	yes	T	LOC
R-02	Bakonybél, Benedictine Abbey	11th C.	yes	E/T	NAT
R-03	Balatonakali, Sárdörgicse church ruin	11th–12th C.	yes	T	REG
R-04	Balatonalmádi – Vörösberény, Reformed fortified church (earlier St Martin church)	11th C.	yes	S/E/T	NAT
R-05	Balatoncsicsó, St Blaise church ruin	13th C.	yes	T	LOC
R-06	Balatoncsicsó, Árokfő church ruin	13th C.	yes	T	LOC
R-07	Balatonfüred, Papsoka, St Michael church ruin	12th C.	yes	S/E/T	REG
R-08	Balatonfűzfő, Máma, St Ladislaus church ruin	13th–14th C.	yes	T	LOC
R-09	Berhida, catholic church (St Ladislaus church)	14th–15th C.	yes	T	LOC
R-10	Csopak, Kövesd St Michael church ruin	13th C.	yes	T	LOC
R-11	Alsó-Dörgicse, Virgin Mary church ruin	13th C.	yes	T	LOC
R-12	Felsődörgicse, St Peter church ruin	13th C.	yes	T	LOC
R-13	Kisfalud-Dörgicse/Kisdörgicse, church ruin	13th C.	yes	T	LOC
R-14	Felsőörs, Mary Magdalene Provostry church	13th C.	yes	S/T	NAT
R-15	Gyulafirátót, Premonstratensian monastery ruin	13th C.	yes	E/T	LOC
R-16	Káptalantóti, St Martin; Sabar Hill church ruin	13th C.	yes	T	LOC
R-17	Keszthely, Egregy, church ruin	13th C.	yes	T	LOC
R-18	Keszthely, Franciscan monastery	14th C.	yes	T	REG
R-19	Kisapáti, Holy Cross chapel	13th C.	yes	T	LOC
R-20	Kővágóörs, Pusztapalota church ruin	13th C.	yes	S/E/T	LOC
R-21	Kővágóörs, Ecsér church ruin	13th C.	yes	T	REG
R-22	Kővágóörs, Sóstókál church ruin	14th C.	yes	T	LOC
R-23	Kővágóörs, Kisőrs church ruin	Romanesque	yes	T	LOC
R-24	Köveskál, Kerekikál church ruin	13th C.	yes	T	LOC
R-25	Lesenceistvánd, catholic church	14th–15th C.	yes	T	LOC
R-26	Litér, catholic church	14th–15th C.	yes	S/E/T	NAT
R-27	Mindszentkálla, Kisfalud church ruin	14th–15th C.	yes	T	LOC
R-28	Monostorapáti, Almád Benedictine Abbey ruin	13th C.	yes	T	LOC
R-29	Nagyvázsony, Csepely; Pusztatemplom church ruin	13th C.	yes	T	LOC
R-30	Nagyvázsony, St Helena church ruin	13th C.	yes	T	LOC
R-31	Nagyvázsony, St Michael Pauline monastery ruin	15th C.	yes	S/E/T	REG
R-32	Nagyvázsony, Tálod Pauline monastery ruins	15th C.	yes	T	LOC
R-33	Nagyvázsony, Nemesleányfalu, St Jacob church ruin	13th C.	yes	T	LOC

Id	Settlement, site	Period	Access	Utilisation	Importance
R-34	Nagyvázsony, St Stephan church	14th–15th C.	yes	T	LOC
R-35	Olaszfalu, Felsőpere church ruin	13th C.	yes	T	LOC
R-36	Örvényes, church ruin	13th C.	yes	T	LOC
R-37	Öskü, Round church	10th–11th C.?	yes	S/T	NAT
R-38	Paloznak, Catholic church	11th C.	yes	T	LOC
R-39	Pécsely, St Peter church	13th C.	yes	T	LOC
R-40	Révfülöp, Fülöp church ruin	13th C.	yes	T	LOC
R-41	Salföld, Pauline monastery ruins	14th–15th C.	yes	T	REG
R-42	Sáska, Catholic church	13th C.	yes	T	LOC
R-43	Sáska, Bakonyszentjakab, Pauline monastery ruins	13th C.	yes	T	LOC
R-44	Sóly, Reformed church	13th C.	yes	T	REG
R-45	Sümeg, Erek church ruin	12th C.	yes	T	LOC
R-46	Szentantalfa, Herend church ruin	15th C.	yes	T	LOC
R-47	Szentbékkálla, Töttöskál church ruin	12th–13th C.	yes	T	LOC
R-48	Szentkirályszabadja, Catholic church	12th C.	yes	T	LOC
R-49	Szigliget, Avas church ruin	13th C.	yes	T	LOC
R-50	Taliándörögd, Felsődörögd St Andrews monastery ruins	13th C.	yes	T	LOC
R-51	Taliándörögd, Dabos Pauline monastery ruins	12th C.	yes	T	LOC
R-52	Tihany, "Monks' cells", Basilitan then Benedictin monks	11th C.	yes	S/T	NAT
R-53	Tihany, Újlak church ruin	12th–13th C.	yes	T	LOC
R-54	Tihany, Benedictine abbey	11th C.	yes	E/T	NAT
R-55	Tihany, Apáti church ruin	14th C.?	yes	T	LOC
R-56	Uzsa, Uzsapuszta Pauline monastery ruins	14th C.?	yes	T	LOC
R-57	Városlőd, Lövöld Carthusian monastery ruin	12th C.	yes	T	LOC
R-58	Vászoly, Holy Cross church ruin	13th C.	yes	T	LOC
R-59	Veszprém, Ruins of Veszprém Valley Nunnery	10th C.	yes	S/E/T	NAT
R-60	Veszprém, St Michael cathedral	13th C.	yes	T	NAT
R-61	Veszprém, Ruins of St Catherine nunnery	14th–15th C.	yes	E/T	NAT
R-62	Veszprém, Ruins of St George chapel	Romanesque	yes	S/T	REG
R-63	Veszprém, Ruins of Gizella chapel	Romanesque	yes	S/E/T	NAT
R-64	Veszprém, St Michael church ruin	Romanesque	yes	T	LOC
R-65	Veszprémfajsz, church ruin	13th C.	yes	T	LOC
R-66	Vilonya, Reformed church	13th C.	yes	T	LOC
R-67	Zalaszántó, Catholic church	13th C.	yes	T	LOC
R-68	Zánka, Reformed church	13th C.	yes	T	REG
R-69	Zirc, Cistercian abbey	12th C.	yes	S/E/T	NAT

Castles and earthworks (compiled by Pál Rainer archaeologist, historian)

Id	Settlement, site	Period	Access	Utilisation	Importance
C-01	Bakonybél, Bakonyújvár	16th C.	no	S	LOC
C-02	Bakonyszentkirály, Zörög Hill	12–10th C.	yes	S/T	REG
C-03	Bakonyszentlászló, Kesellő Hill	12–10th C.	yes	S/T	REG
C-04	Bánd, Essegvár	14–16th C.	yes	S/E/T	REG
C-05	Berhida, fortified church	16th C.	yes	S/E/T	LOC
C-06	Csabrendek, Banyavár	?	no	S	LOC
C-07	Csesznek	13–18th C.	yes	S/E/T	NAT
C-08	Doba, Somlóvár	10th C. BC–1st C. AD, 14–18th C.	yes	S/E/T	NAT
C-09	Döbrönte	14–16th C.	yes	S/T	REG
C-10	Fonyód, Fácános	16th C.	no	S	LOC
C-11	Fonyód, Várhegy, earthworks	10th or earlier	no	S	LOC
C-12	Gyulakeszi, Csobánc	13–18th C.	yes	S/E/T	NAT
C-13	Hegyesd	14th C.	yes	S/T	LOC

Id	Settlement, site	Period	Access	Utilisation	Importance
C-14	Jásd, earthworks	Arpadian Age	yes	S/T	LOC
C-15	Keszthely	16th C.	yes	S/T	REG
C-16	Köveskál, Hegyestű earthworks	Arpadian Age	no	S/T	LOC
C-17	Nagyvázsony	15–18th C.	yes	S/E/T	NAT
C-18	Öskü, castle	15th C.	no	S	LOC
C-19	Papkeszi	14th C. ?	no	S	LOC
C-20	Pécsely, Zádorvár	14th C.	yes	S/T	REG
C-21	Rezi	13–16th C.	yes	S/E/T	REG
C-22	Sümeg	13–18th C.	yes	S/E/T	NAT
C-23	Szigliget	13–18th C.	yes	S/E/T	NAT
C-24	Szigliget, Óvár	Arpadian Age	yes	S/T	LOC
C-25	Tapolca, fortified church	14–17th C.	yes	S/E/T	REG
C-26	Várpalota, Bátorkő	13–14th C.	yes	S/E/T	REG
C-27	Tihany, Csúcs Hill	Arpadian Age	yes	S/T	LOC
C-28	Tihany, óvár	10th C. BC–1st C. AD, 10–11th C.	yes	S/E/T	INT
C-29	Ugod	13–16th C.	yes	S/T	LOC
C-30	Uzsa, earthworks	12–10th C. BC	no	S/E	NAT
C-31	Városlőd, Hölgykő	14th C.	yes	S/T	LOC
C-32	Várpalota, Thury Castle	15–20th C.	yes	S/E/T	NAT
C-33	Veszprém, Castle	10–20th C.	yes	S/E/T	INT
C-34	Zalaszántó, Alsó-Tátikavár	13–16th C.	yes	S/T	REG
C-35	Zalaszántó, Tátika	13–16th C.	yes	S/T	REG

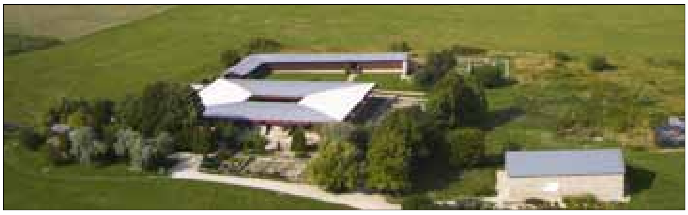


An acient polished axe from Úrkút

only a few archaeological sites have been discovered from the Palaeolithic Age (the paint pit of Lovas, caves in the Bakony Hills). The hunting, then farming village communities of the Neolithic Age and the Bronze Age have left much more traces behind. They built fortifications, conquered the stream valleys of the Bakony Hills and established many stone quarries and industrial areas, which primarily supplied the local demand for stone tools (e.g. Hárskút, Menchely). The chert quarry of the Tűzköves Hill at Szentgál acquired an outstanding significance among the quarries: archaeologists have found its red radiolarite core stones and extremely sharply splitting, chipped pieces (thus representing the state-of-the-art technology of the period) 300–400 kilometres away from the quarry, at excavations in Western and Eastern Europe. Although this most significant Neolithic industrial centre was surrounded by a ring of eight villages in prehistorical times (Lengyel Culture), the main area of the Neolithic settlements was not the Bakony Hills but the Balaton Uplands, the vicinity of Sümeg and the eastern basin of Lake Balaton with a much favourable climate.

The cultures and peoples of later periods also preferred to invade this area. While the conquering Romans favoured the Balaton Uplands, the various peoples of the Iron Age, living before and with them also preferred the more open areas with milder climate, e.g. the vicinity of Somló Hill. Certain archaeological excavation sites though – as the Bronze Age fortifications, earthworks, mound graves of High Bakony or the Roman coins found at Bakonyoszlop – prove convincingly that even this medium high, wet, difficult hill range, covered with dense woodlands provided attractive conditions from time to time for groups of people settling in Transdanubia.

Undoubtedly, it was the Roman conquest of the 1st century that had the greatest impact on the development of the local civilisation before the spread of Christianity. The invasion, resulting in the intense Romanisation of the Celtic, Illyrian, etc. people living here, influenced every aspect of life for three centuries: from farming through culinary habits to burying traditions. This high culture has left observable marks on the landscape as well: one can catch sight of tumuli that hide whole households (Inota), remains of the walls of a military fortress (Fenékpuszta) or carved tombstones built in church walls and milestones recarved to serve as fences. Moreover, one can easily find oneself on a road built by the Romans (Sopiane–Savaria; "the Roman Road" at Lake Balaton). The most prestigious remain of Roman origins in the proposed geopark is the almost fully excavated villa-farm that can be visited even today as an archaeological exhibition site (Nemesvámos-Baláca, see below).



The dwelling house ornamented with artistic frescos and mosaics of Mediterranean style was not the only farming centre of the region. The archaeological traces of a whole network of similar villas prove the intense presence of Roman culture at the Balaton Uplands and even under the present surface of Lake Balaton, which had a lower water level during the first centuries AD (Gyulafirátót, Öskü, Örvényes, Szentkirályszabadja, Kékkút, etc.).

As far as land use is concerned, two significant innovations can be attributed to Roman culture. One of them is the introduction of the Mediterranean style viticulture, which probably represents a tradition that has been continuously present on the area's hillsides facing south. A different grape growing method at the floodplains of Lake Balaton and of smaller rivers may have been present in the farming methods of Hungarians settling in the 9–12th centuries. However, from the 13th century at the latest the most important agricultural activity of the region was represented by the immensely profitable plantations of grape stock rows at Balaton Uplands and on the slopes of Somló Hill including the Roman grape growing areas and even spreading to higher elevations. The most outstanding white wines of the region – juhfark, furmint, sárfehér and kéknyelű – were known in Europe even in the Middle Ages and helped the fame of the wine region to survive even the period of the vine-pest (1880's–1890's) that destroyed two thirds of the plantations. Thanks to their excellent features, Badacsony and Somló Hills had become the most favoured vineyards of the Transdanubian nobility and the wealthy bourgeoisie where trained wine-dressers implemented the first change of vine varieties and equipment in the country and introduced a modern wine-growing technology.

Panoramic view from the fortress of Szigliget, Szent György Hill can be seen in the background (Tapolca Basin)

The other important heritage of the Roman invasion is building with stones. The constructions of earth, clay and wood built by peoples and cultures who had lived here before were replaced from the first centuries AD by locally extracted and processed limestone, red sandstone and sandstone, as the basic building material of the more prestigious dwelling houses, roads, bridges, dams and burial constructions. (The red sandstone quarry in Vörösberény and the sandstone quarry in Bánta are of Roman origins!) These stone constructions became important elements of the landscape and most of them could not be destroyed even by the stormy centuries of the Migration Period. The western and eastern invaders (Huns, Gepids, Langobards, Avars, the people of the Keszthely Culture, Hungarians), who replaced each other during the 4–9th centuries in the Carpathian Basin and thus in the proposed geopark area as well, handed down only their cemeteries to posterity. In contrast to this, the fashioned stones of the Roman constructions can still be seen in the form of picturesque ruins or as parts of the walls of medieval buildings.

The most important stone buildings of the Middle Ages were the Christian churches erected on high grounds, also functioning as fortifications, and the fortresses built on hilltops. The conquering Hungarians arriving to the Carpathian Basin in the 9th century developed a strong church and state organisation in the 10–11th century, which is proved by the high number of Romanesque and Gothic churches that stood in the centre of tiny villages, surrounded by graveyards. Some of them still have its original function as a Catholic or a Reformed church (Berhida, Litér, Szentkirályszabadja, Vörösberény, Nagyvázsony, etc.). Nevertheless, most of them have been destroyed or have turned into ruins and are registered national monuments today, showing the location of villages that have become depopulated during the Turkish occupation and have never been rebuilt (Dörgicse, Tihany, Aszófő, Olaszfalu, etc.).

Szigliget, Avas church ruin (13th C.)

The entire central part of Transdanubia was royal property and a favourite hunting-field in the Middle Ages. The castle of Veszprém – by means of the bishops who were chancellors as well – was regarded as the centre of the queens. The bishop residing in Veszprém controlled a huge bishopric, where the Benedictine and Cistercian monasteries – as first ones founded by a Hungarian king – played an outstanding role (Tihany, Bakonybél, Monostorapáti, Zirc). Later the monasteries of the only Hungarian monastic order, the Paulines, who like woody, abandoned hilly areas, became also important (Nagyvázsony, Salföld, Sáska, Uzsa, etc.). These monasteries and abbeys were not only the centres of culture and – by means of the centres where codices were made by Carthusians (Lövöld) and Paulines (Nagyvázsony) – of literacy, but have also played a role in reshaping the landscape. Deforested areas, fishing ponds, arboretums and herb gardens, anchorages and hidden chapels in deep forests have preserved the remains and the sacral aura of this exquisite monastic culture.

The flourishing culture of the land was broken with the Ottoman-Turk

The R. Catholic church of Felsőörs (13th C.) was built on Lower Triassic Hidegkút Dolomite

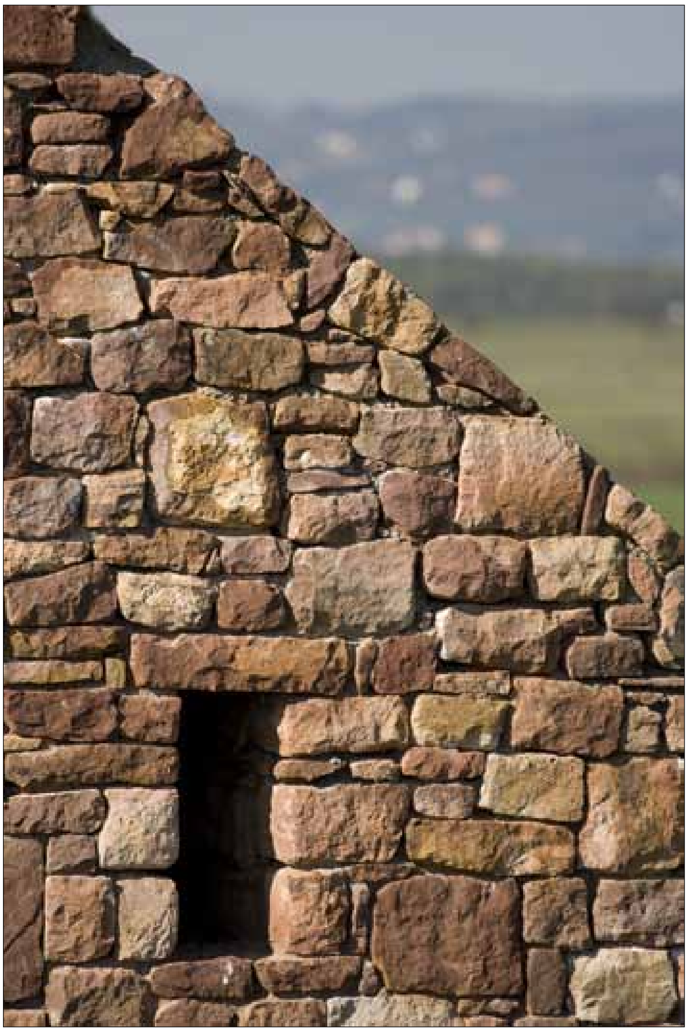
The most visited fortress of the Bakony Mts: Csesznek

conquest. The geopark area bordered by Lake Balaton from the south was situated on the boundaries of the country portion held by the Turkish and of Royal Hungary that had been fighting for its independence for one and a half century. The fortresses of Veszprém and Palota, having a leading part in the battles, and the majority of the fortresses built on the steep sided volcanic hills were erected after the Tatar attack, replacing the Bronze Age, Avar Age and Arpadian Age earthworks with stone walls and bastions built in the 13th century. The ruins of the fortresses blown up at the beginning of the 18th century for political reasons can be seen even today, although many of their finished building stones were taken away by the inhabitants who resettled the area that had been almost entirely deserted by the end of the Turkish occupation.

While the Protestant inhabitants settled on the gently sloping, open areas surrounding Lake Balaton, the vast trackless forests of the Bakony Hills were mostly inhabited by Catholic German and Slovak settlers, reinforcing the cultural differences of the two geographical units. The inhabitants of the Bakony Hills founded settlements even above 400 meters above sea level (Tés, Lókút), which was unusual among Hungar-

One of the many calvaries of the Geopark area, near the village of Vöröstó

ians. Their livelihood was based on handicrafts characteristic of mountainous and forested areas. Besides charcoal- and lime-burning, making of pearl-ash and wooden tools and processing tinder, the manufacture of iron, glass and porcelain based on the processing of the local raw materials thrived until the middle of the 19th century (Kislőd, Csehbánya, Németbánya, Városlőd). Besides industrial activity, farming played a more and more important role by means of deforestation in the Bakony Hills: vast batches of excellent Bakonyian potato participated in the exchange of goods between the Balaton Uplands, producing wine and fish and the edge area of Mezőföld, growing maize. Animal husbandry was an important agricultural branch both in the Bakony Hills and at the Balaton Uplands: keeping swine fed on mast in the mountainous forests and raising sheep and buffalo at the areas alongside the lake. The specific skills of the herdsman families, their knowledge about nature, their artistically fabricated articles and connections to the brigandage all belong to the typical traditions of the region. Another common cultural feature of the different geographical units of the proposed geopark is the use of stone in buildings by the peasants, which is an almost unique phenomenon in the folk architecture of the Carpathian Basin, where walls were mostly made of wood and earth. Thanks to the special protection of their view, some villages have preserved entire streets of fences with the characteristic stone-bastions, and of basalt or limestone



One of the 'washing houses' of Káli Basin, near Kővágóörs (Permian sandstone)

buildings with arched porches, evoking the facades of the noblemen's dwelling houses (Magyarpolány, Vöröstó, Szigliget, etc.). The whitewash ornamented, single- or two-storey press houses and wine-cellars at the Balaton Uplands represent a unique landscape and architectural value. These cellars stand above the rows of wine-cellars known in the historic wine regions of Central Europe primarily because of their rich variety of forms. The stone crucifixes, chapels and statues of folk Baroque style erected on the edge of the Bakonyian villages inhabited by German settlers and the calvaries built on the hillsides have a similar role in the landscape. These distinctive constructions – just as well as the diverse cemeteries, praising the work of local stonemasons or sacred springs that have become places of pilgrimage or the "trees with icons" in the forests – bear testimony to the presence of people, whose lifestyle and way of thinking both helped them to live harmoniously together

A windmill on the Tés Plateau (Eastern Bakony) with the land. People, who have not only dwelled on this land, cultivated it and quarried it, but have also built its elements in their religious life and folk traditions, populating the cliffs, lakes and seas of stones with imaginary creatures and historic heroes.

Biodiversity in the proposed Geopark — linked to geodiversity

The basalt lapillituff is warm enough for this lizard (Lacerta viridis)

The area of the Bakony–Balaton Geopark is one of the most varied parts of Europe from the point of view of the biotic assets as well. The extreme complexity and mosaic-like character of the habitats, the high number of species living here is the joint result of many elements.
The Continental, Atlantic and Mediterranean climates meet at this part of Europe, resulting in the presence of numerous members of the flora and fauna from all the three climate regions. Geodiversity and the variedness of geomorphology add more colours to the picture: an exceedingly large number of soil types have developed on the different bedrocks, according to the features of water effects they have been exposed to. Different types of soils give home to varied plants that adapted to the qualities of the respective soil type. The diversified relief is also an important factor: an entirely different habitat can be found on a rocky ridge, on its shaded northern side or on its hot southern slope exposed to sunshine. The millions of years old creation of nature has been supplemented by man during the last few millennia and fortunately his presence and work has meant not only destruction. Valuable and beautiful examples can be seen of how our ancestors have created a precious and variegated landscape also from an ecological point of view by living together with the conditions of nature, exploiting them within bounds.
There are many wet habitats in the proposed Geopark, such as the maar crater lakes of the Tihany Peninsula, receiving water supply exclusively from precipitation, or Lake Kornyi of the Káli Basin, being filled up with karst water. The characteristic reptile species of swamping lakes covered with reedmace and reed is the pond tortoise *(Emys orbicularis* L.). Characteristic nesting birds of the reed beds of these lakes are the herons heavy in build: the great white egret *(Egretta alba* L.), the purple heron *(Ardea purourea* L.) and the bittern *(Botaurus stellaris* L.).
Fens and marsh meadows exist at those areas where water cover is present only at certain periods of the year. The stands of *Primula farinosa* L., originating from ice age have survived in Hungary only in the fens of the Káli Basin and the Tapolca Basin.
Moving towards the drier habitats in the mountainous areas, dominantly in the Bakony Mts we can find woodlands, while on hilly and plain areas meadows and pastures. The most dominant forests of the Bakony are the medium range mountain beech forests and the sessile oak forests. Small patches of woody areas on rocky ranges and outcrops, talus slope forests, white oak forests inhabiting hot and dry slopes or ravine forests living in narrow gorges are especially significant. Natural grassland patches wedged in between forests give home among others to a rare and precious species of bush cricket *(Saga pedo* Pallas) that lives on Tátika Hill.

Aurinia saxatilis

The region of the white oak scrub forests, one of the most valuable habitats of the Carpathian Basin, stretches in a wide belt on the southern slopes of the ranges of Balaton Uplands and the Bakony Mts. The canopy layer of the arborescent vegetation is unable to close because of the hot and dry habitat, therefore the trees and groves constitute a mosaic with patches of bush and dry grasses. This area is the habitat of many terrestrial Orchid species. At the most extreme locations, especially on dolomite surfaces, where the soil formation is remarkably slow due to the rock-bed, even the grasses can not provide a contiguous soil cover: this is the world of special, extremely specialised species constituting the open rock grasses.
We have shortly summed up habitats moving from dry to wet circumstances. However, further habitats exist that have developed as a result of some special natural features. One of them is the area of natural or artificial cliff surfaces, cracks in cliffs and disused quarry walls. Here the essential conditions are mainly determined by the rock-bed itself.

The old lavender plantation of Tihany

Draba lasiocarpa (on dolomite, Eastern Bakony)

Crambe tataria Sebeok, a species which have become extremely rare, is a good example of species that depend on the bedrock, in this case on loess. The species has only small stands in the Carpathian Basin, and the largest one of them is located exactly on the top of the Balatonkenese Bluff. The lip fern *(Cheilanthes marantae* (L.) DOM.), living only in the basalt rock grasses on the St George Hill in Hungary, is also among these species. Naturally, animal species also choose to live in these special habitats: the bee-eater *(Merops apiaster* L.) and the sand martin *(Riparia riparia* L.) hatch in the hollows deepened in the Pannonian sediment and loess, while ravens *(Corvus corax* L.), peregrine falcons *(Falco peregrinus* L.) and stock owls *(Bubo bubo* L.) find a safe place for their nests at the emerging cliffs of Balaton Uplands and Bakony Mts, on the walls of disused rock quarries.

Woodlands have been deforested and nursed, plough lands, hayfields, grazing lands have been created; vineyards and orchards have been planted in the last centuries. Man has quarried rock for building his houses and has erected long stone fences and heaps from stones found in the vineyards. The varied circumstances resulted in a diverse and mosaic like use of the land. A significant part of the flora and fauna has adapted to the grazing animals, to the extensive orchards: some species disappeared or diminished, other populations grew. At some places, like the Tihany Peninsula, new species occurred, such as the lavender of Mediterranean origin. Adventive and introduced species have partly become integrated members of the ecosystem; others present a serious problem for today and for the future because of their aggressive spread. There are 33 habitat types on the Geopark area that are included in the list of "Special Areas of Conservation" of the Natura 2000 Network.

D. Economic Activity and Business Plan

D.1. Economic activity in the proposed Geopark

The Bakony–Balaton Geopark was a significant mining area, serving as basis for the local heavy industry. Rapidly growing industrial towns (Ajka, Várpalota, Balatonfűzfő) at the edge of the Bakony Mts. provided considerable jobs and increasing population. By the 1980's the region had become one of the developed (chemical) industrial centres of Hungary. After the democratic transformation, with the setback of mining the heavy industrial sectors also diminished. Manufacturing industry still plays an important role in employment and value creation. Several export oriented enterprises occurred in the towns during the last 1,5 decades, thanks to primarily foreign capital investments, resulting dynamic development and new jobs. The hand-painted Herend porcelain, a distinguished product of the region has been produced since the 1800's. The relative level of unemployment (11,7% in Veszprém County) is below the Hungarian average but it shows strong seasonality at Lake Balaton. The area's conditions are unfavourable for agriculture. Barely more than 50% of the land can be cultivated, and the proportion of woodlands is above the national average, around 30%. Viticulture is of high importance and there are several wine regions in the Geopark. The last decades have witnessed a large-scale decrease of people living on agriculture. The role of animal husbandry also weakened but dairy farming is still an important sector. Tourism industry and the tertiary sector play a more and more important role in the area. The number of employees has grown significantly and the number of enterprises is on the rise. The second most important tourist destination in Hungary is the Balaton Region (4 000 000 guest nights in 2010) and the number of accommodations and catering facilities is outstanding. A widening tourism offer is being developed, creating new programs, products and services, which has been fundamental in the re-organisation of the old, one-sided offer that was based solely on bathing tourism. The Valley of Arts Festival and VeszprémFest Music Festival are among the most remarkable annual events. Tourism Destination Management organisations have been established and their regional cooperation has also started. A major attraction of the Geopark is the historical heritage. Cultural and castle tourism is gaining a growing part. Traditional handicraft trade is also significant. The number of visitors attracted by the natural heritage and the marked hiking paths is on the rise (Tapolca Basin, Bakony Mts., Balaton Uplands). The Geopark area is in a special situation as it is divided into several administrative units and bodies. Four counties, three Planning-Statistical Regions and altogether four Tourism Regions cover the Geopark area (although two of them cover only a fraction of it), thus possibilities of applying for financial resources are many. However, this fragmented structure renders cooperation more difficult. The surrounding of Lake Balaton belongs to the Balaton Tourism Region, which holds – thanks to its outstanding importance – a unique legal status. The Geopark area has one of the most favourable situations in Hungary regarding accessibility. It has a close-set main road network, well-organized railway trunk lines and an availability rate of roads reaching the national average, although the deterioration of municipal roads is a disadvantage. A regional airport at Sármellék and the international airports of Budapest, Vienna and Zagreb are within 1,5 hours by car. Besides marked hiking trails, a 156 km long cycle path and 66 km long sections of assigned roads for cycling around Lake Balaton await visitors. Ferries, a car-ferry at Tihany–Szántód and waterbuses provide a network of transport on the surface of Lake Balaton.

D.2. Existing and planned facilities for the proposed Geopark

The Lavender House Visitor Centre in Tihany, opened in 2011 – The Eastern Gate of the Bakony–Balaton Geopark

Facilites interpreting primarily a geological theme, managed by the Applicant and contracted local entrepreneurs (except the Lake Cave of Tapolca), utilised by geotourism and geoeducation: *Hegyestű Exhibition Site of Monoszló, Lóczy Cave of Balatonfüred, Lake Cave of Tapolca, Csodabogyós Cave of Balatonederics, Szentgáli-kőlik Cave of Szentgál, Disused Sand Pit of Várpalota, Lavender House Visitor Centre of Tihany* (opened in 2011 July). The annual average number of visitors/site amounts to 166 590 and a total of more than 850 000 visits were counted (2007–2011 Oct.). Facilities in the Geopark that interpret primarily a non-geological theme, managed by the Applicant and contracted local entrepreneurs: Manor of Salföld,

Take a walk inside a basalt scoria cone... (one of the installations in Tihany exhibition)

One of the Applicant's geotourism-related websites: Csodabogyós Cave (please note that the logo of the Geopark is published at every sites)

Arboretum of Zirc, House of Forests of Bakonybél, Kotsy Water Mill of Zalaszántó with an average annual visitor number of 17 600/site and a total visitor number of 353 500 (2007–2011 Oct.). Facilities utilised primarily by education, including geoeducation: *Open-air School in Tihany* (managed by Applicant), *Open-air School in Bakonybél* (managed by Applicant and contracted local entrepreneur). Their annual average number of guest nights is 1800. These facilities also operate as guest houses for geotourists. The *Breuer László Education Centre* of the Pangaea Cultural and Environmental Association (Geopark Partner) in Pénzesgyőr, Bakony Mts is the site of partly geoeducation activities with an annual average participant number of 900. Pangaea organises the Gaia geoconservation volunteer camp annually with 30–40 participants, within the Geopark area, in cooperation with the Applicant. The *Natural History Museum of Bakony Mts* and the *Mining Museum of Ajka* are also important facilities, managed by other partners, utilised for geoeducation and geotourism. 31 *nature trails* and 1 *trail system* in the Geopark (with second language: 11 English, 5 German) interpret partly or mainly the geoheritage, and are used for education and tourism purposes. 9 are managed by the Applicant, others are maintained by civil organisaitions or municipalities. Other 'tools' available are 4 *photo collections* of the Applicant for exhibitions (e.g. the Cultural Heritage of Bakony-Balaton Geopark' collection), general information panels on the natural and cultural assets of the Balaton Uplands National Park and other protected areas and assets, several hundred kms long marked hiking paths (maintained by hiking clubs, members of the Hungarian Nature Friend Association), 22 *TourInform Offices* operated by municipalities and *Tourism Destination Marketing Associations,* geotour guide books, brochures and leaflets, maps, books and general educational publications of the Applicant and others including the theme of geology also contribute to geotourism and geoeducation activities. The Geopark logo and the *Geopark Partner Label System* (to be improved) are important tools The website of the Applicant (www.bfnp.hu) and the independent webpages of the facilities and caves (www.csodabogyos.hu, www.szentgali-kolik.hu, www.homokbanya.eu (Disused Sand Pit of Várpalota), www.pangea.hu) and of geotour guides (e.g. www.balatongeo.hu) as well as the *GeoMania mailing list* (hosted by the Applicant) and *social media tools* (e.g. the Facebook page of the Geopark) provide information regarding geotourism and geoeducation. Some of the above mentioned facilities – besides functioning as tourism sites – are integrated in the programme of the Applicants' guided tours, in the field visits of university students and class trips of elementary/high school groups. The Dormouse Circuit in Csopak is designed to receive kindergarten groups. The existing tourism infrastructure is described at D.3.

An alternative and very sustainable way to get to the Szentgáli-kőlik Cave (this service provided by a local entrepreneur)

Planned facilities of geoeducation, geotourism and tourism infrastructure

The touristic development of the *Lake Cave of Tapolca,* the *Western Gate of the Bakony–Balaton Geopark* will be implemented by the EU's Regional Operational Program financial resource. Main elements: a new visitor centre with an enlarged area, thematic and interactive *exhibition of karst features,* developed visitor services. The full exchange of the electric lighting system and measures to ensure rock stability is being implemented by the EU's Environment and Energy Operational Program, contributing to the conservation of the cave and to the high quality of interpretation and safety. A long-term plan of the Geopark is the development of the *Geopark Visitor Centre,* at the Hegyestű Geological Exhibition Site or at Kopasz Hill (also in Káli Basin). The Kopasz Hill site boasts with a 260 m long tunnel carved into a volcanic rock, which could be a special element of the future exhibition site. Renewing of the touristic information system of the Káli Basin and the exchange of information panels of some nature trails is also planned. The plans of many of these panels already exist or are under editing and their placement at the nature trail-heads or along the nature trails will be implemented after the – hopefully positive – decision about the EGN membership of the Geopark. This way there is no double-cost of producing and placing and the EGN logo can be indicated. Furthermore, the planning, production and placement of *32 information panels* (21 as stops of four new geological nature trails and as infopanels at the entrances of 11 caves) are included in the running EU project *"Nature conservation of abiotic values on the operational area of the Balaton Uplands National Park Directorate".* Further *geotour-guide training courses* are planned to be organised by the Applicant. The *Geopark Partner brand* is to be developed for accommodations, products, services and organisations to create a network of sustainable and high quality services and products within geotourism and geoeducation. The *web page of the Geopark* is to be fully developed *by the end of March 2012.* A close *cooperation with the Multi-purpose Micro-regional Associations,* based on the cooperation agreement concluded in 2011 is to be developed to promote geotourism, geoeducation and geoconservation via these associations and the member settlements. Via this cooperation, many developments of the Geopark can be accomplished by joint planning and implementing activities of local governments, the micro-regional development associations and the Applicant. The development of the Applicant's facilities not mentioned above and such facilities to be developed by the partner Multi-purpose Micro-regional Associations are planned to be implemented by taking into account the goals of the Geopark and outlining the links between the natural and cultural heritage. The existing networks of cycling, horse riding and hiking routes are also to be developed in the area. The Applicant wishes to contribute to the designation of such routes in order to connect – among others – the sites of geotourism to those routes and to ensure the standpoints of nature conservation. The implementation of these plans will be partly financed by the Applicant and partly as a result of cooperation between stakeholders and the Applicant. The Geosites of educational and/or geotouristic importance are listed at B.3. Plans of their development include the creation of the three above mentioned new nature trails financed, the exchange of old information panels and the production and placement of new panels.

D.3. Analysis of geotourism potential in the proposed Geopark

Tourism is an important sector in the area of the proposed Geopark with a significant share in the national tourism industry. The estimated number of guests in the Geopark area amounts to 382 828 (2010). Around 7,2% of the national result, 1 382 383 guest nights at commercial lodgings were realised in the Geopark area in 2010. The Geopark area in the vicinity of Lake Balaton had an 87% share of these guest nights and generated approximately 5.85 billion HUF gross income of commercial lodgings. Tourist stays are becoming shorter year by year, with an estimated average length of stay in the Geopark of 2.9 days regarding national tourism and 4.75 days of incoming tourism in 2010, with a little higher values at the Balaton area. One-day visits from a distance of a 1.5 hours' drive can be made for a population of more than 7 million people (of which 3.4 million live in Budapest and Vienna).

An exceedingly dynamic development of domestic tourism is experienced in the Geopark's tourism, similarly to the national and international trends. The share of domestic guest nights in the entire Balaton Touristic Region for example grew from 32.2% to 61.8% between 1999 and 2010. However, the proportion of foreign guests and especially guest nights is still significant in this touristic region, with Germany as the most important sending country (around 40%). The number of beds has diminished during this decade but a beneficial transformation has taken place because of the development of several 4- and 3-star hotels and guesthouses in the Geopark area (and youth hostels in the Bakony region), following the related tendencies of demand. The role of spas and wellness hotels is outstanding regarding guest nights and length of stay, especially in Hévíz.

With the above described substantial tourism volume in the Geopark area, the economic features described in Chapter D.1., geotourism has excellent potential in the area. The increasing number of touristic programmes and services, the varied and significant cultural and natural heritage of the area, the EU-related financial resources for the development of the strategic elements of tourism offer, the Tourism Destination Marketing Associations' network and other institutional elements also support our goals. The significant geotourism infrastructure and activities that directly support geotourism is described in Chapter D.2. and D.4. Their financial performance is outlined in the following part of this Chapter.

Business plan with detailed financial information

Background of the project

Preparation of the project started in 2006. So far new facilities, trainings, experts' visits, active participation in Geopark conferences and networking have all contributed to the evolution and improvement of the project. The internal and external environment and resources of the Geopark project is described and appraised in the Application Dossier and in the Self Evaluation Document.

Geopark Strategic Management Plan

Based on the present Management Plan, a *Strategic Management Plan* is planned to be compiled for the Geopark area. On the basis of this strategy, annual Operative Plans are to be outlined by the Geopark Team (later Group) including tasks as: evaluation of visitors, enhancing geotourism products and services (Geopark Parnter Labelling System), strengthening community empowerment, achieving a wide distribution of excellent interpretation within the Geopark, promoting links to stakeholders. The key to success is the partnership with stakeholders (a tool for this is the cooperation agreement with the Micro-Regions) and the strategic development of geofacilities and geoactivities (combining them with other elements of activities) including re-evaluation.

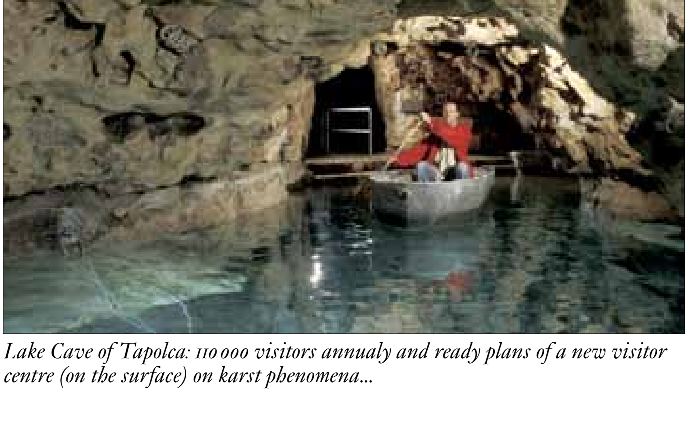
Budgetary Plans of the Bakony–Balaton Geopark

The Applicant is an independently managed state organisation with an independent budget. The plan for its allocated annual income is between 1 666 600–2 333 300 EUR (including less than 30% state support), 50% of which comes from the total income of tourism and education.

75% (!) of this amount was constituted *solely by the admission fees of the geotourism-related facilities* of the Applicant in 2010.

The fundamental frame of the budget of the Geopark is the income of the Applicant's six geological exhibition sites, with an estimated yearly result of 100 000 000 HUF (333 000 EUR). Estimations are based on complete results of 2008–2010, thus yet excluding the income of the Lavender House Visitor Centre, opened in 2011. We are convinced that this is a sufficient and growing background (estimated yearly result of 2008–2011: 127 000 000) for fulfilling the tasks deriving from the expected EGN membership and for future investments in the Geopark (e.g. the planned visitor centre of the Lake Cave of Tapolca). The financial results of these sites – examined between 2008–2011 (Oct.) – is well balanced, their profitability (income/result proportion) is above 30%, despite the economic crisis. The Lake Cave of Tapolca has a major share (80%) of the total result. A relatively smaller income of the Lake Cave of Tapolca in 2011 is due to its earlier closure (in September), which was needed because of the cave reconstruction works. This investment – basically serving geoconservation purposes – will be beneficial also regarding tourism because it contributes to a higher level of services resulting in higher income and visitor satisfaction, thus the investment will be remunerative on the long term. Another EU funded investment is expected to add to the touristic development of the visitor centre of the Lake Cave. The income of geotourism will also be supported by the Lavender House Visitor centre, opened in July 2011. The distribution in time of the annual income of these sites is uneven. Most of the income is generated during the summer and a part of it has to be reserved for the winter season to cover expenses. Commissions to the entrepreneurs who operate the exhibition sites (except the Lake Cave of Tapolca) are drawn monthly. The Applicant does not pay taxes after this result (as it is a state organisation); it cannot take loans and cannot invest in value-bills.

The annual budget of the Geopark is prepared by the Geopark Team (later Working Group). The Geopark Commission approves it during its autumn session. The implementation of the budgetary plans is coordinated by the Geopark Team.



Lake Cave of Tapolca: 110 000 visitors annualy and ready plans of a new visitor centre (on the surface) on karst phenomena...

Sources of the budget of the Geopark:

- the income of geotourism and geoeducational facilities and activities of the Applicant;
- the income of certain geotours provided by Geopark partner geotour guides (those that start from the Applicant's facilities, e.g. the Lavender House Visitor Centre);
- projects financed by successful applications, financed by EU funds;
- foundations (planned);
- sponsorship, advertisement (planned);
- a proportion of the payment of the employees working in the Geopark Team/Working Group, infrastructure background provided by the Applicant (offices, cars, conference participation fees, expertise of other colleagues (e.g. the Ranger Service);
- contributions of the Geopark partners, e.g. geotour guides, municipalities, civil organisations, professional institutions (volunteer work at events, participation in planning and submitting applications, providing expertise, other forms described in the Cooperation Agreement of the Micro Regional Associations – see Annex 4).

Planned Budget for 2012

Investment (funded by the EU)	**EUR**
Environment and Energy Operational Programme (geoconservation)	326 000
Regional Operational Programme (geotourism, Lake Cave of Tapolca)	333 000
Expenditure	
Bakony–Balaton Geopark Contest for elementary school children	1 000
Week of Geoparks Event (planned invited Geopark: Novohrad–Nograd)	400
Events (Applicant's geotours, presence at events, publications, etc.)	2 000
Other elements of awareness campaign (forums, incentives, trainings)	2 000
Income	
Admission fees, souvenirs at exhibition sites and visitor centres	333 000
Guided tours for school groups	2 000
Commission from Geopark partners' geotours	200

D.4. Overview and policies for the sustainable development of geotourism and economy, geoeducation and geoheritage

The regional development of the Geopark is based on several development agencies and strategies. The National Spatial Development Concept (2005–2020), which includes the most important policies regarding the sustainable economic development of e.g. the Balaton Region: improvement of the quality of life of the local population (which enhances satellite services of tourism) and the development of less developed regions (in areas located further away from Lake Balaton) by creating a colourful and sustainable touristic offer based on their special natural features. The extension of the tourism season, improvement of the ecological conditions of the lake and other natural areas, development of sustainable transport, info-communication and services systems are also included. All these aims are fundamental in the Development Strategy of the Balaton Region and that of Veszprém County (mostly covering the Bakony region of the Geopark). The Balaton Information System project, the Cycling-Tourism Project of 2011 in the Balaton Region, the Balaton Blue Wave project aiming at the development of clean beaches and ports and the international Living Lakes project support tourism activities in a sustainable way. The establishment of the Tourism Destination Marketing (TDM) Organisational Model and the foundation of many TDM Associations are essential in the long term planning and implementation of sustainable goals in tourism, based on the cooperation of the stakeholders. The training of geotour guides or-

The very first meeting in 2006 with mayors, representatives of universities, geological institutes, tourism organisations, NGOs, journalists, etc.

ganised by the Applicant is fundamental in developing a locally based expert network. So far 97 certificates have been issued and during the last two years cca. 170 guided geotours have taken place in the Geopark (with 2,400 participants). The Geopark Partner Labelling System and the Applicant's expertise in the related fields also result in a high quality geological experience for the visitors. Most of the geoeducation and geotourism facilities (and their catering services) and activities of the Applicant are run and provided by entrepreneurs (local businesses, local speleological associations), which is also a sustainable way of operating these elements. The period of adventure tours in Csodabogyós and Szentgáli-kőlik caves are limited to protect bat colonies mating or wintering in the caves. Approaching the entrances of these caves is on foot or by horse-chart (provided by a local entrepreneur for a small fee). Exhibition sites and the visitor centre of the Applicant are located to orientate tourism load away from more fragile regions of the national park or other protected natural areas. Some of the facilities use renewable energy.

High quality and long term operation of the Applicant's *partly geoeducational activities* (open-air schools, teacher training courses, guided tours, lectures) are ensured by national accreditation systems and/or skilled entrepreneurs – and the two educational experts of the Applicant are also closely involved in these activities. The *Pangea Cultural and Environmental Association* (a Geopark Partner) organises accredited open-air school programs including the module *'A little geology in the Bakony'*. They also organise the *Gaia Geological Nature Protection Camp,* which, besides achievements in conservation, has educational purposes as well, organised in cooperation with the Applicant. The *'Hedgehog Camps'* for elementary school children have been organised for 20 years for approximately 3000 students, including geoeducation in a very effective way. These occasions are important tools of creating a community of people who care and do (also) for the geological heritage, many of them later becoming members of environmental organisations. The sustainable management of natural, landscape and cultural heritage (e.g. the landscape rehabilitation of illegal waste deposits and other sites related to quarrying activities) is also part of the above mentioned spatial strategies. The EU-financed reconstruction of the Lake Cave of Tapolca includes the sustainable renewing of lighting system (energy-consumption reduced by 83%) and works preventing breakdown. Replacement of ladders in several caves (rust-proof inox material), closing of many caves in order to protect bat habitats, clearing of non-native invasion species at the seas of stones of Káli Basin (promoting interpretation) and the landscape rehabilitation of a disused quarry at Botos Hill, Balatonhenye are excellent examples of the sustainable development of geoheritage. The Strategy and Management Plan of the Applicant overviews and describes several tasks concerning the sustainable development of the above mentioned fields in the Geopark.

D.5. Policies for, and examples of, community empowerment (involvement and consultation) in the proposed Geopark

Since the political changes of the 1980's a high number of civil organisations and tools of involvement have been established to enable citizens to have a growing role in shaping and improving their local areas. However, the administration and also the communities are still carrying

Two of the Applicant's geotour-guides at Vigántpetend, at the stand of the Bakony–Balaton Geopark, (Valley of Arts Festival, 2011)

traces of old-fashioned attitudes regarding involvement and consultation. *The Bakony–Balaton Geopark initiative is an excellent framework of re-energising communities and enhancing their involvement in issues concerning local heritage, economy and education.* We are aware of the fact that any initiative within the Geopark movement can be suited to local needs only with the help of community empowerment. Having looked at the position of the Applicant in the network of institutions, organisations and communities covering the 151 settlements on a more than 3 100 km² large area, we are convinced that the first step to reach out to communities is to *co-operate with the 15 Micro-Regional Associations,* covering all the settlements of the Geopark area. The *Cooperation Agreement* with the Associations is a good example of community involvement regarding the goals of the Geopark as it provides a basis for consultation and communication. The involvement of the communities in the Applicant's planning activities is also ensured by the rotating membership of three Micro-Regional Associations in the work of the *Geopark Commission,* which approves decisions regarding the strategy, actions and budget of the Geopark. Forums for the public (e.g. the one organised by the Applicant in 2006 with cca. 100 participants), presentations about the Geopark and bilateral cooperation agreements with civil organisations and honorary memberships of tourism-focused organisations are examples of our effective tools of community empowerment within the Geopark. Local *kick-off meetings with stakeholders* are planned for the execution of the goals of the Co-operation Agreement with Micro-Regions. The mailing list *'GeoMania'* (hosted by the Applicant) is to be created for the smooth exchange of information regarding development, education and other community issues (planned members: work organisations of Micro-Regions, LEADER groups, local and regional Tourism Destination Marketing Associations, civil organisations, etc.).

D.6. Policies for, and examples of, public and stakeholder awareness in the proposed Geopark

The public and stakeholder awareness activities of the Applicant have already started to spotlight the issue of the Geopark. The future policies need to be prepared on a strategic basis, including evaluation. It is important to build up a continuous, long-term system of activities for awareness rising, together with networking. The *Geopark Team* (later *Geopark Group)* members work on this aspect of Geopark activities as well, consulting with local civil organisations whose activities also focus on this topic. *Press releases,* relationships with the media and public relation work are supported by the already existing activities of the Applicant, coordinated by Annamária Kopek PhD, head of *Tourism and Education Department.* The geotour guides and other Geopark partners are actively involved in events focusing on public awareness building.

The main target groups include opinion leaders, the upcoming young (information society) generation and pedagogues, the local businesses and locals eager to participate in trainings and work as a geotour guide. Visitors and potential visitors of the Geopark are also a very important target group. Stakeholders are employees of the Applicant, high level decision makers, civil organisations, businesses (also handicrafts-men), organic farmers, geotour guides, entrepreneurs working at the Applicant's geotourism/geoeducational facilities and professional local organisations in the tourism, education, research and conservation sectors. The central issues to be communicated may vary according to the target groups. The message *"This Geopark is Our Geopark"* is about building a regional identity in the public, an attachment to the Geopark. *"This Geopark is an Active Geopark"* means that people who live here and who visit the area respect and appreciate (not only) the geological heritage and they are ready to do something for it, to explore its variedness and to protect it. *"Our Geopark – a Chance to Grow, a Chance to Keep"* intends to bring the attention of decision makers, business and entrepreneurs to sustainable economic opportunities and also to motivate the relevant organisations to focus on cooperation and networking.

Examples for activities include the first *Geopark Forum* in 2006 where the stakeholders were informed about the concept of the Geopark and the possibilities of the co-operation, the cooperation agreement in 2011 between the Applicant and the Micro-Regions concerning the goals of the Geopark, the free 'Bakony–Balaton Geopark' geotours of the Applicant, the information stand, and activities of the trained geotour guides at the *Valley of Arts Festival* in 2011, the Geopark leaflet (also in English), the page on the Geopark on the website of the Applicant, the creation and use of the Bakony–Balaton Geopark logo and a *photo exhibition* about the cultural heritage of the Geopark.

An awareness campaign is planned to start right after the declaration of EGN membership – hopefully in the autumn of 2012 –, because this is an occasion that can draw the attention of the public and of the stakeholders. The European Geoparks Week is also planned to be organised annually from 2012 on, as well as the presence at regional events (Valley of Arts, *Eco-Market* in Veszprém). Elements of the printed and interactive media, incentives (postcards, badges, etc.), forums, seminars, lectures at educational institutions, a training and newsletters for the Applicant's employees and for the entrepreneurs working at the Applicant's facilities are also planned to be implemented.

E. Interest and arguments for joining the EGN/GGN

The *unique geological, ecological and cultural heritage* and the *incomparably high level of geodiversity* (on a national scale) provide an *excellent base* for the establishment of the Geopark. Few of the regions in Hungary have been involved in so many scientific publications and ongoing geological researches than this one. The Applicant (following the participation in the EGN's conference at Lesvos) started preparations in 2005 already, and – as it had been obvious from the beginning that the rich geological heritage in itself was not enough for the establishment of a geopark – *launched many new programs* and *initiatives* that opened the door to the sustainable interpretation of geological assets, linked to the biotic and cultural heritage; and to the vitalization of the local economy. The communities living in the former heavy-industry and mining regions may obtain new opportunities if the geotourism potential of the area is exploited in a sustainable way. These opportunities can be effectively supported exactly by the Geopark.

The Applicant has provided *popular geotourism services involving local communities, civil organisations and entrepreneurs* for years. The Applicant was the *first in Hungary to launch geotour guide training courses.* The exhibition of the Applicant's new visitor centre emphasizes the interpretation of geological heritage and knowledge, etc. According to the requirements of the local strategic development documents, the geotourism offer – as a valuable alternative of bathing tourism at Lake Balaton – widens the existing tourism offer with entertaining experiences of high quality. The participation of the settlements – located further away from Lake Balaton – in the touristic and economic processes is promoted by these elements. They also diminish the disadvantages deriving from the short tourism season. We are convinced that e.g. the colourful fences of Káli Basin built of different rock types will represent from now on not merely an aesthetic experience for visitors but will also become symbols of the 'message' and 'philosophy' of the Geopark, thanks to the effective use of communication tools, to the geotours. The *tourism service network* of the proposed Geopark, the *high number of accommodations* (regarding guest nights, the *Balaton Region is the second most popular destination of Hungary),* the several hundred kilometres long marked hiking paths,

the nature trails provide an excellent background for implementing our geotouristic ideas.
Consequently, the *Applicant's aim is not only to have a new, highly prestigious certificate,* because for us becoming a Geopark definitely means the *empowerment of the area and the organisation with a complex strategy, with new functions and ways of cooperation, in order to enhance the provision of the above objectives – and clearly this is much more than the traditional tasks of a national park directorate.* The Applicant is suitable for fulfilling the tasks in connection with the Geopark and for tackling new challenges, because it is in possession of *highly qualified experts* with considerable experience in the fields of *practical geological nature conservation, tourism* and *education* and can present a *robust organisational and financial background* as well as the support of micro regions, state institutions and professional organisations. We believe that the proposed Geopark absolutely deserves the involvement of this Eastern-Central European area into the ever growing network of international geotourism as well. We are also convinced that *the Bakony–Balaton Geopark will be a useful member of the EGN/GGN,* closely *cooperating* with the future associate foreign organisations and the Hungarian–Slovak *Novohrad–Nógrád European Geopark.*