An Improved Methodological Field Practice on Karstic Phenomena in Aggtelek National Park

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***Abstract* — The education of environmental engineers (B.Sc.) includes not only theoretical subjects but field exercises and ecological topics as well. The subject of this paper is a new field exercise in Alsó-hegy. There is an observation trail presenting karstic formations and also vertical caves in Alsó-hegy. This recently introduced field exercise fits into the theoretical courses showing the theories in its reality. The observed geological features were explained in detail and the field trips were managed didactically. The original trail guide was expanded with scientific explanations, practical tricks and data which are in correspondence with the environmental engineer`s expected B.Sc. knowledge. The subject field exercises did not deal only with local specialties, but it provides information on surrounding areas and general topics of karstic phenomena. Other field exercises shall follow the contents of this paper both for Hungarian and foreign students at various levels.**

I. INTRODUCTION

The education of environmental engineers (B.Sc.) contains not only theoretical knowledge but field exercise and ecological topics. A multi-day summer training camp is a good opportunity to provide information in real environment [1-5]. Moreover, such training helps to improve social skills (communication skills, teamwork, etc.), management and evaluation of data [6]. The realistic conditions provide the opportunity for the students to synthesize the knowledge of different courses into a complex vision [2]. The provided proper research methodology (observation evaluations and conclusions) also improved during such an occasion [3].

A national park offers excellent conditions for an effective field practice for environmental engineering students [7-9]. The undisturbed environmental conditions of national parks show natural conditions, which are good as reference values for environmental assessments. There are several karstic regions [10] with caves [11] in Hungary. Therefore, there is an important opportunity here for students to obtain experiences in a karstic region [12].

Aggteleki Nemzeti Park (*Aggtelek National Park*, ANP) was selected for summer field exercises for environmental engineering students (B.Sc.). This national park was founded in 1985. The large numbers of vertical and horizontal caves [13], unique local cultural heritage of the area were the reasons why the ANP selected it into the UNESCO World Heritage network in 1995 [14].

Alsó-hegy (*Lower hill*) part of ANP, was designated for as the target area, for our training camp, because it is an excellent area to observe the karstic formations. Eight big caves Almási-zsomboly (*Almási vertical cave*), Frank-barlang (*Frank cave*), Kopaszgaly-oldali 2. sz. víznyelőbarlang (*Bold side sinkhole cave (No. 2*), Kopasz-vigasz barlang (*Bold consolation cave*), Meteor-barlang (*Meteor cave*), Szabó-pallagi-zsomboly (*Tailor meadow vertical cave*), Széki-zsomboly (*Széki vertical cave*) and Vecsembükki-zsomboly (*Vecsembükki vertical cave*) are all located here.

The trip followed the Alsó-hegyi Zsombolyos Tanösvény (*Vertical Caves Observation Path of Alsó-hegy*) booklet [15]. The booklet directs along the path with 14 stations, and it contains explanatory texts, pictures, and maps of the area and locations of the caves.

Our field exercise does not cover only the data of this booklet, but it provides additional information with scientific explanations and experiments to fit better to our educational system of environmental engineering students. Using the information of this paper, foreign student can also manage a useful field trip in Alsó-hegy region. This trip was adopted for improving the knowledge needs of B.Sc. students. Its several parts, however, are also useful for foreign tourist groups, high school, and M.Sc. students too. The English translations of the Hungarian names of the geographical objects of the path are written in italic letters.

II. AGGTELEK NEMZETI PARK (*AGGTELEKI NATIONAL PARK*, ANP)

ANP is one of the well-known karstic regions of Hungary because it has several unique natural features. The topics of several books on these caves provide in-depth descriptions and reports of their explorations [13, 16, 17].

The rocks of this area are Wetterstein limestone, which was deposited from a shallow sea approximately 220 million years ago [16]. The recent formations have been created during the last five million years.

The micro-region of Alsó-hegy belongs to the Északi-középhegység (*North Hungarian Mountain*). Hungarian-Slovakian border separates into two parts the Gömör-Tornai karstic formation including Alsó-hegy (Figure 1).

The borders of Alsó-hegy are the following: north, Torna patak (*Torna creek*); south, Bódva folyó (*Bódva river*) and Ménes patak (*Ménes creek*); west, Szilicei-fennsík (*Szilicei plateau*). Its area is 50 km^2 and its elevation is

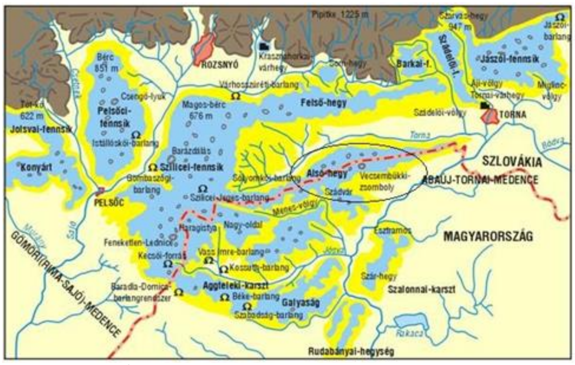


Figure 1. Map of Gömör-Tornai karstic region (Kuczka 2000) The micro-region of Alsó-hegy is circled. The Hungarian-Slovakian border is marked with a bold dotted line.

between 400-500 m [16]. The plateau of this mountain is abandoned, only one settlement, Szögliget is located at its edge. The climate of the area is relatively cool and humid. The average annual temperature is about 8-8.8° C, and the sunny hours are about 1800 annually. The amount of rainfall is around 680 mm in an average year.

The Alsó-hegy is extremely rich in vertical caves. The vertical caves geneses started in this region in the Pliocene era [17].

II. THE DETAILED DESCRIPTION OF OUR FIELD TRIP ON ZSOMBOLYOS TANÖSVÉNYEN (*VERTICAL CAVE OBSERVATION PATH*)

This path is approximately 8.5 km long, and a gain of 355 meters elevation [15]. 14 stations are located along the path highlighting the interesting locations (Figure 2.). The different stations are marked with red numbers in the text.

Trail head 1

The beginning of path 1 is located in the middle of Bódvaszilas village. A map is presented in the trail-head to help the orientation.

Kavacsos *(Pebbly)* 2

The route passes by a typical manorial granary toward Kavacsos. The rock of Kavacsos is a mixture of Late Permian red sandstone and a well-cemented rock (conglomerate).

Figure 2. The 14 stations of the observation trail are called "Zsombolyos tanösvény" [15]. Symbols: semi-dotted line, the country border; circles, station of the observation path.

Macskatemplom *Cat Church)),* **Pályi kút** *(Pályi well)3*

Going further, the path crosses Macskatemplom a large, grey pink-foliated limestone slab (Hallstatt formation) and the Pályi-kút spring.

This place provides a nice example of the karstic erosion processes. The observed cracks have been created by water dissolution and splitting force of vegetation roots. The dried-up spring of Pályi-kút shows that new fountains are born from time to time. The deepening processes of caves produce new springs in a lower elevation than previous ones. The dried-out springs can still function as flood springs after heavy rains or snow melting.

Márvány-bánya *(Marble quarry) 4*

The limestone rocks of Gömör-Tornai karst are good for construction works and decorative functions in many places. Hewn rock slabs mark an abandoned rock mine settled along the trail. The remaining rock slabs show well the structure of the hard limestone, "marble".

Gray calcite crystal veins can be observed on a freshly cut surface. These intrusions cross each other and fill out the cracks of grey or pink patches of the background rock. This texture comes from the genesis of the rock. The original limestone bed had fragmented gravels (breccia), and the spaces among the particles were filled by deposited calcite crystals from the infiltrated saturated water.

Close to the Márvány-bánya can be seen the half demolished Esztramos mountain in the opposite side of Bódva valley. The intensive limestone mining carried away the upper part of Esztramos. This activity left behind a big wound in the original landscape. Unfortunately, the remediation work of the quarry pit has not been started at all.

The trail goes through an oak-hornbeam forest and a bushy landscape. The next didactically important area is a karstic field with small karren ribs (devil plowing, ördög szántás) and cracks. These formations are the consequences of clearances and viticulture in this area. Namely these activities have resulted in intensified soil and rock erosions. This terrain is an excellent example for observing the starting stage of surface karstic erosion.

Bak Antal töbre *(Bak Antal's doline),* **Tektonik-zsomboly** *((Tektonik vertical cave)5*

The next station of this trail is Bak Antal töbre, a typical doline. The dolines are the most characteristic formations of karstic surfaces. The infiltrating water of rains and snowmelts solve the limestone easily, creating depressions. Generally, they are circular, conical shape depressions. The typical measures of the dolines are 50-200 meters in diameter and 10- 25 meters depths in the Alsó-hegy.

The local vegetation differences can be studied well in this doline. The bottoms of dolines have more dense vegetation than edges of the dolines. Namely the soil is thicker in the bottoms of the dolines and the bottoms of them catch the fog, and the runoff water. Moreover, the orientation of the slopes also make differences in the vegetation, because the southern slopes of the dolines get more sunshine than the northern ones.

The Tektonik-zsomboly, is the first vertical cave on the path. The Tektonik-zsomboly has no big depression consequently you can hardly recognize it without seeing the awareness sign. The entrance of the pit is a narrow fissure (Figure 3a). This vertical cave, however, is 80 meters deep and 350 meters in horizontal length (Figure 3b).

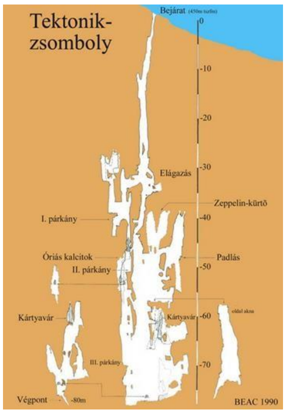


Figure 3a. The entrance hole of the Tektonik-zsomboly in Bakk Antal töbre [17] Figure 3b. The schematic map of Tektonik-zsomboly [17]

The cave starts with a deep vertical pitch. It has no surface catchment area. The entrance is a small hole. The diameters of pitches become broader and broader downward. No sinkhole belongs to this cave at all (Figure 3a). The map of Tektonik-zsomboly (Figure 3b) characterically represents the forms of vertical caves of Alsó-hegy.

According to the present knowledge these vertical caves have been formed by the corrosive feature of water [19]. The creation of holes started from the surface or near to the surface with narrow cracks. The narrow entrance of the Tektonik–zsomboly shows evidence, this vertical cave did not start with a sinkhole. The infiltrating water leaches the limestone along the vertical cracks. These processes are rather intensive in the Alsó-hegy because the geological strata lie in a vertical position. The fissure started to dissolve out along the chemically less resistant stratum. The unsaturated water dissolves the limestone further into bigger and bigger pitches. The broadening holes interconnect with the separate caverns, creating big cavities. During the dissolution processes a small percentage of the rocks (e.g., clay, iron oxide, and silica) stay undissolved. Residual clay materials are deposited at the bottoms of the pitches. The watertight clay layer prevents the water from flowing downward; therefore, the water flows down in the pits in the vicinity, creating multi-pit systems. The rocks erode most intensively close to the surface, because the concentration of the dissolved atmospheric carbon dioxide (aggressive carbon dioxide) is the highest near to the surface. The dissolution processes produce erosion upward too. The upward erosions result in the collapsing roof toward to surface. Finally, the pits get open to the surface. Generally, the tectonic activity also plays role in the genesis of vertical caves.

The Tektonik-zsomboly and other caves of Alsó-hegy are dangerous places; they can be visited only with dedicated guides, who know the local area and help to avoid accidents. Furthermore, experience of alpine skills and appropriate harnesses are required to visit these vertical caves.

The following station of the trail is the Vecsembükk part of Alsó-hegy.

Jóbarát zsomboly *(Good friend vertical cave) 6*

The Vecsembükk is very rich in vertical caves. There are 21 vertical caves in a 1 km^2 area. The Jóbarát-zsomboly cave is moderately deep (29.5 m) with limited horizontal extension (35 m). This cave also situates in the rim of doline, without significant sinkhole.

Vecsembükki-zsomboly *(Vecsembükki vertical cave) 7*

The Vecsembükki-zsomboly is the 3rd deepest cave in Hungary (Figure 4). It is 236 m deep and its deepest pit is 90 m vertically.

The exploration of the Vecsembükki-zsomboly demonstrates the improvement of caving technology. The first attempt was failed to descend into it in 1911. The first successful attempt to reach the bottom of the first pit was made by H. Kessler in 1927. They used rope ladder. Their ladder was not enough long, therefore, they built a temporary belay in 40 m below the surface. Two big expeditions were organized by I. Szenthe to reach the karstic water level in 1969 and 1971. They explored several new pits reaching 236 m depth. The diluted clay and cool temperature prevented the expedition members to reach the karstic water level, which is expected to be approximately 300 meters depth from the surface. These expeditions used ropes and windlasses. The pull-ups were carried out by human pulling from the bottom of the top pit. The trampled path of the pulling groups is recognizable in the doline even today.

These expeditions made several scientific measurements. Meteorological observations showed that the temperature of the cave is rather cold (3-7° C). The increased radioactivity provided evidence of the volcanic origin of the cave debris in the bottom of pits. Probably the volcanic ash of the Mátra covered the surface of the limestone of Alsó-hegy, which played important role in the genesis of these vertical caves. It is worth to note, that, the water of the Vecsembükki-zsomboly appears in Zsámány-kút and Kör-kút springs in Slovakia, not in the neighboring Vecsem-forrás spring on the Hungarian side. The parallel pits of Vecsembükki-zsomboly are very close to each other (Figure 4a). Only thin rock walls separate the shafts. Bridges and ledges divide of the parts of caverns. Thick flowstone depositions coated the walls.

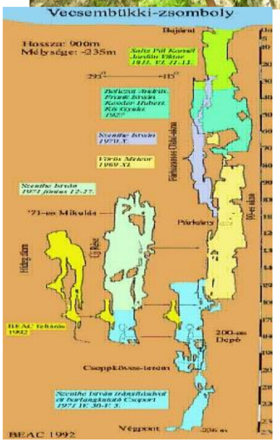


Figure 4a. Alpine mastery and harnesses are needed to discover Vecsembükki zsomboly [20]

Figure 4b The Vecsembükki zsomboly's schematic map [17]

The upper parts of the cave are rich with stalagmite and stalactite dripstones. The palm tree stalagmites can be found in the bottom of the pits. The water drops fall down from high elevations, gaining big kinetic energy. The droplets are dispersed into aerosol caused by the high energy impacts. The crystallizations produce such palm tree formations from aerosols, because the gravitation forces play only a moderate role in the crystallization processes.

The up-to-date caving harnesses (descender and ascender devices) make it possible to descend to the deepest point of the Vecsembükki-zsomboly and ascend less than 4 hours.

Bükk matuzsálem *(Beech Methuselah) 8*

A more than 200 years beech tree over-tops its surrounding woods. Such an old tree could present to the visitors the original vegetation of the plateau without anthropogenic degradation.

Nászút-barlang *(Honeymoon cave) 9*

The Nászút-barlang cave is a short narrow cave (20 m) with sinkhole type genesis. This type of the cave is not frequent in this plateau, only for the curiosity is in the program of Vertical cave path.

Szabó-pallag-zsomboly *(Tailor meadow vertical cave)* and other vertical caves of its vicinity *10-11*

Szabó-pallag is a big human made glade. This meadow is a typical example of middle-latitude dry mountain meadows. The students can determine the typical species following the instructions of the guidebook of the trail and our plant determinant lecture notes.

The following vertical caves are close to Szabó-pallag: Almási-zsomboly (100 m deep), Széki-zsomboly (50 m deep). The most interesting phenomena of the Széki-zsomboly is its helictites. Helictitetes are rare formations of dripstone, in practice, they are bent stalactites.

The Baglyok-szakadéka (*Owl canyon*) is also close to Szabó-pallag. Its depth is 151 meters. Its name was given after the owls frequently nest in the small pocket of the first big pit. The attention of students were raised for the potentially serious environmental pollution risk of the vertical caves at Baglyok szakadéka. This cave is rather close to the road and a trash bag can be easily thrown into the bottom of the first pit of the cave from a vehicle. Such pollution was done at the nearby Kis-zsomboly (*Small vertical cave*) at the end of 1950s. Kis-zsomboly is located in Szilicei-fennsik (*Szilicei plateau*, Figure. 1) in Slovak Republic. Workers of one of the agricultural enterprises disposed several tons of rejected 4,6-dinitro-ortho-cresol into the Kis-zsomboly. The 4,6-dinitro-ortho-cresol was frequently used as insecticide. It is a dangerous poison for mammals, showing LD50 25-50 mg/kg in different species, depending on the route of exposure and the temperature of test conditions. The pollution of Kis-zsomoly was only recognized years later after the disposal. The contamination surfaced in Buzgó forrás (*Buzgó spring*). The Buzgó forrás is one of the main sources of the drinking water supply of Roznava city (~ 20 000 residents). The investment and instillation of extra cleaning equipment was necessary in the waterworks of Roznova due to sediment. The sediment was removed from the bottom of the pit with alpine technic in 1985.

A hunter house is located in Szabó-pallag (11), only one house in the plateau of Alsó-hegy.

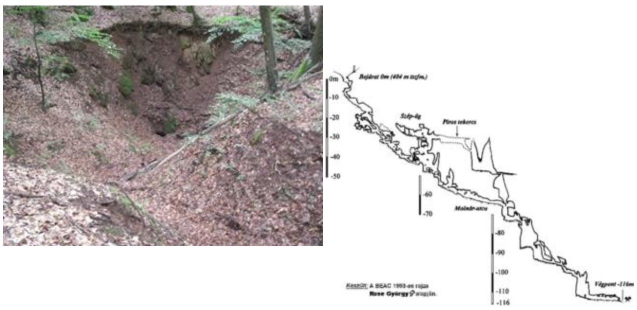
Kis vizes töbör *(Small Watery doline)* **and Meteor-barlang** *(Meteor cave)12*

The path slants in a small valley from that point, to a doline called Kis-Vizes töbör. Rocks of the Kis-Vizes-töbör are different from the characteristic rocks of the Alsó-hegy; they are Hallstat formations (Hangandrotkalk). The students can make comparisons among the different rocks of this field exercise.

The entrance hole of Meteor-barlang is in the bottom of this doline. The Meteor-barlang is not a vertical cave, it has several hundred meters (1670 m) horizontal extension. Titánok csarnoka (Titans hall) is 120 meters long cavern, which is the largest cavern in Hungary. There is a high number of huge colorful stalagmites and stalactites in it.

Nagy-Vizes-töbör *(Big Watery Doline)* and **Pócsakői-viznyelőbarlang** *(Pócsakői sinkhole cave) 13.*

The entrance of Pócsakői-viznyelőbarlang is a typical steep cone shaped depression with soil deposition and stacked big rocks (Figure 5). The entrance of Pócsakői-



viznyelőbarlang is at the bottom of the cone. It has 87 meters horizontal and 51 meters depth expansions [17].

Figure. 5a. The cone shaped entrance of Pócsakői-víznyelőbarlang [6]
Figure 5b. Schematic map of Pócsakői-víznyelőbarlang [17]

It has a definite catchment area. The sinkholes swallow up the dragged rocks and soil. The run-off water can drag particles into deeper horizons. The dragged rock can carve the wall of the waterway, making it broader. More and more dissolution of rocks transforms the sinkholes to a bigger depression, the doline. The sinkholes frequently dissolve out caves in their lowest points. The drained water of Pócsakői-víznyelő breaks out on to the surface via the Vecsem spring [11].

Szőlős-kerti vagy Barlangkutató forrás *(Vineyard or Caver spring) 14*

The last station of the observation path is the spring of Szilas creek, which is called Szöllös-kerti or Barlangkutató spring.

Sandstone flakes were found around the spring. This observation suggests, that the spring locates in the frontier line of water-permeable calcium carbonate rock and watertight sandstone rocks. The students measured the discharge of the spring. The method bases on the filling tract of the 5 liters bucket. 151 l/min discharge was measured.

IV OTHER ACTIVITIES IN CONNECTION TO FIELD PRACTICE

To get a holistic view of the karstic phenomena several other activities were done during the summer practice. Ecological status (Diesel method) and some chemical parameters were established for Kecső-patak *(Kecső creek*), a small brook. The nitrate, nitrite, calcium, magnesium, chemical oxygen demand, temperature, pH values were measured at more than 10 different locations. 5 springs of Alsó-hegy were also tested on the Hungarian side. Horizontal caves (Baradla, Béke, Vass Imre) with cold water genesis were visited. A cave with hot water genesis (Rákóczi) was also surveyed.

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