Underground pseudomontaneous relief shapes as geotouristic objects

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Abstract
The article analyses the underground pseudomontaneous relief shapes as potentional geotouristic objects. In the first part of the article we introduce results based on analyses of scientific papers, specialized resources from other natural, technical and social scientific disciplines, as well as our own field research. Basic evaluation methodology of the individual types of underground pseudomontaneous relief shapes is proposed. At the end of the paper we briefly introduce the possibility of using the underground space of Krupina city as geotouristic object. This underground pseudomontaneous space has all the prerequisites to become a top destination for underground geotourism.

Key words: pseudomontaneous relief shapes, anthropogenic underground space, analyses of shapes, geotourism, geoturistic objects, evaluation

INTRODUCTION

Underground pseudomontaneous anthropogenic forms are nowadays several times larger than shapes created by mineral extraction, or for mining purposes, referred to as montaneous anthropogenic landforms. By using the latest techniques and methodologies of longwall mining, the frequency and size of montaneous landforms is gradually increasing. Anthropogenic relief shapes are essential for the functioning of technical progress of modern contemporary human society.

Underground pseudomontaneous relief shapes are as old as the human society. First archaeologically documented and purposefully created subsurface anthropogenic landforms in construction of underground structures are dated back to the period of European prehistory, around 4000 BC. These underground shapes currently represent important objects for the world geotourism e.g. Hypogeum in Malta, tombs of ancient Egypt (Kubba el-Hawa, Bani Hasan, Valley of the Kings, Valley of the Queens), rock temples of ancient Egypt (Abu Simbel), rock temples in India (Ajanta, Baha'is, Kanheri, Bedse, Ellora, Elefanthia), "rock city" in Jordan (Petra), complexes of underground cities (Cappadocia in Turkey, southern Italy, south-eastern Spain, northern Tunisia), water tunnels - "quanats" - the oldest working underground pseudomontaneous anthropogenic landforms in the world (Middle East, Mediterranean, southwest China). A broad group of ancient underground monuments consists of constructions such as the water tunnel on the island of Samos, Roman catacombs, traffic tunnel near Naples, water tunnels in Rome and countless other places (tunnels, water tunnels, tombs, temples, underground dwellings) protected as UNESCO World Heritage Sites (Hronček 2013a).

Numerous underground pseudomontaneous sites, that have not been discovered for geoturism yet, can be found in Slovakia. The largest and the most significant include town undergrounds of Krupina, Trnava, Nové Mesto nad Váhom, the oldest road tunnels (tunnel in the castle Lednica, Gergely´s tunnel, Kelemen´s

tunnel, Stratenská rock gate) and railway tunnels (Bratislava, Slavošovce, Pod Dielikom, Telgárt, Čremošné), castle undergrounds (Slovenská Ľupča, Modrý Kameň), undergrounds of largely destroyed rural gentry residences, water tunnels of hydro power stations (Dubová, Jasenie, Staré Hory) and many other objects registered as national cultural and technical heritage (Hronček, 2013a).

The most well-known underground pseudomontaneous landforms searched for touristic (geoturistic) reasons are e.g. the largest castle cellars in Central Europe in Červený Kameň Castle, wine cellars in various wine regions of Slovakia (only seasonally opened to public), undergrounds of some castles (cellars, casemates, wells) or freely available undergrounds of castle ruins, and many more, representing part of a wider cultural and technical heritage as the main objects of tourism.

The first step towards their discovery by geotouristic clients is the detailed processing and presentation in terms of geology, anthropogenic geomorphology, history, cultural and technical attributes, geography and social requirements.

PSEUDOMONTANEOUS RELIEF SHAPES

Pseudomontaneous relief shapes are shapes that feature all of the corresponding characteristics typical for montaneous shapes, but they did not originate for the purposes of mining nor as a result of mineral resources extraction. *Pseudomontaneous shapes are any objects and shapes located underground and created using the procedures employed in mining* (e.g. by digging of underground areas and shapes), *yet the causes, requirements and, above all, the purpose of their origin is different than the extraction of mineral resources.*

We can thus state that they were created using mining procedures - digging of bore holes, shafts, chambers or other shapes, but they are intended for sectors of industry other than mining itself. These underground surfaces created on purpose by employing mining techniques most often assume the forms of bore holes, chambers, cross holes, tunnels, big caverns and such. The Slovak linguistic equivalent of pseudomontaneous shapes of anthropogenic relief is the term "non-genuine mining relief shapes created by man".

Research of pseudomontaneous anthropogenic relief shapes utilizes the same scientific methodology that applies to geomorphology or anthropogenic geomorphology. A detailed and comprehensive overview of the scientific methodology for the study of anthropogenic geomorphology with particular focus on montaneous anthropogenic geomorphology was presented in a separate monography written by the collective of authors together with P. Rybár and K. Weis (Hronček et al., 2011).

We have composed a basic categorization scheme of the individual types of non-genuine anthropogenic montaneous relief shapes based on analyses of scientific papers, specialized resources from other natural, technical and social scientific disciplines, as well as our own field research (Hronček, 2013b).

This subdivision is easy to follow, logical and it guarantees correct analyses of the individual non-genuine montaneous shapes of the anthropogenic relief which can be used for the purposes of research in the field of anthropogenic geomorphology. Such subdivision can also be applied to other related scientific disciplines - montanistics, historic geography, geography, montaneous tourism, environmental sciences, landscape ecology and other geosciences.

Underground pseudomontaneous anthropogenic relief shapes can be subdivided into these basic groups:

1. According to the basic shape
2. According to slope angle
3. According to geometric shapes of the objects
4. According to the shape of the cross

section
5. According to the method of digging
6. According to the location within the landscape
7. According to reasons that lead to their creation
8. According to the distribution of mass
9. According to size
10. According to the composition of rocks
11. According to age
12. According to the purpose of use for the individual sectors of industry

1 According to the basic shape

The basic shapes of pseudomontaneous anthropogenic relief shapes are derived from its mutual length, width and height. On the basis of these characteristics we recognize linie, areal and hall pseudomontaneous anthropogenic shapes.

These must not have only the shape of rectangular cuboid, but also other basic or derived geometrical shapes.

The basic characteristic for linie shapes is, that its length is multiply larger beside its width and height. These are for example chambers, tunnels and bore holes.

Two horizontal dimensions (width and length) of areal shapes dominates over its height. It means that beside its height these shapes gain big planes. The typical areal shapes are for example garages, warehouses, parking places and subways.

All the dimensions of hall (cave) shapes are approximately equal. These are for example underground stadiums, power plants, store tanks and others.

Underground shapes (objects) created in the underground mined spaces, for example are pillars and benches.

2 According to slope angle

The divesting of pseudomontaneous anthropogenic relief shapes according to slope angle is intrinsic mostly for linie shapes, but it's applicable also for the other shapes. The slope angle of the pseudomontaneous relief shape is slope between the lengthwise centre line and assumed horizontal plane. According to slope angle we can divide pseudo-montaneous anthropogenic relief shapes into:

- Horizontal – slope angle of lengthwise centre line up to 10º
- Slant – slope angle of lengthwise centre line from 10º up to 60°
- Bevel – slope angle of lengthwise centr line from 60º up to 90°
- Vertical – slope angle of lengthwise centre line 90°

3 According to geometric shapes of the objects

The divesting of pseudomontaneous anthropogenic relief shapes according to geometric shapes of the object is not accurate, but more orienting or informative. Ideal shape, which expressly matches some of the basic shapes of the objects, is hard to find in the field (in practice). This divesting is more about combination of individual basic shapes of the objects. In practice always one basic shape dominates over the others. For example, the underground sports hall has the shape of the cuboid with rectangular socle or rectangular upper arch; caxern of the underground power plant has the shape of cuboid, barrel etc.

We recognize these basic shapes of pseudomontaneous anthropogenic relief shapes according to basic geometric shapes of the objects: prismal (socle may have the shape of quad, rectangle, trapezium, triangle, polygon), cubic, barrelal, conical (blanted cone), pyramidal (socle may have the shape of quad, rectangle, triangle, polygon and frustum) and combinations of basic shapes of geometrical objects.

4 According to the shape of the cross section

For designing underground buildings is very important the choice of the shape of the cross section. The shape of the underground profile of the future underground building is chosen foremost regarding to purpose to which should the underground building serve. The important factor of the profile choice are also the

conditions of ambient rock environment. So the physical, mechanical and chemical characteristics of the rocks. Dimensions of the cross section given in meters and their area of cross section measured in square meters.

According to the shape of the cross section we recognize following basic shapes: orthogonal (rectangular, quadrial), trapezium, circular, ellipsoidal, arched and combinated.

5 According to the method of digging

Pseudomontaneous anthropogenic relief shapes digged from the surface. All shapes, digged from the surface have its own influx (chamber, tunnel). Often it is so-called introductory work, which is dedicated to open the field for underground build-up from the surface. To this work knot other pseudomontaneous anthropogenic relief shapes.

Pseudomontaneous anthropogenic relief shapes digged from the underground. The digging of underground fields without the surface influx. Whether linie shapes or chamber shapes.

Pseudomontaneous anthropogenic relief shapes digged horizontal. Chipping of the horizontal (mostly linie) underground field with lengthwise centre line with dawnword less than 10° to horizontal line.

Pseudomontaneous anthropogenic relief shapes digged vertical. Chipping of the vertical (mostly linie) underground field, which lengthwise centre line contains the angle 60° - 90° with vertical line.

6 According to the location within the landscape

Mountain pseudomontaneous anthro-pogenic relief shapes are chipped in order to bridge mountain-ridges and convexic relief shapes. These are mostly linie underground relief shapes chipped for purpose of traffic, whether roads or railways, watter lancing and diversion from cities, industry, etc.

Planar pseudomontaneous anthro-pogenic relief shapes are build in planar relief. Purpose, shapes and size of their creating is different. This includes all types of pseudomontaneous anthropogenic relief shapes.

Underwater pseudomontaneous anthro-pogenic relief shapes are chipped under water flows (natural or manmade), water areas, narrow seas and sea canals. These are mostly linie shapes with communication character.

Urban pseudomontaneous anthropogenic relief shapes are situated in city centres with lack of free space for their expansion. Urban underground buildings are one of the main subjects of technical sciences (underground engineering)

7 According to reasons that lead to their creation

According to reasons that lead to their creation we recognize ecological, climatic, protective, technical, scientific and re-creative shapes.

- Ecological – determining factor of their creation is preservation of the environment and negative impact on landscape. These are for example underground dumps, underground reservoirs, underground traffic in cities, etc.;
- Climatic – created owing to minimize climatic impact on their commercial use according to latitude. These are for example underground power plants(to eliminate water freezing in colder latitude), underground cellars and warehouses(to keep stable climate underground);
- Protective – created to protect from natural hazards and from hazards of human (military) activities. These are different drainage systems (tunnels), but mostly underhround military buildings;
- Technical – gain ground more and more in present modern, technical and global world. These are different technical solutions, which are making the existence of human society easier. These shapes are mined out for road traffic, railways and other specific traffics, also

for duty of water by water tunnels.

- Scientific – claim to building underground laboratories and research centres, owing to specific and on the ground hardly reachable research conditions. (e.g. Cern)
- Re-creative – claim to building underground sports centres and areals (sports halls – hockey, handball, atletic, swimming pools, shooting ranges, climber walls etc.)

8 According to the distribution of mass

According to the distribution of mass of the mantle, in which were the underground spaces mined out, we recognize 2 groups of pseudomontaneous relief shapes. These are hollow and replete shapes (entities).

Mostly appearing and dominating are hollow shapes – underground sinuses. In geometry are hollow shapes designated as negative entities. These hollow shapes are all tunnels, inspection chambers, chambers, tubes, caves, so all mined out spaces in underground.

Replete pseudomontaneous anthropogenic relief shapes are compared with hollow shapes not so usual and have smaller dimensions. Replete shapes are always situated in space or are parts of hollow shapes.

9 According to size

We can use 4 size categories to classify pseudomontaneous anthropogenic relief shapes. To categorize shapes into separate size categories suffices to meet sizes in one of length, width or height.

We recognize nanoshapes, microshapes, mezoshapes and macroshapes:

- Nanoshapes have smallest size and reach dimension up to one meter,
- Microshapes are small and its dimensions are up to 10 meters,
- Mezoshapes reach middle sizes, tenths of meters and sometimes hundreds of meters,
- Macroshapes are the biggest and reach hundreds of meters even kilometers.

10 According to the composition of rocks

We can divide pseudomontaneous anthropogenic relief shapes according to its localization in rock complexes, so it means in what rocks are mined out:

- Homogenous shapes have homogenous (the same) petrographic composition in its whole capacity,
- Inhomogeneous shapes have different petrographic composition,
- According to rock type (granite, calcite, basalt, clay, etc.) in which are mined out, eventually which one creates replete shapes.

11 According to age

Categorizing according to age is clear in cases that we know the age exactly on the basis of archive documents, letters, maps, plans and materials with other origin. We express it in absolute numbers.

Determining the age of pseudomontaneous anthropogenic relief shapes is important in cases, when we do not have any archive documents, letters, maps a plans available to clearly determine its age. In this case we must during terrain researches to classify the shapes into age categories.

Application of this categorization exacts critical approach from researcher and his great theoretical but foremost practical knowledge and skills from terrain practice.

According to age we divide pseudomontaneous anthropogenic relief shapes to live, mature, fleeting, extinct and renewed:

- Live are shapes, which are built at the time, its mining is in progress;
- Mature shapes serve the purpose to which were created;
- Fleeting shapes are abandoned through research and do not serve its primary purpose and begin to dissolve. The dissolution is long term procedure, into which enter many other factors (natural, anthropogenic – social-economical);
- Extinct shapes can dissolve by natural way, stop serve its primary purpose and begin to deteriorate step by step. Natural

extinction is incomparably longer than anthropogenic interference (clearage);
- Renewed shapes were reintegrated by underground building, cavity, modification, etc., but must not serve its primary purpose but are modified for other commercial use.

12 According to the purpose of use for the individual sectors of industry

We divide pseudomontaneous anthropogenic relief shapes according to the purpose of use for the individual sectors of industry in context of present modern society progress into 9 groups. These are industrial, agricultural, residential, water management, transportation, military, funeral, celebrational and last group consists of re-creative, scientific and sport shapes.

POSSIBILITY OF USING THE UNDERGROUND PSEUDOMONTANEOUS RELIEF SHAPES IN GEOTOURISM

Based upon our experience in field research and scientific work in the area of montaneous landforms and currently with underground pseudomontaneous landforms we can say that the first step for their further use in science and research, and also in practice (including geoturism) is their detailed and systematic examination and processing in terms of geology, anthropogenic geomorphology, history, cultural and societal attributes and so on. We used the methodology introduced by us to present a comprehensive evaluation of these shapes.

In the research and processing of underground montaneous anthropogenic landforms and their subsequent use in geoturism we must proceed in accordance with the applicable laws of the Slovak Republic. The most important thing is to comply with the provisions of the Mining Law on the Protection and Use of Mineral Resources no. 44/1988 Z.z. (Anonymus 1988), the Law on the Protection of Nature and Landscape no. 543/2002 Z.z. (Anonymus 2002), and also the Law on the Protection of Monuments no. 49/2002 Z.z. (Anonymus 2002).

The latest core works in the field of geotourism had been used for processing of pseudomontaneous underground anthropogenic landforms as potential geoturistic targets, including works of T.A. Hose (Hose, 1999), R. Buckley (Buckley 2003), C. Schejbal (Schejbal, 2005), R.K. Dowling, D.Newsome (Dowling & Newsome, 2006), R.K. Dovlingom (Dowling, 2009), R.K. Dowling, D. Newsome and colleagues (Dowling, Newsome eds., 2010) and D. Newsome, R.K. Dowling and colleagues (Newsome & Dowling (eds.), 2010).

Natural and anthropogenic landforms and geolocations were analyzed as geoturistical objects in works of T. Šmolka and colleagues (Šmolka et al., 2006), P. Rybár, B. Baláž and L. Štrba (Rybár et al., 2010) and P. Rybár (Rybár, 2012).

Classical montaneous and anthropogenic shapes of relief in scope of their geoturistic use are mentioned in works of C. Schejbal (Schejbal, 2005; 2011), P. Rybár (Rybár, 2010), P. Rybár with co-authors (Rybár & Hvizdák 2010; Rybáret al., 2010; Rybár et al., 2012), K. Weis (Weis, 2009; 2012) and P. Hronček (Hronček, 2009; 2012). Geoturism in natural underground caves and mines in Italy was described by M. Gorofano and D. Govoni (Gorofano & Govoni, 2012).

All of the mentioned methodologies can be applied to the use of underground pseudomontaneous anthropogenic landforms in geoturism.

EXAMPLE OF UNDERGROUND PSEUDOMONTANEOUS RELIEF SHAPES AS POTENTIONAL GEOTOURISTIC OBJECTS

Urban underground in Krupina began to be digged in the medieval period

immediately after the foundation of the settlement on the banks of river Krupinica. Bela IV. restored town privileges of Krupina in 1244 A.D. The first written mention of the underground excavated in the volcanic tuf is dated 1444 and refers to cellars under the Hussite bastion near the Catholic Church (Lukáč et al. 2006).

We can assume that underground spaces of Krupina were digged in the early days as cellars and were gradually growing and expanding together with the growing importance of the town for the adjacent mining area. Cellars served mainly as warehouses for agricultural products, wine, fruit and other agricultural goods. Fire protection was undoubtedly also one of the original functions. Protection against military danger was very important right from the beginning and these underground spaces officially served during the World War II as air raid shelters.

Multifunctional use of underground space (as evidenced by its retained local names - underground passages, catacombs, tunnels, cellars) enables us to proclaim it as "urban underground" in terms of methodology of underground pseudo-montaneous forms of anthropogenic relief. However, it is undisputed that urban underground of Krupina is missing one of the main characteristic dimensional features of urban underground, which definitely is the extensive interconnection of major underground spaces.

The biggest underground spaces were digged under the houses in the town square and the adjacent streets, which formed the original space of the medieval town fortified with walls. Large underground spaces are known beneath the Svätotrojičné square over which a new town house was built in the early 20th century. The original medieval town hall stood in this place and its underground spaces are called Kopňova cellar. Large underground spaces were also under the old meštianskymi houses that stood in place of today's post office building (Eisner´s house) and services building (Kohn´s house). These underground spaces were downfallen and subsequently buried during new construction.

Underground space underneath the Argay´s house, currently the Special primary school in the Partizánska Street, is proclaimed to be the largest one. Extensive underground spaces in the Sládkovičova Street are under the Gogalovsky´s house, today´s museum of A. Sládkovič, and under the building of the Roman Catholic parish opposite the museum. This underground space follows beneath stamped neighboring houses, which were in some cases mutually connected (Lukáč et al., 2006). Such an extensive underground space could not emerge within a few decades, but had been built gradually over several centuries.

Fig. 1 Underground spaces beneath the city Krupina, **Photo by**: Hronček

Fig. 2 Underground spaces beneath the city Krupina, **Photo by**: Hronček

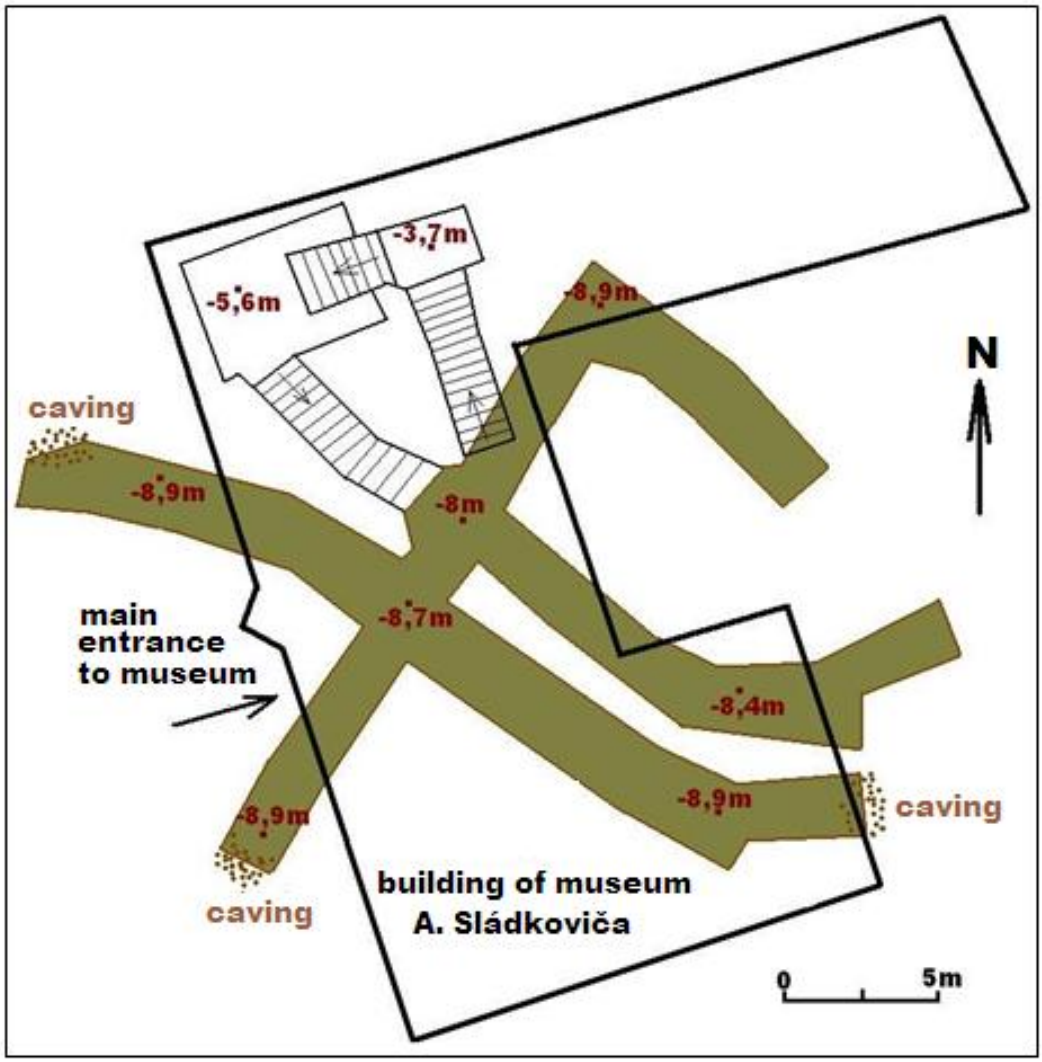

Fig. 3 Underground spaces under the house of Gogalovský, today a Museum of A. Sládkovič (from the materials Museum of A. Sládkovič compiled by P. Hronček)

Underground passages and chambers of different sizes and profiles were digged by hand from the 13th until the 19th century using unchanged tunneling techniques. Traces of hand digging (excavation) can be easily read on sidewalls and frontwalls of corridors even today. Spaces were mined using handtools for mining or modified agricultural tools - picks, hoes, chisels and hammers.

Entry into the underground space is usually located under condominiums or less frequently standalone. However, a separate location on a land parcel does not exclude that it had been originally found under a building or was reconstructed. The underground area is usually entered through an inclined corridor with wooden or stone stairs. Main corridors form underground chambers usually about 1.8 to 1.9 meters high, frequently with a width of 2.5 meters. Ceilings are mostly carved into circular or elliptical arches. Main chambers digged parallel close together have massive pillars left for static reasons. Smaller corridors deviating from the main ones served most probably as storage areas. Their lengths ranges from few meters to several tens of metres. System also constists of narrower corridors, but the vast majority of them is collapsed nowadays. Blind windows are struck in the walls of chambers and corridors and ledges that served as storage spaces or as benches are also left. Narrow chimneys, which ended hidden in the walls of buildings or in the surrounding land parcels, had been made to ensure ventilation. In the lowest part of the corridor system a square tank was constructed in the floor to serve as a drainage area. The square tank has a footprint of 3 x 3 metres, 4 metres in depth and is an endpoint for small gravity converged channels along the walls of the corridors. The collected water was brought up from here to the surface. The depth of underground spaces is variable and ranges from 2 - 3 metres up to 9 metres below the surface.

Fig. 4 An Advertising leaflet invitation to "... after the secrets of underground tunnels" in Krupina (Archives of the Museum of A. Sládkovič)

CONCLUSION

Urban underground of Krupina is still closed to the public and the majority of Slovakia's population is completely unaware of these historical treasures. Entrance into the underground is currently quite complicated. It is possible only by agreement with the staff of A. Sládkovič Museum and only for professionals, schools and student excursions. Underground is made available to the public sporadically during the action entitled "... after the secrets of underground tunnels." This year the event was held twice on the 28th April and the 25th August. Organizers of this event are the Town Cultural Center and the Museum of A. Sládkovič in Krupina.

Persistent access of at least a portion of underground space in Krupina would undoubtedly contribute to the increase of tourist attractivity of the city. Underground spaces could be interesting not only for experts in natural, historical and social science disciplines, but also for the general public and families with children as well.

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