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ENDOKARSTIC RELIEF WITHIN THE NATURAL RESERVE AREA OF "REPEDEA HILL FOSSIL SITE"

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Abstract

This study aims to analyze the endokarstic relief of the reserve from Repedea Hill. Although there have been made many geological and geomorphological researches on this sector of the Moldavian Plateau, the endokarstic relief remained largely unexplored until now. The main geomorphological factor in the evolution of this type of relief is the geological substrate from which the lithological component stands out as importance. In the Repedea reserve area the thickness of the lithological association is about 10m and favourable to karstification, composed of oolitic and lumashelic limestone and sandstone. The Repedea oolitic limestone appears as a succession of layers with thicknesses of 2-40 cm separated by intercalations of fine, conchiferous sands of 0.5 - 10 cm. These resistant rock packages have conducted to the forming of a structural karst plateau called the Repedea plateau. The high position of this karst plateau from the whole relief of the studied area can be considered a determining factor for the formation of a suspended authigenic karst with vadose hydrological regime. 9 caves were mapped in the Repedea reserve area and they are located on a relatively small surface of approx. 7 ha. The total length of the mapped underground galleries is of 401 m, thus determining an average density of 5.7 km/sqkm. Unlike the Carpathian caves, in Repedea Hill, the rock type and the local hydrological characteristics do not favour the emergence of massive carbonate concretions because the caves are in a continuous process of caving. In conclusion, the endokarstic relief from "Repedea Hill fossil site" reserve is well developed, strongly differentiating from other endokarstic areas of Romania.

Keywords: *oolitic limestone, endokarstic relief, caves, Repedea Hill*

Rezumat

Relieful endocarstic din perimetrul rezervaţiei naturale "Locul fosilifer Dealul Repedea". Studiul de faţă vizează analiza reliefului endocarstic aferent rezervaţiei din dealul Repedea. Deşi asupra acestui sector din Podişul Moldovei au fost făcute numeroase cercetări de natură geologică sau geomorfologică, relieful endocarstic a rămas în bună măsură necercetat până în prezent. Factorul geomorfologic determinant în dezvoltarea acestui tip de relief este substratul geologic din care se detaşează ca importanţă componenta litologică. În perimetrul rezervaţiei Repedea grosimea asociaţiei litologice favorabile carstificării constituite din calcar oolitic, calcar lumaşelic şi gresii este de cca. 10m. Calcarul oolitic de Repedea se prezintă ca o succesiune de strate cu grosimi de 2 - 40 cm separate de intercalaţii de nisipuri fine, cochilifere de 0,5 - 10 cm. Aceste pachete de roci rezistente au favorizat formarea unui platou carstic structural numit platoul Repedea. Poziţia ridicată a acestui platou carstic faţă de ansamblul reliefului din zona studiată poate fi considerată una determinantă pentru formarea unui carst suspendat autigen cu regim hidrologic vados. În perimetrul rezervaţiei Repedea au fost cartate un număr de 9 peşteri dispuse pe o suprafaţă relativ restrânsă de cca. 7ha. Lungimea totală a galeriilor subterane cartate este de 401 m rezultând astfel o densitate medie de 5,7 km/km^2 . Spre deosebire de peşterile din Carpaţi în dealul Repedea tipul de rocă cât şi caracteristicile hidrologice locale nu favorizează apariţia concreţiunilor carbonatice masive deoarece peşterile sunt într-un continu proces de prăbuşire. În concluzie se poate afirma că relieful endocarstic din rezervaţia „Locul fosilifer Dealul Repedea" este bine dezvoltat diferenţiindu-se pregnant de alte arii endocarstice ale României.

Cuvinte-cheie: *calcar oolitic, relief endocarstic, peşteri, Dealul Repedea*

INTRODUCTION

"Repedea Hill fossil site" reserve is located at 9 km Southwards of Iaşi in Repedea Hill belonging to Iaşi Coast, at the contact between the Central Moldavian Plateau and the hilly plain of Jijia. The mathematical location of the reserve is at the intersection of the parallel of 47°05'12" North latitude with the meridian of 27°38'20" East longitude (Fig. 1).

The study area

The perimeter of Repedea Hill was declared a reserve since 1953, being the first geological reserve of Romania. The initial scientific reserve area was 1.9 hectares, but, in 1973, it was increased to 5.8 hectares, with a buffer zone of 38.5 hectares, with a total of 44.30 hectares. The reserve scientific area of 5.8 hectares is represented by the western and north-western slope of Repedea Hill, including the limestone walls, the former quarries (oolitic

limestone), the caves and an area of the structural plateau. The buffer zone of the reserve is largely located on the Repedea structural plateau, which represents a reversed cuesta. Many Basarabian lithological outcrops which lay along the Western and North-Western steep of the hill are protected within the scientific reserve and contain a rich and representative Sarmatian fossil deposit, representative for the Moldavian Platform. The value of this reserve is amplified by the fact that **Grigore Cobălcescu** (1862) accomplished the first geologic study of these limestones in the paper „***Calcariul de la Răpidea"***, thus writing the first page in the history of Romanian geology.

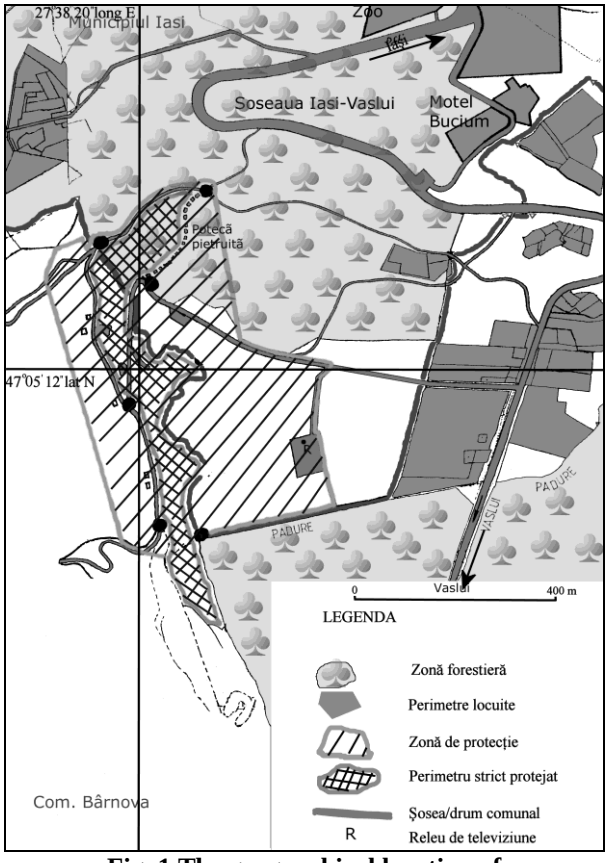

Fig. 1 The geographical location of „Repedea Hill fossil site" reserve

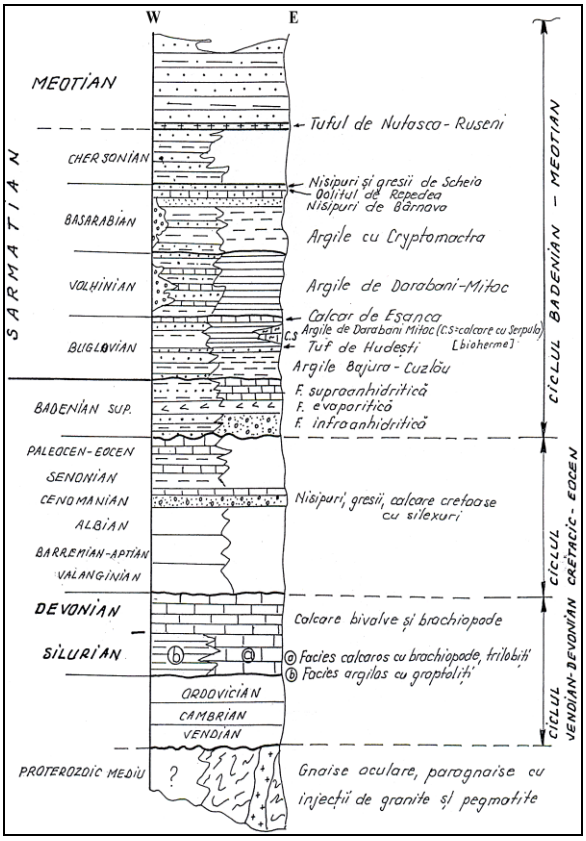

Fig. 2 The lithologic succession of the Moldavian Platform (after M. Brânzilă, 1999)

DATA AND METHODS

The methodology used in this study is based on the following steps:

- the analysis of the existing bibliographic and cartographic materials;
- geomorphologic field mapping;
- topographical mappings of the caves;
- using the "Toporobot" speological software for creating the cartographic materials of the caves.

RESULTS AND DISCUSSIONS

The main objective of this study concerns the analysis of the endokarstic relief of Repedea Hill reserve. The geological substrate, from which stands out as importance the lithological component is the determinant geomorphological factor in the development of this type of relief. The lithology of the reserve belongs to the last cycle of sedimentation within the Moldavian Platform, formed of Basarabian sediments. The entire cuesta escarpment from Repedea Hill has altitudes up to 310 m in its lower part, on a complex of clays and marl rocks with intercalations of fine sands known as "the layers with Cryptomactra pesanseris" (Fig. 2). A complex of sands overlaps above these, at altitudes ranging between 310 and 377m, on which there are oolitic limestones and sandstones with Mactra Podolica. In the reserve area, the thickness of the lithological association consisting of oolitic limestone, lumashelic limestone and sandstone is about 10m (Fig. 3).

The Repedea oolitic limestone appears as a succession of layers with thicknesses of 2-40 cm separated by intercalations of fine, conchiferous sands of 0.5 - 10 cm. The layers have irregular

surfaces, noticing a gradual transition from limestone or compact oolitic sandstone to the same rocks, increasingly porous and brittle up to interstratificated sands.

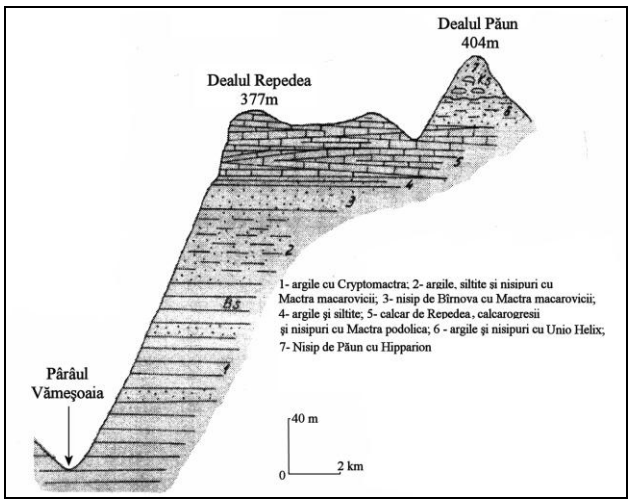

Fig. 3 Geological profile through Repedea Hill (processed after L. Ionesi, 1994)

An alternation of levels is noticed in the upper part of the succession, made up of lumashelic limestone with mactra, mixed oolitic–conchiferous limestones and oolitic limestones, grouped cyclically. The rocks layers are crossed by a system of differential compaction cracks with rough surfaces, filled with fine sand (I. Kalmar, 1991).

The bioclasts are particularly important for this protected area, which are represented, according to their frequency, by fragments of bivalves, benthic foraminifers sometimes complete with lodges filled with calcite. Small gastropods and tubes of worms are seldom seen. The bioclasts have different sizes, ranging from a few centimetres (mactrea, cents, Solen) to 0.05- 1.00 mm.

In the lithologic substrate of the Repedea reserve, the oolites are represented in varying proportions, from 5 to 85%, they have spherical shapes, rarely ovoid or irregular and do not exceed 0.4 mm in diameter. In most cases, the oolites are simple and centered on the sand.

Oolites also appear seldom, with two or three centers successively unified and covered by common layers increasingly closed, having spherical shape. Inside the oolites, a core can be distinguished, but also at least two to ten concentric layers of fine granular, filamentous calcite (oomicrite).

From a petrographical point of view, a generic term was issued for these rocks - the Oolite of Repedea; in fact, several varieties may be recognized when using this term.

Thus, based on chemical analysis it was found that 38% of the predominantly oolitic rocks are mostly grouped into the category of dolomitic calcareous sandstones and less into sandy limestones (Kalmar, 1991).

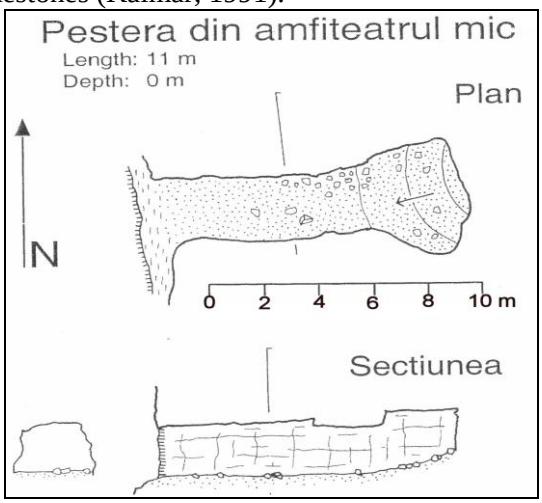

Fig. 4 The cave plan and section from the Small Amphitheatre

In what concerns the genetic process of oolites, Kalmar (1991) notes that the pure chemical precipitation of Calcium carbonates can not take place in environments with low alkaline reserve. The same author promotes the supposition that a primary pellicle of green - blue algae is installed around future cores, respectively around the granules of different compositions which assimilate, through photosynthesis, the carbon dioxide from water and the soluble bicarbonates, precipitating monogranular calcium carbonate alongside with the accretion of carbonate or non-carbonate material. In this way, a filamentous layer of sedimentation will be formed, with a thickness of 5 to l0 microns, which will stifle the algal colony installed around the core-grain. This layer will be the support of a new colony of algae, which continues the precipitation activity, the phenomenon being repeated until reaching a critical sized-form in relation to environmental tension, whereafter the multilayer corpuscles are either deposited or disaggregated. Gradually, the accumulated oolites are invaded by calcite crystals with radial disposition that will become the cement of constitution, filling the voids and forming the oolitic limestone.

In comparison with other varieties of limestone, the Repedea limestone is much more friable, having a resistance to compression from 140 to 269 kgf/cm^3 (Table 1).

In terms of geological structure, the layers of sedimentary rocks from Repedea Hill substrate have an inclination of less than 0.5 degrees, on a NNW-SSE direction.

The relief of Repedea reservation is the result of the external agents modelling the geological substrate having a monoclinal structure derived from the old Sarmatian plain of marine accumulation. Thus, subsequent to the withdrawal of the Sarmatian sea, the area was primarily subject to river erosion exerted by the new installed catchement.

Table 1 The physical-mechanical characteristics of Repedea oolitic limestone compared with some rocks within the Carpathian area (Chelărescu et al. 1956)

Petrographic types	Specific weight g/cm^3	Resistance to compression kgf/cm^3	Content in carbonate %
Tithonic Limestone	2691	963	90-99
Doamna Limestone	2700	1500	53-65
Tarcău sandstone	2770	1448	-
Repedea limestone	2690-2730	140-269	77

The fluvial geomorphological system of the area has evolved so far, noticing the formation of the subsequent valley of the Bahlui, which withdrew Southwards, forming the steep slope of Iaşi Coast, which corresponds to the cuesta escarpment. This cuesta escarpment cuts off the layer's heads of rocks from the stack of Basarabian sediments to the upper part, where the oolitic limestones and Repedea sandstones outcrop (Fig. 3).

The evolution of the catchment was carried out in parallel with large slope processes which evidenced the morphological effect of the monoclinal arrangement of the geological layers and the maintenance in relief of the sectors where the more resistant rocks outcrop (oolitic and lumashelic limestones etc.). These packages of resistant rocks favoured the formation of a karst structural plateau called Repedea plateau.

The high position of this karst plateau as compared to the entire relief of the studied area can be considered a determining factor for the formation of an authigenic suspensive karst with a vadose hydrological regime. The water coming from rainfalls enters the soil covering the karst plateau, with a vertical downward direction (within the vadose area) until it intercepts the packages of limestone from where the penetration into depth is directed by the network of litoclases (cracks) that affect the packages of lumashelic and oolitic limestones.

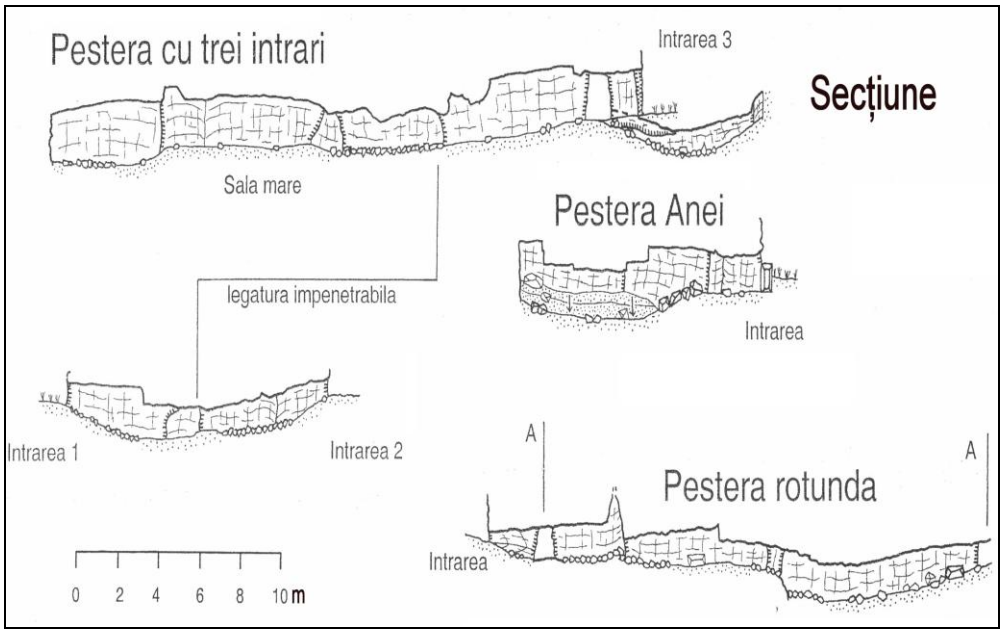

Fig. 5 The longitudinal topographical section of: the Cave with three entrances, the Round Cave and Ana's Cave

Near the slope corresponding to the escarpment of the cuesta, the limestone packages are affected by an additional network of fissures that had appeared due to the gravitational traction specific to slopes. The fissures of gravitational traction which are oriented parallel to the line of the slope are better developed and have directed the overall development of underground galleries (Fig. 7).

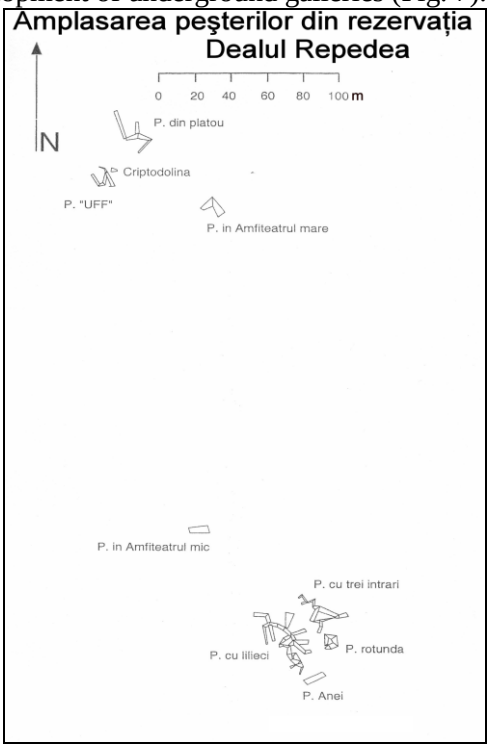

Fig. 6 The caves location from Repedea Hill reserve

Regarding the underground galleries from Repedea Hill there were and still are some discussions about the names of the grottoes or of the caves. No longer insisting on the etymology of the word *grotto*, we reproduce some views about the definition of the cave in the following.

The cave is any natural void found within the crust of the Earth (M. Bleahu, 1982).

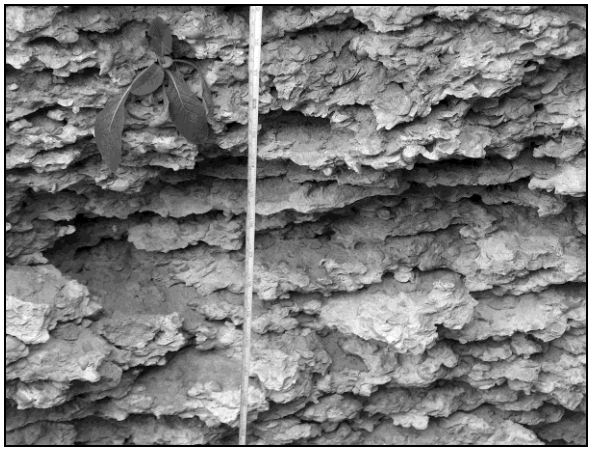

Fig. 7 Lumashelic limestone and sands (lithologic layer in which there are formed the Repedea caves)

According to the law of protected areas in 2001, the cave's definition is the following: "*The cave is a cavernament of natural geomorphological origin, whose dimensions give the interior an absolute obscurity*". A completion can be added to this definition, which singularizes the concept of *cave* with a broader sense: "*For an underground void to be considered a cave, the minimum length should be of 5 meters and the width or height should not exceed the length*." Given the opinion of most professionals in the spelaeology domain on the concept of *cave*, we believe that all the natural underground voids from Repedea reserve area fall into the generic category of caves.

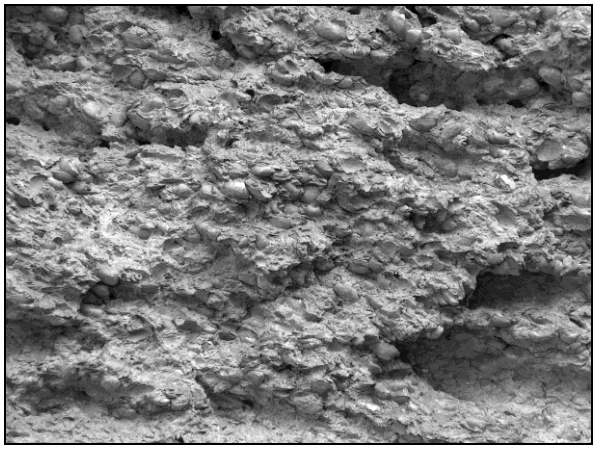

Fig. 8 The compact lumashelic limestone (the lithologic layer which limits the vertical development of the caves)

In Repedea reserve area, 9 caves were mapped, located on a relatively small surface of approx. 70 000 sqm, resulting a density of karstic holes (number of caves/ surface to be karstic) quite high compared to other karst regions of Romania in 2007: 2.32 caves/sqkm in the Occidental Carpathians; 1.92 caves/sqkm in the Meridional Carpathians, 1.22 caves/sqkm in the Oriental Carpathians and only 0.09 caves/sqkm in Dobrogea.

Fig. 9 Bats hibernating in the Cave with bats

In what concerns the density of the underground karst network (the length of the galleries / the surface to be karstic), it can be stated that on a karstic area of seven hectares the full length of the mapped underground galleries is of 401 m, resulting a density of 5.7 km/sqkm.

This density value is very high when compared with the maximum values of the Occidental Carpathians where, the density of the underground network is of 1.4 km/sqkm in the upper catchment of the Someşul Cald.

Fig. 10 Minor carbonate concretions

The peculiarity of the karstic relief's evolution within this area is given by the infiltration of the water from rainfalls in the network of cracks and fissures, which affect the packages of carbonate rocks. The water currents concentrating on certain alignments operate by removing the sand (from the rock arrangement), contained within the rock packages, thus resulting in centimetre-sized underground voids. Under the effect of gravity, the tiny packages of carbonaceous rocks within the stratification with the sands that were washed collapse, thus enlarging the underground galleries.

The vertical development of these galleries is limited by the thickness of the lithologic packages that favour the karstification. Taking into consideration the mapping carried out on all caves in Repedea karst plateau, the observation that resulted is that most galleries have heights ranging from 2 to 3 m, except for the Cave with Two Entrances from the Great Amphitheatre having heights up to 4-5 m.

This development that exceeds 4 m vertically is mainly caused by a diaclase of gravity traction, oriented towards NNW-SSE, which favoured the caving in of a large quantity of lumashelic limestone from the compact layer of approximate 2 m thickness, situated above the stratified package formed of limestone and sand, where the cave has developed (Fig. 4 and 5).

The best developed endokarstic network within Repedea Hill belongs to the Cave with Bats totalizing 160 m length and a 6 m difference of level (Fig. 8 and 9).

The name of this cave is due to the presence of nine species of bats in the galleries, all belonging to the Vespertilionidae family (Fig. 13). The network predominantly grows on NNW-SSE direction, parallel to the slope nearby and has a rectangular layout, caused by the intersection of gravity traction diaclases with the litoclases of tectonic evolution within the area.

In some cases, large rooms can be formed through processes of caving, whose area can exceed 100sqm (The Cave within the Plateau) (Fig.16).

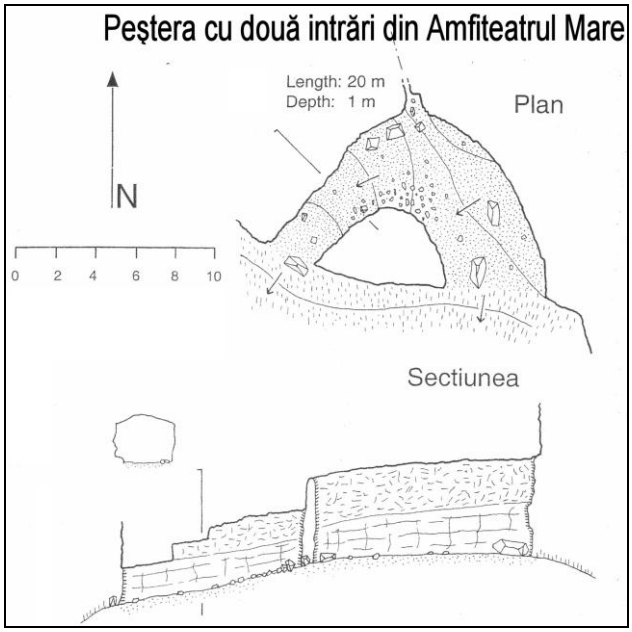

Fig. 11 The plan and the section of the cave within the Great Amphitheatre

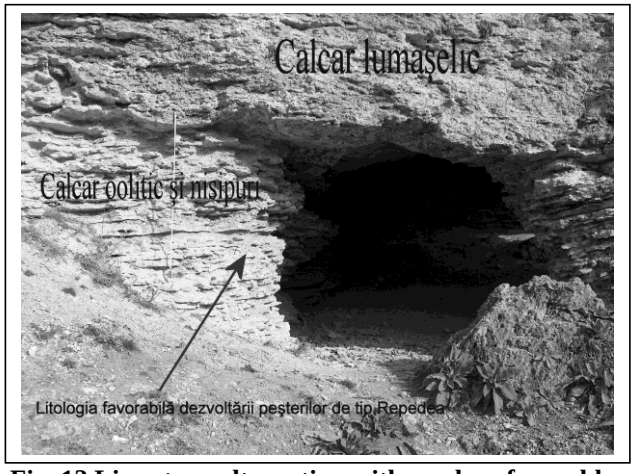

Fig. 12 Limestone alternating with sands, a favorable substrate for cave formation

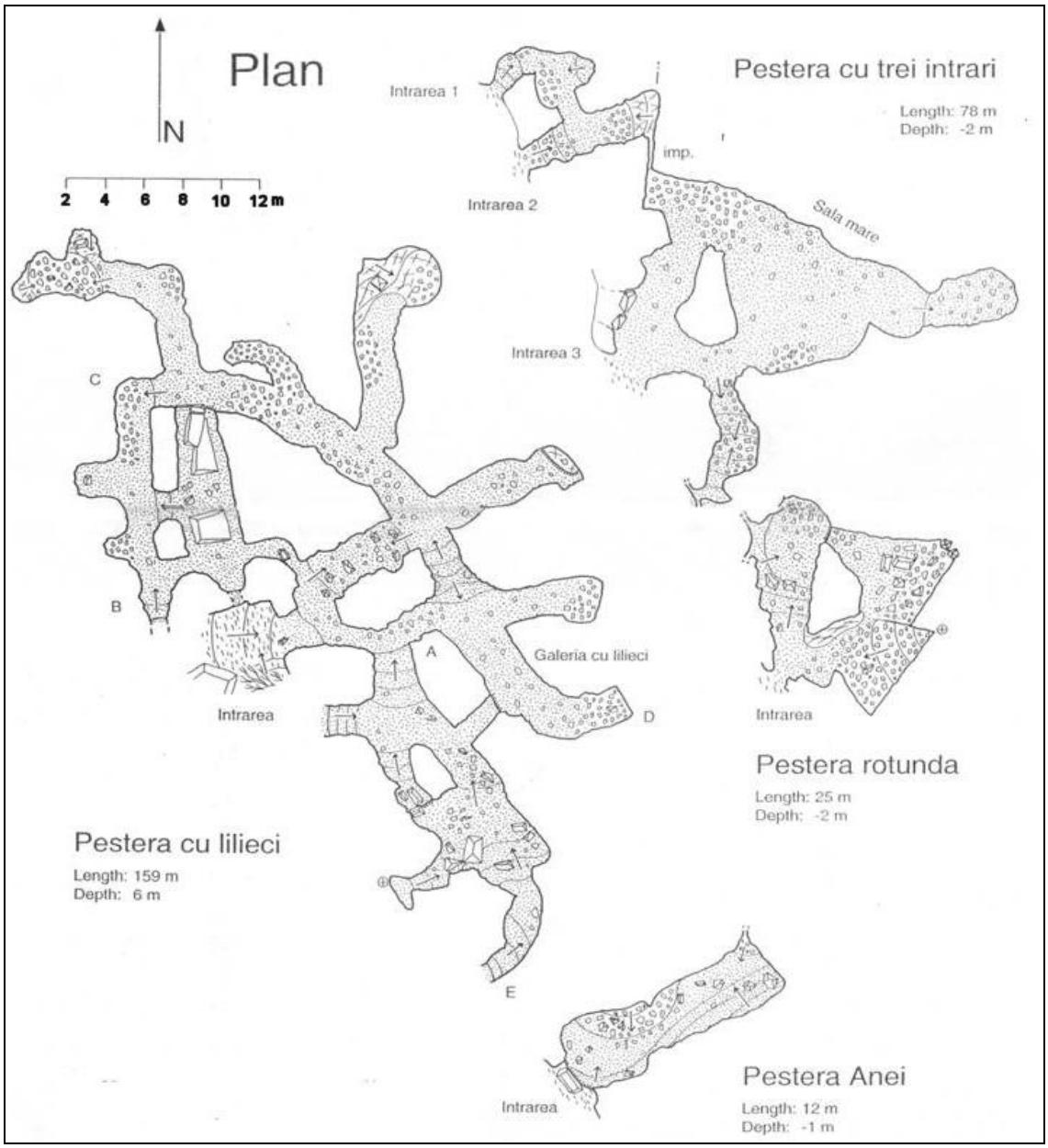

Fig. 13 Topographic plans of the caves:
The Cave with Bats, The Three Entrance-Cave, The Round Cave and Ana's Cave

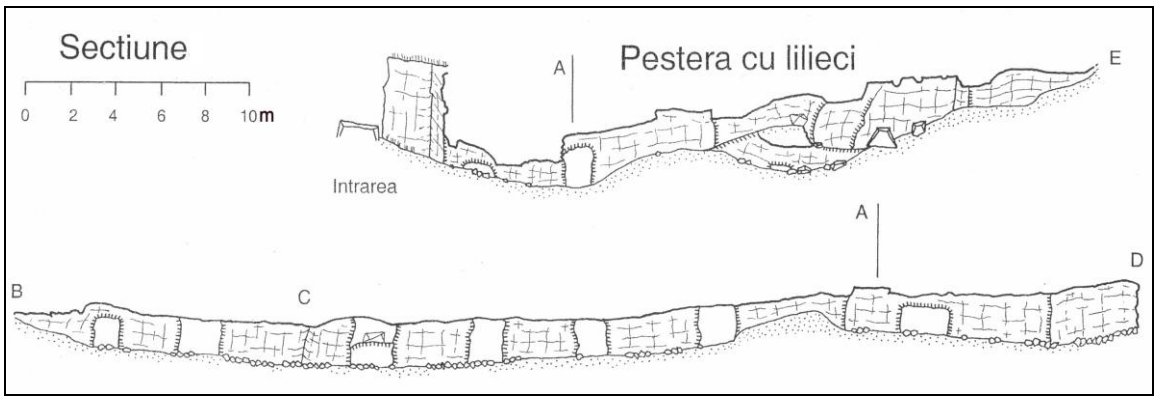

Fig. 14 The longitudinal topographical section of the Cave with Bats

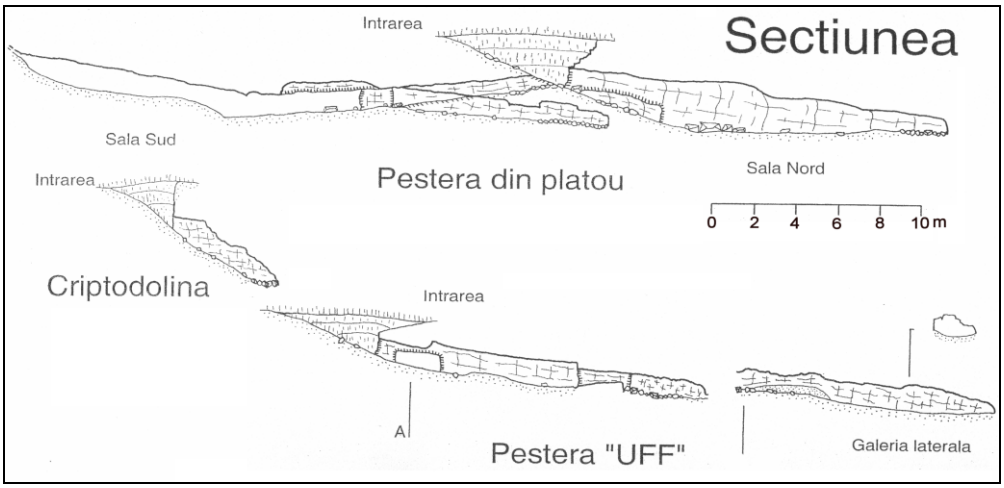

Fig. 15 The longitudinal topographical sections of:
the Cave within the Plateau, Criptodolina and the UFF Cave

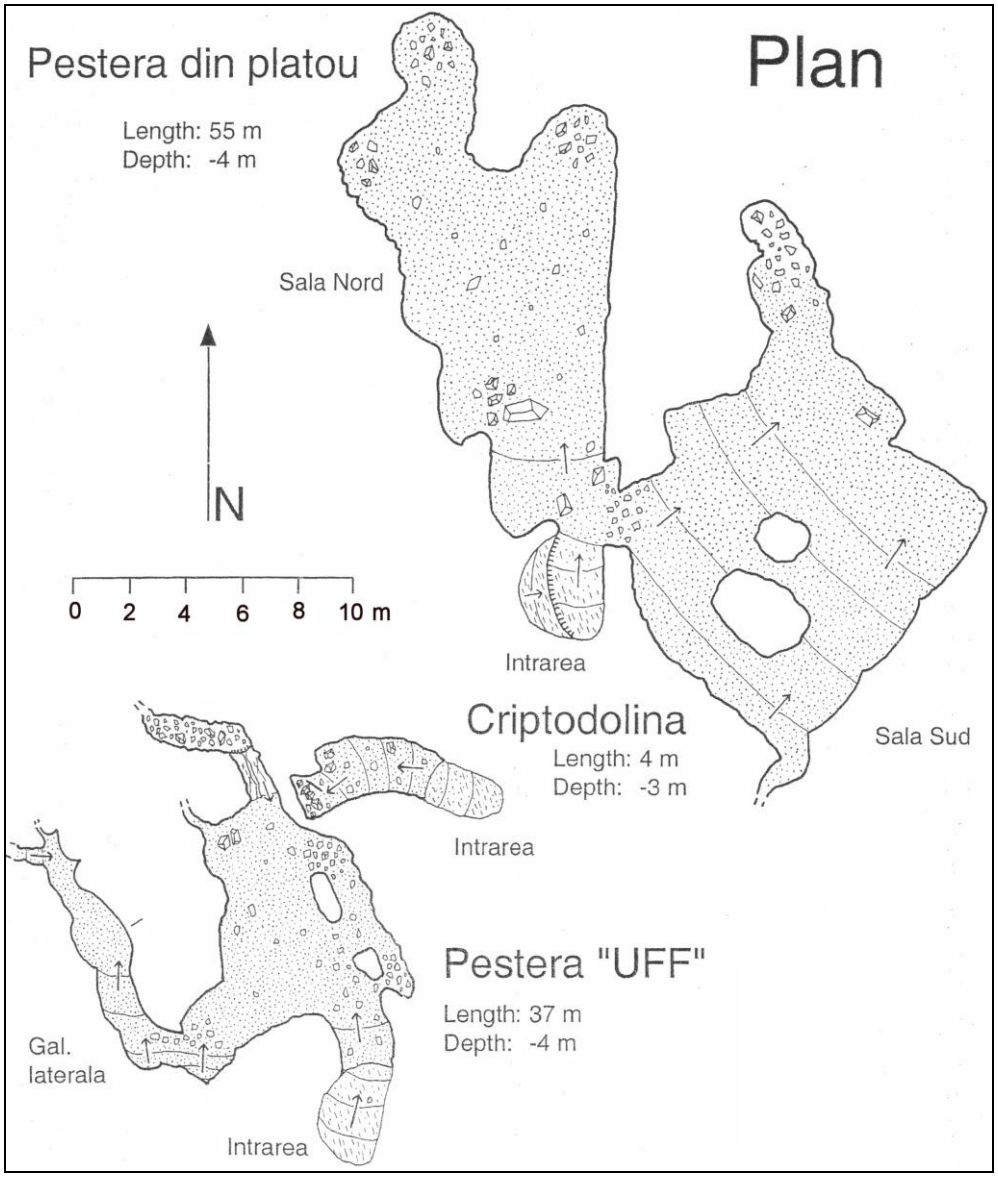

Fig. 16 The topographical plans of the caves: The Cave of the Plateau, Criptodolina and The UFF Cave

It is noteworthy that most of the cave entrances were opened by the regressive evolution of the slope which confines the Repedea karst plateau, while the rest of the entrances have been opened by a series of cavings affecting some dolines existing at the edge of the plateau (The Cave within the plateau, Criptodolina and the Uff Cave), (Fig. 16).

The morphology of the underground galleries is represented by the appearance of broken rock caused by caving.

The walls are uneven, with fragments of lumashelic limestone on the verge of being broken, in intercalations with horizons of slightly moist sand. Unlike the Carpathian caves, formed in massive limestone that allow the formation of speleothemes, at Repedea, the rock type and the local hydrological characteristics do not represent a premise for the emergence of massive carbonaceous concretions; in some places, there are some calcite concretions formed on some ceilings, but which are not maintained for long because the caves are in a continuous process of caving (Fig. 14).

The cave floor is composed of incasion detritus, consisting of sands and clays with a thickness of up to 0.5 m, in which angular fragments of limestone are embedded.

The Caves of Repedea are endokarstic formations which did not receive the erosive action of water, always remaining fossil galleries. The formation of the caving debris is primarily physical, a series of chemical processes contributing to these.

CONCLUSION

In conclusion, the genesis of the karstic relief within Repedea plateau area is highly dependent on three local physical-geographical factors:

- lithological (the presence of limestone packages in tight alternation with layers of fine sand);
- tectonic-structural (the existence of a network of cracks related to the tectonic evolution of the region and gravity traction diaclases);
- hydrological - geomorphological (processes of erosion and dissolution exerted as an effect of vadose water infiltrating in the rock mass).

Given both the particularities of the karstification conditions and the morphology of the karst specific to this protected area, there can be observed that the resulted endokarstic relief differs significantly from other karst areas in Romania.

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