Karst processes in concrete structures Case study: bunkers and casemates of Second World War (Bistrița-Năsăud County, Romania)

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GEOREVIEW

ABSTRACT: Concrete structures may be affected by processes of dissolution of the cement from which they are constructed under the action of water infiltration (ground water, rain, snow), resulting in dripping speleothems (stalactites, stalagmites) and composite dripstone-flowstone genesis (veils, curtains). This study examines three concrete structures, built during the Second World War (bunkers, casemates) in the county of Bistrița-Năsăud, to highlight the mechanisms that govern these processes and their relevance in the scientific and tourism plan.

KEY WORDS: karst, parakarst, pseudokarst, dissolution, speleothems, casemates, bunkers, sapper

1. Introduction

Anthropogenic structures built of concrete may favour the development of dissolution processes of cement and the occurrence of drip water spleleothems, such as stalactites, stalagmites and calcite draperies. The dissolution of cement requires the presence of water, which can come from infiltrating groundwater (buried structures case) and those resulting from rainfall and melting snow (buried and covered by soil or discovered structures case). Also, another important factor is the mass cracks in concrete structures that allow faster infiltration of water loaded with calcite. The diversity of speleothems formed in this way is reduced and their sizes depend on the flow and speed of groundwater infiltration, affecting the rate of dripping water charged with calcite.

Concerning the classification of these processes of dissolution seen in anthropogenic concrete structures in the karst morphology domain requires some clarification of terminology. Thus, by Anelli (1963), karst is a terrain developed by dissolution of limestone; parakarst is a terrain formed by dissolution in other rocks; pseudokarst is a terrain developed by others processes, such as lava flows, glacial erosion, thawing and piping, talus accumulation etc. (Halliday, 2007) ; after Monroe (1970), karst is a terrain, generally underlain by limestone, whose the topography is chiefly formed by the dissolution; after Grimes (1975), pseudokarst is a morphology resulted by non-solutional processes, and this does not involve the presence of limestone; after Grimes (1997, 2011), karst is landforms that occur in limestones by solutional processes and other processes (hydraulic erosion); parakarst is landforms formed by solution in non-carbonate rocks; pseudokarst is landforms developed by other processes than solution; after Halliday (2007), karst is a type of terrain or landscape characterized by dissolution processes at the surface or in depth, and analog types of karst, developed through non-solutional processes would represent pseudokarst; after Dictionary of Geography after Spectrum Academic Publishing, Heidelberg (2001), parakarst means karst in poorly soluble rocks or pseudokarst.

In the context of this paper, even if it seems a little forced, the dissolution processes of cement (produced by processing limestone) of anthropogenic structures researched can be called karst processes and the landforms resulted belong to karst morphology. The speleothems produced through concrete degradation of anthropogenic structures are similar in shape with the true speleothems, developed in limestone caves, but the processes leading to their formation are rarely the same. This ”speleothem”, truly resulted from leaching, form as a result of calcium hydroxide being leached from concrete and deposited as calcium carbonate.

2. Methods

To achieve this study were methodological several stages as follows:

1)consulting the literature in the field of terminology related to karst morphology (Anelli, 1963 Grimes, 1975, 1997, 2011; Halliday, 2007; Monroe, 1970);

2)conducting field research for the observation, measurements, and analysis of karst processes in concrete structures;

3)consulting of geologic and topographic maps related to study area (Bleahu, Bombiță, Krautner, 1967; Topographic Maps, 1984, 1985);

4)consultation of works and sites related to military fortifications during the World War II: -Brașcanu, 2013a; Brașcanu, 2013b; Brașcanu, 2014;

-G-53. Instrucțiuni asupra lucrărilor genistice de campanie pentru trupele de toate armele ale Forțelor Armate ale R.P.R., 1959 (G-53. Instructions on campaign engineering works for the all weapons troops of the Armed Forces of R.P.R 1959);

-http://www.zmne.hu/tanszekek/Hadtortenelem/konyv/arpadvonaleng.htm;

-https://ro.wikipedia.org/wiki/Romania_in_al_Doilea_Razboi_Mondial;

-http://en.wikipedia.org/wiki/Military_engineering; http://en.wikipedia.org/wiki/Fortification);

5) Data processing and drawing conclusions.

3. Results

3.1. The Bunker from Valea Teiului (Șanț commune, Bistrița-Năsăud County)

The Valea Teiului bunker is located at the entrance of the village Șanț (fig.1), at the base of a rocky wall developed on Eocene limestones (Bleahu, Bombiță, Krautner, 1967), on the front of a erosional level (600-650 m) in contact with Someșul Mare meadow (Topographic Map, 1985) (fig.2). The bunker is on private property and was accidentally discovered in 2008, its mouth being covered by colluvial material deposited at the base of the rocky wall, and the niche at the cave entrance was widened later.

This bunker, with a casemate situated in front of it, at the meadow level, is part of the fortification system called Arpad Line, which was arranged by horthyst armies between 1942- 1944 to defend the borders of Hungary after the Vienna Diktat in 1940 (fig.2).

The bunker is constructed of ferro-concrete, occupies a pre-existing cavern formed in Eocene limestones and has three elements:

-a semicircular entrance, represented by the original cave mouth, located in a small niche formed at the contact of the rocky wall with deluvio-colluvial deposits (fig.3);

-a sloping couloir, 4,5 m long, reinforced with concrete and iron;

-the bunker itself, with tubular shape and a vaulted ceiling (fig.4).

The bunker height is 2.5 m, length 4.5 m and width 2.5 m. The walls and ceiling are strongly fractured, favouring water infiltration. On the floor of the bunker there is a small pond and pieces of detritus. The access couloir is covered with detritus resulting from the collapse of the ceiling.

Figure 1 Geographic location of bunker from Valea Teiului
(Source: http://pescarul.powweb.com/judete/harta_judetului_bistrita.htm-with changes)

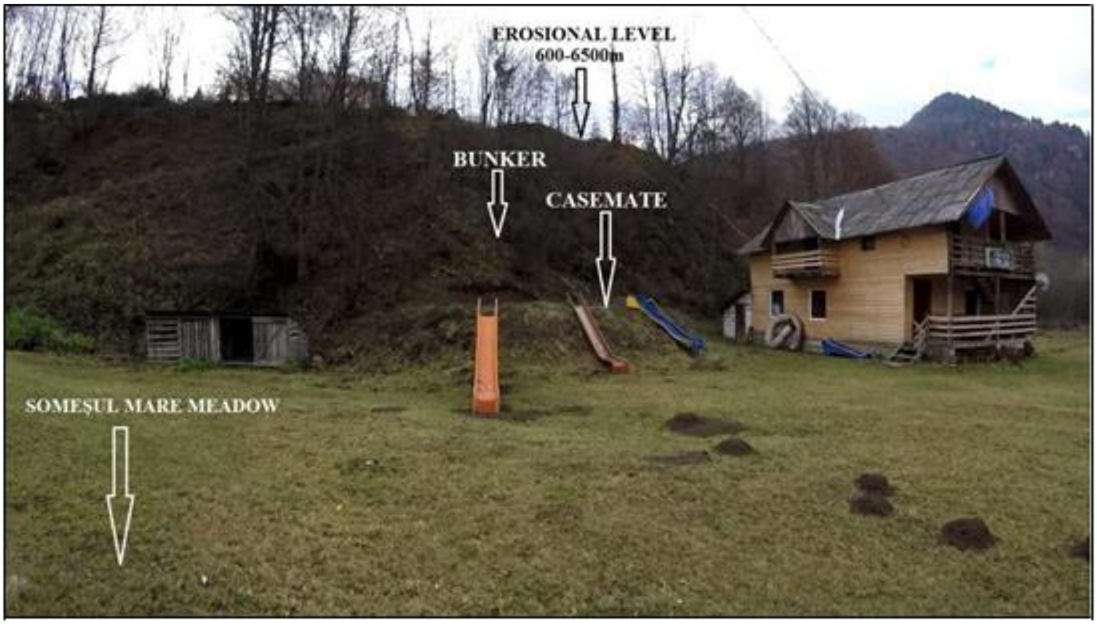

Figure 2 The position of the bunker from Valea Teiului in the local geomorphologic system.

Figure 3 The entrance of the bunker from Valea Teiului.

Figure 4 The interior of the bunker from Valea Teiului.

The bunker communicates through a tunnel with a casemate, situated in close proximity, to the deluvio-colluvial slopes, in the Someșul Mare meadow. This casemate is covered by soil and vegetation, has a circular shape, with a stone wall inside and a parapet of soil (fig. 2). The tunnel entrance is located outside the entrance to the bunker, but was destroyed and at present is covered with detritus.

It is possible that the initial cave entrance has been covered, and communication between the bunker and casemate to be done through the tunnel collapsed.

The particular feature of this bunker is given by the presence of dripwater speleothems of dropping generated by the dissolution of the Eocene limestone and of the cement. The dissolution processes are favored by the rich groundwater flow and by the presence of cracks in the ceiling of the bunker.

Dripping speleothems are represented by thin stalactites, whitish or dull brownish in colour, dense, with lengths up to 20 cm, formed on the vault of the bunker, and a group of 4 stalagmites, developed on the floor bunker three of them shorter (4-6 cm), while the largest has a length of 22 cm (fig. 5, 6). This difference of stalagmites dimensions may be due to water different drip rates.

At the present, the dripping is particularly active, which will help the developing of existing speleothems. Thermal variations and concrete dissolution under the action of infiltration water accelerate the breakdown, which is manifested by the collapse of the ceiling in both, the access corridor and enclosure bunker.

Figure 5-A group of stalactites on the ceiling of the bunker from Valea Teiului.

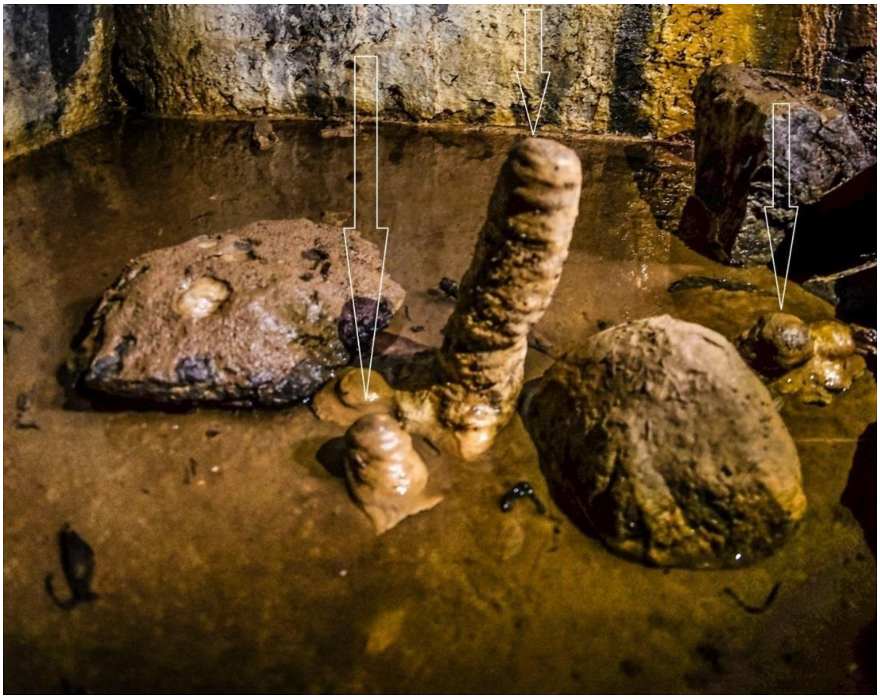

Figure 6-The group of stalagmites on the floor of bunker from Valea Teiului

3.2. The casemate from Bârgău Gorge (Tihuța Canton, Bistrița-Năsăud County)

This structure is located in the Bârgău Gorge, Tihuţa Canton sector, at the confluence of Corca and Poștei streams forming the Bârgău river (fig. 7). The casemate was buil on the erosional level located at 950-1000 m, under Precub Hill (1054 m) near the National Road 17 (Dej-Vatra Dornei (Topographic Map, 1984) (fig.8);

The casemate located at the northern end of a trench, is formed by two side walls inclined inwards, with a thickness of 50 cm, and a 100 cm thik flat roof of reinforced concrete supported by iron beams, for the most part covered with soil and grass vegetation (fig.9).

The casemate enclosure has a height of 2 m, width 1,5-2 m and a length of 4 m. The entire structure is dislocated, because it was dynamited during the withdrawal of the horthyst troops in the fall of 1944.

Similar to the bunker of Valea Teiului, the pillbox from Bârgău Gorge is part of the Arpad Line, along with other fortifications represented by trenches, gun positions, and obstacles made of reinforced concrete (pyramids or dragon teeth), their role being to oversee the road from Bârgău Valley leading to Dorna Depression.

Figure 7 Geographic location of the casemate from Bârgău Gorge
(Source: http://pescarul.powweb.com/judete/harta_judetului_bistrita.htm-with changes)

Figure 8 The position of casemate from Bârgău Gorge in the local geomorphologic context

Figure 9 View of casemate from Bârgău Gorge

These fortifications were built on chattian-burdigalian (Oligo-Miocene) sedimentary rocks, represented by sandstones and clays (Bleahu, Bombiță, Krautner, 1967).

A few rows of witish stalactites, up to 4 cm long, have formed inside the casemate, on the iron beams. They resulted from the dissolution of cement under the action of rainwater the one resulted from snow melting (fig. 10).

Figure 10 Stalactites in the casemate from Bârgău Gorge.

4. Discussions

The presence of dripwater speleothems in the bunker from Valea Teiului is due to dissolution processes active on the Eocene limestones, and concrete.

The stalactites from the casemate from the Bârgău Gorge was dry at the moment of observations, and are attributable to the dissolution of concrete during rainy periods or after snow melting. This process and the shorter transit of less satured water, although the pillbox has a subaerial position, is reflected in their small size, and lack of stalagmites. The lack of stalagmites may be due to the fact that this pillbox hasn`t got a concrete floor and, therefore, water dripping from the ceiling seeps into the ground.

But not all structures of this type sustain the dissolution processes, resulting the formation of speleothems. For example, in the bunkers on the Ponce Hill (Ilva Mica commune, Bistrița- Năsăud County) are missing (fig.11, 12). These bunkers (chambers and couloirs), built by concrete, are buried under a thick layer of oligo-miocene sandstones and clays (1-2 m). Their walls has a 50-80 cm thick, and has many cracks and dislocations. Although is observed the water infiltration process, there are not stalactites or stalagmites. The lack of speleothemes may be due to the undersaturated water with respect to calcium carbonate (not enough dissolved material), therefore resulting in no carbonate deposition. Initially, we assumed that speleothems from bunker of Valea Teiului is due to the presence of Eocene limestones, but discovering the stalactites in pillbox of Bârgău Gorge we concluded that the main factor is not the rock, but the cement structure is built.

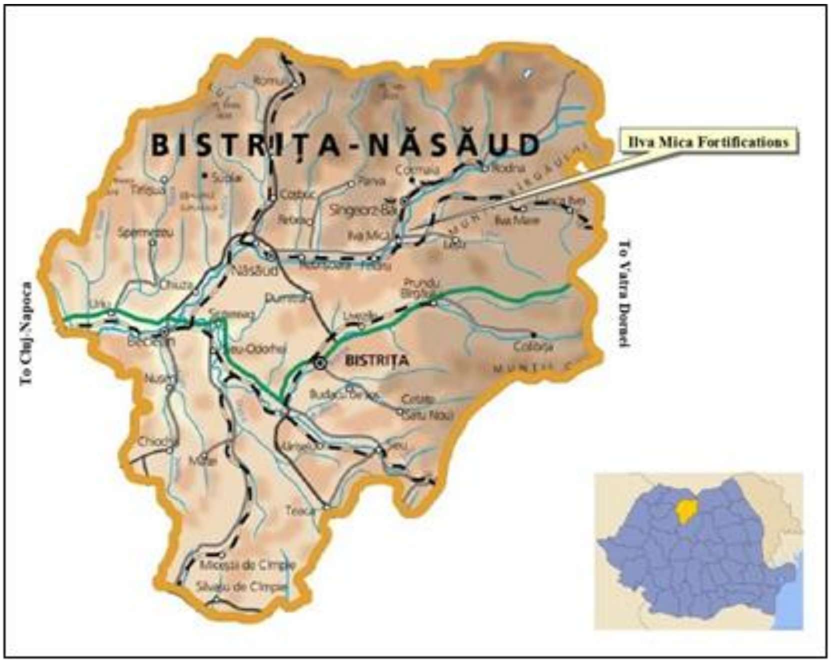

Figure 11-Geographic location of bunker from Ilva Mică
(Source: http://pescarul.powweb.com/judete/harta_judetului_bistrita.htm-with changes)

Figure 12-Inside bunkers of Ilva Mică

4. Conclusions

Concrete structures, like bunkers and casemates from Second World War, may be affected by dissolution processes of concrete under the action of water infiltration (it either groundwater, rainfall or melted snow), resulting in the formation of speleothems (stalactites, stalagmites, draperies). The relevance of these processes and forms can be found in the scientific results (illustrating the karst processes developed in concrete structures) and for tourism (attractive targets).

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