TECTONO-KARST DEPRESSIONS IN THE CENTRAL-WESTERN AREA OF THE MEHEDINŢI MOUNTAINS (SW ROMANIA)

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Abstract. The horst structure of the Mehedinți Mountains, bounded to the east by the Mehedinți Plateau, and to the west by the Cerna Graben, has been leveled by the Râul Șes II karst planation surface, at an altitude of 1250-1030 m. Part of the Mesozoic sedimentary cover, limestones developed in Urgonian facies widely outcrop, overlying the crystalline-granite bedrock. On a system of faults adjacent to the graben, close to the Cerna Valley slope, uvala and mega-sinkhole depressions, with various depths, have been developed. From NNE to SSW they are extended over a distance of 14 km and an area of 10.376 km^2. Their orientation follows the direction of the faults to which they are related. The entire plateau presents an endorheic character. There were three different stages of genesis and evolution of the depressions: (1) active valley; (2) Quaternary tectonic hanging of the valley; (3) endorheic evolution. Recent depressions evolved only during the last two stages. The most developed depressions are opened westward, as a consequence of the eastward retreat of the Cerna Valley tectonic slope. The rainfall infiltration water is drained towards east and west, outflowing at the base of tectonic sunken blocks as permanent springs with maximum flow rates of up to 50 l/s.

Key words: Tectono-karst depressions, mega-sinkholes, groundwater drainage paths.

1. INTRODUCTION

On the central-western area of the Mehedinți Mountains (Fig. 1), land unit of the Southern Carpathians, large tectono-karst depressions, with a particular genesis and evolution, have been developed.

Fig. 1. Location of the study area within Romania.

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The geological setting of the Mehedinți Mountains high plateau has been presented on medium-scale maps (sheet L-34-106-C, Baia de Aramă). More detailed geological/hydrogeological studies were carried out in the north (IANCU, 1976), east (PREDA et al., 1974; STĂNOIU, 1982) and west (NĂSTĂSEANU, 1982). VÂJDEA (1988) provided a general tectonic picture of the area, describing the main faults alignments.

The above-mentioned author presented the striking direction of the faults parallel to the Cerna Graben master-fault. Along the L_{31} fault, between two west-side tributaries of the Cerna River – the creeks Arşasca (to the north) and Țăsna (to the south) – there are 8 depressions, 120–380 m deep. The tectonics and the geological structure have influenced the slopes morphological evolution, the valleys hanging at hundreds of meters over the Cerna River (POVARĂ, 1999). The tectonics and the geological structure are also the main factors influencing the groundwater flow through limestones within this area (STĂNOIU & POVARĂ, 2000).

The tectono-karst depressions are bounded to the east and to the west by a row of limestone ridges, fragmented towards the Cerna River by shallow valleys (Fig. 2). A comprehensive description of these landforms was provided by SENCU [1975, 1981 (in MADELEINE ALEXANDRU et al.)]. The same author also explained the general processes which led to their genesis. The morphogenetic classification of the depressions was carried out by POVARĂ (2012). The rainfall water, infiltrated on the endorheic plateau from the upper area of the Mehedinți Mountains, is drained to the east and to the west, supplying either karst springs or outlet caves. The karst springs flow rate varies between 2-150 l/s.

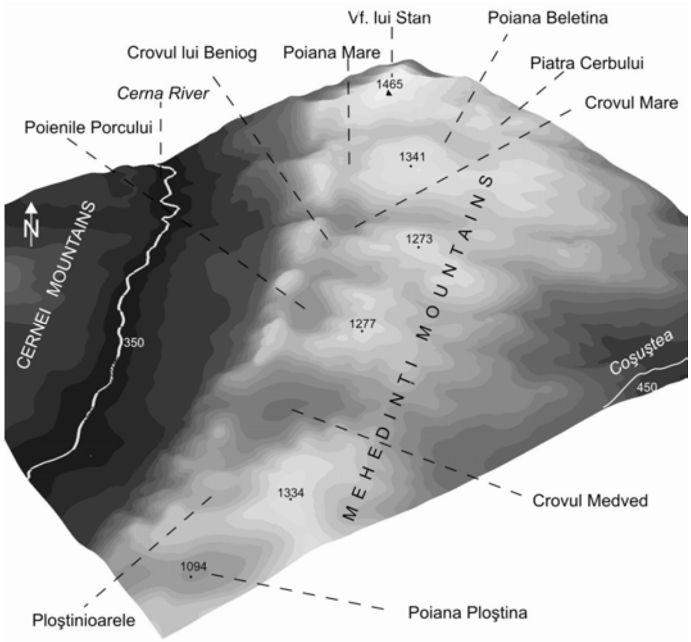

Fig. 2. Aerial view of the tectono-karst depressions from the Mehedinți Mountains plateau.

e. On the depressions circumference there is a fragmented level of shoulders, located at 20-30 m, which can be linked to a slope break noticed on the longitudinal section of the valleys.

f. On Beletina, Crovul Mare and Crovul Medved depressions, run-off sporadically follows snow melting, and the water is drained towards swallow holes located close to the Cerna slope.

g. The slopes morphology is typical for the bare limestones, on which karren and chimneys steeper than 45^g have been developed. On Beletina, Crovul Mare, Crovul Medved and Poiana Balta Cerbului depressions, the slopes have been affected by gravitational processes or by shallow, dry karst valleys.

3.2. MORPHOMETRIC FEATURES

The karst depressions characteristics vary in a very wide range (Table 1). The depth was established between the bottom and the saddle-shaped area which separates two adjacent depressions (h_1), but also between the bottom and the altitude of 1250 m a.s.l., below which the karst processes have played an essential role (h_2).

Table 1

Morphometric features of the karst depressions (parameters calculated according to Troester et al., 1984)

Depression	L (m)	l (m)	H (m)	Depth (m)		$\frac{L}{l}$	P_s*	R_d** $\frac{(L+l)}{2}$	R (m)	S (km²)
				h_1	h_2					
Poiana Beletina	2 125	1 875	1 194	56	56	1.13	6.33	11.200	270	2.163
Poiana Piatra Cerbului	1 400	400	1 215	35	35	3.5	–	3.150	264	1.013
Poiana Mare	800	300	1 188	50	62	2.66	6.40	2.750	253	0.319
Crovul Mare	800	500	1 020	85	230	2.0	2.64	5.525	326	2.108
Poienile Porcului	1 600	450	1 090	45	160	3.56	2.57	4.610	170	1.510
Crovul lui Beniog	370	250	1 110	30	140	1.48	3.4	930	200	0.037
Crovul Medved	1 150	975	965	170	285	1.18	3.64	18.060	360	2.137
Ploştinioara de Jos	370	250	1 050	85	200	1.48	2.33	2.635	275	0.081
Ploştinioara de Sus	375	190	1 118	20	132	1.97	2.30	565	207	0.071
Poiana Ploştina	700	520	1 094	115	156	1.35	3.40	7.015	240	0.937
										Total 10.376 km²

The landform energy was determined between the bottom and the maximum altitude recorded on the circumference.

The dimensions in horizontal projection were measured for the first plane which completely crossed the depression (Fig. 4).

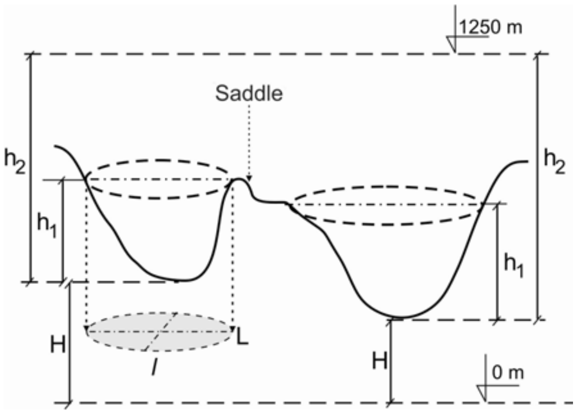

Fig. 4. Morphometric parameters of the tectono-karst depressions: L – large axis; l – small axis; H – absolute altitude of the bottom; h_1 – altitude difference between the depression close contour and its bottom; h_2 – altitude difference between 1250 m a.s.l. and the depression bottom.

Analyzing the data presented in Table 1, it can be remarked that most depressions are karst megaforms, developed on 0.3-2.16 km^2. Taking Poiana Beletina as an example, if we will also add its subunit – Poiana Piatra Cerbului – its total area will be 3.176 km^2. The altitude measured on the depressions bottom oscillates between 965-1215 m a.s.l., while their depth varies between 35-285 m, with respect to a hypothetical, initial surface, located at 1250 m a.s.l. (Fig. 5). Thus, their deepening rate was very different.

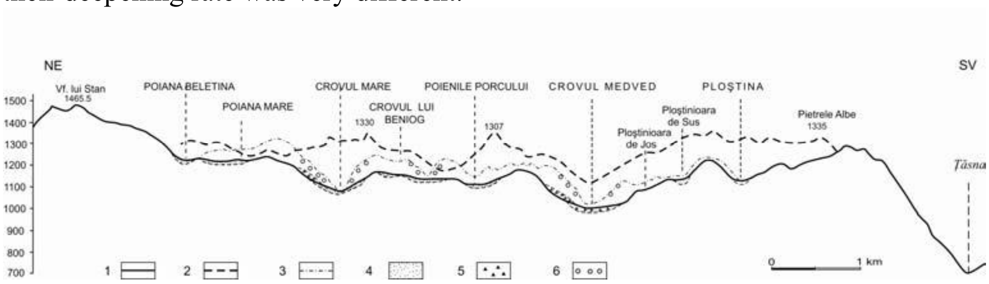

Fig. 5. Longitudinal section across the tectono-karst depressions from the Mehedinţi Mountains, between Vârful lui Stan and the Ţăsna Valley: 1. Section line across the depressions; 2. Section line across the eastern ridges; 3. Section line across the western ridges; 4. Decalcification clay; 5. Quaternary detrital deposits; 6. Flysch patches on the depressions walls. It can be noticed that the line of the eastern ridges is 100–200 meters higher than that of the ridges neighbouring the depressions towards the Cerna Valley.

The symmetry index (I_s) calculated for Crovul Medved, without considering its two lateral subunits, is 1.5, while taking them into account it increases up to 1.92. Both values are typical for the landforms developed along a preferential direction. The I_v index = 1.13 calculated for Poiana Beletina leads to a false picture of the depression, denoting a nearly circular form. The image has been corrected by the product of symmetry (P_s = 6.33), indicating an irregular form, with an eccentric intersection point of the axes. The case of Poiana Mare (P_s = 6.40) is similar.

3.3. DEPRESSIONS MORPHOGENESIS

The depressions genesis was explained by SENCU as related to the widening of a gravitational traction fracture, parallel to the Cerna slope, by the limestone dissolution and gelifraction processes (SENCU, in MADELEINE ALEXANDRU et al., 1981). We cannot agree with this hypothesis, since the gravitational traction did not caused the distension of a rock fracture. It should be considered a force which has only amplified the distension of the L_{31} fault main plane, along which the depressions have been developed. Moreover, at the scale chosen by the author, which implies a length of 6 km and a depth of hundreds of meters, the gelifraction influence should be excluded, since the upper part of the fault plane has been covered by a detrital deposit that protects it from the effects of the negative temperatures. Instead, the gelifraction can be regarded as a process which caused the mechanical widening of open fissures, influencing the evolution of the karst and mechanical slope processes.

The depressions underwent three distinct evolutive stages.

I. Active valley stage, when the valley shoulders noticed on the longitudinal section were formed, and the lateral evolution of the slopes was initiated. This stage begins with the isostatic uplift of the bedrock along with the sedimentary cover.

II. Tectonic hanging of the valley. It is very probable that this process comprised two subphases, marked on the longitudinal section of the valleys by slope breaks at ±1100 m and ±900 m. The landforms have been modelled mainly by the karst processes, but also by the slope and fluvial processes. The vertical evolution of the karst processes has been favoured by a higher hydraulic conductivity, due to the “positive flower structure”-type faults (Fig. 6 and Fig. 7), related to the L_{31} fault, which allowed the formation of several depressions (Ploştinioarele, Poienile Porcului and Crovul lui Beniog) independently of the presence of pre-existent valleys. The run-off and the gravitational processes have reworked the flysch deposits, transporting the rock fragments towards the newly formed depressions. The run-off water amount, influenced both by the climate and by the lithology (the water being supplied from either karst springs or flysch outcropping areas), led to a more active vertical evolution within Crovul Mare and Crovul Medved. The other depressions have evolved slower, only by karst denudation and slope processes. The climate change at the end of the Pliocene caused a decrease in the rainfall amount and, as such, of the run-off and karst denudation intensity.

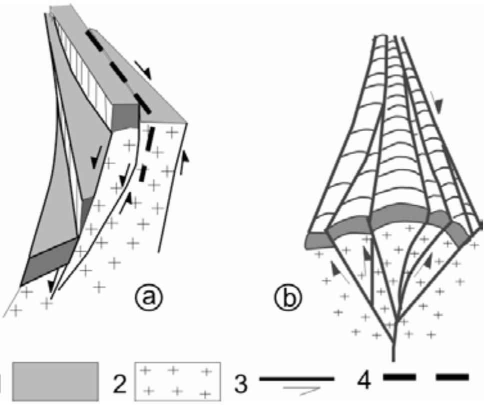

Fig. 6. Distribution of secondary folds and faults, in an ideal right-lateral strike-slip fault system, in the context of transpressional tectonics (according to Fossen, 2010). a. Negative flower structure; b. Positive flower structure. 1. Urgonian (Lower Cretaceous) limestones; 2. Granite bedrock; 3. Strike-slip fault; 4. Brittle deformation of limestones.

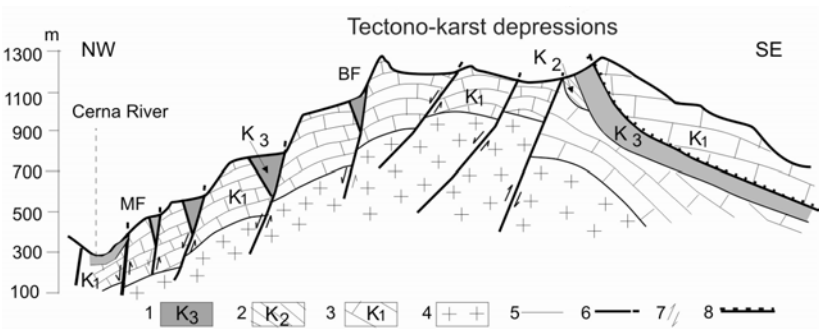

Fig. 7. General tectonic cross-section of the Mehedinți Mountains: 1. Upper Cretaceous (Wildflysch Formation); 2. Nadanova Formation; 3. Urgonian limestones; 4. Proterozoic granite bedrock; 5. Geological boundary; 6. Fault; 7. Strike-slip displacement on fault; 8. Overthrust; MF – Master-fault of the Cerna Graben; BF – Border-fault of the Cerna Graben.

III. Endorheic evolution stage, the actual one, implies a complete subterranean water drainage, while the depressions evolution is mostly controlled by non-karst processes. All the swallow holes noted within the depressions are only 3-4 m deeper than the old river beds, indicating that this stage was recently initiated. It should be considered that after the tectonic slope formation, this has constantly retreated towards east, continuously affecting old valley sectors and water divides. Only the upper reaches of 1.5-2 km previously longer creeks are still preserved. The rapid slope retreat, influenced by the Cerna River proximal location, at hundreds of meters below it, has strongly modified the aspect of the longitudinal section. It should be admitted that the left slope of the Cerna Valley underwent a very fast uplift, which has highly influenced the present-day valleys.

3.4. MORPHOGENETIC CLASSIFICATION OF THE DEPRESSIONS

According to SENCU (1975), the above-described depressions can be grouped in three distinct categories: poljes, uvalas and sinkholes.

The classification of the poljes is controversial. GAMS (1978) applied three previously used criteria:

a. subhorizontal bottom, developed either on bedrock or unconsolidated sediments, with or without one or two terraces. The flat aspect of the bottom may be due to Pliocene or Quaternary detrital deposits, which cover older karst landforms (MIJATOVICI, 1984)[1];

b. closed, endorheic basin, bounded at least on an edge by steep slopes;

c. karst drainage.

Even if it could evolve to such a landform, none of the previously presented depressions meets the criteria to be considered a polje or the features of the karst catchment depressions, thoroughly described from the Pădurea Craiului Mountains (RUSU, 1988). The Beletina Depression is widely opened towards the Cerna slope, but it is followed by gorges and steps. They represent relict valleys, cut downstream and remodelled by karst and slope processes, with a recent (postglacial) karst drainage. If the Cerna slope retreat will be slower than the karst denudation, Beletina will evolve to a border or structural polje[2]. Currently, it cannot be regarded as a polje.

Crovul Mare (Photo 2) and Crovul Medved are complex landforms, more evolved than a sinkhole or a mega-sinkhole, both of them being followed eastward by a short, but well developed valley. The evolution of these landforms are controlled less by the karst denudation than by the fluvial and slope processes. They are former karst depressions, remodelled by recent morphogenetic processes.

Poiana Mare and Poienile Porcului are uvalas, the first being less evolved than the second one, which is much deeper and already regressively affected by the valleys formed on the Cerna slope.

Poiana Ploştina, the best outlined depression, which, being covered by a forest, is also the least affected by slope processes, is a mega-sinkhole opened by a slope valley, while Crovul lui Beniog is a mega-sinkhole as well.

4. CONCLUSIONS

On the Urgonian limestones from the central area of the Mehedinți Mountains, bounded eastward by the Mehedinți Plateau, and westward by the Cerna Graben, on a total area of 10.376 km^2, 8 tectono-karst depressions, uvalas and mega-sinkholes,

[1] The author mentions Duvanjsko Polje, on which the boreholes have crossed 2,000 m thick, continental and lake, Neogene deposits.

[2] Gams (1978) identified five types of poljes: (1) *border poljes*; (2) *piedmont poljes*; (3) *structural poljes*; (4) *overflow poljes*; (5) *baselevel or water table poljes*. Ford & Williams (1992) joined the types 1-2 and 3-4, due to the insignificant differences between them, defining three types: (1) *border poljes;* (2) *structural poljes;* (3) *baselevel poljes*.

have been developed. The morphogenetic processes have been influenced by the major fault related to the Cerna Graben fault (which formed a positive flower structure), by the dissolution processes undergone by the Lower Cretaceous limestones, by the gravitational distension and by the gradual retreat of the Cerna slope. The genesis and the evolution of the depressions comprised three stages: (1) active valley, (2) tectonic hanging of the valley, as a consequence of the Cerna River deepening during the Quaternary, controlled by a landform energy of more than 800 m, and (3) a slow endorheic evolution, caused by the lack of run-off. There is a single depression – Poiana Beletina – which illustrates all the evolutive stages, the other mentioned landforms denoting only the stages 2 and 3.

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