MORPHOMETRIC AND MORPHOLOGICAL SUITABILITY OF THE RELIEF FROM THE CRUCII LAKE BASIN (STÂNIŞOAREI MOUNTAINS)

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ABSTRACT. Due to high rainfall in 1978, was a landslide that crossed the stream Cuejdel Stânişoarei Mountains. Slip was favored by a forest road construction. In a first phase to form a lake of about 250-300 m, 25-30 m wide and 4-5 meters maximum depth. In the summer of 1991, for the same reasons, took place a further landslide, which led to the formation of the largest natural dam lake in the country. Newly formed natural dams present a height between 25 and 30 m, with higher values to the left and towards the lower right with a total length of 80 m. The lake water has been steadily and stood at an absolute altitude of 665.5 m (until 1994-1995). As a result of strong floods and widened the opening of the lake water level dropped. Under these conditions the lake has the following characteristics: surface area of 12,2 ha, 1,0 km in length and average width of 102 m. After this period morphological and morphobatimetrics studies of the lake, and on the characteristics of the receving basin were thinning. It aims the study morphometric and morphographical on modern techniques, of the Crucii Lake reception. It is envisaged the morphometry and morphological suitability of the relief with essential role in the genesis of Crucii Lake.

Key words: natural dam lake, receving basin, morphometrics, morphological suitabillity.

1. INTRODUCTION

Natural dam lakes in Romania are rare but extremely interesting in terms of the formation and hydrological behavior. All lakes formed after the blocking of the watercourses through landslides have formed the Eastern Carpathians: Rosu, Crucii, Dracului, Iezerul Sadovei, Bolatau etc. Of all of these the most studied is the Rosu Lake (Enea et al., 2010, Nicu and Romanescu, 2010; Romanescu and Stoleriu, 2010).

Crucii Lake is known as the Cuiejdel. It represents a relatively recent lacustrine unit, which was completed over several phases of formation. This process started in 1978, when a large proportion landslide damed the Crucii valley. The completion occurred in 1991, when amid high rainfall occurred new mass movements. In 1991 the natural dam completely blocked the entire valley, causing the accumulation of large amounts of water. Thus was formed the biggest natural dam lake in Romania.

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Being one of the most interesting lakes of this type in Romania, developing a complex morphology and sheltering a rich biodiversity, this lacustrine unit presents a great scientific importance. Despite the features mentioned can say that this aquatic unit is extremely weak studied in terms of hydromorphological: Ichim, 1969, 1973, 1979, Rusu et al., 2001, 2002; Rădoane, 2002-2003; Surdeanu, 1998 etc.

The present analysis represents an update of geographic information. It is an analysis of the modern receving basin, covering in particular its morphometry, morphology and suitability of the landscape. Highlighting the physical and geographical characteristics meets a larger project of analysis of the entire river system created by the emergence of Crucii Lake.

2. LOCATION AND LIMITS

Crucii Lake is located in Stânişoarei Mountains in the upper basin of the river Cuiejdiu (98 km^2, 24 km), on the middle of the stream Crucii (8,77 km^2, 3,3 km), left tributary Cuiejdiului, about 21 km NNW of Piatra Neamt. It has a length of 1 km, an area of 12,2 ha, maximum depth of 16 m and a water volume of about 907,000 m^3.

Latitudinally is between 47º01'54" lat. N and 47º02'25" lat. N and the longitude is between 26°12'50" long. E and 26º13'14" long. E.

The delimitation of the receving basin is given on the alignment of the Tarniţelor Peak (1081 m) and Garcina Massif (873 m) north, the Muncelul top and peak (1067 m) to the east, Crucii Hill and Piciorul Rotund to the west. Has an area of 8,75 km^2, of which 48,22% is of the sub-stream Crucii, 29.25% comes from Glodu sub-stream and the remaining 22,53% is attributed to small tributaries (Fig. 1).

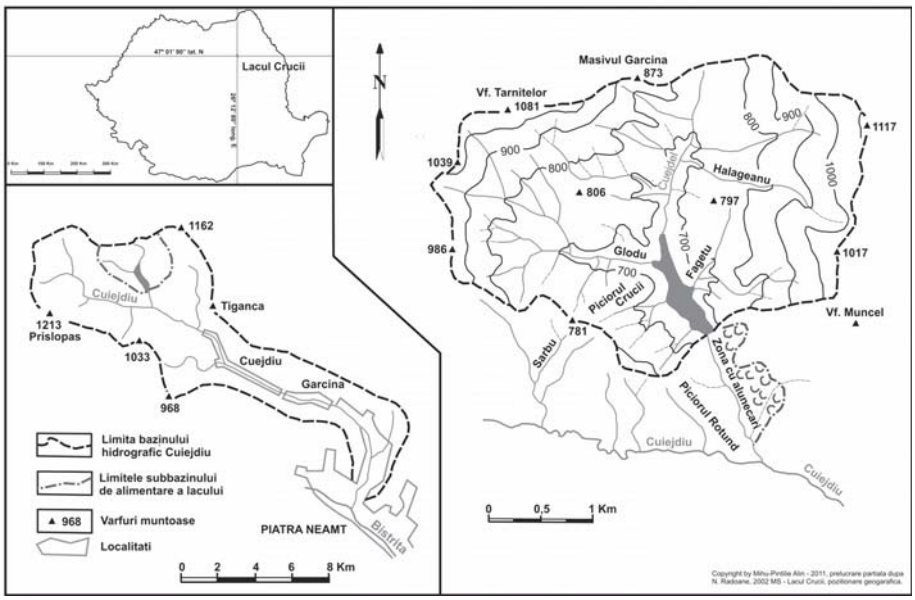

Fig.1. ***Geographical location of Crucii Lake***

Following the morphological features of the basin, Crucii lake is elongated on the main valley (NW-SE). At the junction of the main tributary (Crucii rivers and Glodu) branch off the two valleys, with more expansion on the main valley. Lake water level was steadily and stood at 665,5 m absolute altitude up to 1994-1995 when there were many floods that have enhanced the form of channel opening (Rădoane, 2002-2003).

Crucii Lake is not the only lacustrine basin in the country formed after the dam of the watercourses by landslides, and could be recalled here lacustrine units with the same genesis: the Rosu Lake on Bicaz, Iezerul Sadovei on Sadova, Bolatau Lake from the same basin of Sadova etc. Because of the size, Crucii Lake is considered the biggest natural dam lake in Romania. As a result of various geomorphological factors that induce a transient status of these types of lakes, and also as a result of the accelerating clogging the situation of this aquatic unit is getting complicated

Lacustrine unit Crucii Lake was originally called Lake Cuiejdel, named after the creek tributary of Cuejdiu that was dam. Today is often used the name Crucii Lake, becoming hydronym independently and formally established by local authorities.

3. RESEARCH METHODS AND TECHNIQUES

In researching this area was used the mapping method with the help of a series of topographic maps in scale 1:25.000, 1983 edition, from which they extracted all major morphometrics elements of the receving basin. Global Mapper software was used vs. 11 vs. TNT Mips. CorelDRAW 69 and 4. To calculate the morphometric coefficients were applied the determination formulas proposed in the specialty literature by Zavoianu, 1978 (form factor and report form), Miller (quoted by Gâştescu, 1968, 1971) (the ratio of circularity), Zavoianu, 1978 (elongation ratio) Cebotarev, 1957 (quoted by Zavoianu, 1978) (development coefficient of watershed) etc.

For the making of the favorability morphologic analysis there were consulted a number of publications from the specialty literature, research reports and a series of thematic articles, and as a support for comparison, all of these were accompanied by satellite imagery and orthophotoplanes.

4. RESULTS AND DISCUSSION

Reception basin morphometry

The morphometric data extracted from the topographic maps show that the Crucii Lake receving basin has an area of 8,77 km^2, occupying 8,94% of the catchment area of Cuejdiului. It is a relatively small area compared to the size of the lake. It is this parameter reveals that the lake is a complex construction, which was not created by the existence of a catchment but of a collateral factor.

The maximum length, on the NE-SW direction, is 3,312 km, and the average is 2,67 km. Width, due to the shape of the basin, given by the extinction of the two main tributaries, Cuiejdel and Glodu is 4,25 km. Watershed rises to altitudes above 1000 m, mainly in the west and northeast sectors. Its length is of 12,75 km (Fig. 2).

The lenght of the drainage network is 24,19 km, its main tributary streams Cuiejdel, Glodu, Fagetu, Hălăgeanu and a series of smaller tributaries, most of torrential character.

Altitudinal space that is part of the Crucii lake catchment takes place on about 539 m, the highest altitudes are found in the western sector (Magurii Hill, 1117 m, Muncelului Peak, 1076 m), but also in the north-eastern (Tarniţelor Peak, 1081 m, Massif Garcina, 873 m). Minimum share of the basin is found in the lake outlet, somewhere around 578 m.

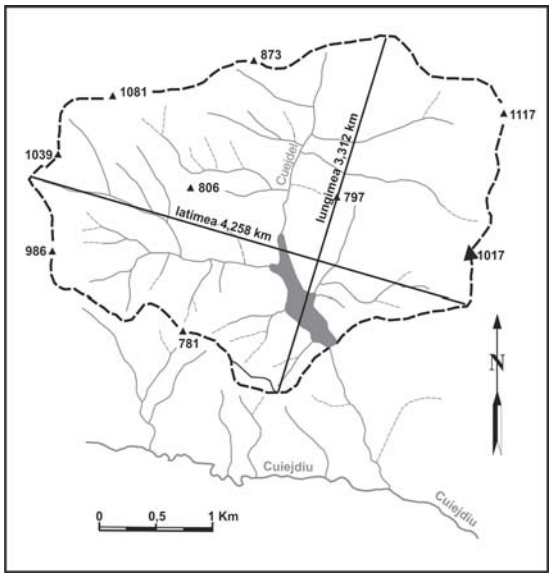

Fig.2. ***Receiving basin of Crucii Lake***

Main morphometric parameters were calculated: the shape, circularity ratio, coefficient of asymmetry, the degree of elongation and the development coefficient of watershed. These indicators fit the Crucii lake basin in the group of small basins, circular, with a relatively differentiated asymmetry, having a more pronounced expansion of the left side, and a high degree of development of the watershed (Table 1).

Morphological favorability

Geological conditions

In terms of lithology Cuejdiul basin has a geological structure dominated by the existence of the eastern ends of the marginal crease, east of Tarcău Canvas. There are facies alternating different lithological resistance. Facies rocks are striped lengthwise and parallel to the direction NNW - SSE, suffering great tectonic movements in the horizontal plane. The adaptation to the structure is partly evident.

River Cuiejdu cut obliquely, and sometimes cross these structures carving the valley. He cut several rock bands badenian age, apţiană, albiană and senonian. Cuiejdelul is subscribe to priaboniene facies, represented by marls and sandstones with globigerine quartz of Lucacesti facies (upper priabonian). For lower priabonian are representative marls and gray clay, marly limestone and sandstone from the layers of Bisericani. Layers of Plopu with marls gray clay green and

calcareous sandstones with hieroglyphics are also found. Oligocene is composed of quartz sandstones and shales of Kliwa.

Table 1. ***Main morphometric features of the receiving basin***

Nr. ctr.	Morphometric elements	Value	Unit measure
1.	Area	8,77	km^2
2.	Length	2,677	km
3.	Width	4,258	km
4.	Maximum length	3,312	km
5.	Water course lenght	4,96	km
6.	Perimeter	12,75	km
7.	Minimum share	578	m
8.	Maximum share	1117	m
9.	Spring altitude	750	m
10.	Asymmetry coefficient	0,26	-
11.	Form factor	0,80	-
12.	Circularity ration	0,67	-
13.	Elongation ratio	0,95	-
14.	The coefficient of watershed development	1,21	-
15.	Report form	0,86	-

The presence of the marginal crease is highlighted by a clear predisposition lithological and an advanced degree of vulnerability to surface erosion processes and mass movements. The layout of the overthrust canvas scales, with higher strata nearly vertical, creates premises for erosion in the longitudinal way on the loose bands, and the occurrence of landslides or rock collapses or of huge amounts of material. In this way the consuming of the slopes is made by combining the two categories of processes: erosion and mass movements.

The morpholitology of the area can be defined, in these circumstances, as the main support for the changes in the landscape, being in the same interface as its parameter and with great sensitivity and responsiveness to all external impulses (Rusu, 2004).

Dynamic aspects of geomorphology and watershed Cuejdel and Cuejdiu are induced by the belonging of the micro-region dominated by the characteristics of the flysch deposits showing a superficial mantle very susceptible to external energy flows. For this reason, the deposits register the fastest speed changes in thickness and spatial redistribution in preferential directions, vertical or parallel to the stable substrate.

Geomorphological aspects

Geomorphological processes that govern the Crucii Lake basin are conditioned, in particular, by altitude, through imposing the settings of morphogenetic conditions, and develops according to the categories of existing rocks. Flysch zone is located entirely within the denudational morphogenetic floor. In this case the distribution and intensity of geomorphic processes undergo some changes according to the slope, exhibition, lithological variety, afforestation, season, etc.

Erosion in the surface, coupled with steep slopes and slopes with greater depth of the landslides and of the racord from the flysch zone, it shows an intense activity. On the cleared slopes on the left of the valley of Cuejdiu, with greater consistency of the landslides material, surface erosion is increased. The process is enhanced by the stronger impact of forestry activities. The most affected is the lower third of slopes, which was largely deforested and reforested recently.

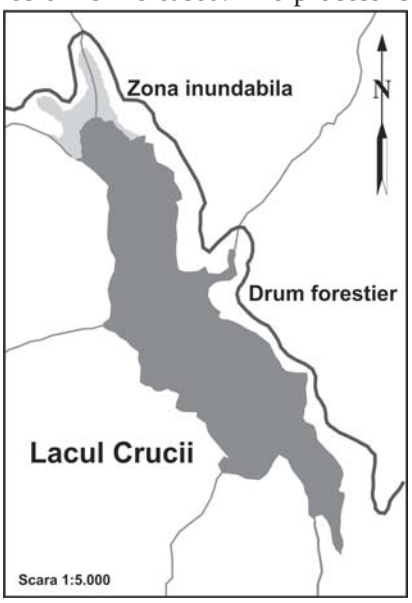

Fig.3. ***Forest Road along the left side of Crucii Lake***

Heavy erosion occurs in the basins Cuejdel and Cuejdiu on both types of rocks (priaboniene and oligocene), but with different intensities and effects. This type of erosion takes special accents in the altitude range 800-900 m, where precipitation exceeds 600-700 mm / year. It is present in forested areas but also in those without forest cover. There had been a series of torrential valleys, which favored the slopes most often exceed 30°, which denotes the relative youth of the processes of erosion. Both slopes and their thalweg present rugged shingle accumulations of gravels of different sizes, resulting in the fixed disintegration of the cut rocks.

Linear erosion has taken and deepened the cracks along the slope, resulting forms similarto the erosion gullies. Heavy erosion on flysch rocks created a wide range of forms, such as rain gutters and organisms evolved. Primary factor in the onset of rains in the catchment Cuejdel activity is the climatic factor, with precipitation ranging from 700-900 mm / year, correlated with the presence of flysch deposits up to an altitude of 900 m and slopes ranging from 12-30°. In this way it explains the existence of epigenetic gullies, with longitudinal profil, broken by rapids, on the right side of the valley Cuejdel.

Gullies have a higher frequency on the slopes along the valleys and tributaries, due to a richer human fingerprint. Many of the torrential organismes took and deepened the channels created by the wheels and logging equipment. Another factor that led to the intensification of the phenomenon of gullying is rebuilding roads, along the old guilles, resulting in two adjacent gullies. The multiple gullies are frequentlyr on the right side of Cuejdiu.

Landslides have a greater frequency on the flysch slopes due to favorable lithology and of the developnment of the landslide material. The trigger of the emergence of mass movements is given by the heavy rains, but also by massive deforestation, due to favorability lithology (Fig. 4). High consumption areas appear at the top of the slopes, on the slopes, inter-sculpted peaks and interfluvial, being affected by landslides in steps. On the rest of the slope are found landslides under

the form of monticuli, waves or nest (on the right of the river Cuiejdu and on the left of the stream Cuejdel). The most common type of landslides are the detrusor ones and are triggered at the top of the slopes, in the form of steps. By their pushing nature they trigger landslides in waves at the bottom.

Genesis of the Crucii Lake

Crucii Lake was formed after the dam of the main course by a large landslide (35 ha), which occurred on the left side of the valley Cuejdel in several stages. It debuted in 1978 when has ocurred the first mass movement with a tendency to block the valley. Paroxysm was reached in 1991, when landslide material blocked the entire valley.

Rainfall from may to august reached the amount of 741.4 mm. The thickness of slipped deposits vary between 5 and 25 m in the dam area. Their dynamics is still strong. In the period 2003-2004 was a new road that begins in the village Cracaoani, encompassing almost the entire left bank of the lake.

The causes behind the outbreak of accumulation may be natural (natural rainfall, earthquake in 1990 with the value of 5,4 on the Richter scale) and anthropogenic (forest road construction in the area which was later destroyed by landslides).

5. CONCLUSIONS

The genesis of Crucii Lake from Stânişoarei Mountains is related by the suitability of the geological substrate to the production of landslides. Mountainous terrain with slopes up to 30° tilt, the overlapping substrate lithology consists of a sequence of rocks and deposits permissive, are the premises for large gravitational movements. The appearence of the biggest natural dam lake in Romania, almost identical with the genesis of Rosu Lake, Bolatau, Iezerul Sadovei lake and many other establishments of its kind in the Eastern Carpathians mountain range, was determined by morphological suitability of the landscape.

Geographical observations revealed that the reception basin of the Crucii Lake, characterized by a complex morphology, but also the recent dynamics, presents a number of issues that betrays the instability of slopes with direct implications on current morphometry. For this reason, the study of Crucii Lake complex, small lakes in the area, sliding occurred between waves and the receiving basin, presents a great scientific importance for maintaining unchanged and unspoiled natural heritage.

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