Forum geografic. Studii și cercetări de geografie și protecția mediului
Volume XII, Issue 1 (June 2013), pp. 25-36
http://dx.doi.org/10.5775/fg.2067-4635.2013.021.i

New Techniques for the Analysis of the Limno-morpho-bathymetric Parameters in the Lacustrine Basins. Case Study: Red Lake in the Hăşmaş Mountains (Romania)

Gheorghe ROMANESCU [1*], Cristian STOLERIU [1]

[1] University „Alexandru Ioan Cuza" of Iasi, Department of Geography
* *Corresponding author*, geluromanescu@yahoo.com

Received on <10-01-2012>, reviewed on <10-02-2012>, accepted on <11-03-2013>

Abstract

Red Lake in the Hăşmaş (Curmăturii) Mountains was formed by the natural barrage of the Bicaz brook in 1837. The north-western slope of the Ghilcoş Mountain, covered with gravel, slide as a result of the alteration layer water saturation following the abundant rains in that period. The lake has an „L" shape, or the shape of a leg with the foot oriented towards north. Red Lake is supplied by several brooks with permanent character: Oii, Ghilcoş, Vereşcheu, Suhard. As a result of the measurements we made in the summer of 2009, using Leica Total Station and sonar, the following data were obtained: area 12.01 hectares; perimeter 2905.79 m; maximum length 1361.72 m; maximum width 160.24 m; maximum altitude upstream in the south 965.199 m; maximum altitude upstream in the north 966.041 m; maximum depth 10.50 m etc. The greatest depths, of 10.5 m, are recorded in the central sector, close to the outlet of the two arteries. In a transversal profile, the western bank is steeper and hard (lithologically), and the eastern bank is mild and crumbly (landslide diluvium). In the same way the submerse slopes are maintained as well. New techniques of analysing the hydro-morphological parameters for a lacustrine basin have been used. Methods specific to land geomorphology (slope inclination, slope orientation etc) have also been used. The cartographic representation, as a new thing in the field, is suggestive, and helps in elaborating an interdisciplinary interpretation, of a limno-ecological nature.

Keywords: *natural barrage lake, geomorphology, bathymetry, cartography, Red (Rosu) Lake (Romania)*

Rezumat. Noi tehnici pentru analiza parametrlor limno-morfo-batimetrici în bazinele lacustre. Studiu de caz: Lacul Roșu din Munții Hășmaș (România)

Lacul Roșu din Munții Hășmaș (Curmăturii) s-a format ca urmare a barării naturale a pârâului Bicaz în anul 1837. Versantul nord-vestic al Muntelui Ghilcoș, acoperit cu pietriș, a alunecat datorită saturării cu apă a stratului de alterare în urma precipitațiilor abundente din acea perioadă. Lacul are forma literei L, sau a unui picior cu talpa orientată spre nord. Lacul Roșu este alimentat de câțiva afluenți permanenți: pârâul Oii, Ghilcoș, Vereșcheu, Suhard. În urma măsurătorilor efectuate în vara anului 2009, utilizând Stația totală Leica și sonarul, au fost obținute următoarele date: suprafața 12,01 ha, perimetrul 2905,79 m, lungimea maximă 1361,72 m, lățimea maximă 160,24 m, altitudea maximă în sud 965,199 m, altitudinea maximă în amonte în nord 966,041 m, adâncimea maximă 10,50 m. Cele mai mari adâncimi, de 10,50 m, sunt înregistrate în sectorul central, aproape de gura de vărsare a celor doi emisari. În profil transversal, malul vestic este mai abrupt și mai dur (din punct de vedere litologic), iar malul estic este mai lin și friabil (deluviu de alunecare). În același mod se mențin și pantele submerse. Pentru realizarea acestui studiu au fost folosite noi tehnici de analiză a parametrilor hidro-morfologici specifici unui bazin lacustru. Reprezentările cartografice, care sunt o noutate în domeniu, sunt sugestive, fiind utile pentru elaborarea unei interpretări interdisciplinare, de natură limno-ecologică.

Cuvinte-cheie: *lac de baraj natural, geomorfologie, batimetrie, cartografie, Lacul Roșu (România)*

Introduction

Red Lake is the best known Romanian acquatorium created as a result of a landslide which caused a barrage in the course of Bicaz brook. Still, a complete geographical and limno-ecological study has not been done yet. From a morphological and morpho-graphical point of view, there were several attempts, but most of the times they were incomplete. The best known research paper was elaborated by Pandi G. in 2004, but it is published in Hungarian and it does not include a modern, interdisciplinary, geo-ecological study of the Red Lake lacustrine basin system.

Thanks to very accurate last generation instruments, and to the qualified personnel in taking very fine measurements, a series of measurements on the morphometry and morphology of Red Lake were taken. We hope that these measurements will represent a basis for complex geographical, geological, biological, economic studies, and they will lead to new interdisciplinary research directions – limno-ecological ones.

The geomorphologic methodology for land areas is applied to the morpho-bathymetry of the lacustrine basins. The principles are the same, in another field, collateral to limnology, but important from a geographical point of view. The majority of the parameters known in the immerse territories will be found in the aquatic submerse territories as well, but on a different scale and with other influences.

The most important studies on Red Lake and the surrounding area were elaborated by: Bojoi, 1968; Cărăuşu et al., 1971; Ciaglic, 2005; Dobrescu and Ghenciu, 1970; Ghenciu, 1968 a,b; Ghenciu and Apavaloaie, 1969; Ghenciu and Carausu, 1970; Gaştescu, 1971; Grasu and Turculet, 1980; Mihăilescu, 1940 cited by Popp; 1941; Pandi, 2004; Pandi and Buzila, 2004; Pandi and Magyari, 2003; Pelin, 1967, 1971; Pişota and Nastase, 1957; Pişota and Nastase, 1957., ; Popescu and Dimitriu, 1950; Popp 1941; Preda, 1967, 1971; Preda and Pelin, 1963; Puşcariu, 1939; Romanescu, 2009 a,b,c; Senchea, 1948; Udrişte, 1963; Xantus and Xantus, 1999 etc.

From the international literature we used only the studies helping in supporting some hydro-geomorphologic ideas: Clague et al., 2006; Gagnon et al., 2008; Godet et al., 2009; Holden, 1998; Lampert and Sommer, 2007; Nolan and Brigham-Grettej, 2007; Reshef et al., 2007; Torabay et al., 1991; Wetzel, 2001.

Fig. 1 Geographic location of Red Lake on the Romanian territory

Red Lake is situated in the Central Group of the Eastern Carpathians, within Hăşmaşu Mare (Hăghimaş) Massif and its main tributaries are Oaia, Vereşcheu, Licoş and Suhard brooks (Fig. 1).

It is a natural barrage lake. It was created in the summer of 1837, when, following a period of abundant rains, a landslide diluvium detached from Ghilcoş (Ucigaşu) Mountain and created a barrage in the course of Bicaz brook. Behind the landslide wave, a lake was created and this lake inherits the tree trunks of the forest covering the sliding slope (Bojoi, 1968; Mihăilescu, 1940 cited by Popp, 1941; Pişota and Nastase, 1957).

The mathematical coordinates of the lake are: 46º47'0'' N latitude in the southern sector, 46º47'37'' N latitude in the northern sector, 25º47'0'' E longitude in the north-western sector and 25º47'30'' E longitude in the eastern sector.

In the Carpathian Mountains, there are several lakes emerged as a result of the landslides which created a barrage in the course of the rivers (Vulturilor, Crucii, Bălătău, Dracului etc.), but Red Lake is the best known and studied.

The name „roşu" (red) comes from the fact that at sunrise, the sunrays fall directly on the reddish clays of the western slope (Piciorul Licoş), and it reflects on the relatively clear waters of this aquatorium.

Methods and technique

The field measurements were taken by using LEICA TCR 1201 total station, which, together with LEICA GPS 1200, is part of 1200 LEICA SYSTEM.

The Topographic Headquarters in Gheorgheni gave us the coordinates of the topographical marks. The measurements were taken starting from the Topographic Mark number 15, situated on the right side of the lake, at 986.275 m altitude, and the orientation was done towards the mark on Suhard peak, at 1507.0 m altitude. From the Topographic Mark number 15 the measurements started effectively. Seven station points were radiated, by using wood stakes in different zones of the lake, for an optimum cover of the whole area. After finishing the measurements, the data were processed by using AutoCAD software.

At the same time, a GPS was used in order to establish the exact perimeter of the lacustrine basin and of the typical humid zones in the Red Lake.

The data of the topographical surveys were represented in Stereographic Projection 70. All the topo-geodesic works which were done on the territory of Romania were executed in Stereo Projection System 70 or Stereographic 1970: maps and cadastral plans, topographic maps etc.

The bathymetric measurements were taken by using Valeport Midas Surveyor echo sounder (Bathy-500DF Dual Frequency Hydrographic Echo Sounder). The resolution of this echo sounder is 1 cm/1 cm and it includes GPS navigation.

The contour of the lake was established on the basis of the topographical measurements and GPS. The whole lacustrine surface was scavenged by using the sonar. In this case, over 80,000 points were inventoried and about 50,000 were graphically interpolated.

A certain difficulty in establishing the correct depths was generated by the fact that the signal of the echo sounder can easily penetrate the extremely watery silt from the bottom of the lake. In this case, the thickness of the sediment is added to the depth of the lake, instead of being considered a consolidated layer. That is why several corrections were done and supplementary measurements were done by using string and weights.

As a result of the fact that the lake still preserves a multitude of tree trunks, the bathymetric measurements were affected. In order to avoid errors, the „parasites" which frequently appeared in the measurement operation were eliminated.

In order to process the bathymetric data and realize the thematic maps, TNTMips v.7.2 and ArcGis v.9.3 software was used. Therefore, the numeric model of the land was realized and it was graphically used for different purposes. These are new graphical representations in the mathematical modelling of the lacustrine basins. In this case, the working techniques for the land geomorphology have been used: slope value, slope orientation, hypsometric integral. On the basis of the numeric model of the land, for each bathymetric level, the corresponding water volume was calculated.

Results and Discussions

The topographic measurements indicated the following values: area – 12.01 hectares (120,134.44 m^2); perimeter 2905.79 m; maximum length – 1361.72 m; maximum width - 160.24 m; maximum altitude upstream in the south (the outlet of Oaia brook) 965.199 m; maximum altitude upstream in the north-west (the outlet of Suhard brook) 966.041 m. The length of the main sector (the outlet of Oaia brook and the river mouth) is 958.89 m. The length of the secondary sector (the outlet of Suhard brook and the river mouth) is 403.32 m. The area indicated in other recent studies is 11.6 hectares or 116,500 m^2 (Pandi, 2004).

The river mouth, or the tributary sector of Red Lake, is situated at an altitude of 965.05 m. The difference of level between the outlet of Oaia brook and the river mouth is 14 cm. Between the outlet of Surhard brook and the river mouth there is a level difference of 99 cm. Therefore, the slope of Suhard brook is greater and the bottom of the valley is deeper. The smaller distance also indicates a greater level difference. Oaia brook and the adjacent lacustrine sector implicitly have a greater length but a smaller slope. In this case, the sedimentation rate could be higher, as the current has a lower velocity and the elimination of the alluvia is slower.

There is a relatively great difference between the altimetric data of the lacustrine basin, especially for the average level of the lake, in the studies of different authors: Pişota and Năstase, 1957, Udrişte, 1963, Bojoi, Pelin, 1967. According to the data obtained in the measurements taken in 2009, the altitude of the lake level is 965.10 m, but in other recent studies, the value of 978.17 m is indicated (Pandi, 2004). The difference could be explained by the different methods which were used in establishing this altitude. In the present case, topographic measurements were taken, while in other studies, the altitude was established on the basis of the topographic maps which have been achieved so far.

The lowest depths are recorded in the upstream sectors of the two branches, at the outlet of the most important brooks: Oaia and Suhard. This fact is a result of the relatively reduced solid transport of the two water courses. The low solid discharge is the result of a high forest cover degree which has been preserved since the formation of the lake. Low depths are also recorded next to the river mouths of the small torrents coming from the mountain sectors with high slopes.

The greatest depths, of 10.5 m, are recorded in the central sector, at the confluence of the two main arteries or behind the landslide wave which closed the basin (Fig. 2). The higher level difference between Suhard brook and the river mouth causes greater depths on this alignment, as compared to the one situated between Oaia brook and outlet. Until now, only maximum depths of 9.70 m were measured (Pandi, 2004). The measurements taken in the summer of 2009 indicated slightly higher values: 10.50 m. The depth of 10.5 m is indicated in only one study (Cazacu et al., 2009). It is important to mention the fact that these measurements were taken in a period when important amounts of precipitation were recorded over a long period of time. This fact caused a slight increase of water level, but not higher than 20-30 cm. From this point of view we cannot give accurate figures on the periodic variations of the levels, as the hydrological observations are not made systematically, and in most cases, they are false.

In a transversal profile, a clear asymmetry of the slopes can be noticed. In the remote sector, towards Ghilcoş Mountain, from where the sliding material fell off, the slope becomes milder, while on the opposite slope (lithological) the slope is very steep. The greatest level difference is recorded in the sector of the river mouth, where there are the greatest depths as well. A perfect symmetry is recorded in the upstream sectors, where the silting is predominant and the quantity of the sliding material is reduced.

The greatest slopes are found on the western and northern banks, where the rocky slopes have an almost vertical fall in the lacustrine basin. These sectors are well forested, they do not represent the source for any significant water courses and the quantity of alluvia material is low. A different situation occurs on the opposite slope, the eastern slope, where the landslide diluvium manifested. In this case, the slopes have low values and the plant community could develop. This latter sector is strongly fragmented by several torrential arteries. They are anthropically controlled at present, as the road linking Bicaz and Gheorgheni crosses this area.

We have to mention the fact that in the areas with reduced depths, where light penetrates to the bottom of the lake, a vegetation specific to the humid areas developed, and therefore, extended wetlands appeared. Vegetation has its main contribution to the fast silting in the upstream sectors of the two branches. At the same time, it created a soil typical to the lacustrine basins, called limnisoil.

The letter „L" shape is given by the existence of the two important valleys: Oaia in the central-southern half, and Suhard in the north-western sector. The central-southern branch of Oaia valley is affected by the landslide body, with a clear asymmetric transversal profile. The branch of the Suhard valley is not affected by landslides, but it has an asymmetric transversal profile due to the significant silting towards the northern bank. From this bank, several torrential organisms bring alluvia material and deposit it under the form of small submerse cones of fan-delta type. The same micro-morphological formations can be found on the eastern slope of the main valley as well.

The water level is situated at an altitude between 966 m and 965 m, and definitely not at an altitude of 978 m, according to the data supplied by Pandi G. in 2004. In fact, the whole range of morpho-metrical data should be revised, as, until present, it is only the information taken from the topographical maps drawn between the 1950s and 1970s that has been used.

After the numeric model of land was done, with drawing up of the bathymetric curves, the map of slope inclination was elaborated. According to these parameters, there are favourable or non-favourable conditions for the installation of vegetation or for the sheltering of organism communities. From this point of view the vertical walls are non-favourable, while the plane surfaces are favourable to the development of the lake communities.

The highest percentage is registered by the slopes between 0-3º (over 50%) and the lowest values, by the slopes with values between 45-66º (under 2%). A quite important percentage (almost 10%) is recorded by the slopes between 5-10º and 15-25º (Fig. 3).

At low depths (0-1 m, 1-2 m) the average slopes are predominant, while at high depths (especially for the depths between 8-9 m, 9-10 m, over 10 m) the low slopes are predominant. For the depths exceeding 9 m the slopes with values between 0-3º are predominant, therefore, a uniformity of the bottom lake occurs.

A very important ecological characteristic for the lacustrine basins is represented by the banks orientation (slope orientation) according to the cardinal points (Fig. 4). In this case, the wind rose is considered. The orientation of the banks towards sun or in the shadow of the sun, leads to a different distribution of the lacustrine organisms. The method is used by geomorphologists and climatologists in order to point out the role played by insolation on the terrestrial surface. The phenomena are similar within the lacustrine basins, depending on insolation. In the case of Red Lake the situation is somehow complicated. The elongation on a north-south direction, induce an eastern orientation to the western slopes, and a western orientation to the eastern slopes. The value of insolation cannot be distributed evenly, as the two neighbouring mountain sectors do not have the same altitude. This is why the lacustrine surface is lighted by the sun later in the morning, as compared to the sunset.

The slopes with high slopes receive less light, and the plane slopes, more light.

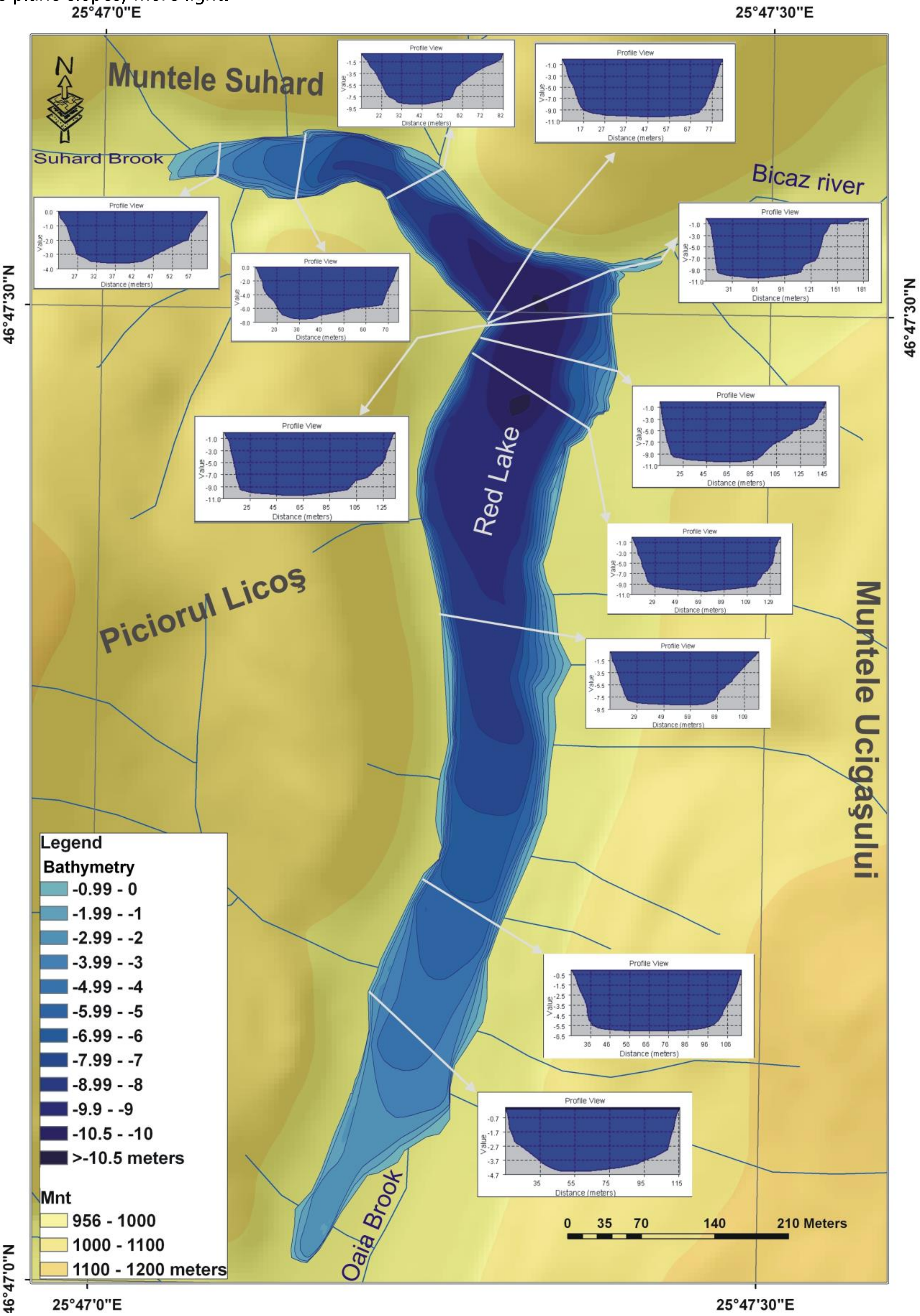


Fig. 2 Bathymetric map of Red Lake and transversal profiles in the lacustrine basin

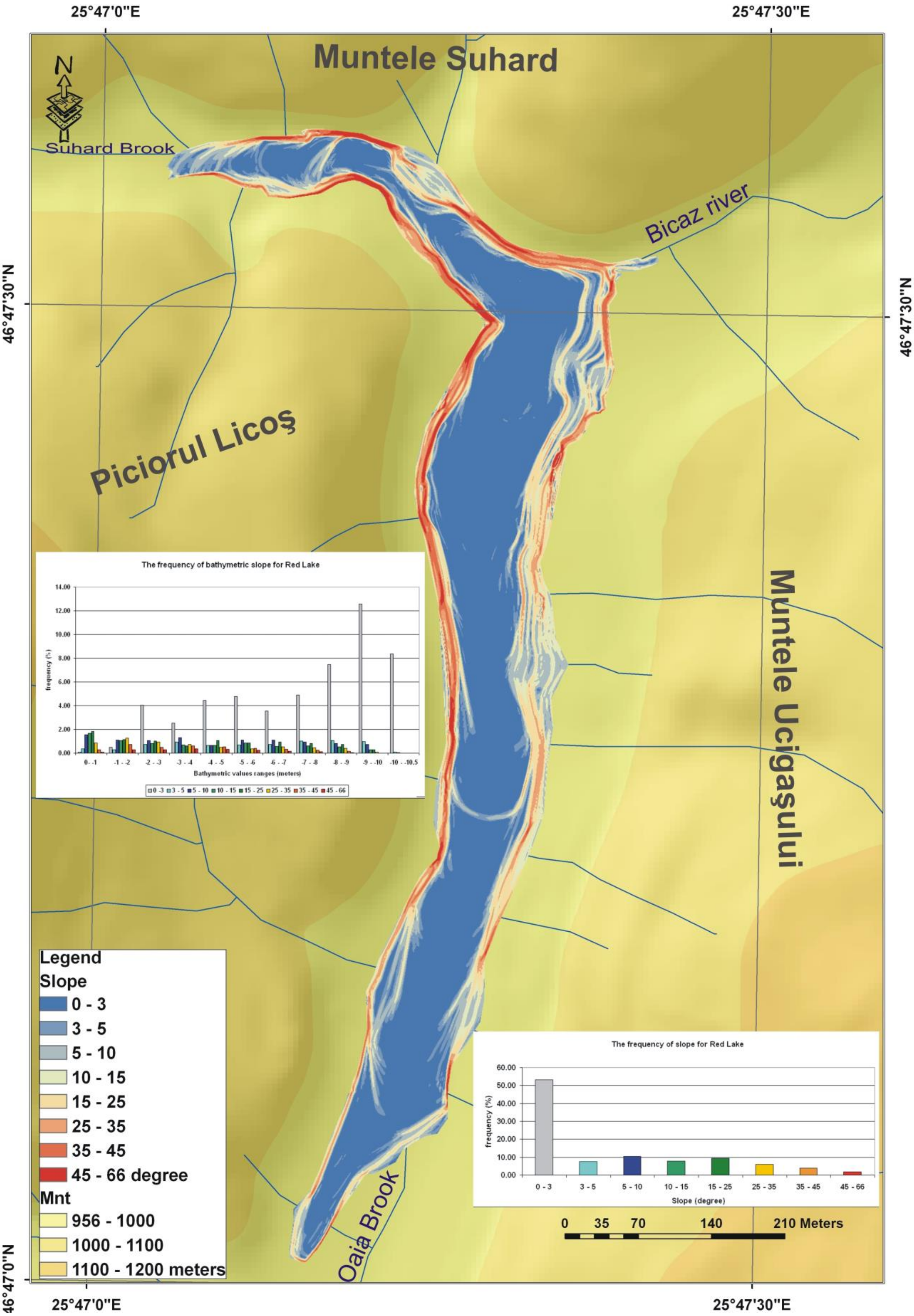


Fig. 3 Value of slopes in Red Lake basin

Forum geografic. Studii și cercetări de geografie și protecția mediului
*Volume **XII**, Issue **1** (**June 2013**), pp. **25-36***
*http://dx.doi.org/**10.5775/fg.2067-4635.2013.021.i***

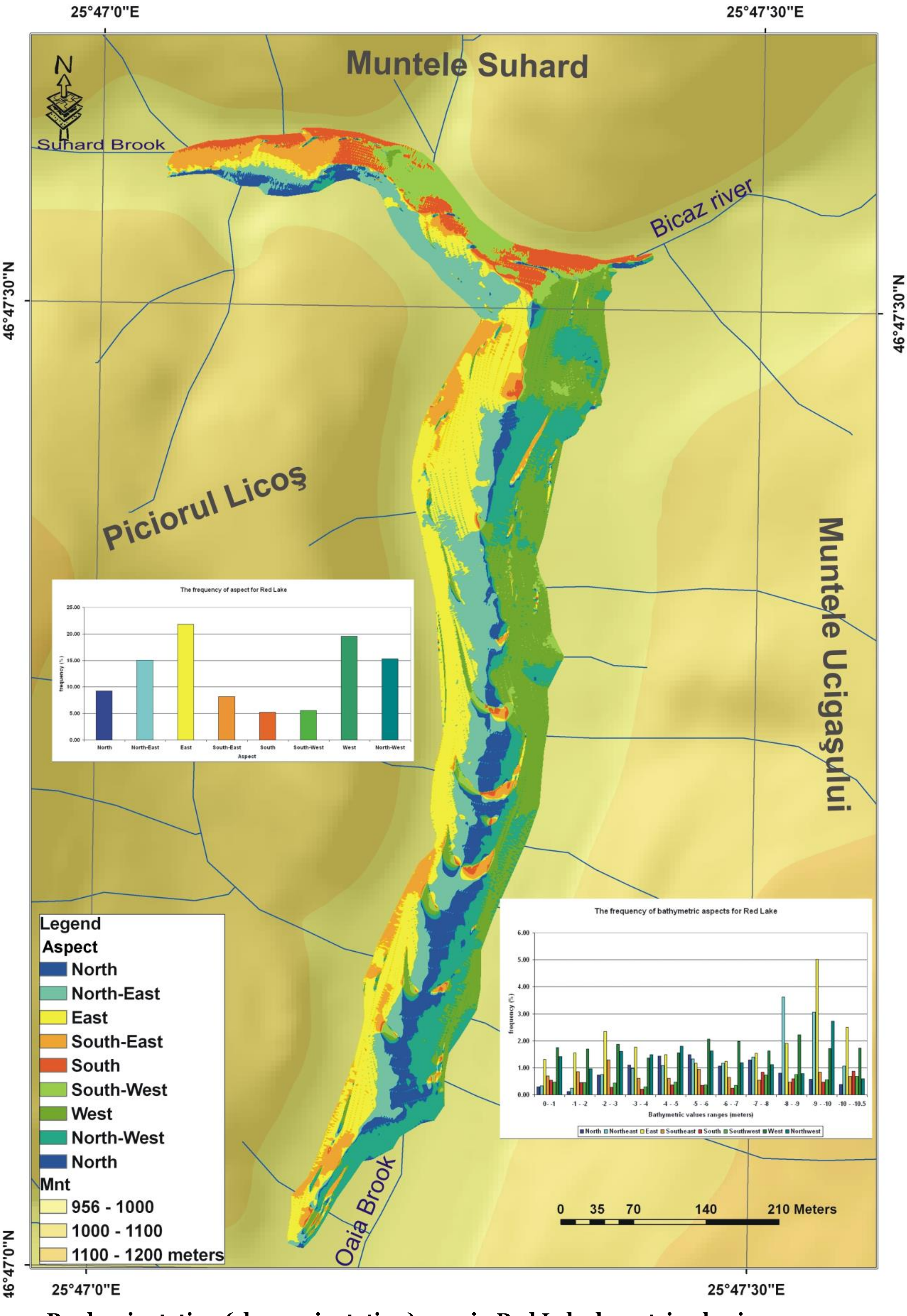


Fig. 4: Bank orientation (slope orientation) map in Red Lake lacustrine basin

The highest values are characteristic to the banks with eastern, north-eastern and north-western orientation. They follow the general orientation of the lake and its elongated shape. The lowest values are characteristic to the southern and south-western banks.

There are important differences in the orientation of the banks at different depths. The general situation is somehow changed in the middle part of the lake, between the depths of 4-5 m, 5-6 m, 6-7 m, where other orientations are predominant. At higher depths, the eastern and north-eastern orientations are predominant, and this is due to the inclination of the submerse glacis formed at the base of the lithologic slope (hard).

The slope affected by the landslide, with mild slopes, has a general westwards orientation, while the opposite bank has an eastwards general orientation.

The longitudinal profile representation is done in such a way that one can notice, at the same time, all the three sectors. The diagram is accompanied by the plane image of the lacustrine basin.

In a longitudinal profile, one can notice the relatively high slope in the sector between Oaia brook and the river mouth, with the value of 10.5 m at 958.89 m (11º) (Fig. 5). The slope of the sector between Suhard brook and the river mouth has the value of 10.5 m at 403.32 m (26º). In the latter case, the slope is much greater, and therefore, great depths are maintained during the whole course. The landslide wave next to the river mouth has a slope value of 56º.

The landslide wave blocking the basin of Red Lake presents a slope with vertical values, well defined, with little changes along time. It is precisely the weak changes that permitted the maintenance of the water volume and the existence of the lake itself.

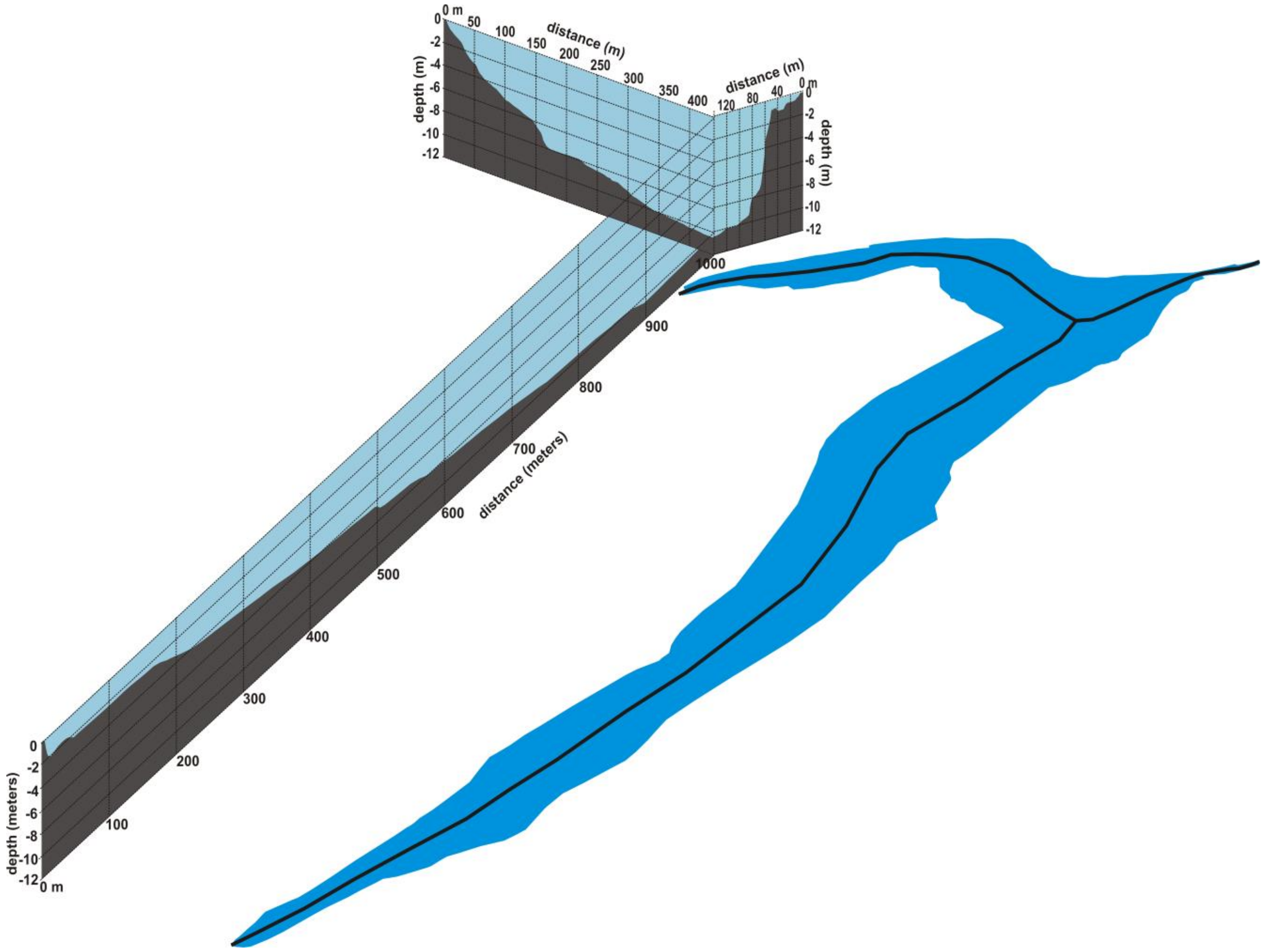


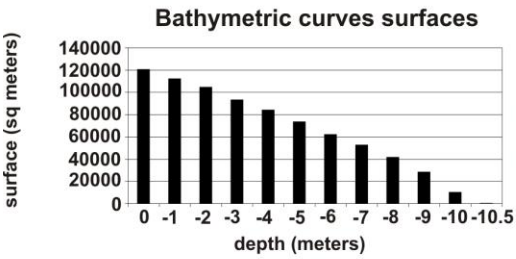
Fig. 5: Diagram of the longitudinal profile in Red Lake (the proportion of shapes and lengths for the two components – Oaia and Suhard streams - is maintained)

Forum geografic. Studii și cercetări de geografie și protecția mediului
*Volume **XII**, Issue **1** (**June 2013**), pp. **25-36***
*http://dx.doi.org/**10.5775/fg.2067-4635.2013.021.i***

The greatest depths, of 10.5 m, can be found at the confluence of the two arteries, Oaia and Suhard, behind the wave which closed the lacustrine basin for good. The significant depths in this sector could be a result of the existence of certain circular bottom lake currents. These currents can be generated when the longitudinal currents turn back after hitting the barrage. In this case, under-washing of the riverbed bottom occurs and certain enclaves with great depths are created. They can have a temporary character, and they are obvious only for very high speeds of the depth currents. During the torrential rains, great swirling currents are developed, and they represent an extra supply for the lacustrine basin. The most obvious swirling occurs at the confluence of the two currents and their impact with the landslide wave of the river mouth. During the quiet moments of the affluent hydrographical arteries, the swirling forces can be diminished, and the alluvia flow can reduce temporarily the small irregularities of the lake thalweg.

The vertical distribution of the depths creates a transversal profile of the lacustrine basin in the shape of a conical bag (Fig. 6). In reality it is a landform with reverse position as compared to the immerse one. The greatest area values belong to the isobaths with the value of 0 m. The -1 m isobath covers an area of 11.236 hectares and the one with the value of -10 m only 0.056 ha. At the level of each bathymetric curve, an equivalent of solar energy is received. This varies depending on turbidity, transparency, vegetation cover degree, ice sheet cover degree (isolated or continuous) etc.

For each bathymetric interval (0 – 1 m: 1 – 2 m etc.) an equivalent water volume - Vp corresponds. The latter has specific physical – chemical and biologic characteristics, and according to them, certain ecological functions can be assessed. For each interval, there is a correspondent for immerse surfaces, of the landforms, affected by the exogenous factors. If the climatic parameters change every 100 m of altitude on the immerse landforms, the same thing happens within the submerse landforms, but on a more diminished scale. At the latitude where Romania is situated, the temperature decreases with 0.6ºC for each 100 m of altitude. In the case of Red Lake, this parameter is 1ºC for each meter of depth. The same thing happens with the other physical – chemical parameters. The life conditions on the highest peaks of the mountains are severe; we can say the same thing about the greatest depths of the lacustrine basins.



Bathymetric curve value (meters)	Surface (sq m)	Partial volume (m^3)
0	120520	116417.68
-1	112363	108509.45
-2	104701	99039.55
-3	93484	88731.81
-4	84063	78699.91
-5	73456	67751.06
-6	62202	57390.04
-7	52709	47121.63
-8	41747	34801.54
-9	28291	18531.23
-10	10263	4410.97
-10.5	564	
Total volume = 721404.87 m^3		

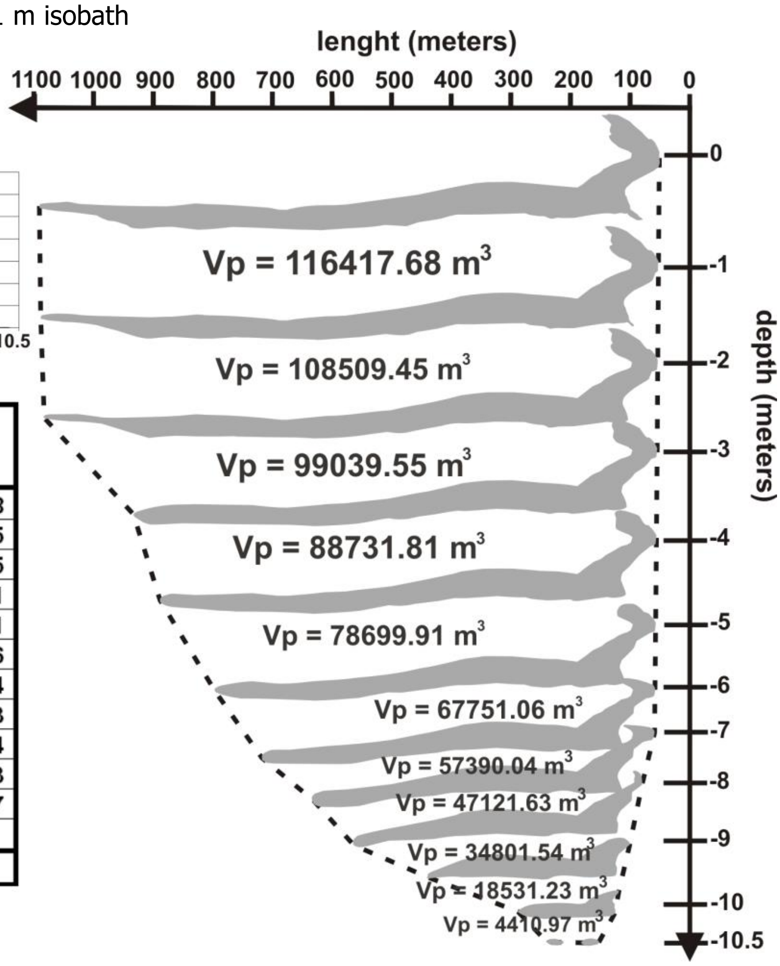


Fig. 6: Vertical distribution of the bathymetric curves and the equivalent area occupied on each depth interval (1 m/1 m)

In order to study the temporal evolution of the lacustrine basin, a hypsometric integral specific to the immerse landform units was made (Fig. 7). This is based on the estimation of the immerse landforms erosion degree.

The whole area of the graph represents the initial volume of the landforms. The area situated under the hypsometric curve represents the present volume of landforms. The ratio between the two volumes indicates the value of the hypsometric integral (Strahler, 1952). At the surface, the situation is the following: a concave curve reveals old landforms, and a convex curve indicates young landforms, with weak erosion phenomena. For Red Lake the values are higher than 1 (convex curve), which demonstrates a permanent accumulation of material and an ageing of landforms. The phenomenon is exactly the opposite of the one occurring on the land.

The hypsometric integral is a graphical representation of the relationship between altitude and area. The calculation formulas for the two axes are:

For oY axis: y=h/H, in which h = altitude of a point in a horizontal-transversal section (meters) and H = maximum altitude of the studied area (meters). For oX axis: x=a/A, in which a = the relative surface occupied by (square meters), A = total area (square meters).

By analysing the hypsometric integral for Red Lake lacustrine basin, one can notice a permanent accumulation and a continuous modification of the submerse slopes as a result of the accretion (bottom and lateral).

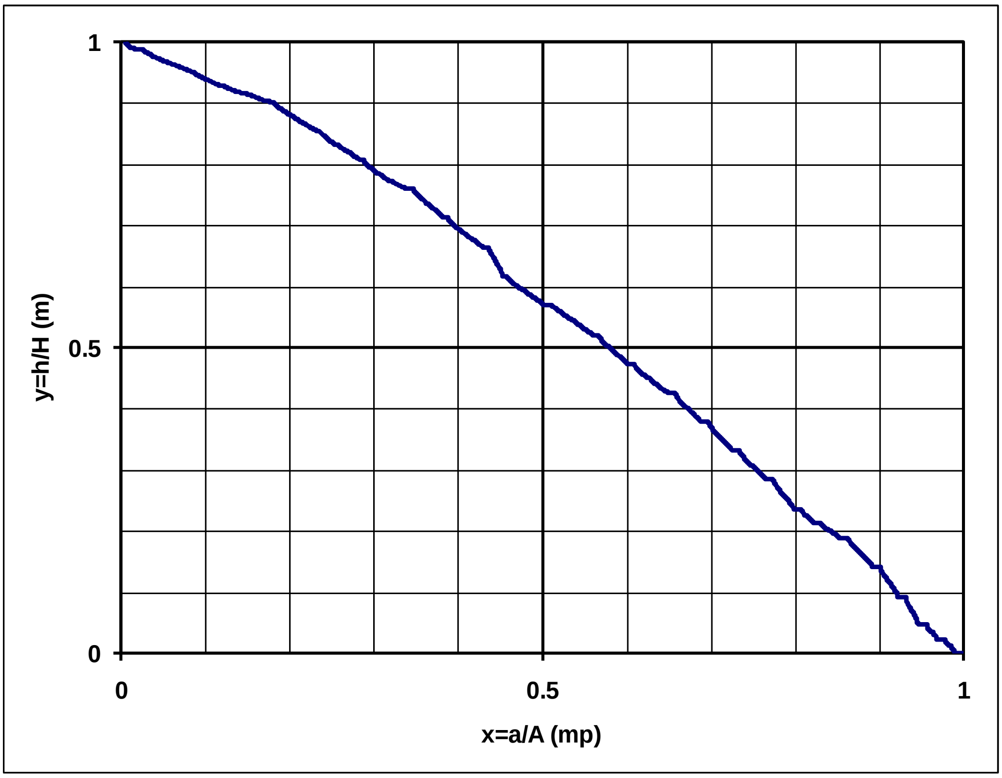


Fig. 7: Hypsometric integral of Red Lake basin

Conclusions

Red Lake is the best known natural barrage lake in Romania and it represents, together with the Bicaz Gorges, the main tourist attraction in the area of Hăşmaşu Mare (Hăghimaş) Mountains.

Although the lake is a distinct entity from a limnologic point of view, most of the studies had only a limited character, without an interdisciplinary approach. Due to a less accurate methodology and outdated instruments, even this study includes inaccurate date from a morphometric point of view (topography, bathymetry).

For a correct understanding of the morphometric data, the geomorphological methodology specific to positive, immerse landforms, has been applied. The methodology is similar for the negative landforms, such as the lacustrine basins. The novelty hydro-geomorphological data are corroborated with an innovatory cartographic material, created in order to have a clear and quick understanding of the reality. The existence of morpho-metrical data and their correct interpretation could lead to a new re-evaluation of the hydrological, biological, ecological, economical parameters etc. Morpho-bathymetry of a lacustrine basin represents the base for the limno-ecological interpretation.

The long existence of such an aquatorium is due to balanced hydrological balance, favourable from this point of view, but also to a reduced silting. The reduced silting index is a direct result of the continuous presence of vegetation layer, especially the coniferous forests, in the surrounding area, and of the high hardness of the geological layer (crystalline schists and limestone).

References

Bojoi, I. (1968), Contributii la sedimentologia Lacului Rosu, *Lucrarile Statiunii de Cercetari Biologice, Geologice si Geografice Stejaru, Piatra Neamt, 1, pp. 87-105.*

Cazacu, C., Brustur, T., Szobotka, S., Melinte, M. C. (2009), Studii asupra sistemelor hidrografice in aria Parcului National Cheile Bicazului – Hasmas, *Sesiunea de Comunicari Stiintifice GEOECOMAR, Constanta, p. 171-180.*

Carausu, S., Ghenciu, V., Timofte L.I. (1971), Unele date cu privire la trasaturile hidrofizice ale Lacului Rosu din perioada august 1968 – septembrie 1969, *Analele Stiintifice ale Universitatii Alexandru Ioan Cuza, Iasi, XVII, 2, pp. 425-445.*

Ciaglic, V. (2005), Contributii la cunoasterea caracteristicilor hidrologice si hidrogeologice ale muntilor Ghilcos-Haghimas-Mezinul si a conditiilor care le determina, *Editor Gh. Romanescu, Editura Terra Nostra, Iasi.*

Clague, J., Luckman, B.H., Van Dorp, R.D., Gilbert, R., Froese D., Jensen B.J.L., Reyes A.V. (2006), Rapid changes in the level of Klaune Lake in Yukon Territory over the last millenium, *Quaternary Research, Elsevier, 66, pp. 342-355.*

Dobrescu, C., Ghenciu, V. (1970), Aspecte din vegetatia Lacului Rosu, *Studii si comunicari, Muzeul de Stiintele Naturii, Bacau, 3, pp. 129-136.*

Gagnon, P., Scheibling, R.E., Jones, W., Tully, D. (2008), The role of digital bathymetry in mapping shallow marine vegetation from hyperspectral image data, *International Journal of Remote Sensing, 29, 3, pp. 879-904.*

Ghenciu, I.V. (1968), Regimul de oxigen al Lacului Rosu, *Comunicari ale Sesiunii Stiintifice, Universitatea Alexandru Ioan Cuza, Iasi, p. 184-196.*

Ghenciu, I.V. (1968), Regimul termic al apei Lacului Rosu, *Comunicari ale Sesiunii Stiintifice, Universitatea Alexandru Ioan Cuza, Iasi, p. 145-160.*

Ghenciu, I.V., Apavaloaie, M.M. (1969), Contributii la cunoasterea regimului de precipitatii din zona Lacului Rosu, *Analele Stiintifice ale Universitatii Alexandru Ioan Cuza, Iasi, XV,1, pp. 29-40.*

Ghenciu, I.V., Carausu, S. (1970), Cateva date cu privire la dinamica cantitativa a fitoplanctonului din apa Lacului Rosu in perioada iulie 1967 – decembrie 1968, *Analele Stiintifice ale Universitatii Alexandru Ioan Cuza, Iasi, XVI, 1, pp. 147-163.*

Gastescu, P. (1971), Lacurile din Romania – limnologie regionala, *Editura Academiei Romane, Bucuresti.*

Godet, L., Fournier, J., Toupoint, N., Olivier, F. (2009), Mapping and monitoring intertidal benthic habitats: a review of techniques and a proposal for a new visual methodology for the Europa coasts, *Progress in Physical Geography, 33,3, pp. 378-402.*

Grasu, C., Turculet, I. (1980), Rezervatia Lacul Rosu – Cheile Bicazului. Particularitati geologice si geomorfologice, *Ocrotirea naturii si a mediului inconjurator, 24.2, pp. 135-145.*

Holden, H. (1998), The scientific issues surrounding remote detection of submerged coral ecosystems, *Progress in Physical Geography, 22,2, pp. 190-221.*

Lampert, W., Sommer, U. (2007), Limnoecology. The Ecology of Lakes and Streams, Second Edition, *Oxford University Press, New York.*

Nolan, M., Brigham-Grettej, J. (2007), Basic hydrology, limnology, and meteorology of modern Lake El'gygytgyn, Siberia, *Journal of Paleolimnology, 37, 1, pp. 17-35.*

Pandi, G., Buzila, L. (2004), Caracteristici hidro-geomorfologice ale sedimentarii in Lacul Rosu, *Geography within the Context of Contemporary Development, Cluj-Naspoca University Press, Cluj.*

Pandi, G., Magyari, ZS. (2003), Realizarea hartilor batimetrice pe calculator. Modelul Lacul Rosu, *Studia Universitatis Babes-Bolyai, Cluj, pp. 55-60.*

Pandi, G. (2004), A Gyilkos-Tó. Hidrogeográfiai tanulmány, *Editura Casa Cartii de Stiinta, Cluj.*

Pelin M. (1971), Consideratii asupra tectonicii regiunii Lacul Rosu – Piatra Unica, *Analele Universitatii Bucuresti, Bucuresti, XX, pp. 64-76.*

Pisota I., Nastase A. (1957), Lacul Rosu, nod de confluenta a trei bazine hidrografice, *Probleme de geografie, Bucuresti, 4, pp. 151-205.*

Popescu G.A., Dimitriu A. (1950), Observatiuni piscicole la Lacul Rosu, *Buletinul Institutului de Cercetari Piscicole, Bucuresti, IX, pp. 33-47.*

Popp N. (1941), Cronica Geografica, A) Fapte. Congresul Profesorilor de Geografie de la Piatra Neamt, 18-21 mai 1940, *Buletinul Societatii Romane de Geografie, Bucuresti, LX, pp. 317-342.*

Preda I. (1967), Deplasari de teren in zona Lacu1ui Rosu, *Comunicari de Geologie, IV, Bucuresti.*

Preda I. (1971), Consideratii hidrogeologice asupra Muntilor Haghimas, *Buletinul Societatii de Stiinte Geologice, Bucuresti, XIII, pp. 92-106.*

Preda I., Pelin M. (1963), Contributii 1a cunoasterea geologica ai împrejurimilor Lacului Rosu (Carpatii Orientali), *Societatea de Stiinte Naturale si Geografice din Romania, Comunicari de Geologie, Bucuresti II, pp. 107-116.*

Puscariu V. (1939), Lacul Rosu si Cheile Bicazului, *Editura Touring Clubul Romaniei, Cluj.*

Reshef M., Ben-Avraham Z, Tibor G., Marco S. (2007), The use of acoustic mapping to reveal fossil fluvial systems – a case study from the southwestern Sea of Galice, *Geomorphology, Elsevier, 83, pp. 58-66.*

Romanescu G. (2009), Trophicity of lacustrine wetlands on the Carpathian territory of Romania. A case study from the East Carpathian mountains, *Lucrarile Seminarului Geografic „Dimitrie Cantemir”, Universitatea Alexandru Ioan Cuza, Iasi, 29, pp. 5-13.*

Romanescu G. (2009), Trophicity of lacustrine waters (lacustrine wetlands) on the territory of Romania, *Lakes, reservoirs and ponds, 3, pp. 62-72.*

Romanescu G. (2009), The physical and chemical characteristics of the lake wetlands in the central group of the east Carpathian Mountains, *Lakes, reservoirs and ponds, 4, pp. 94-108.*

Senchea N. (1948), Formarea lacurilor din Romania, *Revista Stiintifica "Vasile Adamachi", Iasi, XXIV, pp. 46-52.*

Strahler A.N. (1952), Hypsometric (area-altitude) analysis of erosional topography, *Bulletin Geological Society of America, 63, pp. 1117-1142.*

Tarabay A.B., Villela R.G., Espino G.L. (1991), Limnological aspects of a high-mountain lake in Mexico, *Hydrobiologia, Springer, 224, 1, pp. 1-10.*

Udriste O. (1963), Lacul Rosu si imprejurimile, *Editura Meridiane, Bucuresti.*

Wetzel R. (2001), Limnology. Lake and River Ecosystems, 3rd Edition, *Academic Press.*

Xantus L., Xantus J. (1999), Hagymas-hegyseg es a Gyilkos-to kornyeke, *Pallas Akademia, Csikszereda.*

