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MORPHOMETRY OF LAKE SFANTA ANA, ROMANIA (LAKE SAINT ANN)

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Abstract

Lake Sfanta Ana is one of the most emblematic lacustrine complexes of our country. In this context, its monitoring is not only necessary but also compulsory. The study of its evolution and the forecasts are done easier because we have had hydrotopometric highs for about 100 years, even if the frequency of evaluations has not been periodical. The morphometric elements have had a normal evolution, of continuous diminution, specific to lacustrine complexes. The modification rates of the morphometric parameters are different, but they all highlight the necessity of taking urgent measures of protection, in order to slow down the filling speed of the lake basin. Silting is fast due to anthropic influences. The tourism activity produces, direct and indirectly, alluviums that reach inside the lake, due to the processes occurred on the slopes of the crater. We must find a modus vivendi, which is possible in theory, so that tourism and environment protection may "live together" in harmony.
Keywords: Lake Sfanta Ana

1. FACTORS OF INFLUENCE

The crater of Ciomad Massif-Eastern Carpathians mountains, represents a very clearly delimitated area. This fact refers not only to the line of watershed but also to the differences of level from one side and another of this line. Inside the crater, the level of water of Lake Sfanta Ana, situated at 944 mdM, is 360 m below the watershed in the northern area and 110 m below in the southern area. The surface of the crater is 3.48 sq. km., which means that is ten times bigger than the surface of the lake. From this territory, the mass movement processes, the areal and linear erosion, transit more and more important quantities of material, which reach the basin.

The factors that have determined the modification of morphometric elements of the lake fall in two groups: factors represented by the active forces and factors represented by the passive forces, the forces of resistance.

The active forces act upon the adjacent surface and determine its general denudation, especially the areal and linear erosion. From this point of view, the rain drops, the areal drain and the concentrated drain have an essential role. The rain drops act upon the adjacent surface by hitting – displacing – breaking up – spreading the solid material. From the point of view of the quantity and of the intensity of the showers, the rain represents an active and potentially significant force in the area.

The areal drain erodes the upper layer of solid material only in case of turbulent movement. The form and inclination of the slope, the roughness of the surface enable such hydraulics for the movement of the water layer in the crater of the lake. At the same time, the relation between the time of the drain concentration and the effective duration of the rain ensures the development of a drained layer with optimum thickness and an active role. The irregularities of the crater surface enable successive concentrations of materials and energy, so that the water resulted from the rain and melting snow is channeled over the maximum slopes. As a consequence of these processes, the drain undergoes quantitative and mainly qualitative transformations and the linear erosion becomes active. It is the most efficient in the erosion process of the crater surface.

The forces of resistance are represented by the basic rock, by the soils and by the vegetal layer. The rocks that cover the crater, especially the pyroxene, amphibole and biotite dacites, as well as in situ or modified pyroclastites, develop a strong resistance against the denudation forces. They resist both to chemical reactions and to mechanical erosion. However, the vegetation has the main role of protection. The role of the rain diminishes significantly because the surface is protected mostly by the forest vegetation and, in some places where the latter is missing, by the grass vegetation. The vegetal layer absorbs most of the rain and delays the reach of water to the soil surface. At the same time, the absorption of a part of the ground water by the vegetation diminishes the quantity of water that has an active role in the process of erosion. We also have to mention the role of secondary protective layer of the inferior vegetal level of the leafy forest and of the thick layer of leaves from the soil of the coniferous forests.

However, vegetation has also an active role in the process of silting. Big quantities of leaves, especially in the leafy forests, get in the lake basin through the wind. Another aspect of the biotic silting results from the existence of the shore vegetation. Here we have to mention particularly the formation of peat moss in the north-western extremity of the lake. Its surface increases not very quickly, but constantly. At present it occupies a surface of 12,400 sq. m. and it is more than one meter thick. On the shore strip, in some eastern and southern areas, there are other associations too, formed mainly by different types of sedge. Their remains contribute to the silting of that shore areas.

The soil developed under such litho-vegetative conditions has limited processes of podzolization, with a well structured skeleton, fact that confers resistance against the action of denudation agents.

Consequently, we may say that there is a report of dynamic equilibrium between the active and passive natural factors in the Ciomad crater. This fact ensures a relative good protection of the adjacent surface. The material eroded and transported towards the lake basin, under natural conditions, does not represent dangerous quantities.

However, another factor interferes in this relative equilibrium and determines a state of disequilibrium in this as well as in other areas. This is the anthropic factor. In the past people had built cart tracks that linked the lake and the edge of the crater, then an asphalted road that went downwards from the chalet to the lake. These roads do not show centers of erosion because the cart tracks were abandoned and now are covered by vegetation and the asphalted road is relatively well designed and built.

Still, the tourist activity has a very negative effect upon the processes of erosion. A path goes downwards, on a relatively abrupt slope, from the chalet to the north-western shore of the lake. It passes through the forest and crosses the asphalted road many times. A very active system of ravines, with many alluviums, developed along this path. Big quantities of eroded material are transported through this system towards the lake, and real alluvial cones appeared in the lower parts of some of them.

The ravine system of the north-eastern part of the crater develops on a 100 m altitude range, the upper part being situated at 1060 m, and the alluvial cones deposit at 960 m. The system includes six ravines of different lengths, out of which three have secondary branches. The differentiation of the ravines is made by the serpentines of the road that goes downwards to the lake, so that the 1st, the 2nd and the 3rd ravines practically succeed one after another. This alignment is the most active because here the main path goes downwards from the chalet to the lake. The 4th, the 5th and the 6th ravines represent, in fact, different torrential units. They are less active, the 6th being covered with grass on certain parts.

2. HISTORY OF THE RESEARCHES

The basis of the morphometric analyses is represented by the five bathymetric measurements, which were performed in almost one hundred years: 1909 – 2004. Before the first scientific measurement, there were more or less exact references or partial measurements that had contributed to the knowledge of the lake and of the area.

J. Gelei performed the first bathymetric high of Lake Sfanta Ana basin in 1909. He gave us the first bathymetric map of the lake. It is worth to mention the method of measurement that was used, which seems archaic now, but which gave special results, valid till nowadays: “The distance was given by the measuring tape, and the angle of the sector against the meridian was shown by the mining compass. As a result of the measurement, I drew the outline of the lake like a polynom… I wrote exactly the distances of the shore points, so that I could draw the real line of the shore… The role of the measuring tape, for measuring the depths, was carried out by a two-pound-old weight, which I had bought in Bixad… The role of a boat that glided over the water was carried out by a six meter long and three meter width raft… The third instrument was a 500 m long cord… On the cord, the distances were marked with beer caps, which were tied every 5 meters… I performed 665 measurements along the 17 directions marked with the cord and written on the map with broken lines… I continued the measurement each 10 meters, and each 5 meters only near the shore, where the ground was deepening suddenly".

Regarding the maximum depth of the lake, Gelei did not give an exact number because he noticed that light and thick alluviums covered the bottom, and the measurement device penetrated easily into them. He wrote that he had measured nine meter depths many times. He also said that he had not found the maximum depth in the middle of the lake, but in the southern area, in the edge of the crater, where the two axis of the lake met. He had also noticed the relatively small depth in comparison with the size of the lake. Because the measurement was performed in a dry period, he estimated a medium depth of more than four meters.

After almost 50 years after Gelei, I. Pisota and I. Nastase had performed other bathymetric measurements in 1957. They reached the conclusion that the morphometric elements had generally diminished, that the northern and the western shore had moved forward, that the form coefficient of the lake had changed and that the medium depth had not been modified. They mentioned a maximum depth of seven meters, but the isobath of their map marked a surface of more than 17,000 sq. m, which meant that there were bigger depths. In relation with the submerse form of the lave basin, they wrote that there was a 280 m long light slope in the north-eastern part, which deepened suddenly for 96 m in the southern part. The most important result of their research was the new bathymetric map of the lake. They also mentioned the fact that the volume of the lake increased with about 40,000 m^3 after the snow melt.

The elements presented by P. Gastescu in 1971 are very similar to those of Pisota and Nastase. The volume and the wet perimeter were unchanged, the maximum depth was the same, but the length and the width were a little bigger. It was interesting that the surface of the lake was bigger than the surface measured by Gelei. He mentioned the fact that the maximum depth decreased with five meters in about one hundred years, which was the result of the general small depth of the lake, and the consequence of the form of submerse cone.

Cs. Janosi and J. Benedek performed measurements in 1971, too. Their multilateral activity is known especially from the indirect references and their own manuscripts, as they wrote down little information. Janosi performed bathymetric measurements and drawn up an exact map of the lake basin. From the morphometric data, we may see of the lake size diminished in comparison with Pisota and Nastase's measurements.

In 20014, some students of the Faculty of Geography of Cluj performed observations and complex measurements of the Lake Sfanta Ana and of the adjacent area. They performed the measurements with modern instruments of high precision. For the first time, they performed a bathymetric measurement using an echo-sounder. The results indicated a decrease of the whole morphometric parameters.

3. MORPHOMETRIC ELEMENTS THAT WERE MEASURED

The elements that were determined through direct measurements during the researches are: wet perimeter, maximum depth, length, width.

Table 1. Morphometric data that were measured

Year	Author	Perimeter (m)	Maximum depth (m)	Length (m)	Width (m)
1909	Gelei	1749	8-9	680	470
1957	Pisota	1737	7.0	620	464
1971	Gastescu	1722	7.0	643	488
1971	Janosi	1712	7.2	618	477
2004	Pandi	1685	6.1	612	450

The wet perimeter decreases by each measurement, 64 m per total. The linear tendency of decrease is very pronounced, but the polynomial tendency is more significant. The intensity of the phenomena is due to the washing of the mineral material from the crater slopes towards the shore. Big quantities of leaves from the adjacent forest get here, too. At the same time, the remains of the aquatic vegetation gather close to the shore. All these phenomena diminish especially the length of the shore. This tendency becomes more prominent during the last period, a fact that is illustrated by the polynomial tendency.

There were references regarding the maximum depth before the measurements mentioned above. There were references regarding 11 – 12 m depths in the second half of the 19th century (Hanko, 1896). If we take into consideration the seven fathom mentioned in 1840 (National Conversations magazine), the total decrease of the maximum depth is 6.9 m, in 164 years. The reference to the maximum depth of seven meters in 1957 and 1971 is not very exact, because it comes in contradiction with the bathymetric maps. The maximum depth of 7.2 m, of Janosi, decreases considerably till 2004. The pronounced diminution of the maximum depth indicates the existence of a specific dynamic of the water, which may modify the deposits on the shore.

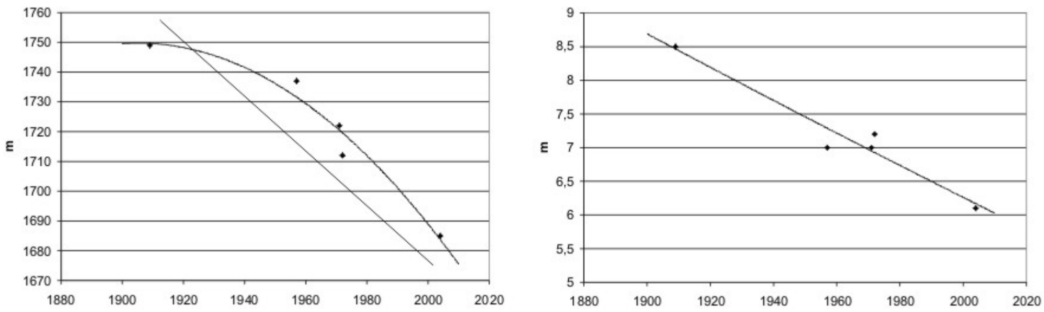

Fig. 1. Evolution of the perimeter and of the maximum depth

The length and the width of the lake do not change so spectacularly. The length decreases by 68 m, which is a 10% diminution. The width is 20 m smaller, which is 4% diminution. The development of the pear moss in the north-eastern corner of the lake contributed to this situation, too.

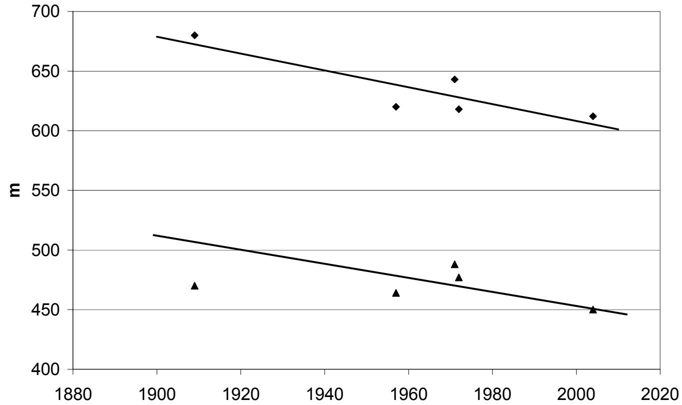

Fig. 2. Evolution of the length and of the width

The morphometric diminutions in the last 33 years are also very important. Therefore, the wet perimeter decreases by 27 m, the maximum depth decreases by 1.1 m, the length decreases by 6 m and the width decreases by 27 m, the last being the result of the tourism activities developed on the beach near the landing stage.

4. MORPHOMETRIC ELEMENTS THAT WERE CALCULATED

The morphometric elements that were calculated also demonstrate the evolution of the lake. Their determination was possible only in the context of the bathymetric measurements, carried out since 1909.

Table 2. Morphometric data that were calculated

Year	Author	Volume (m^3)	Surface (sq. m)	Mean depth (m)	Mean width (m)
1909	Gelei	862483	213910	4.0	315
1957	Pisota	786360	195280	4.0	315
1971	Gastescu	780000	220000	3.5	342
1971	Janosi	724920	193829	3.8	314
2004	Pandi	580150	189900	3.1	310

We may see a continuous decrease in the lake surface, except in 1971, when it was determined by P. Gastescu. The total decrease is of 24010 sq. m, which illustrates a pronounced tendency. In the last 33 years the surface decreased by almost 4000 sq. m.

The diminution of the volume is more significant than the diminution of the surface, which reached a value of 282,333 sq. m. The polynomial tendency shows that the tendency has become more prominent during the last period. The diminution in last 33 years is of 144,770 m^3.

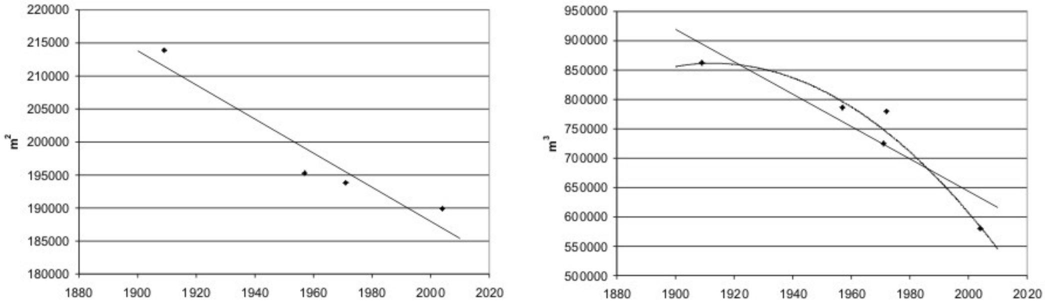

Fig. 3. Evolution of the surface and of the volume

The average depth is about one meter smaller, the average width is five meters smaller, and the average length is five meters smaller.

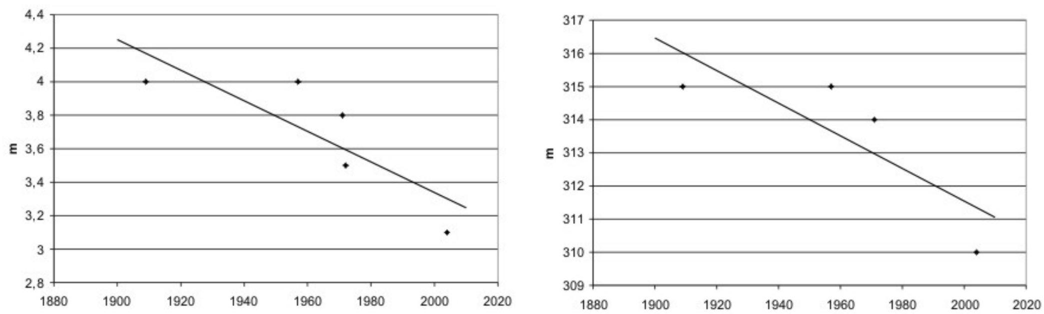

Fig. 4. Evolution of the mean depth and of the mean width

5. CONCLUSIONS

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