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THE LAKES FROM ROŞIA MONTANĂ

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Abstract

The mining industry related to the gold-silver ores has created some particular category of lakes, rare at national level. These small lakes have been used for processing the raw material extracted from the open pits or mine galleries. In the past at Roşia Montană were more than 100 lakes with this type of use, but now only few have remained. The paper will analyze the morphometrical and qualitative water features of the lakes and also the will emphasize the touristic potential of these water bodies.
Keywords*:* lakes, mining, water quality, metallic ions

1. Introduction

In the neighbourhoods of Roşia Montană town can be found several man-made lakes, known as "tăuri", which according to the DEX dictionary states for a small lake with shallow waters. For the processing of the ores, extracted from the oldest mining region of Romania, special traditional mills moved by water are used, located very close to the pits or mining galleries (Corpade *et all.*, 2004). Due to low discharges of the streams in this area, the construction of man-made lakes has appeared as a necessity, for the dry seasons. The lakes have been built by private people, associated in groups or as individuals, in the first part of the XX-th century.

2. Lakes inventory

In present days the majority of the lakes are eutrophicated and clogged. The largest lakes have been used also for amusement activities (swimming), and for

fishing, but now are badly managed and are tend to be clogged. Otherwise, the largest parts of the 69 "tăuri", respectively 60 of them are drained, with no water. The disappearance of those lakes is due to the actions of human intervention like: drainage of the lakes, changes in the shores configuration, and changes in the way of terrain uses (Bătinaş *et all*, 1999). The other nine lakes are very small, occupying different position around the village of Roşia Montană. In the table below, are presented the main morphometrical features of the lakes (Table 1).

Table 1. Main morphometrical features of the lakes from Roşia Montană*

Nr.	Lake name	Mean depth (m)	Area (m^2)	Volume (m^3)	Source type
1	Tăul Mare	4,9	32210	160660	creeks
2	Cornei	1,8	8830	15930	creeks
3	Brazilor	3,0	7800	22000	creeks
4	Ţarinii	2,6	10480	27300	creeks
5	Anghel	1,8	4250	8500	rain
6	Cartuş	2,0	750	1500	rain
7	Găuri	3,0	2400	7200	rain
8	Muntari	1,0	1200	1200	rain
9	Ţapului	0,5	2000	1000	rain

* values were adapted after Decei (1981) and Popescu-Argeşel (1984)

Tăul Mare is the largest of the nine remaining lakes, built in 1908, being situated in the upper part of the Roşia Basin and its tributaries with origins in the vicinity of Vârşii Mari peak (fig. 1). The lake is situated at about 930 m altitude, with a tentacle form, developed on the tributaries valley. The dam of the lake is built from stone masonry and has a height of 25 m and a length of 160 m (Decei, 1981). A discharge drain gallery with sliding valves is built in dam basis. The water volume stored in the back of the dam is over passing 160 000 cubic meters, and the medium depth is about 4,9 m. The lake is feeded by three creeks, with a discharge flow of 10 l/s and by a cold spring, situated in the northern part of the lake. In the south-western part of the lake it can be found the concrete hydraulic well which assures the water flow into the Pârâul Mare creek (Breazu, 1980).

Tăul Cornii is situated on the upper part of Corna stream, right-hand tributary of the Abrud Valley, at about 500 meters from Brazi Lake. It has a bean shape, orientated north-south, at an altitude of 930 meters. The lake lies in the back of a dike made by a stone wall built in steps, with a 200 meters length and a concrete well for water discharge. The evacuation system runs under the dyke through an iron tube with 50 cm in diameter and 30 meters in length (Decei, 1981). Like other reservoirs the lake knows an advanced stage of clogging. The north-western slope, is affected by two torrents and has created a very sinuously shore line. The maximum depth is developing near the dike and does not exceed 3.6 meters. The

medium depth is about 1.8 meters; the volume accumulated in the reservoir is closing to 16000 m^3, while the surface is about 8830 m^2.

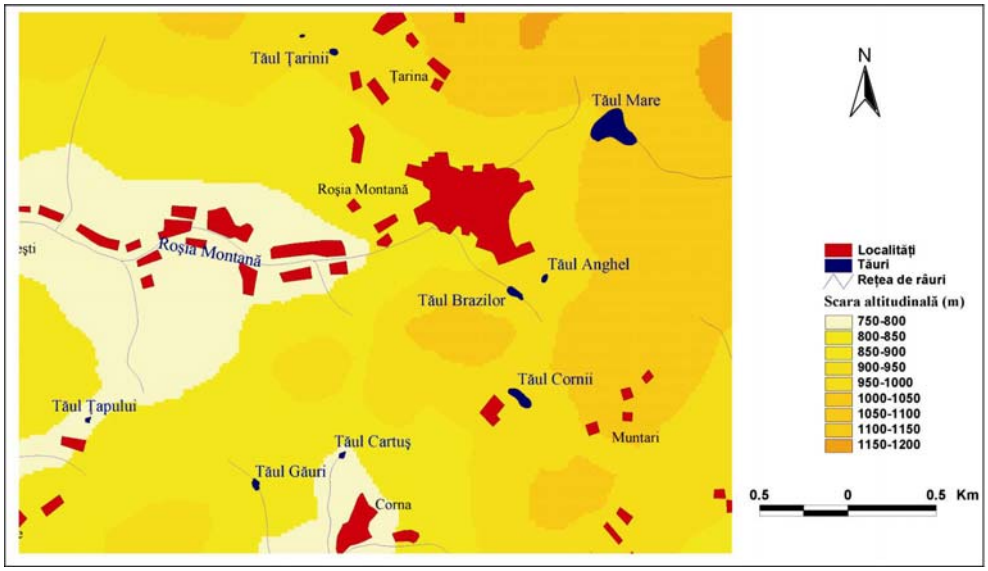

Figure 1. Map of the lakes from Roşia Montană

Tăul Brazilor is situated on the opposite slope of Ţarina Lake, in the upstream part of Roşia Montană, into a very pleasant sight (fig. 1). It is the third lake by size from the area, being situated at about 950 m altitude. The lake has a circular form, with a surface of 7800 m^2, a length of 108 meters and a width of 104 meters (Decei, 1981). The lake is supplied by Brazi Creek, with a discharge flow of 6 l/s. The water supply is also assured by the trickling waters drained from Anghel Lake, situated upstream at about 120 meters. In the front of the 10 meters height' dam has been determined the maximum depth of 5.5 meters, while the medium depth is around 3 meters the water volume stored in the lake is close to 22000 m^3 (Breazu, 1980). Despite the rocky shore, the water in the lake is turbid, due to the trickling waters from the slopes.

Tăul Ţarinii is situated in the north-western part of Tăul Mare Lake, at an altitude of 950 m. It has an ellipsoidal shape, being built in 1912, by damming the Ţarinii Creek with a stone wall of 135 meters in length (Decei, 1981). The water flow is assured through a concrete reversed-well which runs by an underground tunnel. The catchment area of the lake is about 2 km^2, with south-eastern oriented slopes, covered by grass or with bear rock. In the back of the 10 meters height' dam, the lake covers a surface of 10 480 m^2, with a maximum depth of 4.5 meters and a mean depth of 2.6 meters.

Tăul Anghel is situated at about 987 m altitude, with an oval shape, developed on the north-east – south-west direction, with grassy shores, with a small

sinuosity. The lake is dammed by a 40 meter dike, on the south-eastern part of the lake. The hill flow has created a small creek which brings in the reservoir about 2 l/sec. The length of the dike is about 100 m, with a wide of 54 meters (Decei, 1981). The deepest point is situated in the centre of the lake and it's about 4.5 meters. The surface of the lake is 4250 square meters and the volume reaches 8500 cubic meters. The overflow of the excess volume of water is done through a so-called „prea plin" built in the dike body, and the evacuation is made through a tunnel with fetter, situated on the south-western part of the reservoir. The lake is gaining water from several springs situated on the north-western part of the lake.

Tăul Cartuş is situated in the proximity of Brazi Lake, with smaller features, due to the very narrow river bed, where it was formed. The reservoir, with an advanced rate of clogging, has a small surface, of about 730 square meters and a maximum depth of about 2 meters.

Tăul Muntari is situated near the village with the same name, on the source area of a spring which runs into the Buciumanilor Valley. This lake is the oldest lake in the area used for the wooden stamps. With a surface of 1200 m^2, the lake has a maximum depth of 2 meters, being covered with a thick layer of silt on the bottom (Decei, 1981). The lake has almost a perfect round shape and is supplied by 2 creeks with a cumulative discharge of 5 l/s. The south and western shores are covered with shave grass while the north one is steep towards the beech woods.

Tăul Găuri is situated in the back of Cetate quarry, near the waste dumps, in the upper part of a creek which runs towards Cornei Valley. The lake is dammed by a small wall of stone, and is one of the smallest lakes from the area.

The water inflow in the lakes is due in the first place by direct rainfalls, slope flow through the torrents. The lake water supply is made by variable discharge flow, according to the seasons. The highest discharge values were recorded on the streams which flow into Tăul Mare reservoir (21 l/sec.). The Ţarina and Brazi lakes are depending on a few streams with discharges between 10 and 11 l/sec. The underground flow into the lakes is increasing in the periods between rains, but does not provide a constant level of water in the lakes. The loss of water is done by two ways: the underground flows through the rocks, but also by the bottom pipes or by the dyke pipes situated on the highest level.

The lacustrian flora and wildlife's is represented by the following item: Spirogyra Algae, microscopic algae, reed, and other aquatic plants. On the shores the vegetation is formed by arborescent species like: willows and wicker on the slopes by deciduous and coniferous woods. The lacustrian fauna is represented by zooplankton which is consumed by the fish species: chub, carp, and trout (colonized). In the present days the fish population is very low, due to human intervention and also due to natural process of clogging and vegetation development.

3. Phisyco-chemical features of lakes´ water

The small reservoirs from the Roşia Montană area are not used for any particular economic purposes, being capitalized eventually in touristic and fishing activities. Thus, in the Tăul Mare and Tăul Brazilor the bathing is frequently practiced in the summer season. Fishing is not a frequent activity, because the fish population is very weak and does not include valuable species, although there are good conditions for ecologically important species. Water thermic amplitude is quite low (16 °C-July, 6 °C-November), and the pH lies between the neutral interval limits, with values from 6.5 to 8.2 units; the electric conductivity is around 71 mV (October, 2006). The water supply of Ţarina Lake is made through a creek with a discharge around 5 l/s, a pH between 6,3 and 7,5 and a water temperature oscillating between 8 ºC (April and November) and 19 ºC (August). The dissolved oxygen reaches high values (9 mg/l). The water samples taken from Brazi reservoir have indicated temperature values of 14-15°C (September 2004), a pH between 6.3-7.9 and electric conductivity of 57 mV (Bătinaş, 2007). The Anghel reservoir, with a smaller water supply, has a higher summer temperature (20 °C) and a pH of 6.2 units (fig. 2).

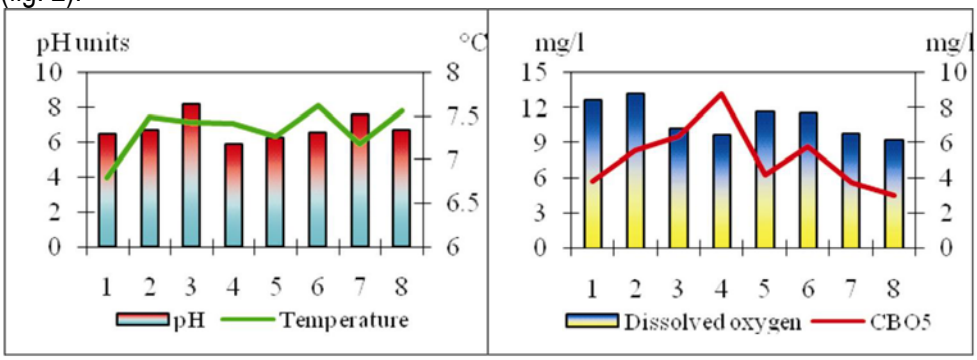

Figure 2. Physical parameters monthly variation in the lakes water (1.Cartuş; 2.Corna; 3.Mare; 4.Brazilor; 5.Ţapului; 6.Găuri; 7.Anghel; 8.Ţarinii)

The physico - chemical water indicators from the lakes are comprised in the typical limits of high altitudinal lakes, with high oxygenation, proper for the development of fish population. Thus, the pH and water temperature are oscillating in small limits, as presented in the diagram from figure 2. The oxygen regime shows a good water aeration, in which the oxidation processes of organic substances are relatively reduced.

The chemical composition of the water has particular features related to the geology, soil typology and location of the lake towards the potential sources than can change water quality (acid mine drainage that are running from the rock dumps). In the table above are presented the concentrations of cations and anions which

define the water chemistry of the lakes (Table 2).

Table 2. Major chemical ions and water mineralization of the lakes (mg/l)*

Nr.	Lake / Ions	Ca^{2+}	Mg^{2+}	Na^{+}	Cl^{-}	SO_4^{2-}	HCO_3^{-}	NO_3^{2-}	Mineralization
1	Cartuş	25.94	3.61	1.09	6.75	52.74	30.50	0.79	123.93
2	Corna	43.46	6.20	2.29	6.75	43.71	106.75	0.21	213.39
3	Mare	37.26	3.89	1.93	6.75	26.23	79.30	1.24	157.72
4	Brazilor	29.28	3.13	1.90	6.21	13.53	82.35	0.14	138.73
5	Ţapului	17.94	2.58	0.79	6.21	2.35	73.20	0.26	105.04
6	Găuri	50.48	14.03	2.23	6.21	63.14	146.40	0.45	283.71
7	Anghel	13.66	1.23	1.51	2.33	2.30	39.65	0.29	62.07
8	Ţarinii	28.50	2.76	2.08	10.30	5.64	79.30	0.22	132.18

* values obtained from „Roşia Montană Gold Corporation" (October, 2003)

Thus, the highest values related to the cations group are recorded to calcium, followed by magnesium and natrium (fig. 3). The largest values in the anions groups are recorded for sulphates, bicarbonates and nitrates.

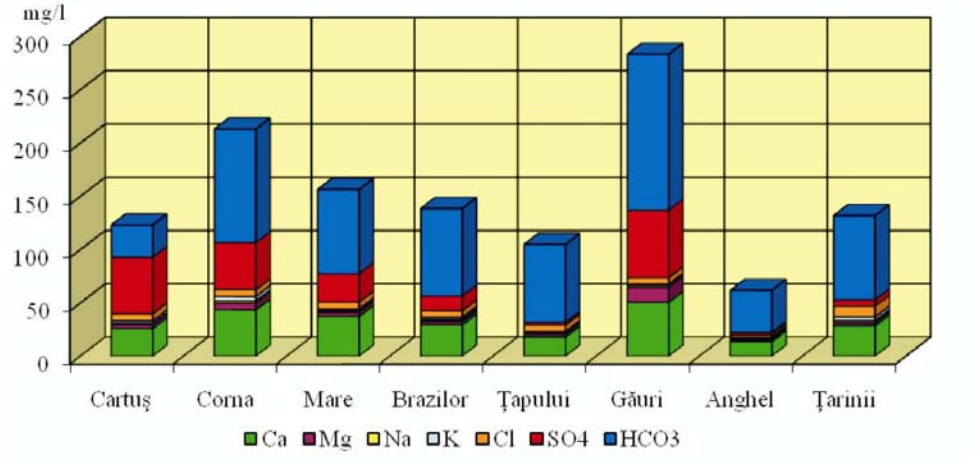

Figure 3. Chemical composition of the lakes from Roşia Montană

Based on the values presented above we can say that the bicarbonate ions are dominating the chemical composition, against sulphates and calcium. The other ions have a small amount and do not change significantly the values of water mineralization (Bătinaş, 2007).

The water analysis has lead to the identification of two classes of water mineralization:

- Bicarbonate water, calcium group, type II (C_{II}^{Ca}) for the majority of the lakes: Corna, Mare, Brazilor, Ţapului, Găuri, Anghel and Ţarinii;
- Sulphated water, calcium group, type II (S_{II}^{Ca}), for Cartuş Lake.

The water mineralization is higher, just in the case of Găuri Lake (283,71 mg/l), situated near the rock dumps deposit resulted from Cetate quarry. The others lakes have a low mineralization (fig. 4). The minimum values were established for the water from Anghel Lake.

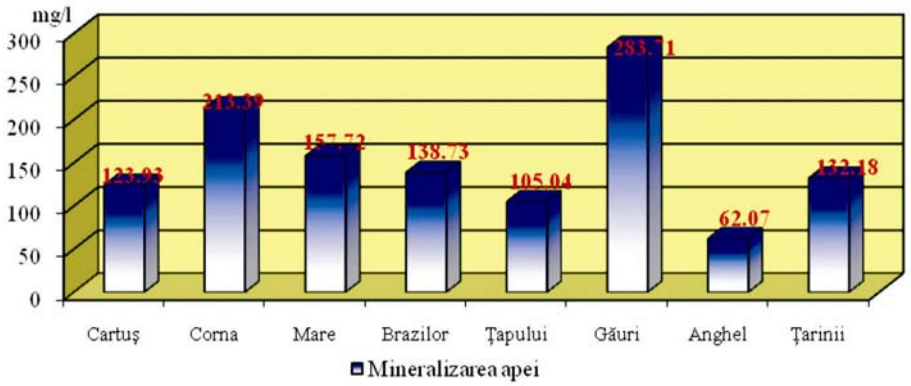

Figure 4. Water mineralization of the lakes from Roşia Montană

Beside the major ions presented above, the water of the lakes also has small concentrations (µg/l) of dissolved metallic ions. The area is well known for its major gold-silver deposit but the rocks are containing also important quantities of metallic ions combined in different chemical compounds, mainly as sulphurs.

In table 3 are presented the concentrations of several metallic ions that are usually found in mining waters. The main proportion is related to zinc, selenium, molybdenum and copper, followed by nickel and chromium. The smallest amounts are recorded for cobalt and lead. Also the water contains some small traces of mercury, a toxic element for water life

Table 3 Minor ions in the water of the lakes from Roşia Montană (µg/l)*

Nr	Lake / Ions	Cu	Ni	Pb	Zn	Cr	Co	Hg	Mo	Se
1	T. Cartuş	8.744	9.51	0	46.72	0.92	0.023	15.6	22.4	34.14
2	T. Corna	5.936	0	0	36.24	1.721	0.215	10.72	31.1	23.49
3	T. Mare	4.028	0	0	26.85	1.641	0	6.81	18.5	25.58
4	T. Brazilor	1.672	0	4.3	34.17	3.852	2.914	4.71	10.7	19.56
5	T. Ţapului	36.65	2.289	0	149.1	19.52	4.121	4.5	8.69	30.83
6	T. Găuri	32.6	2.415	0	30.57	0.664	0.403	3.72	29.7	55.52
7	T. Anghel	2.174	0	0	14.18	1.969	0	6.09	1.44	29.46
8	T. Ţarinii	187.2	0	0	43.56	3.279	4.621	12.92	6.35	76.11

* Values obtained from „Roşia Montană Gold Corporation" (October, 2003)

The highest values are recorded in Ţapului and Ţarinii Lakes, where the weight of the metallic ions, is exceeding 255 µg/l, while the smallest concentration values are found in the water of Anghel Lake (fig. 5). The high values recorded for

the water of Ţarinii Lake, is explained by its position, on the external slopes of Cetate quarry.

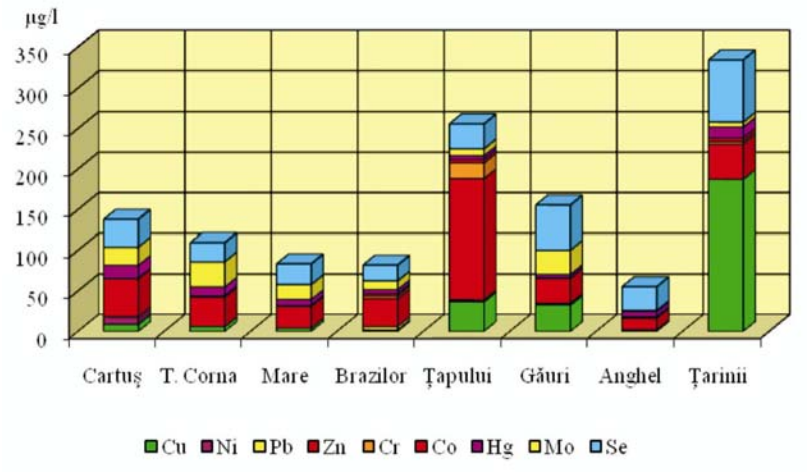

Figure 5. Metallic ions in water of the lakes from Roşia Montană

From the detailed analysis of each chemical ion, the highest values are associated to zinc, copper and selenium, while the smallest concentration are recorded to chromium, cobalt and mercury.

4. Conclusions

The lakes from the vicinity of Roşia Montană village are one of the rarest categories of lakes found in Romania, a reminder of the ancient extraction methodology used for gold and silver mining in the last century. Today the lakes are abandoned for mining use, but can be used for fishing or tourism activities (Popescu-Argeşel, 1984). Despite their small size, the lakes represent an important role regarding the touristic potential of this area that can be developed in the near future. The controversial project managed by a foreign company, related to the gold-silver deposit is now suspended by the authorities. The lakes are now in the administration of the village town hall. Thus, it has established the idea of a possible concession of the lakes for the arrangement of fishing reservoirs. The quantitative and qualitative features of the water are defined by the role of the climate, and alimentation sources, but also by the mining activities which are affecting the area, from the ancient times.

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