THE CLASTOCARSTIC (CROV) LAKES IN BRĂILA PLAIN. GENESIS, HYDROLOGICAL FEATURES, PRESENT CONDITION

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ABSTRACT.- The clastocarstic (crov) lakes from the Brăila Plain. The wide development of interfluvial spaces (30-40 kms wide) dipping very slightly (10-15 m/30-40 kms), the presence of loess-like deposits and eolian sands reduced fragmentation leading to the predominance of clasto-carstic depressions (crovs) realized by suffusion and setting processes. The semiarid continental temperate climate featured by hot summers and cold winters;the quantity of the precipitations is small (450-550 mm/year two thirds of which fall in winter-spring) while potential evapo-transpiration is high (some 700 mm/year) whinch means a deficient humidity (of some 150-250 mm/year. Against this morphological, litilogical and climate background the local water network is represented by a few waterways with temporary flow which ends up toward the confluence with fluviatile limans and in "crov" lakes that have a permanent/temporary regime, too. Most of these lakes are distinguished by a high degree of mineralization which makes them fall into group of brackish and sault lakes.Some of these lakes have used for balneary treatment (for instace Lacul Sărat-Brăila, Movila Miresii) and fish breeding (Plopu, Secu, Lutu Alb).

Key- words:suffosion**,**,depression, salt/fresh/brackish lakes, utilisation

1.GENERAL CONSIDERATIONS

The clastocarstic(crov)lakes represent a typical category as morphogenesis, morphological, hydrological and hydrochemical features, particularly for the Bărăgan Plain, which includes the Southern Bărăgan, the Central Bărăgan (the Bărăgan of Ialomiţa) and the Northern Bărăgan (Brăila Plain) (fig.1.).

The Romanian name of *crov* (suffosion depression), frequently encountered in the Bărăgan, designates the sinkholes in loess deposits; they are also named *găvane* in the Teleorman plain and *padine* in the Ialomiţa-Ilfov Plain, without being differentiated genetically or as size or shape. These names have been taken over in the denomination of certain localities situated more or less in the above-mentioned plains.

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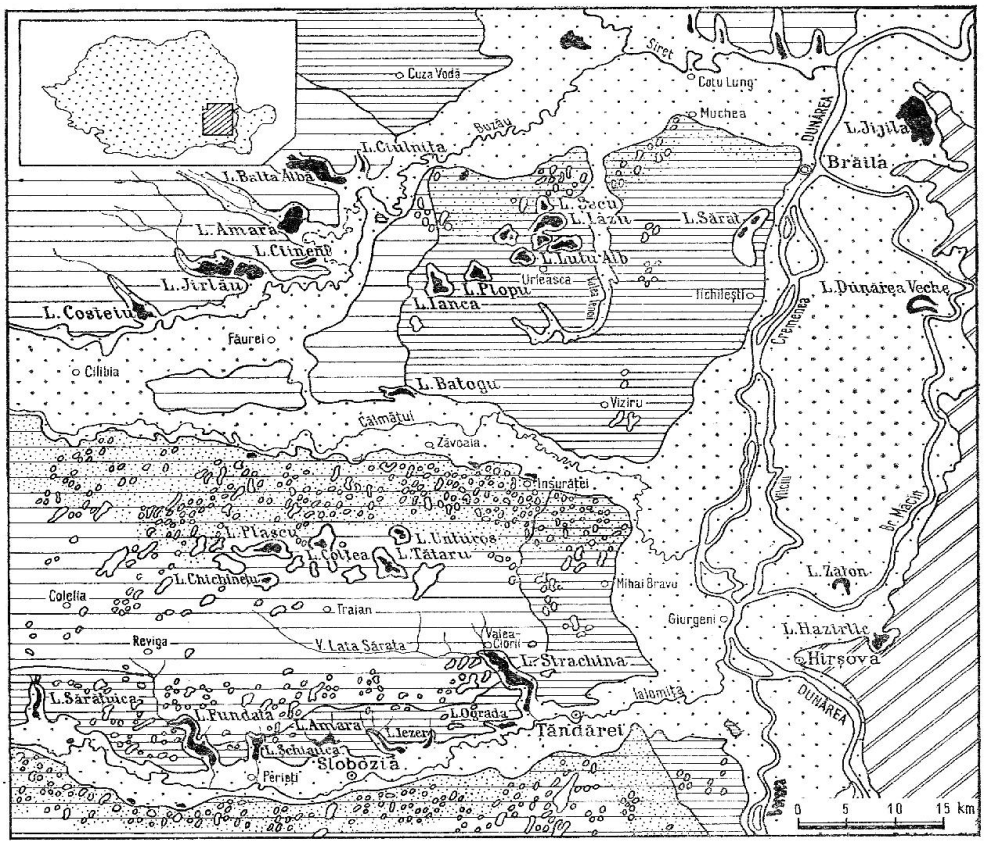

Figure 1. The lakes from the North-East Romanian Plain.

2. GENESIS OF THE CLASTOCARSTIC (CROV) DEPRESSIONS

Regarding the genesis of the crov depressions, there are some explanations, namely: the loessoid deposits of the Southern Romanian plain – particularly those in the Bărăgan - are between 5 and 30 m thick, their content of $CaCO_3$ is of 12 up to 17%, their porosity is of 58-62%, and the water drainage surfaces (interfluvial areas) have a low inclination (0.6-0.7‰), on which the meteoric waters stagnate during the periods when there is excessive water, favoring their infiltration and development of the sinking process through ***chemical*** and ***mechanical suffosion***.

The result of the complex sinking process, the physical-mechanical and chemical properties of the deposits sunk from the bottom of the suffosion depressions are modified compared to the initial ones, as follows: the dimesional weight is bigger, up to 200 g/m^3, the volume of the porosity becomes lower, going

down to 30-40%, the permeability becomes low; the $CaCO_3$ quantity is higher in the cementing horizon, favoring the water storage (M. Pascu, 1961).

The thickness of the loessoid deposit in the Brăila Plain is lower compared to the southern areas, thus, it is 5-7 m in the marginal parts and just 2-3 m in the central area, where one can find the largest depressions occupied by lakes.

The configuration of the relif of the Brăila Plain is simpler compared to that of the Southern Bărăgan and of the Central Bărăgan, due to the lower number of the depressions and secondary valleys. Here, one can no longer see a multitude of depressions, since they are less numerous but their surfaces are larger, and they are grouped in the central area, namely – Ianca (5 km^2 and 10 m deep), Plopu (5 km^2 and 10 m deep), Lutu Alb (5.6 km^2 and 6 m deep), Iazu-Movila Miresii (4 km^2 and 9 m deep), Secu-Movila Miresii (1.5 km^2 and 8 m deep), and Esna (3.2 km^2 and 6 m deep) (fig. 2).

Foto Movila Miresii Lake

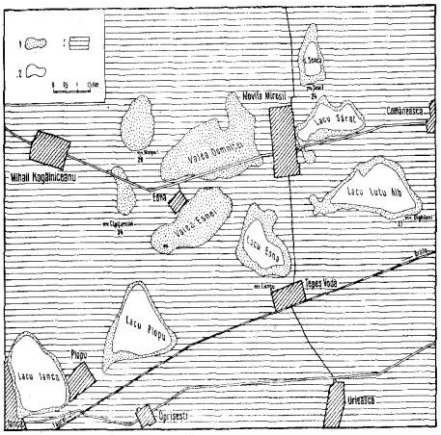

Figure 2. The area with crov **lakes**

The loessoid deposit in the Brăila Plain - where there are also the largest lacustrine depressions - is less thick compared to the Central Bărăgan and the Southern Bărăgan, therefore, the sinking-suffosion process does not have a suitable support to occur. Thus, some researchers, although admitting the sinking process in the depressions genesis, also consider that it involves the influence of the preloessian relief and the deflation (G. Vâlsan, 1917) of the morphology inherited after the drying/withdrawal of the Levantine-Quaternary Lake, or the erosion/abrasion processes, in the case of the existance of lake water (P. Coteţ, 1957).

A particular position among the lakes of the Brăila Plain is that of Lacul Sărat (The Salty Lake), which lies near the homonymous locality and 5.5 km away from Brăila Municipality - sometimes considered as a part of it, which is why it is known in the geographic literature as ***Lacul Sărat-Brăila***.

Although in many specialty papers it is included in the category of suffosion depression, this lacustrine depression is a fragment of a depleted branch of the Danube situated on the last terrace of the Danube, also named the Brăila terrace. Being isolated from the fluviatile activity / modeling, the depression developed later on through the action of the sinking processes.

Lacul Sărat-Brăila consists of two basins - Lacul Sărat I (78 ha and 1.15 m maximum depth) and Lacul Sărat II (110 ha and 1.10 m maximum depth) (fig. 3).

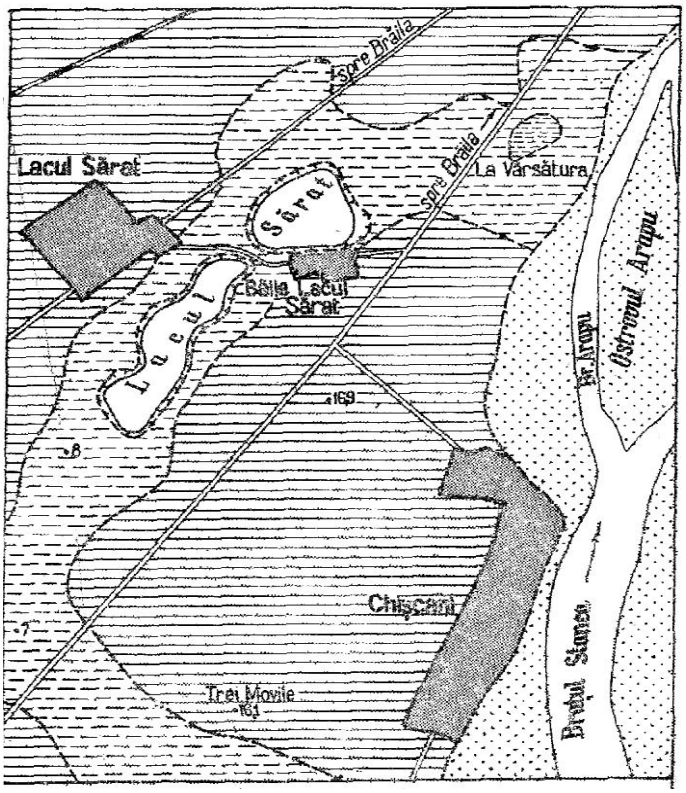

Figure.3. The Salt-Brăila Lake

3. THE ORIGIN OF THE SALTS

On the origin of the salts in the crov lakes and in the fluviatile limans of the Buzău and Ialomița Rivers, as well, there are several opinions/hypotheses, namely:

* The lakes' water salts could come from the Sub-Carpathian saliferous massifs, through the underground waters and reach the crov depressions as salty ascensional springs (Gr. Ştefănescu 1888, C. Istrate 1884). This hypothesis has

some shortcomings, such as the existence of the phreatic and deep fresh waters around the crov depressions, the long distance from the saliferous massifs (up to 120 km), the interposition of faults and river beds with significantly thick alluvions, such as those of the Buzău River.

* The salts could be a "heritage" from the old Sarmatian Sea, which lasted intermittently up to the end of the Pleistocene (of the Quaternary), and occupied the Eastern part of the Romanian Plain. This hypothesis is supported by hydro-chemical analogies (made by P. Poni, 1900) with the chemism of the Amara-Ialomiţa, Fundata, Ianca, Sărat-Brăila Lakes, which is closer to that of the Black Sea. C. Brătescu (1921) explains in the same way the origin of these salts but the arguments supporting the continuity of these depressions since the Pleistocene remain isolated and epeirogenetic. In the opinion of C. Brătescu, the chemism of the lakes is older compared to that of the salty limans, which have a secondary salinization.

*The salts of these depressions come from the phreatic and deep waters that reach the earth's surface through evapotranspiration and the driving of the resulted salts through the runoff in the lakes (G. Murgoci 1908, P. Petrescu 1940, E. Liteanu and C. Ghenea, 1962, P. Gâştescu, 1965). Regarding this hypothesis, there are two more interpretations: *the first one* (L. Mrazec 1901 and H. Ioaniţoaia 1970) is that salts would result by washing from the saliferous clays of the basis of the loessoid horizon (Movila Miresii, Secu, Lutu Alb Lakes): *the second one* (N. Florea, 1970, P. Gâştescu, 1971) is that the hydro-chemical type and the salinity result from the metamorphosis of the underground waters and of the meteoric ones that have reached the lakes, under the influence of the current climatic conditions, according to the model (fig. 4).

Aridization conditions

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Bicarbonated (carbonated ↔ sulphated ↔ chlorinated) class

Pluviosity conditions

←----------

Figure 4. Metamorphosis of the hydro-chemical types, depending on the climatic conditions

4.HYDROLOGICAL FEATURES

The configuration of the lacustrine depressions, the size and shape of the drainage basins determine certain particularities of their hydrological regime. Thus, the drainage basins of the lakes situated in suffosion depressions is limited, in most cases, to the upper limit of the depressions, compared to those of the fluviatile firths. A significant indicator in the hydrological regime of the lake is the

lacustrine surface index (K), as a report between the surface of the drainage basin **(Fd)** and that of the lake **(Fl) (K=Fd/Fl).**

The **K** index value, in the case of the fluviatile limans, in the area of the North-Eastern Romanian Plain is ***over 10***, going up to 40-50 and ***under 5*** for the depressions, being frequently between 1 and 3 (tab.1).

Table 1. The lakes of Brăila Plain – morpho-hydrographic features and use *

Lake	**Fd (km^2)**	**Fl (km^2)**	**K**	**P / T**	**Thc**	**Use**
Ianca	5.0	3.2	0.64	P	CL-NA	alneotherapy-partly, locally
Movila Miresii-Iazu	6.0	2.05	0.34	P	Cl-Na	balneotherapy-locally
Movila Miresii-Secu	2.5	1.5	0.60	P	HCO3-Na	fish breeding
Plopu	5.0	3.0	0.50	P	Cl-Na-tranz	fish breeding
Esna	3.2	2.6	0.81	P	Cl-Na-tranz.	XXX
Lutu Alb	5.6	2.0	0.35	P	Cl-Na-tranz.	fish breeding
Sărat-Brăila	3.0	1.72	0.57	P	Cl- Na	balneotherapy-nationally

***** Fd- depression area; Fl- lake area; K – lacustrine area index K=Fl/Fd; P- permanent /T – temporary lake; Thc- hydro-chemical types; U-use

In the lakes,as mentioned above, through the depression's morphological configuration, the surface discharge is limited and episodic for the low slopes whose depth does not go over 10 m, and the discharge out of the lake is inexistent at the analyzed ones. In exchange, the underground contribution is frequent, by which the permanence of the Brăila Plain's lakes is assured, considering that precipitations **(X)** are of about 500 mm/year, with a multiannual variation of ± 20 mm, yet they may also be ± 200 mm, depending on the droughty or rainy years and the potential evaporation **(Z)** is of 900 mm/year, and even 1,000 mm/year; thus, there is a negative potential balance in these lakes **(X - Z= - ΔV).**

The Brăila Plain, characterized by a semi-arid temperate continental climate and by lakes situated in semi-isolated depressions from a morpho-hydrographical perspective, records periodical climatic variations reflected in the respective hydrological balance, in the hydro-chemical types, predominantly chlorosodic-magnesian, in the mineralization degree from *brackish* up to *salty* and *hipersalty* (Movila Miresii-Iazu, Sărat-Brăila), with some fresh exceptions, which also have a proper use (balneotherapy, pisciculture) (tab. 2).

A large drainage basin compared to the size of the lake assures - through the runoff - a higher water input to the hydrological balance, certainly under the conditions of the respective region's climate. In the case of crovs, we can

appreciate that only during the quick-shower precipitations there is an episodic discharge from the depressions' flanks into the lake **(Y_I)** and there is no discharge going out of the lake through emissary **(Ye).**

Referring to the hydrological balance of the crov lakes of Brăila Plain, it has two fundamental components: precipitations received by the lacustrine wetlands **(X)** and evaporation of the same area **(Z).** To these components, depending on the morpho-hydrological conditions, one can add the discharge out of the surface drainage basin into the lake **(Y_I)** and out of the lake **(Ye**), the underground contribution by lateral springs and submerged springs **(U_I)** and the infiltration in the lacustrine wetlands **(Ui),** expressed by the relation:

$$(X + Y_I + U_I) - (Z + U_i) = \pm \Delta V \text{ or } X + Y_I - Z \pm U = \pm \Delta V, \text{ from}$$

± ΔV is the difference of water volume (accumulated or lost), calculated for a certain time period (usually, one year).

$$(X + Y_I + U_I) - Z = \Delta V$$

Out of the lakes of the Brăila Plain, two lakes have been selected, which characterize the genetic types of the lacustrine depressions for which the hydrological balance has been calculated according to the relation K=Fd/Fl (tab. 2).

Table 2. Hydrological balance characteristics of the lakes.

Lakes	*FL* **Km²**	*K FL/ FD*	**X** *N.10³ MC /%*	**Y_I** **N.10³ mc /%**	**U_I** *N.10³ MC /%*	**Z** *N.10³ MC /%*	**Ys Mm ± ΔV**
Movila Miresii	0,20	0,244	1000 / 66,6	70 / 4,7	4300 / 28,7	1410 / 100	0
Sărat-Brăila	0,02	0,025	97 / 51,2	31 / 16,2	63 / 32,0	189 / 100	0

5. LAKE WATER QUALITY

As mentioned in table 2, the use of the lakes in Brăila Plain is for ***balneotherapy*** (Sărat-Brăila, Movila Miresii-Iazu Lakes) and ***pisciculture*** (Movila Miresii-Secu, Plopu, Lutu Alb Lakes). Their surveillance is carried out, as a rule, by the Water Management System (SGA) of Brăila, but in the case of fish breeding, they are supervised by the farmers who have their custody, and Sărat-Brăila Lake is, of course, supervised by the administration of Lacul Sărat Resort. As for Movila Miresii Lake, which does not have special facilities, the surveillance is the responsibility of the authority of the homonymous commune.

Regarding the therapeutic qualities of Lacul Sărat-Brăila, they have been in the attention of many chemists, biologists and balneology doctors beginning with the end of the 19th century and the beginning of the 20th century (Romniceanu

1887, Gr. Ştefănescu 1888, P. Bujor 1900, V. Dumitriu 1908), the ***Balneology Institute*** continued paying attention to them beginning with 1956 and they continue to be researched at present, given the balneotherapeutic potential of the over-salty water and of the sapropelic mud-***peloid***, which has determined the development of the homonymous resort operating throughout the year.

Out of the physical-chemical and biological researches of the Balneology Institute, one could find out that under the conditions of a high salinity (over-salty lake), the phytoplankton flora and zooplankton fauna are characterized by a low number of species but by a high number of individuals, favorable to the appearance of the ***therapeutic mud-peloid*** used in the medical treatment. The estimations on the ***peloid*** reserves were of 66,000 m³ in 1975 in Lacul Sărat I, and of 93,000 m³ in Lacul Sărat II (V. Ştef, 1975, Valeria Trică, 1980).

In 2004, SGA-Brăila made some physico-chemical tests on the quality indicators at Lacul Sărat-Brăila and Movila Miresii, by which their quality condition was established, in point of the therapeutic potential of their chlorine, sodium and magnesium content (tab 3).

Table 3. Values of the quality indicators (SGA-Brăila, 200**4)**

Lake / Indicators	Sărat-Brăila		Movila Miresii-Secu	
	average	**maximum**	**average**	**maximum**
pH	8.47	8.63	9.5	9.65
CBO_5	127.8	160	1,224	1,438
CCOMn	352	448	1,400	1,680
P_{total}	0.61	0.69	0.12	0.13
N_{total}	0.17	0.198	1.61	1.79
Sodium	29,975	40,950	68,300	98,500
Sulphates	35,392	50,784	25,056	40,320
Chlorides	48,990	67,450	89,637	122,475
Settled residue	170,740	251,600	254,075	388,800

CONCLUSIONS

The lakes of Brăila Plain have been researched by some important scientists in point of:

* the way of formation of the depressions (sinking by chemical and mechanical suffosion, deflation, remains of a Levantine-Quaternary lake);

* the origin of the salts contained in the chemistry of the lakes of the Sub-Carpathian and ascensional saliferous deposits in the lacustrine depressions,

remains of the Levantine-Quaternary lake, through the evaporation of the underground waters at surface and runoff;

* the lakes' water balance in relation with the semiarid climatic conditions of the Eastern Romanian Plain (Bărăgan) and underground water supply by ascensional springs;

* the quality of the lake waters – at some of them given by the high mineralization degree of the peloid– used mainly in balneotherapy, at Lacul Sărat-Brăila and locally at the lakes of Movila Miresii and Ianca ;

* the brackish /fresh water lakes - Plopu, Lutu Alb, Movila Miresii-Secu are used in pisciculture.

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