



## ANTHROPO-SALINE AND KARSTO-SALINE LAKES FROM OCNA ȘUGATAG – MARAMUREŞ (ROMANIA)

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### Abstract

The basin of diapir anticlinal from Ocna Șugatag entered into the accelerated transformation soon after the cessation of exploitations (the beginning of the years '60). Along of the most 50 years of evolution formed and disappeared lacustrine basins, all on natural way in little dolines, mostly all of them, through the breakdown of galleries or halls of salt exploitation, with the individualization of greatest lacustrine basins. These dynamics rearward are very accelerated, the evidence beeing the crumbling of some portions of borders with a rhythms of 0.5 – 1.5 meters on year. The phenomenon of collapse of the mines is far from beeing finished because the most of these (Mihai and Dragoș) are little affected and the support piling have a reduced diameter. In conditions of the exploitation of the brine from underground in balneary aim, it is possible that in short time to assist to new lakes formation with an bigger surface than ones existing.

**Keywords:** diapir, anthropo-saline lakes, karsto-saline lakes, brine use, epoch and spatial evolution, risk phenomena.

### 1. INTRODUCTION

The scientific researches about quality of salt water from lakes began something more later (the IX<sup>th</sup> century), and were made by doctors, chemists or biologists to the solicitation of the administration of the salt mines, in the aim of touristic or treatment bases improvement. On this line, can be mentioned Pataky S., to Ocna Sibiului (1820), Hanko I., to Turda (1844) and to Sovata (1879), Lengyel B., Telegdi L. and Roth V., to Sovata (1898), Entz G. (1886), following several physico-chemical parameters (temperature, salinity), or biotic constitutive of the salt lakes water.

The researches are intensified in the first half of the XX<sup>th</sup> century: Kalecinszky S. (1901 - Sovata), Visky J. (1911 - Turda), Maxim I. Al. (1929-1943 - Sovata, Sic, Ocna Sibiului, Turda) etc. and were directed especially on the physico-chemical parameters study, but also on the dynamics of the lake basins.

In the second half of the same century appears the first limnological studies and complex hidrogeographical studies elaborate by Gâstescu P. (1963 and 1971) and more later by Sorocovschi V. (2005), as well as studies about the lake basin dynamics accomplished by Marosi P. (1959 - Ocna Mureş), Pişota I. and Popa Gh. (1960 - Sovata), Bobeică I. (1969 - Ocna Sibiului), Panait I., Şişman I. and Bobeică I. (1969 Sovata), Pânzaru Th. (1960-1970 - many locations from Ardeal), Trică Valeria (1983 - Sovata).

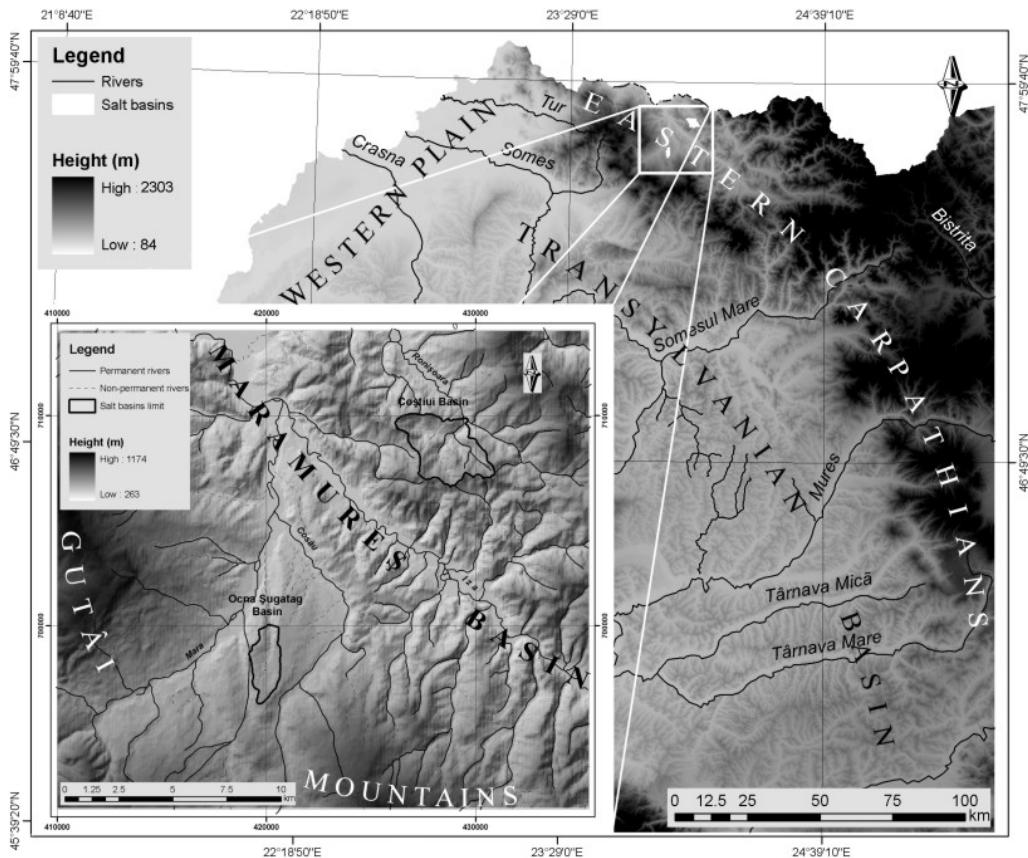
Because the formation of the lakes from the valley of diapir anticlinal from Ocna Şugatag began relatively late (after the exploitation derelictions and the suffusion of the mines - 1 September 1950), the researches about the massif of salt were undertaken more of geologists: Popescu-Voiteşti I., Szentes F., Niculescu N., Dessila Marcela, Năstăseanu S., Maxim I. Al. etc.

The research of the lake complex was hardly realized in the aisle September 1966 - December 1968 by Pânzaru which succeeded a complete counting of all lacustrine units, as well as a extremely rigorous mensuration of the morphological elements and the morphometric of these, followed by a detailed analysis. The two studies of the mentioned author, at which there were added the sensitive prolation achieved of the undersigned, underlay at the comparative analysis of the evolution of lacustrine units which I achieved in the present work.

The massif of salt from Ocna Şugatag represents an apophysis of the unique massif from Maramureşului Basin, apophysis that reached to be diapir, at the surface of the land, exteriorly was cut off of the erosion from Pliocen, after all being covered of the warehouses deluvio-coluvial of the piemont of quaternary age (Pânzaru, 1969). The hypothesis is sustained also by other authors, between whom Popescu-Voiteşti, 1953; Năstăseanu, 1956; Iorgulescu et al., 1962.

Piedmontaneous counterpane from the north of Gutâi Massif, which is expanded between the rivers Mara and Cosău was removed through erosion of to Salt Brook, resulting an oval microbassin of buttonhole type, with the big axis oriented on the direction North-South, that corresponds to the superior basin of mentioned brook (fig. 1).

The versants of the basin are steeped on the eastern and the western flanks and slowly in south, where the torrential erosion penetrated regressive in the piemont structure. The bed of the bassin presents a chaotic relief, result from the conjugated actions of the air's agents and Salt Brook and the antropic factor, which besides the disorderly storage of the sterile from the extraction of the salt, also created conditions for an accelerated dissolution of the mineral, as exteriorly, and much more in the underground. The result is the appearance of more lakes, on the emplacement of the ex mines or in little sinkholes formed through the dissolution salt and the sedimentary material covering subsidence.



**Fig. 1. The position of the buttonholes basin of diapir anticlinal in the space of Maramureş Depression.**

The drainage system exteriorly organized and the underground water control toward the wells collectors permitted the scroll activity of extraction salt within across 24 of June 1948, when the watter infiltrized through the ceiling of the Dragoş mine (last which operated). The consequence was the effectuation of a geological complex study about the mines and surrounding territory, in the year 1949. The conclusions study were not at all favorable continuing exploitations, were revealed meshes of lines of which fissure furrows zone, inclusively the massif of salt; These facilitates a good underground drainage of the water and massive infiltrations to the rooms of exploited salt.

Taking count of these conclusions, the organs of domains disposed the cessation of the extraction of the salt at 11 may 1950, and the official closing of the salt mine at 31 may 1950. The cessing of water extraction from main mines (Bogdan, Mihai and Dragoş), as well as disassembling the underground installations which was acomplished at 1 of September 1950, moment in which began the suffusion of all underground wholes and the accelerated dissoloution of the salt.

## **2. METHODS**

If our predecessors disposed just of levels and theodolites, for topometry operations and a simple manual derrick, for the batimetric, the technical recent endowments realized by the institution facilitated the development of campaigns of quick and accurate measurements.

For the effectuation of the topometry were used doubled Trimble and Magellan GPS terminal, in the sectors with consistent crownings of the arbors, of theodolites. For the batimetrical realization were used simple derricks or with winch, in the case of little lakes with difficult access, and on Gavrilă Lake was succeeded the profiles drawing with derrick ultrason; in the less deep zones the profiles were doublated through classic measurements. For another determinations (ex. physico-chemical parameters), was used a portable case for the water quality able to measure the values of 8 parameters (transparency, temperature, pH, conductivity, oxygen dissolved, salinity, resistivity, the saturation in oxygen).

The centralization and information processing was realized in computerized version using the endowment soft from Hydrologic-Hydrometric Laboratory and of the university: Microsoft Office XP; The Scientific Software Group's "Groundwater Modelling System-GMS"; The Scientific Software Group's "Watershed Modelling System-WMS"; The Scientific Software Group's "Surface-Water Modelling System-SMS"; ESRI ArcView 3.x; ESRI ArcGIS/ArcINFO 8.x.

## **3. RESULTS**

The effect of the underground salt dissolution and at the diapir surface was the forming of 8 anthropo-saline lakes and of 35 karsto-saline lakes (Pânzaru, 1969), many among these beeing some little sizes pits. In the present moment there are preserved just 8 anthropo-saline lakes (some of the old ones disappearing and other new ones appearing afterwards) and just 4 carstosaline lakes, the rest of them beeing clogged and filled up with higrofila and hidrofila vegetation (fig. 2 and 3).

The anthropo-saline lakes (antropogenous) formats, at large in, through the breakdown of the ceiling of the salt mines as consequence of the sustaining pillones dissolution inside the exploitations rooms. The process took place because of the phreatic waters infiltration inside the salt mines and the suffusion after the evacuation of the fittings of exploitation. On the respectively emplacement were formed some huge pits, which gradually were filled up with water either from precipitations and the stream of versant, either from underground contribution. In many cases, the halina solution formed inside the mines arrived at saturation, through these stoping the dissolution process and conffering a relative stability to the sustaining elements that remained unaffected.

The karsto-saline lakes constituted in sinkholes, formed, on two ways: through the crumbling of little amplitude of the ground which was covering some underground gaps , produced at the surface of the salt massif of the infiltration of underground waters; *through the slow subsidence* of the ground, after the chemical suffusion, respectively the outcrop

dissolution from the vesture salt, or the mineral from massif exterior, followed by the mechanic suffusion under the effect of the waters of infiltration or the underground ones.

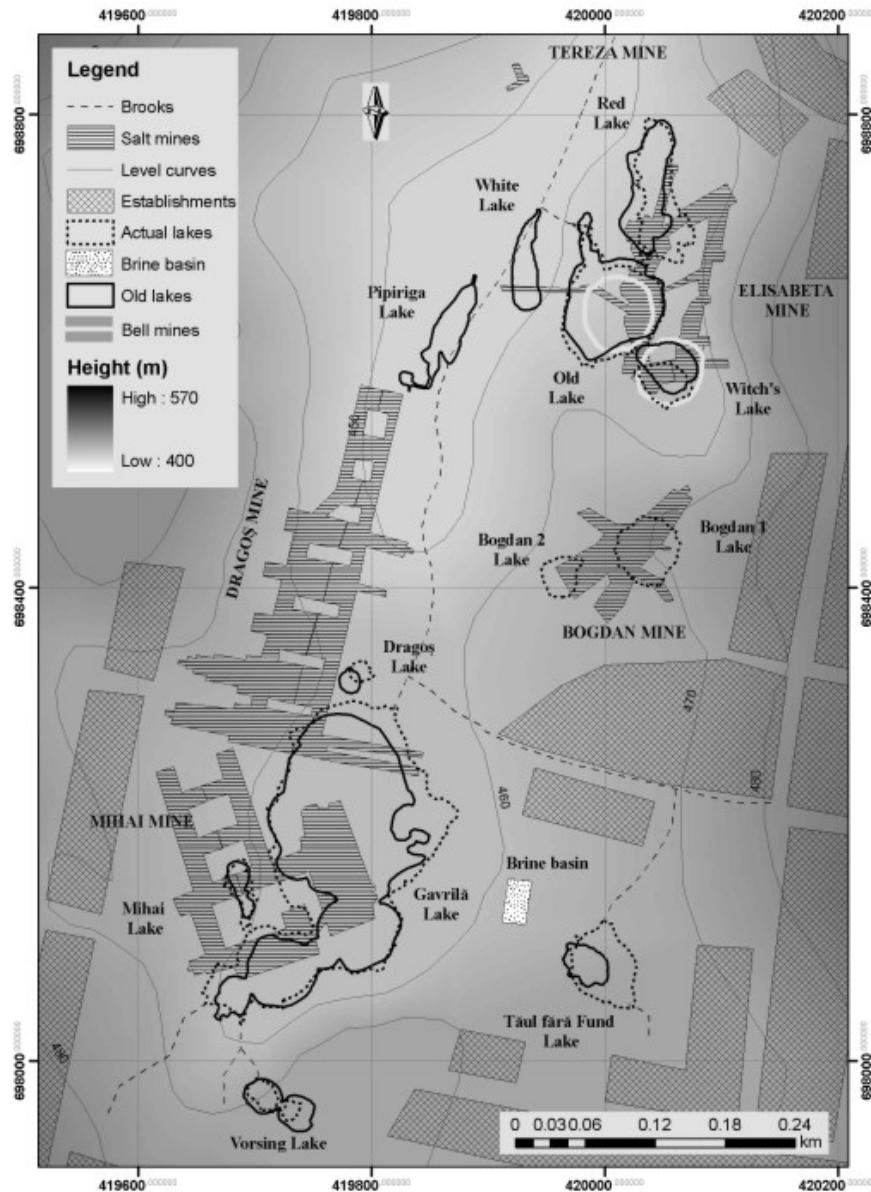


**Fig. 2. The clogged up basin of the ex – karsto-saline lake Pipiriga de Jos from north zone of the lake complex from Ocna Șugatag.**

In the previous studies the professor Pânzaru identifies three zones of repartition lacustrine units on the contents of the basin (p. 253). *Southern zone*, that involves more antroposaline lakes, between which Gavrilă, Tăul Fără Fund, the basin of the old station and some lakes carstosaline ex. Vorsing, Mihai etc.

*Zone of north-east*, which cotains, among other things, the anthropogenous lakes of Witch, Old and Red and some karsto-saline lakes (White Lake). *Pipiriga zone*, constituted in totally from karsto-saline lakes, between which the lakes Pipiriga de Sus, de Mijloc and de Jos, Fountain from Slatina the other little expanse of water numbered by the author with arabian digits (the lakes 4 ... 25 – fig. 3).

In the present the configuration of the lacustrine complexe from Ocna Șugatag is modified, through this relieving *a dynamics extremely active* of the depressions hearth and the base of the versants. So, *the lakes from southern zone* registered mostly important extensions of the surfaces through the breakdown or erode of the borders, their number remaining about same. *In northern zone* the spatial repartition of the lakes is very changed; mean while other surfaces of water disappeared entirely, their place have been taken of little plateau without vegetations (increassted salinity ex. Pipiriga Complex) other units registered the transformations of the basins, including the position, under the effect of massive landslides from the left versant of the basin (the lakes Red, of Witch and Old - fig. 4).



**Fig. 3. Old lakes and new lakes in the diapir anticlinal basin from Ocna Șugatag.**

As a result of the continuing process of dissolution of underground salt the new lake units appeared, respectively the lakes Bogdan 1 and Bogdan 2, appearing a new sector in the central area of the basin. They were formed and evolved in the '70<sup>th</sup> – '80<sup>th</sup> years by the collapse of the Bogdan mine and of the south-west part of the rising who work in addition (fig. 3).



**Fig. 4. Massive landslides on the right slope of the Ocna-Şugatag basin above the lakes of Witch (1), Old (2) and Red (3).**

The lakes Bogdan 1 and Bogdan 2 represents some of the most spectacular drives, because of their shape, but also the difference between the level of cornice collapse and water mirror, but, unfortunately, lakes became residual warehouses, in the last years.

#### 4. DISCUSSION

Dynamics widening of the diapir anticlinal basin from Ocna Şugatag is highlighted also by the change in time of the main morphometrical elements of the lakes (table 1).

**Table 1. The dinamics of main morphometrical elements of the salt lakes from Ocna Sugatag.**

Nº	Element / Lake	Year of survey	Surface (S-m <sup>2</sup> )	Lenght (L-m)	Medium width (B <sub>m</sub> -m)	Maximum width (B <sub>max</sub> -m)	Medium depth (h <sub>m</sub> -m)	Maximum depth (h <sub>max</sub> -m)	Volume (V-m <sup>3</sup> )	Perimeter (m)	Quotient of sinuosity
1	Vorsing *	1968	1514	69.5	21.78	30	2.82	6.9	4277	204	1.48
		2006	673	54.65	12.31	22.2	1.14	4.1	764	155.1	1.69
2	Gavrilă **	1968	23542	341.5	68.94	134	10.58	29.95	249102	1048	1.93
		2006	28312	338.78	83.57	162.26	9.7	25.7	274667	953.9	1.6
3	Mihai *	1968	672	47.5	14.15	20	0.87	3.8	587	131.5	1.43
		2006	764	62.09	12.3	24.89	0.9	3.1	687	154.8	1.58

4	Taul Fara Fund **	1968	1625	48.5	33.51	31	1.39	32.9	2259	132	0.92
		2006	2858	85.93	33.26	54.75	1.41	31.5	4042	228.5	1.21
5	Dragos **	1968	70	10.3	6.8	9.9	1.28	17	89	30	1.01
		2006	246	22.17	11.11	18.17	1.2	15.2	295	63.4	1.14
6	Bogdan 1 **	1968	-	-	-	-	-	-	-	-	-
		2006	2324	61.08	38.05	56.58	3.07	7.3	7146	192.2	1.12
7	Bogdan 2 **	1968	-	-	-	-	-	-	-	-	-
		2006	871	42.92	20.3	34.12	1.1	2.7	962	116.5	1.11
8	Of Witch **	1968	1758	56.8	30.95	43	3.49	6.8	6133	160.5	1.08
		2006	1171	52.59	22.27	35.3	2.98	6	3485	143.6	1.18
9	Old **	1968	6226	130	47.89	85.5	6.13	15.7	38175	369	1.32
		2006	6012	129.9	46.28	93.72	5.51	12.7	33149	374.5	1.36
10	Red **	1968	3337	125	26.7	45	1	2.25	3337	342	1.67
		2006	3590	129.07	27.81	46.5	0.76	2.1	2743	389.3	1.83
11	Pipiriga de Jos *	1968	1708	105	16.27	26.5	2.04	2.65	3485	248	1.69
		2006	-	-	-	-	-	-	-	-	-
12	White *	1968	1348	84.5	15.95	23.5	0.31	0.74	420	190	1.46
		2006	-	-	-	-	-	-	-	-	-

\* karsto-saline lake

\*\* anthropo-saline lake

In this regard, in addition to the appearance or disappearance of some lakes is noted significant increases in volumes or areas under effect of salt dissolution, under the emersion slope collapse or under border withdrawal (lakes Gavrilă – with the lake from Ocna Mureş the largest in the country, Taul fără Fund, Mihai and Dragoş), or, conversely, reductions of these items under the effect of landslides, the slope alluvial flow and clogging (lakes Vorsing, of Witch and Old).

Also, phenomena and processes specific to this category of lakes maded their mark on the borders evolution, proved by their perimeter and quotient of sinuosity transformations.

The Red Lake is a special category, the one intermediary of two types of evolution. Although the area has increased slightly, following the resetting of the basin, the volume and maximum depth were easily reduced because of silt transport and of wave slide as it affects three-quarters of the perimeter. Unfortunately anthropogenic interference (with bulldozers and excavators) on the Red Lake and several other lakes after concession in the current year, yet passed its negative impact on the ecosystem.

This intervention was made only for the purpose of their arrangement for recovery, not in the conservation and protection. All the contours of the lakes were enclosed by the fence to use resorts and sailing them, and the Red Lake has been arranged for fishing. By this it renounced to therapeutic mud valorisation and will reach an aggressive exploitation of the lake only with salt water in the complex, the Old Lake.

Also, an another negative element is constituted by the intens extraction of the brine which deals the underground gaps of the infallen remanent salt mines (especially the Dragoş mine) in the aim of balneary capitalization by the new and old balneary stations and by the numerous and actual private basins. The brine extracted is quickly replaced by the fresh water of phreatic horizon which reactivate the dissolution and can generate new collapses, with the formation of new lakes, just else big than one existences.

## 5. CONCLUSIONS

The diapir anticlinal basin from Ocna Şugatag is some from most active from the country, the dynamics of its hearth being very active. The evidence represents it an appearance and a disappearance relative shortly of numerous lakes, as well as the quick transformation of the actually lakes.

The utilization of new technique in the observations and measurements achievement, as well as in the remaking of the results data leads to notable performances in the emphasis of the specific process and phenomena of this variety of lands.

It is identified numerous elements of risks behind of old and actually chaotic intervention of the human factor about the equilibrium among the elements of saline system, binded of the irrational potential this capitalization.

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