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PHYSICAL PROPERTIES OF LAKES WATER FROM SOMEŞAN PLATEAU

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Abstract

Comparing with other subunits of Transylvania Plateau, the lakes from Someşan Plateau are smaller in number and extention, and present no genetical diversity that reflects itself in the physicals characteristics of lake's water. We analised the most important physical features of lakes water from the region in study (temperature, color, transparence, conductivity), and also the variation of these features at the water's surface, and also on the vertical.
Keywords: Someşan Plateau, freshwater lakes, salt lakes, heliothermaly

General considerations

Someşan Plateau lies in the north-north-western compartment of the Transylvania Depression, as one of the three big parts of the Transylvania Plateau. The singularity of the this plateau is given not only by the unity of the fluvial system, but also by the relative chilly and moist climate, given from the existence of higher relief and from the slow advection of air masses from west and north-west through the "Someşan Gate". Beside these components there are the particularities of the biopedogeographic cover near the forest environment – especially on higher hills – and of the luvisoils with different levels of clay migration. Another particularity is its mostly rural character. Following the particularities of the geographic components, there have been located some subunits in the Someşan Plateau (Fig. 1).

You can find in this plateau multiple lakes with various morphometric, hydro and physical-chemical characteristics. There are fewer and smaller lakes in this plateau than in other subunits of Transylvania Plateau.

1. Physical characteristic of lakes water

The variation of physical parameters of lakes water can come from the accumulation type, the lake's litologic and morphologic conditions, and also from the pollution sources. The physical characteristics of lakes water have been analyzed using few data found in bibliography and field research.

1.1 The temperature of lakes water

The evolution of water's temperature is determined by meteorological parameters (insolation and thermal oscillations of atmosphere, wind's mechanical action) and influenced by the physical-geographical features (altitude, landforms etc.), by the basin's mophometric and hydric elements (surface, depth, volume etc.), the water's salinity etc. The water's temperature changes from a lake to another. A very important thing is the moment when the samples are tapped, with the direct influence of solar radiation over the water's surface.

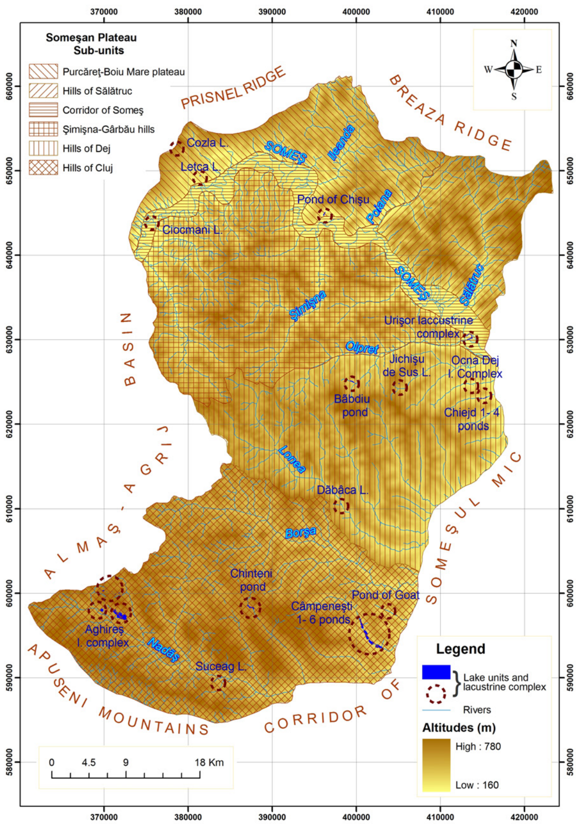


Fig. 1. Repartition of the lakes and of the geographic subunits of the Someşan Plateau

1.1.1 Thermal regime of lakes water

The thermal regime and its expression (heat content) depend on the lakes area's climatic conditions. We can mention as one of the most important factors air's and wind's mechanical action. Beside these external factors, the thermal regime and the thermal energy storage and retention capacity effect lake's own characteristics, such as water's density and mineralization. Because the water has a low thermal conductance, there exists a difference between the vertical temperature's distribution, observing a thermal stratification.

The lakes water heating process starts at the surface and ends at the bottom, creating a thermal stratification in the absence of convection currents. According to the hydric, chemical and morfobathimetric features, the thermal regime shows different aspects from fresh water to salt water lakes.

For fresh water lakes, water's temperature evolution is connected with the evolution of air's temperature, because of the low depth (mostly between 1.5 and 2 m) and low water volume.

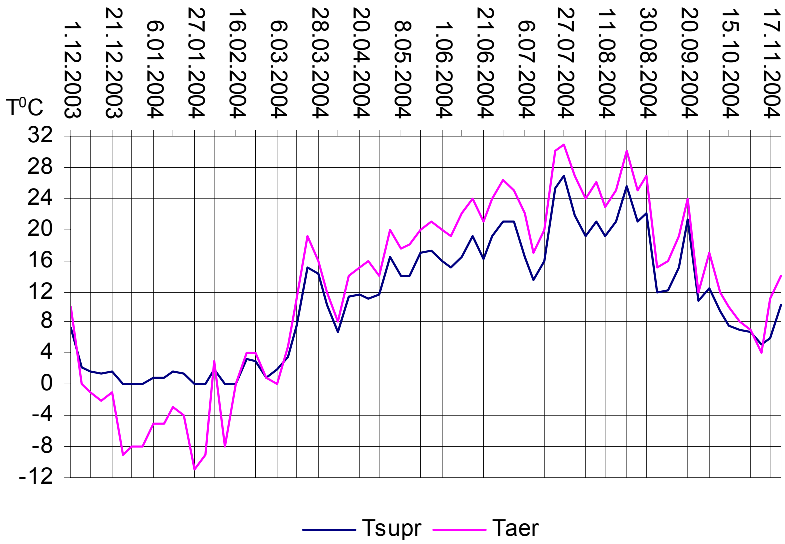


Fig. 2. The evolution of air's and fresh water lakes temperature

There are three stratification types in this vertical variation: *direct* (in summer), *reversed* (in winter) and *homothermal* (in spring and autumn), that never realized at 4^o C.

The annual cycle of thermal regime begins with the disappearance of ice bridge, a moment that signs the beginning of spring's thermal season. The reversed thermal stratification, coming from the winter regime, changes into a homothermal stratification, with temperatures between 9 and 10^o C.

Because of the low depths, the homothermal stratification in ponds has a short lenght, becoming straight a direct thermal stratification.

Once the direct stratification, very stabile most of the time starts the summer thermal season, when surface temperatures reach 25.6º C in August 21, 2003 (Chinteni Lake). Because of the lakes low depth, a small wind speed can disturb the thermal gradients inside the hole vertical, appearing a short time homothermal stratification.

Once the air’s temperature drops gradually at the end of September, the lakes water loses the heat provision, very often appearing homothermal stratification, that coincides with the begining of the autumn thermal season. The gradual loss of heat provision determines the formation of reversed stratification, with temperatures near 0º C. This thing permits the formation of ice and the begining of winter time, with surface temperatures between 0^0 C and 3.1^0 C on Chinteni Lake, and 0º C and 0.9º C on Laguna Albastră.

In the reversed stratification of the winter time there have been between 3.8º C and 5.1º C on Chinteni Lake, and 3.6º C and 4.4º C on Laguna Albastră.

For salt water lakes there are some differences in the temperature’s vertical repartition, especially in the deep ones (over 5-10 m) and in the existence of a fresh water layer, that works as a thermal isolator. These lakes have a distinct thermal structure, known as “paradoxical stratification” or “thermal anomaly” (Touchart, 2002). This thermal structure – *mezothermal stratification* – consists in the presence of a layer of 2-3 m thick, placed in metalimnion, with higher temperatures than the surface layer (epilimnion) and the immediately below layer (hypolimnion). The double thermal stratification appears mainly in summer’s heating period, but can also appear from spring time till October.

The *heliothermy* is a thermal characteristic that belongs to many salt lakes, that consists in the storage of Sun energy and its transmission to deeper layers. The appearance of this phenomenon depends on some factors : the existence of a thin sweeter water layer at the surface over a saltier one; the increased salininity growing with the depth; the high concentration of salts close to saturation; the diminished agitation imposed by wind and by bathing to stop the disrupt of salt and fresh water distribution (Gâştescu 1985).

The salt water lakes heating phenomenon has been researched for the first time in Transylvania by S. Kalecinsky (1901, Ursu Lake from Sovata), and after that fully reasearched by Al. I. Maxim (1929, 1931, 1937 şi 1942) and M. Alexe (2010).

1.1.2 Case studies

To show the details of thermal regime in fresh water lakes, we have chosen two distinctive units with known water temperature data. In the summers of 2008 and 2009, Pandi and colab. made observations on Laguna Albastră, and Floarea – Greta Neacşu made the same kind of observations in 2003 and 2004 on Chinteni Lake, and in August 17, 2009, on Ciuculat I and II. On Chinteni Lake, the research was made at surface and bottom, and on Laguna Albastră at 4 depths (Table 1). We had many observations processing and analyzing of water temperatures.

Tabel 1. Localization of sample prelavation points from Laguna Albastră Lake (Pandi and colab., 2010)

Prelevation number	Localization		Prelavation depth (m)			
	Latitude N	Longitude E				
1.	46.89011	23.29229	0	2	4	6
2.	46.89008	23.29135	0	2	4	6
3.	46.88969	23.29062	0	2	4	4.3
4.	46.88974	23.29010	0	2	4	5
5.	46.89036	23.29080	0	2	4	6

In Chinteni Lake, the prelavation period is longer and much complex, so we could make a more detailed analyze water temperature evolution. So, the springtime warm-up is more intense in the 3[th] decade of March. The first of March presents a reversed stratification, with higher temperatures of water at the bottom of the lake ($4,7^0$ C – $4,8^0$ C) than at the surface (1^0 C – $3,5^0$ C).

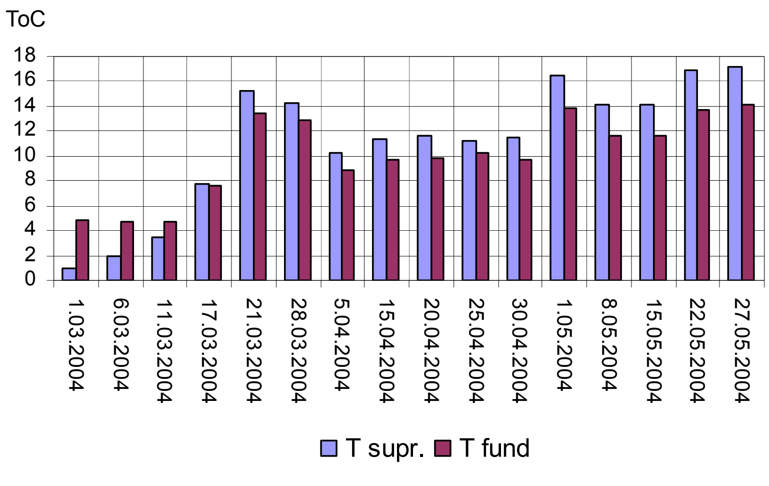


Fig. 3. Chinteni Lake water temperature's evolution in springtime (adaptation after Floarea Greta Neacşu, 2004)

The total disappearance of winter phenomena took place between March11 and 14, 2004, after a short period with homothermy between March15-17. The temperatures were of almost 7^0C and were well represented on March 17, 2004. After this date we have only direct stratification for the hole springtime, with a rise in temperature values of even 17°C at surface and 14.1°C at bottom (Fig. 3).

In summer we have a continuous direct stratification, specific to this period, because the thermal energy stored up by the surface layer is propagated easily to the bottom of the lake because of small depths (maximum depth of 2.1 m).

In summer, the surface water temperature reaches 27°C (July 27, 2004) and 21.5°C at bottom (Fig. 4). Similar data have been record on August 21, 2004.

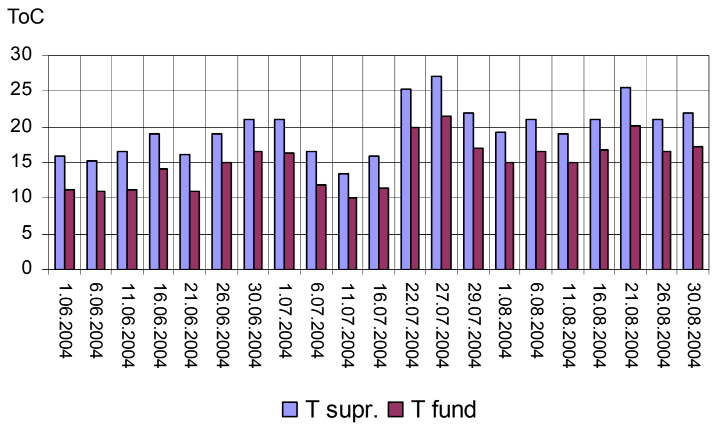


Fig. 4. Chinteni Lake water temperature's evolution in winter (adaptation after Floarea Greta Neacşu, 2004)

In autumn, because of the decrease in air temperature and gradual transfer of thermal energy gathered in summer, there begins a chilling process of lake's water. In September, at the beginning of autumn, the surface temperature has an average temperature of 1-1.5°C higher at the surface than at the bottom. In the 3[th] decade of September, the surface temperature decrease because of the transfer of thermal energy (Fig. 5). The gap between surface temperature and bottom temperature is smaller, reaching some tenths of degree, and at the end of October it reaches 0. From the 3[th] decade of September and till the 3[th] decade of November we have homothermy, well represented by the values from October 30 (6.9°C) and November 10 (4.9°C).

Water's maximum temperature in autumn appeared at the beginning of the second decade of September (21.2°C) and the minimum at the end of the first decade of November (6.9°C) (Fig. 5).

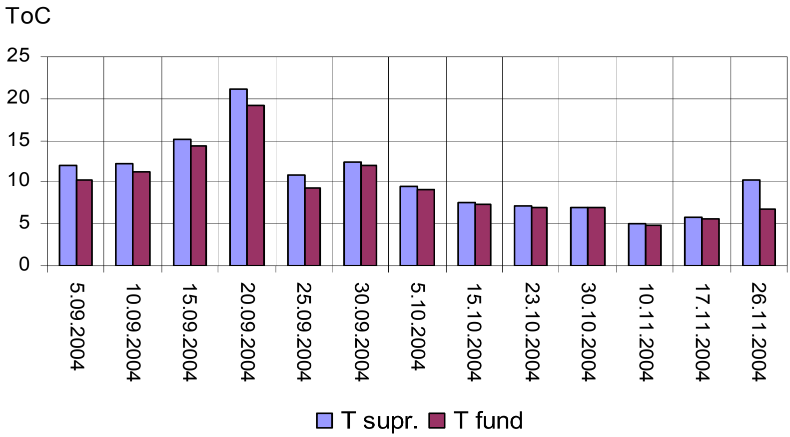


Fig. 5. Chinteni Lake water temperature's evolution in autumn (adaptation after Floarea Greta Neacşu, 2004)

The winter period is marked by thermal energy losses and by the passage from homothermy (typical for autumn time) to reversed stratification with lower temperatures at the surface (between 0 and 2°C) and higher at the bottom (between 4 and 5°C). In Fig. 6 is represented the reversed stratification on Chinteni Lake from the winter of 2003-2004.

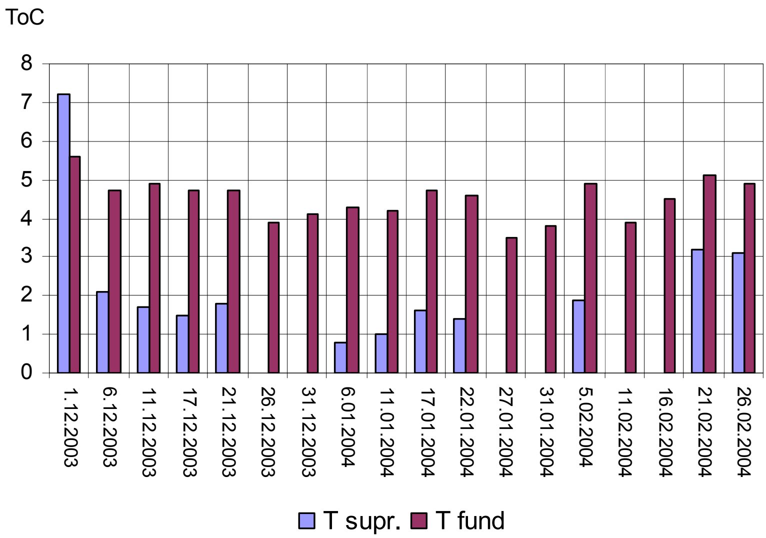
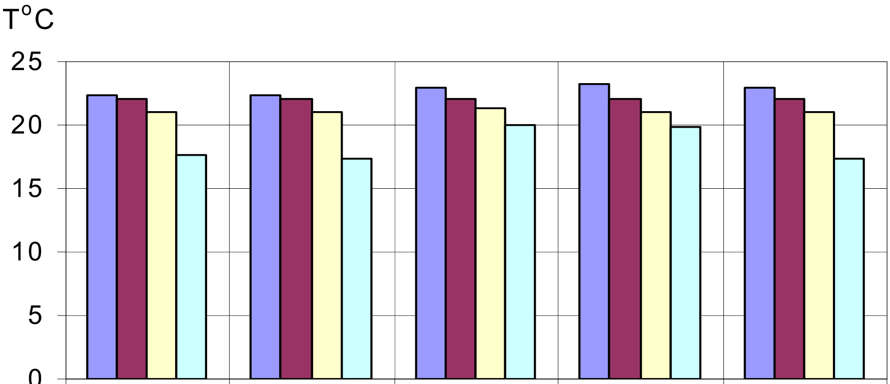


Fig. 6. Chinteni Lake water temperature's evolution in winter (adaptation after Floarea Greta Neacşu, 2004)

The surface water layer hasn't had as big fluctuations as air's temperatures because of ice bridge formation, acting as a surface buffer. The bottom layer temperatures fluctuations are smaller than the surface ones, but the temperature is higher because of the reversed stratification.

At the end of February, when the ice bridge is thinner and more fragmented, the influence of temperature is more powerful especially over the surface layer.

The summer highlights very well the direct stratification, as it's shown in the vertical variation of water on Laguna Albastră Lake. The surface temperatures from the five verticals are between 22 and 24°C, and they decrease as the depth grows, reaching 17-20°C (Fig. 7). The temperature's decrease with the depth is a slow phenomenon. The variation gap is of 5.6°C in vertical V and of 2.9°C in vertical III (Fig. 7).



	V1	V2	V3	V4	V5
0 m	22.4	22.4	22.9	23.2	23
2 m	22	22	22.1	22	22
4 m	21.1	21.1	21.3	21	21.1
6 m	17.6	17.4	20	19.8	17.4

Fig. 7. The vertical variationof water temperature from Laguna Albastră Lake in summer time (adaptation after Pandi and colab., 2010)

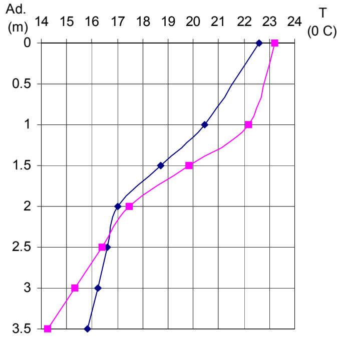
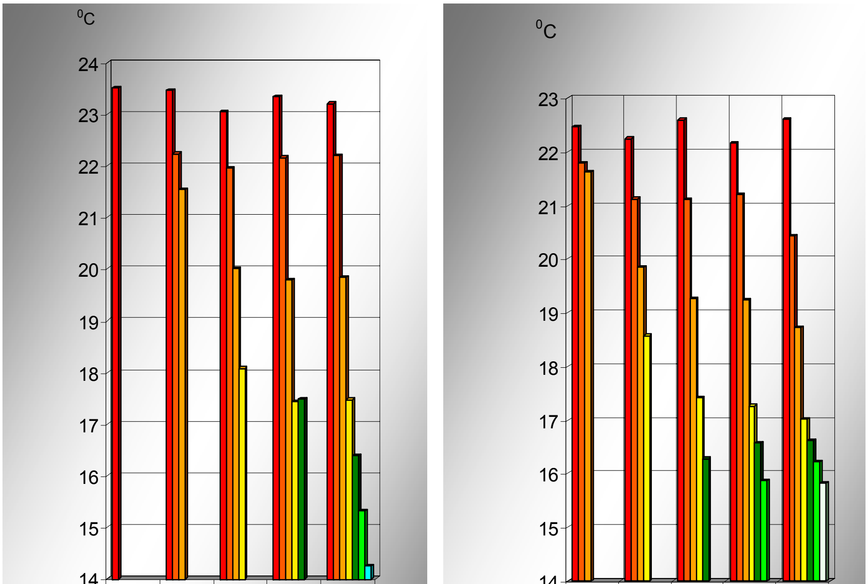


Fig. 8. Vertical thermal profile

There has been found a very powerful direct stratification after the observations made on August 17, 2009, on Cuciulat I and II lakes.

After the analyze of the water temperatures from the five sample verticals, we found that the values from Cuciulat I Lake remained at 23.2°C and 23.5°C, and dropped with the depth, reaching 19.8°C - 21.5°C at 1.5 m, 17.5°C – 18.1°C at 2 m, and 14.3°C at the bottom (Fig. 8). The values from Cuciulat II Lake decreased with 0.6°C - 1°C to those from Cuciulat I Lake, even though till the depth of 2 m the values were close (Fig. 9). After 2 m, the differences exceeded 1°C.



	V1	V2	V3	V4	V5
0 m	23.5	23.5	23.0	23.3	23.2
1 m		22.2	22.0	22.2	22.2
1.5 m		21.5	20.0	19.8	19.8
2 m			18.1	17.4	17.5
2.5 m				17.5	16.4
3 m					15.3
3.5 m					14.3

	V1	V2	V3	V4	V5
0 m	22.5	22.2	22.6	22.2	22.6
1 m	21.8	21.1	21.1	21.2	20.4
1.5 m	21.6	19.8	19.3	19.2	18.7
2 m		18.6	17.4	17.3	17.0
2.5 m			16.3	16.6	16.6
3 m				15.9	16.2
3.5 m					15.8

Cuciulat I **Cuciulat II**

Fig. 9. The repartition of water temperature on Cuciulat I and II lakes on the sample verticals from August 17, 2009

The Cabdic Lake (from Ocna Dej) water thermal regime used the data from research campaigns made by Mircea Alexe in the spring of 2003 and the summer of 2004.

These investigations revealed that the heliothermy phenomenon appears in more than one lake from Transylvania Depression, but with different time periods and intensities. At Cabdic Lake, the maximum value of 29.2°C appeared on the thermocline in August, 2004.

From the analysis of the values obtained in the two campaigns (Alexe, March, 2003 and August, 2004), appears that at the beginning of springtime, in March, there still was a reversed stratification, with higher temperatures at the bottom of the lake (18°C) that at the surface (6.5°C).

There can be observed after analyzing the water temperatures vertical variation from August, 2004 (with the maximum temperature), that there appears a sudden drop of temperature till the depth of 10 m, where it reached 16°C. From here till at the bottom there was the same temperature, with a depth homothermy (Fig. 10).

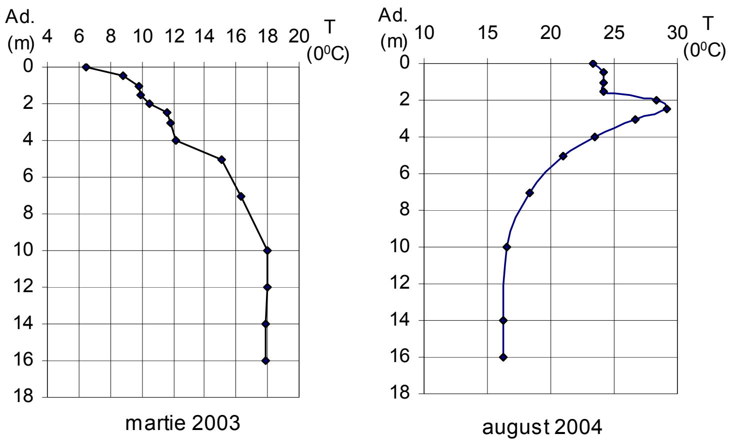


Fig. 10. Vertical thermal profile from Cabdic Lake

The heat content presumptive stored in the heliothermal layer has been determined by Alexe (Tabel 2) following the next equation:

$$q = \rho \cdot c \cdot t$$

where,

q – energy quantity;

ρ – water density;

c – water specific heat, even with 1;

t – water temperature.

The heat content hypothetically stored in the heliothermal layer depends on the water volume from the heliotermal layer (Table 2). Only

11.4% (1543 m^3) from the hole Cabdic Lake's volume (13499 m^3) belongs to the heliothermal layer.The heat content can vary between 509 kcal·10^5 (over 30°C) and 848 kcal·10^5 (over 59°C).

Tabel 2. Heat content presumptive stored in the heliothermal layer of some salt lakes from Transylvania Depression (after M. Alexe, 2010)

Lake's name	Location	Total water volume (m^3)	Water volume in the heliothermal layer (m^3)	Heat content (kcal.10^5)				
				30°	35°	40°	45°	50°
Sovata	Sovata Depression	271472	80935	26708	31160	35611	40063	44514
Sic	Transylvania Plain	5699	643	212	247	283	318	353
Cojocna	Transylvania Plain	29676	4241	1399	1633	1866	2099	2332
Cabdic	Someşan Plateau	13499	1543	509	594	679	763,8	848

This thermal energy from the heliothermal layer can be used in balneotherapy, but also in other fields, such as energy industry.

In summertime appears only the direct stratification, given by the presence of a warmer surface layer, a thermal jump layer with high gradients, that connects the surface with depths of more than 5 m. Between 0-2 m exists a isothermal layer, with temperatures of 23-24°C, and after that appears the direct stratification, with over 15°C, even in lower layers.

In spring autumn and winter appears the reversed stratification, with higher temperatures at the bottom of the lake. In this season, the reversed stratification appears only at the beginning of spring, in March, and at the end of autumn, in November.

1.1.3 Ice formations

Ice formation process depends on the air's temperature (the time with negative values) and the mineralization degree. The first formations that appear on lakes are ice formations, and after that bank ice, and finally ice bridge, that covers the entire lake surface. The ice formations period starts in December and lasts till the end of February.

The ice needles appeared on Chinteni Lake the earliest in the 3rd decade of October (October 26, 2003) when have been recorded temperatures below 0°C, especially during the night. The needles were equally distributed on the both sides of the lake.

After the decrease of temperature and after maintaining negative air temperatures, slowly appears bank ice in the second decade of November. In some lake parts, the bank ice width reached 2 m. It slowly grew in surface and thickness, so in the second decade of December appeared an ice bridge by joining the bank ice. The ice bridge lasts between 40 and 60 days. In some winters appeared some abnormalities from the mean values. So, in the winter 2002-2003, the ice bridge last for over 90 days. There have been made two profiles from 2 to 2 m, to gain samples for measuring the ice thickness. The ice bridge thickness depends on how long the negative temperatures last and on its extension. So, once the temperatures become more negative, the bridge grew to 10-12 cm in the second decade of December 2003, and to 35-41 cm in the 3[th] decade of January 2004. The Chinteni Lake reached its maximum ice bridge extension of 41 cm in January 30, 2004 (Fig. 11).

Note that at the lake's tail, with a depth below 0.5 m, the ice bridge showed some parts without ice. Also in this part, on the right bank, there were enough areas where the ice was not uniform. In March the ice bridge was not uniform, so the samples were taken only in two points because the ice was very thin. The ice bridge broke and transformed into ice floes.

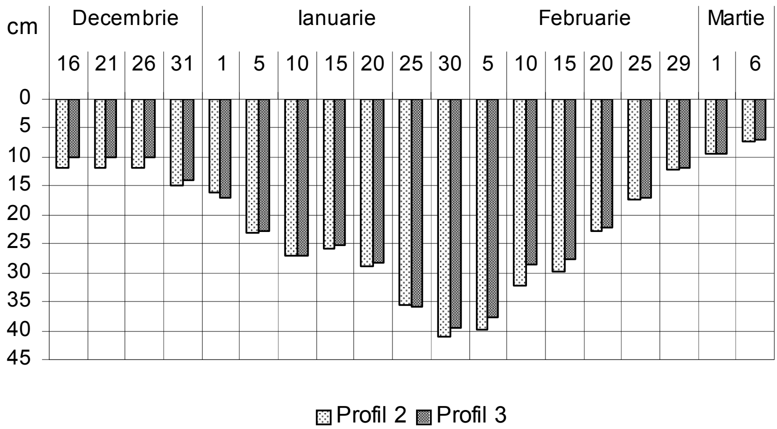


Fig. 11. Ice bridge thickness evolution on Chinteni Lake (adaptation after Floarea Greta Neacşu, 2004)

2. Lakes water transparence and color

Transparence and color are some very important water's physical characteristics that depend on the lake's water supplies, on the water dynamic, on the quantity and quality of mineral and organic floating substance, on the mineralization level, on the presence/absence of fito- and zooplankton, on the lake's position, on how deep and how well are absorbed the rays of light, on the climatic conditions etc.

Most fresh water lakes from this region have a low transparence because their small depth permits the strong winds to stir up bottom particles. The same low transparence appears in the lakes with many tributaries, because these bring a lot of floating alluviums that stay for a long time in the water mass. The bigger is the turbidity, the lower is the transparence. The transparence is bigger in the lakes with well developed vegetation in the confluence areas, that retains some floating alluviums.

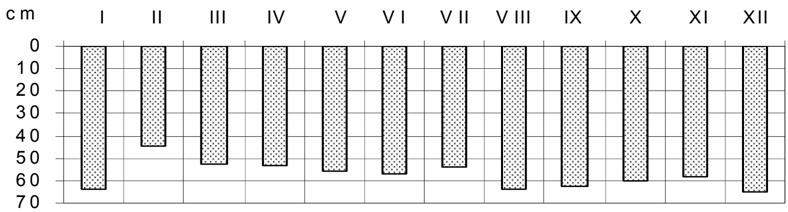


Fig. 12. Mountly water transparence variation on Chinteni Lake in 2004 (adaptation after Floarea Greta Neacşu, 2004)

The mean annual value of water transparence on Chinteni Lake is of 57 cm. The mean monthly values are close to one another. Still there two periods with higher values over 60 cm – in December-January and August-September (Fig. 12). The lowest values appear at the end of winter (February) and in springtime (March and April). Other low values appear in autumn – November – because the rainfall is more abundant in this period.

Lakes water *color* is given by the selective absorption of light, by the domination of some organic or mineral dissolution or floating substances, by the fito- and zooplankton.

3. The conductivity

The electric conductivity depends on the dissolved salts quantity that dissociate in ions under the action of electric current (electrolysis). The specific electric conductivity varies after the salts concentration, and after the salts type. So, the values for conductivity have a wide range from the surface to the bottom of the lake.

Analyzing the conductivity values for the water from Chinteni Lake taken from 6 profiles, some observations can be made. The values obtain in these profiles have no differences on vertical and small differences on horizontal. The biggest values appeared on profile 2 and the smallest on profile 3 (Fig. 13). The conductivity values from Laguna Albastră Lake were measured at the surface and in other 3 points (2 m, 4 m and 6 m deep). The smallest values, in all four cases appeared at surface (884 - 894 µS/cm). The conductivity grows with the depth because the water mineralization grows. So, the maximum values appeared at the deepest points (898 - 920 µS/cm). The differences between surface and bottom remain of 30 µS/cm on verticals 1, 2 and 5, of 15 µS/cm on vertical 4 and of only 4 µS/cm on vertical 3 (Fig. 14).

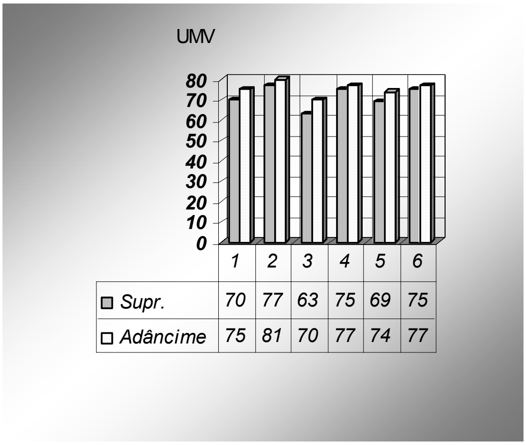


Fig. 13. The vertical variation of water's electric conductivity on Chinteni Lake (adaptation after Floarea Greta Neacşu, 2004)

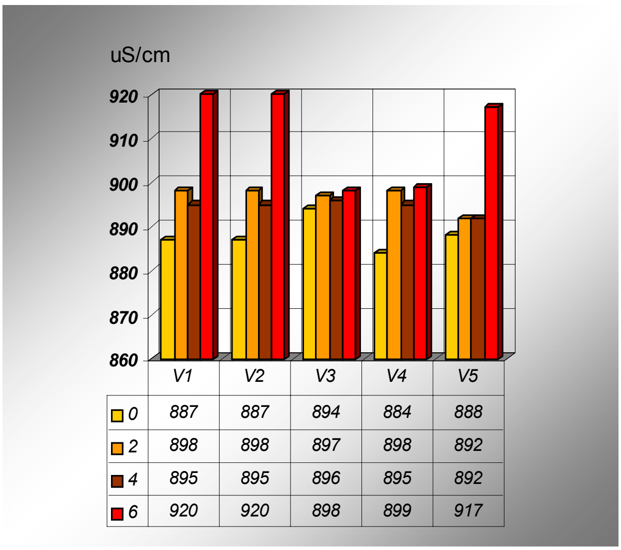


Fig. 14. The vertical variation of water's electric conductivity on Laguna Albastră Lake (adaptation after Pandi and colab., 2009)

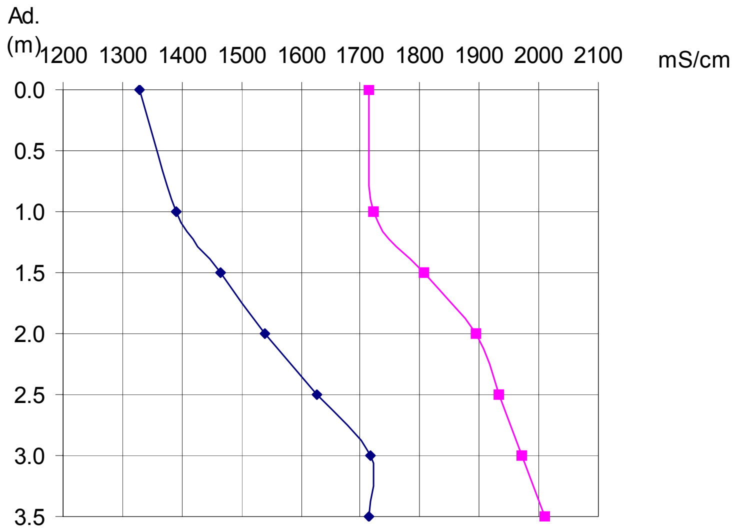


Fig. 15. Water's electric conductivity variation on Cuciulat lakes (August 17, 2009)

The water conductivity values are bigger in Cuciulat lakes, over 1300 μS/cm, because the of the water's higher mineralization degree. The bigger values appeared on Cuciulat I Lake, of 1713 μS/cm at surface and 2010 μS/cm at bottom. On Cuciulat II, the values kept between 1328 μS/cm at surface and 1714 μS/cm at bottom. Both lakes present a suddent growth of electric conductivity values after the depth of 1 m (Fig. 15).

For salt lakes, the water's conductivity values have a strong connection with the salt stratification. Some modification can appear in the lakes used for recreation (as at Cabdic Lake), with the mixing of surface waters, that changes the natural distribution of salt with the depth, and also of conductivity. There exists a strong connection between salinity and conductivity. So, once the mineralization degree grows with the depth, the same grows the electric conductivity, especially between 2 m and 6 m (244 μS/cm), after that the values maintain a straight line to the bottom of the lake (Fig. 16).

For salt lakes with small depths, there appears a relative homogeous distribution of conductivity at every depth.

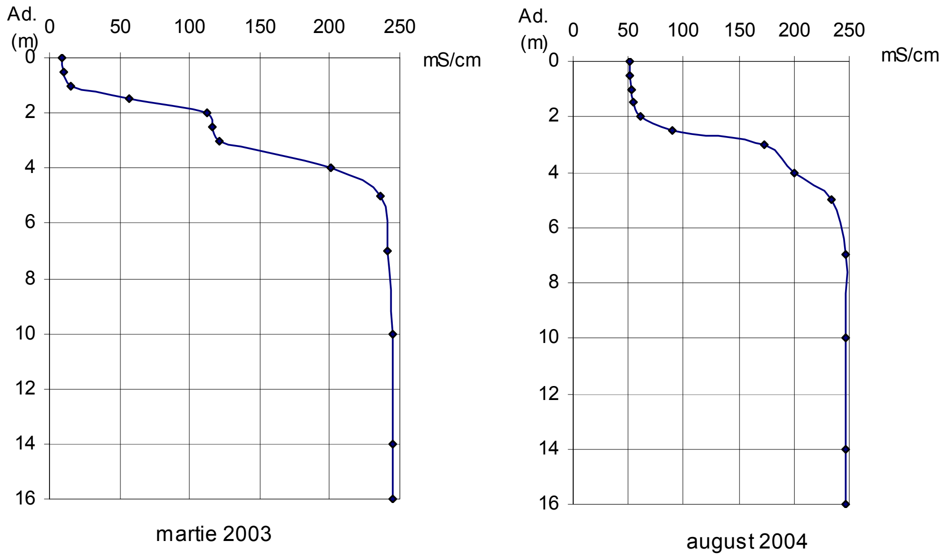


Fig. 16. Water's electric conductivity variation on Cabdic Lake

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