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The impact of mining upon the features of the Blue Lagoon Lake in the Aghireşu area

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Abstract: The substrate of Aghireşu area contains several resources, which in time it was exploited and processed in locality. Among them is the brown coal, the gypsum, the kaolin. The exploitations began in galleries, and then passed to phase of surface quarries. After mining was formed several lakes trough the collapse of the galleries; to them was added the artificial lakes too. The Blue Lagoon Lake is a hydrological unit, the most representative of mixed origin. The water characteristics of the lake are under the influence of mineral composition of the substrate, the activity of mining, the erosion processes, the characteristics of lakes depressions, the climate elements, etc. The water physical and chemical properties are analyzed in space and time scale variation. Sampling and analysis made afford to compare the values in horizontally and vertically plain.
Key words: surface quarries, hydrological units, physical features, hydro-chemical characteristics.

Zusamenfassung: Das Impakt des Bergbaus von Aghireşu auf die Eigenschoften des „Blauen Haffes‟. In der Unterschicht von Aghiresu gibt es mehrere Bodenschätze, die der Zeit entlangt geforscht waren und örthlich verarbeitet waren. Zwichen den Bodenschätyen gab es braunkohle, gips, kaolin. Die Forschungen wurden in den Stollen begonnen, dann gingen an der Erd oberfläche weiter. Als Folge des Berghaus haben sich mehrere Seen in den sterilen Schachthalden und durch das Zusammenbruch einiger Sollen gebildet. Dazu kamen auch einige künstlich gebildeten See. Das „Blauen Haff‟ ist die wichtigste hydrologische einheit, das eine gemischtestammung besitzt. Die Eigenschoften des Seewassers sind unter dem Einfluß der mineralischen zusammensetzung der Bodrnschichte der Bergbauaktivität, der unteraeroben abtragungsprozesse, die Charakteristiken des Seebodes, der klimatischen Elemente. Die physikalischen und chemischen elemente des Wassers sind in ihren räumlischen und zeitlischen Abwechslung untersucht. Die ausgeführten Analysen und voreussetzungen erlauben das Vergleich der Ergebnisse im senkrechten und waagerechten Plan.
Schlüsselwörter: Forschungen an der Erd oberfläche, Hydrologische Einheiten, Physische Characteristisch, Hydrochemische Characteristisch.

Tartalom: Az Egeresi altalaj többféle ásványkincset tartalmaz melyek kitermelése és helyi feldolgozása már a régebbi időkben megkezdődött. Ezek közül a barnaszén, a gipsz és a kaolin a legjellemzőbb. A kitermelés eleinte mélységi bányászással történt, utólag fokozatosan áttértek a felszíni kitermelésre. A kitermelés megszűnése után a bányavágatok beszakadása során valamint a felgyülemlett meddők mélyedéseiben bányatavak keletkeztek melyek mesterséges tavakkal egészültek ki. A Kék Lagúna, mely a legjellemzőbb hidrológiai egység vegyes kialakítású víztükör. A tó vizének kémiai összetételét a vízi medence talajalkotói, a bányászat, az erózió, a külső környezeti tényezők stb. alakították ki. Kutatásaink eredményeinek célja a víz kémiai, fizikai időszakos összetevőinek változásait követte. A próbák és ezek elemzésének eredményei a vízréteg függőleges és vízszintes adatainak összehasonlítását szolgáltatják.
Kulcsszavak:felszíni kitermelés, hidrológiai egységek, fizikai tulajdonságok, hidrokémiai jellegzetességek.

Rezumat. Substratul zonei Aghireşu conţine mai multe resurse, care de-a lungul timpului au fost exploatate şi prelucrate în localitate. Printre ele cărbunele brun, ghipsul, caolinul. Exploatările au început în galerii, iar pe urmă s-a trecut la faza carierelor de suprafaţă. În urma mineritului s-a format mai multe lacuri în haldele de steril şi prin prăbuşirea unor galerii, la care sau adăugat lacuri artificiale. Laguna Albastră este unitatea hidrologică cea mai reprezentativă, de origine mixtă. Caracteristicile apei lacului sunt sub influenţa compoziţiei minerale a substratului, a activităţii miniere, a proceselor de eroziune subaeriană, a caracteristicilor cuvetei lacustre, a elementelor climatice etc. Elementele fizice şi chimice ale apei sunt analizate în variaţia lor spaţială şi temporală. Prelevările şi analizele efectuate permit compararea valorilor în plan orizontal şi vertical.
Cuvinte cheie: exploatare de suprafaţă, unităţi lacustre, caracteristici fizice, caracteristici hidrochimice.

Introduction. The locality of Aghireşu is situated in the Someşan Plateau, which is a definitive geographic sub-structure of the Transylvanian Depression. In this area the relief of the plateau is drained by the major course of the Nadăş river, which in its turn is a left side affluent of the Someş Mic river.

The western part of the Someşean Plateau is a rich area because of different resources. The brown coal mining dates from the second half of the 19th century. Starting with 1878 the extensive usage and the exploitations cover a surface of 216 ha from the territory of the Aghireşu, Ticu, Dâncu and Băgara localities. Later on this area extended to 622 ha, and in 1903 became property of „Compagnie des Mines de Transylvanie", leading to massive colonizations with workers. The coal was used in the hydropower plant from Aghireşu and in the railway transport. The exploitation reached an end in 1970, even though there still are resources to be recovered in the future.

In 1887 a new industry emerges in Aghireşu and that is the process of burning the plaster stone, exploited in the area of Leghia.

The prospects of developing the range of usage for the siliceous-kaolinous sands date from the end of the 19th and the beginning of the 20th century. The process of obtaining the kaolin from sands was put into practice starting with 1934. The first exploitations were made underground but these were low productive and very expensive (Figure 1). The next step was to redirect the production towards the quarries from the surface. Once they were started, the works exposing the earth layer beneath the surface, that preceded the exploitation, led to the show up of numerous dumps. These usually have a roundly shape in the centre of which we can nowadays find that lakes are located.

Figure 1. The opening to the old mining galleries

The premises to the formation of the useful minerals. The Transylvanian Depression started its evolution at the end of the Cretaceous – the beginning of the Paleogene, as a vast sinking area of the intensely fragmentized bedding, surrounded by the mountainous frame (Ciupagea et al 1970). In this buffer zone the sedimentation was very intense as a sequence of the fast surface erosion and of the existence of a less deep sea. The rise of the Someşan Plateau underwent through different stages. The waters fully receded only in the Sarmatian, in the south-eastern part of the area.

The most important events from the Aghireşu area took place in the Paleogene when the salty water deposits mingled with those characteristic to the lakes. Thus based on their paleontologic content several layers of earth were defined (Savu 1973).

The layer of the inferior striped clays represents the first type of deposits in the Transylvanian Depression and pertains to a continental lacustrine phase. This is rendered through the red clays, the argillaceous sandstones, within which gravels and pudding stones lenses occur. The thickness of these deposits varies between 100-200 m. The reddish colour is due to the alteration specific to the subtropical climate (Petruvian 1973).

The inferior marine series is made of all the strata between the two series of striped clays, comprising both salt water and lagoon like features. A marine transgression took place in its bedding leading to the formation of several layers, amongst which are the plaster strata, thick up to 50-100 cm. The next to follow are the layers of green-yellowish marls and chalkstones with Nummulites and on top of there are the grey clays with shell snails. The inferior marine series ends with the rough inferior chalkstone layer, made of concrete chalkstones, rough white materials and chalky sandstones. Due to its characteristics, this is a good building material.

The layer of the superior striped clays, thick to 40-60 m, has a similar composition to the inferior one being made of red and green clays, white sands and interbeddings of lenses, making up a continental salty water like structure.

During the Superior Eocene, after a new transgression, the superior marine series is deposited; this is made plaster stones layer (6-7 m), within which the oolitic deposits and the stratum of the superior rough chalkstone are found. This is used as a building material. On top of these layers, the marl-argillaceous schists are found, closing the series of the Eocene sediments.

The sedimentary series of the Oligocene begins with the Mera Layer made of green marls, sandy clays, chalky sandstones and marl sandstones, sometimes with interbeddings of pudding stones. The next to come are the Ticu Layer, containing pools of brown coal laid in three different horizons. In the lower part, the Ticu Layer are mostly represented by reddish clays, with interbeddings of sands lenses, and in the upper part there are the clays with cockle shells. These are followed by the Valea Almaşului Layer, made of sandstones, clays, sands and the Cetăţuia Layer, containing kaolinous, quartzous sands. They are exploited in the quarries from Băgara, Aghireşu and Corneşti and are processed at Aghireşu-Fabrici. Once formed through the decomposition and the alteration of the quartzous and sparry rocks in the crystalline mountainous area, and following their transport and deposition in a tabular trap structure, these materials became kaolin like.

At the end of the Oligocene the area is completely lifted and is from now on submitted to the actions of the environmental agents. During the glaciations a periglacial climate was prevailed over this territory. The main forms of quaternary accumulations are to be found only in the riverbeds and in the bottomlands, comprising sands and clays.

The kaolinous deposits. The kaolinous-quartzous sands from the Aghireşu area represent the most important source of kaolin from across our country. The kaolin is formed from feldspars that underwent an ascendant alteration, to a hydro-thermal or to a meteoric alteration. In this specific area the kaolin has a secondary origin, being the result of the levigation of the primary kaolin and their storage in a lake-like or a lagoon like environment with an interbedded structure. Its bedding is made of quartzous crystallized sands, thick to 2-15 m, above which comes a layer of white sand, scarcely kaolinous, of about 3 m and another stratum of kaolinous sands, grey-whitish of about 4 m. The final layer is made of concrete rough sands, scarcely ferruginous, thick to 2-3 m, made of grey quartzous sandstones, out of which some 0.2-1 m thick patches were left out. Then a layer of sandy marl comes being as thick as 30 cm and then the sandy clays, thick up to 5 m. The binding between these sands is the kaolin, which imprints a white color to the rock.

The deposit inclines from the east to the west, with an obliquity of 5-10^{o} towards the north-east and north and presents some subsidence due to the fissures (Figure 2).

The mineralogical study of the kaolionus rock from Aghireşu has presented the following component minerals: quartz, kaolinit, muscovit, sericit, biotit, chlorit, limonit, pyrite, oligist, ilmenit etc. The dominant mineral is the quartz, which represents about 80-85% from the total useful rock. The kaolin appears in a proportion of 8-18% from the useful rock.

The kaolinous sand is exploited in quarries and transported with vehicles or on transportation lanes to the plant where they are processed and where, through different decomposition and distribution procedures and according to the granulation limit of 0.1 mm they are separated in two fractions between the sands and the kaolinous slurry. These are hydro-cyclonated gradually, the result flowing from each phase is passed through mobile griddles of control, and then they become thicker in type Dorr decanters. Then they are filtered and dried in multi-tub ovens.

This is the main process to obtain the kaolin for the fine ceramics with a concentration of 30-31% Al_2O_3. In the same time several types of kaolin are produced for the fractious materials industry having a concentration of 28-30% Al_2O_3.

Figure 2. The exploited industrial area (Google Earth 2009)

The lake structures. The existence of the lakes from Aghireşu is due to the exploitation activities of the useful minerals, and mainly of the kaolin.

The initial water accumulations were made by the human in order to use the water to washing the exploited material. Amongst these are the lakes near the locality of Băgara, which used to have numerous drainage channels around the quarries.

Then other lakes formed where the galleries collapsed. The erosion on the surface and the infiltrations watered down the galleries roofs and favored penetration of the water underground. The circuses of these lakes have very irregular shapes and in some cases, they even communicate through old galleries. Their origin is thus complex, both anthropic and natural (Figure 3).

The local sedimentary material, which is very rotten, the existence of the completely unstable dumps, the lack or the insufficiency of the vegetation and the erosion processes all contribute to the accelerated deposition on the lake depressions. The anthropic or semi-anthropic origin of the lakes carries in itself the possibility of irregularities in the natural environment, which also brought its share to the intensification of the erosion and the deposition. The depressions thus formed by collapses have a higher degree of instability and the shores present a greater chance to develop quickly different forms of the areal and the linear erosion. In the same time the decrease of depth causes a fast development of the vegetation, the induction of the improving processes, and so, the deterioration of the physical, the chemical and the biological qualities of the water lake (Pandi & Berkessy 2008).

The largest lake in this area is the Blue Lagoon. It is a lake created through a collapse; its irregular shape is determined by that of the quarry and of the initial galleries. The shoreline is very sharp in the northern and the western parts, while it is very smooth in the other sides. The material taken away and transported by the torrents is accumulated in the shape of a submerged platform. The crystal surface covers 22000 m^2.

The lake has a length of 255 m and a width of 132 m. The maximum depth decreased a lot due to the deposits brought, currently being of only 7 m. The water volume in the lake's depression is of 50000 m^3.

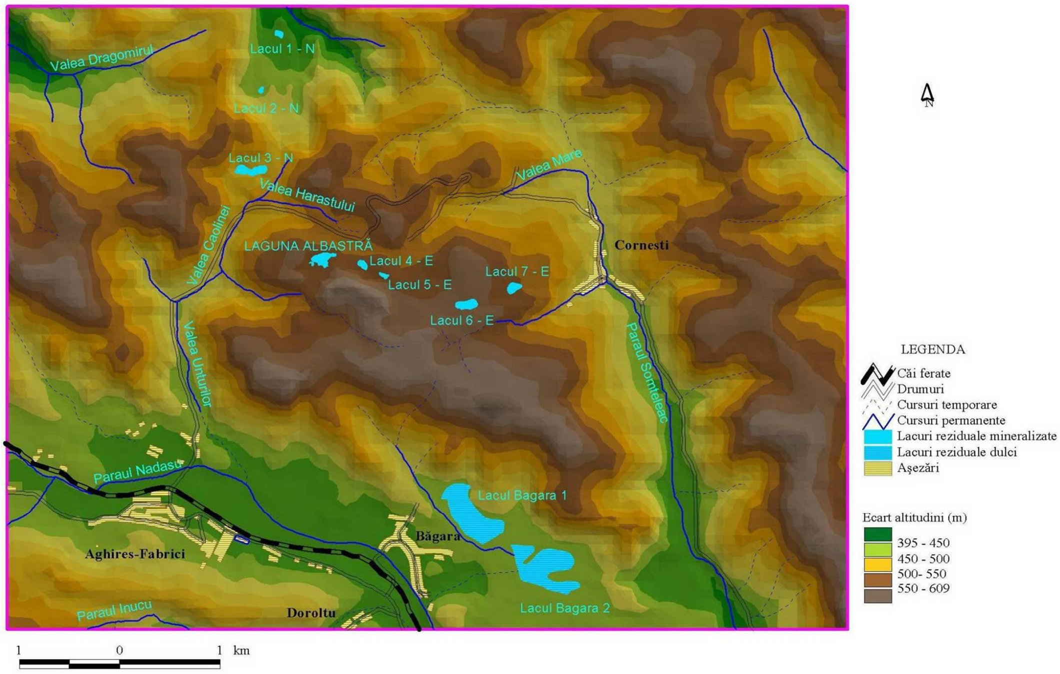

Figure 3. The lake structures from Aghireşu
(authors of the map: Şerban G. and Pandi G.)

Material and Methods. In order to qualitatively assess the water from the Blue Lagoon, (Figure 4) samples were taken from the surface of the water (S) as well as from the bottom of the depression (F), in different characteristic points. The quality of the water was estimated based on the determinations and the observations made during the winter as well as during the summer in order to find the substance and the energy modifications from the mass of the water. The water samples were analyzed in the field as well as in the laboratory, by using a pH-meter, a multi-parameter and a spectrophotometer.

Figure 4. The Blue Lagoon

Results and Discussion. The features of the water lake vary due to the natural and the anthropic agents, which present great space-time variability. The main natural agents are the geological substratum, the climate, the geomorphologic and the vegetation conditions, which directly influence the hydrologic and the thermic regime of the water. In close relation to these the physical-chemical-biological behavior of different components also varies. Most of the variations in time of the quality of the water are based on the internal processes (Pandi 2004).

In addition, the sediments from the bottom of the lake can be considered as a witness of the quality of the waters, defined through color and granulation. Also, in estimating the features of the water, the characteristics and the extension of the anthropic activities must be kept in mind. Given the fact that the lake depression was formed through a collapse in an area where kaolin was exploited, these are reflected in the evolution of the quality of water.

The physical features of the water. The temperature is closely connected to the thermic variations of the air above the lake. During the summer the temperature was observed in four verticals, at the surface and on the bottom of the lake. At the surface of the water the values are almost identical, while on the bottom, differences of some tenths of degrees were recorded. The comparison between the temperatures values along the verticals indicate a slight decrease of the values towards the bottom of the lake, which do not go beyond 1°C (Şerban et al 2007). It can be thus stated that the lake's temperature is uniform; this is also a natural consequence of the volume and the relatively small depth (Figure 5).

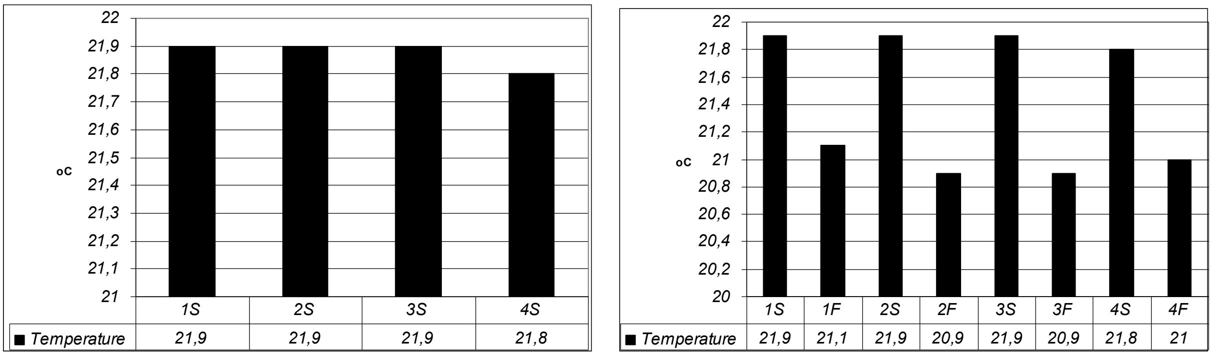

Figure 5. The variation of the temperature in the hot season, at the surface and on the vertical

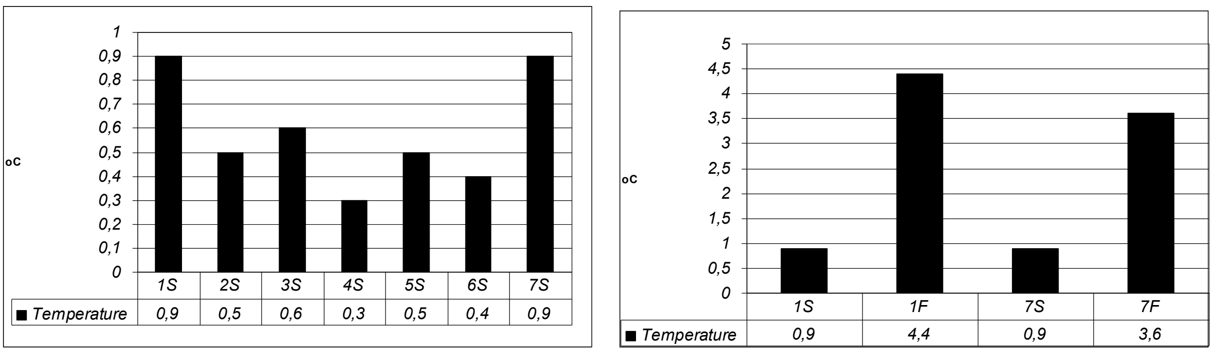

Figure 6. The variation of the temperature in the cold season, at the surface and on the vertical

During the winter the temperature was measured in seven points at the surface and in two points from the bottom. While performing the observations the ice bridge was 20-25 cm thick and the air temperature was of -7°C. Taking also into consideration the thermo-isolating role of the ice bridge, the temperatures of the water measured under the ice were below 1°C. On the vertical, relatively significant thermic oscillations were noticed, pointing out differences of about 3°C. It is thus obvious the reversed stratification, typical for lakes during the cold season (Figure 6).

The water transparency stretches from high to medium values, depending on the concentration of the dissolved and the substances in suspension. During the rainy periods the transparency is very low due to the sediments brought from the surrounding slopes submitted to erosion. Sometimes the waves created by the wind can also impact on the transparency of water.

The results of the measurements with the Sechi disc indicate a transparency which varies between 2.5 and 5.6 m. During the hot season the transparency of the water is lower also because of the rains that wash away the attached hydrographic basin, due to the very powerful sun rays and nevertheless the tourists, who artificially cause turbulences in the water. The values are constant on all three verticals. During the winter the clarity of the water increases to doubled values due to the lack of erosion and drainage, but also because of the tourists' absence. The values are slightly different, oscillating between 4.0-5.6 m (Figure 7).

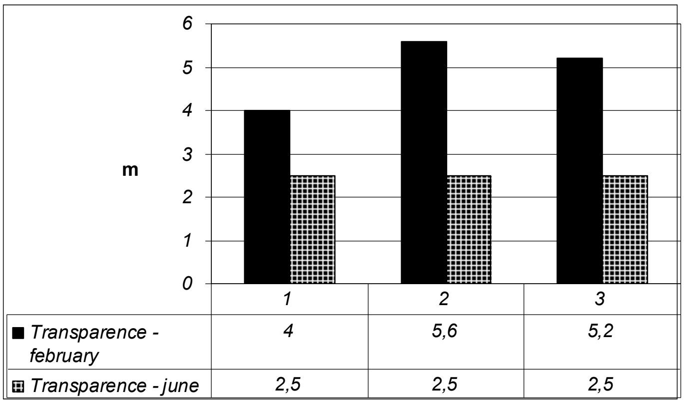

Figure 7. The variation of the transparency

The color of the water varies according to the mineralization, the deposits from the bottom of the lake, the temperature and the turbulences. Thus, a greenish color can be noticed during the winter, while the color is more bluish during the hot season. This is where the name of the lake comes from, the Blue Lagoon.

The electric conductivity depends on the concentration of salts dissolved in the water, which offers the poli-phasic fluid the ability to conduct the electricity and the temperature. During the summer this parameter was measured in four points, both at the surface and on the bottom of the water. The values present no great oscillations at the surface, ranging between 920 µS/cm and 911 µS/cm (Figure 8).

The variation according to the depth differs from a vertical to another. In points one and three the values are almost identical. At vertical two the surface has a much lower value, while at the vertical four the situation is reversed.

During the winter, measurements in seven points were performed on the surface of the water, while to its depth this process was performed on two verticals. Both the absolute values and the range of the oscillations are much higher than during the summer. The electric conductivity oscillates between 1000 µS/cm and 744 µS/cm at the surface. The tendencies are different between the two measurements on the vertical, though the differences maintained are approximately equal and have a value of about 15 µS/cm (Figure 9).

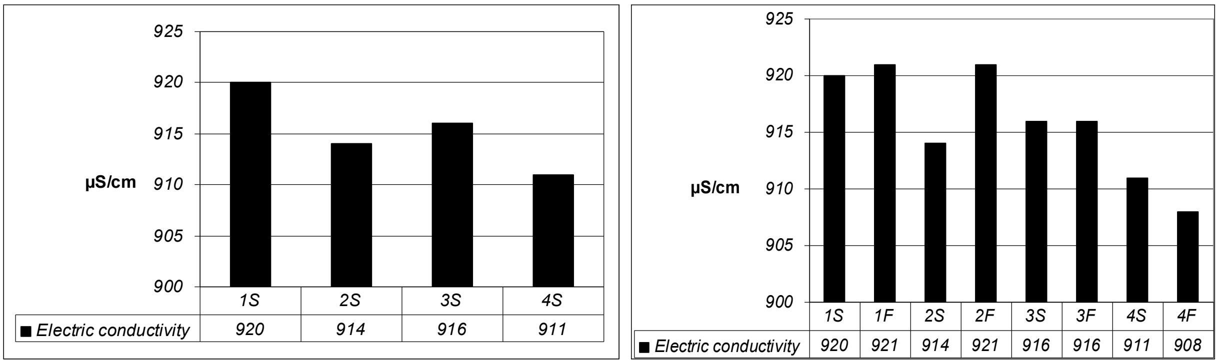

Figure 8. The variation of the electric conductivity in the hot season,
at the surface and on the vertical

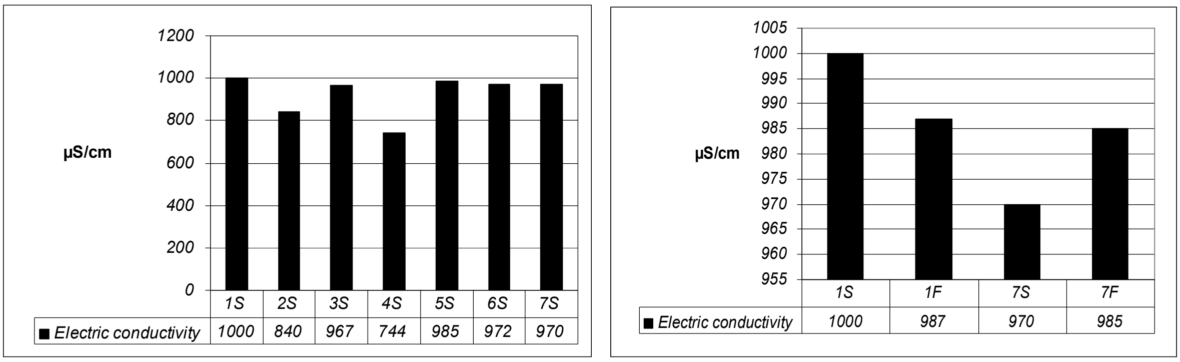

Figure 9. The variation of the electric conductivity during the cold season,
at the surface and on the vertical

Hydro-chemical features. The agents that determined the chemical composition and the mineralization degree of the water lake are mainly the petrography, the surface drainage, the soil cover and the particularities of the lake depressions.

The concentration of the hydrogen ions imposes clear seasonal variations. During the summer the values are low due to the waters coming from the mining activities and the natural washing of the dumps. This decrease brings about the rise of the material solvability, thus their possible mobilization in sediments. In the four points of sampling from the surface of the water the values of the pH oscillate between 6.06-5.65.

Going further in depth the general tendencies are preserved; on the bottom the values recorded are always lower than at the surface. In the hot season, the low values of the pH lead to a decrease in the quantity of dissolved oxygen, which worsens the life conditions for the aquatic organisms (Figure 10).

During the winter the pH values are significantly higher because the barren soil is not transported towards the water following the diminished surface erosion. At the surface, out of the seven measured points, the values are close to 7.4 in six of them. There is only one point where the value comes close to 7.9. This difference is to be noticed as well between the two verticals of analysis. The differences between the surface and the bottom are not high the values being almost identical (Figure 11).

The mineralization degree is highly differentiated. Generally, the concentrations are high, leading to an excessive loading of the water. This situation is favored by the anthropic origin of the lake depression and the mining activity from the area.

The cations are represented by calcium, magnesium and sodium. The calcium comes from the dissolution of the sulphates and the carbonates from the sarmatian sedimentary rocks. The quantity of dissolved calcium varies between 181 mg/l at the surface and 217 mg/l on the bottom of the water. The magnesium has an inorganic nature, the same as the calcium, and it can be found as a bicarbonate, sulphate or carbonate. It has lower values than the calcium, ranging from 105 mg/l at the surface and 118 mg/l on the bottom. A very slight variation on the vertical can be noticed. The sodium plays a very important part due to the presence of the clays and the fine marls. At the surface of the water the values are even lower (63 mg/l) than in the depth (84 mg/l).

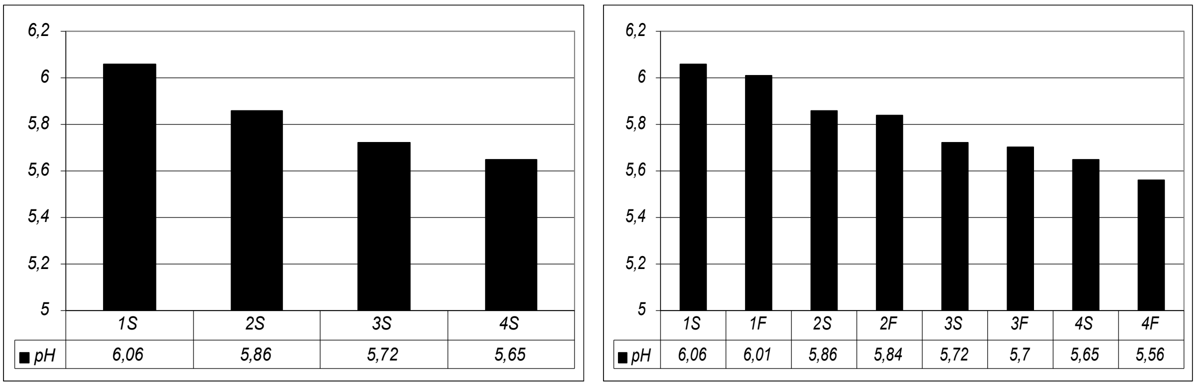

Figure 10. The evolution of the pH during the hot season,
at the surface and on the vertical

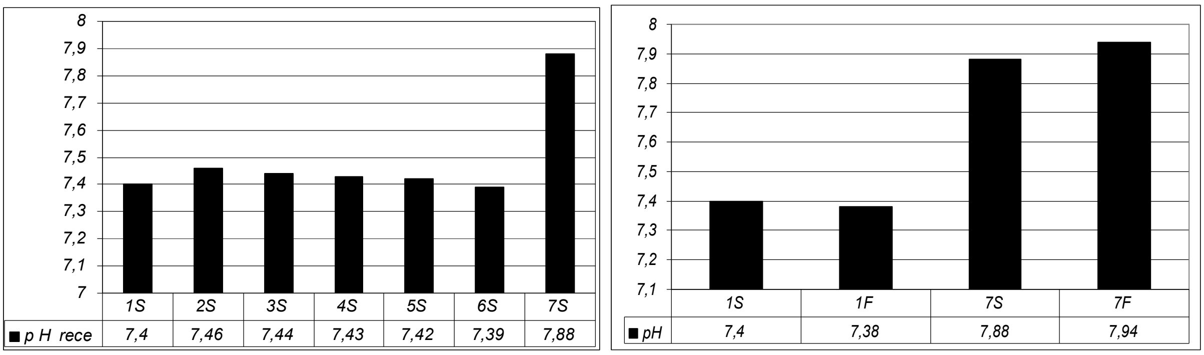

Figure 11. The evolution of the pH in the cold season, at the surface and on the vertical

From amongst the anions, the sulphates are those to be found in large quantities. The plaster stone deposits represent their main source from the bedding, which is emerged in several places. The concentration at the surface is very close to that from the bottom of the water: 234 mg/l, respective 246 mg/l. The chlorides come from the levigation of the sedimentary rocks, which are rich in clays. From the quantitative point of view they appear directly proportional to the sodium. Another major source is the coal deposits. No high differences are noticed on the vertical, the values ranging between 189-195 mg/l. The sources of bicarbonates are the alteration and dissolution processes from the chalky and carbonate rocks. The concentrations from the water are low and have close values.

The dissolved oxygen is only dimly present. The loading of the water with different substances resulted from the mining activity leads to this situation. The very low quantity of oxygen has a restrictive impact upon the development of the aquatic vegetation. The analyses were performed in June, taking into consideration five points from the surface and from the bottom of the water. In both series of determinations high variations can be noticed.

The quantity of dissolved oxygen stretches between 0.9-4.4 mg/l at the surface. The figures from the bottom are always lower than those from the surface on the vertical.

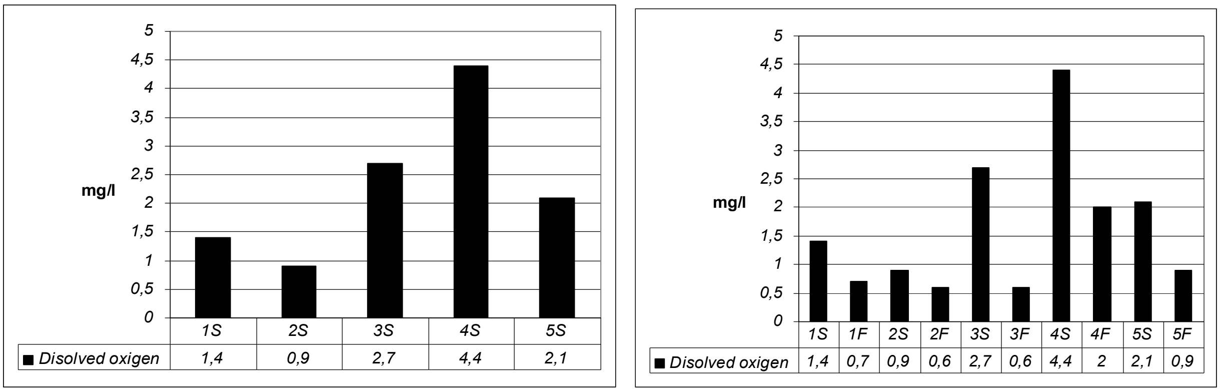

Figure 12. The evolution of the dissolved oxygen at the surface and on vertical

On some verticals the differences are high (2.7 mg/l to 0.6 mg/l and 4.4 mg/l to 2.0 mg/l), in others are very low (0.9 mg/l to 0.6 mg/l) (Figure 12).

Conclusions. The mining activities led to the formation of lakes which have different dimensions and a mixed origin. The water has various properties according to the geological substratum, the surface erosion and the mining activity.

The lake under study, the Blue Lagoon, stands for a representative example. It considered a residual lake due to its industrial function.

In order to take advantage of this complex of lakes it is necessary that they are rehabilitated from the functional point of view also taking into consideration the physical-chemical features of the water which were pointed out throughout this work.

An option in this case could be the complete re-structuring within a project for the touristy interest.

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