# MINING LAKES OF THE AGHIREŞ AREA: GENESIS, EVOLUTION AND MORPHOMETRIC ASPECTS

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**ABSTRACT. – Mining lakes of the Aghireş area: Genesis, evolution and morphometric aspects.** Mining activities are heavily influencing and destroying the landscape worldwide. In Aghireş mining perimeter, exploitation workings have led to extreme and irreversible environmental damages, especially regarding the geomorphologic and hydrological situation. After cessation of underground mining and initiation of quarry exploitation, certain mining galleries collapsed and were afterwards flooded by precipitation and re-ascending groundwater, leading to the formation of lacustrine units. Later, the abandoned quarries have undergone the same flooding process. In this paper, we report on the genesis, evolution and the current characteristics of these bodies of water, referred to as mining lakes. In addition, using the GIS technology, the morphometry of the mining lakes is presented in this paper. Due to their predominant current use, as for recreational purposes, the sustainable management of the mining lakes is an important ecological and socio-economical factor for the Aghireş area. For the majority of mining lakes, restoration measures may be necessary due to the demands of the European legislation as well as to the demands of a specific socio-economic use in the future (e.g. bathing lakes or fishing lakes). These aspects of investigation will constitute a prerequisite for effective environmental management and rehabilitation strategies.

**Keywords:** mining lakes, open-pits, kaolin, morphometry, rehabilitation.

## 1. INTRODUCTION

Mining activities involve a high degree of environmental degradation, with negative effects on all the territorial components. In Aghireş area there are a number of environmental disruptions caused by mining. Within this area, the environmental impact is primarily caused by the former mining activities, and then by the current exploitations, which presently take place only in certain areas. The environmental disruptions mostly occur in the geomorphologic and hydrologic systems. Hence, following the former exploitation of the quartz-kaolin sand deposit, many territories remained stripped of their ground cover, aspect which caused a significant degradation of soils and geological substrate. Thus, the relief displays strong anthropic features, the landscape being a desolate one, in the form of badlands.

In addition, following cessation of underground workings, some galleries collapsed, causing other environmental impacts. The collapses were caused by the superficial erosion and infiltrations which thinned the roof of the galleries, favoring the water penetration in the underground (Sorocovschi and Șerban, 2010).

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In the late 70's, the collapsed galleries and some remaining open-pits were flooded, leading to the formation of aquatic units (Şerban et al., 2009), referred to as mining lakes in this paper.

Thanks to these lakes, the former active mining area became an attraction for local people, who saw a refuge and a place for recreation in it. This shows that there is a special interest for the mining lakes and that through special rehabilitation plans the area could be well emphasized, giving to the whole region a new value, with effects beyond its borders. And as a prerequisite for effective management and rehabilitation strategies, environmental studies must be carried out in the region, in accordance with European legislation and the best available techniques worldwide (Nixdorf et al., 2005).

In the present study, attention was focused on the genesis, evolution and current characteristics of the mentioned lakes, the results following to be used for developing appropriate solutions for impact mitigation and implementation of appropriate rehabilitation strategies. In addition, using the GIS technology, the morphometric features of the mining lakes were analyzed, as the combined result of the geological conditions, the excavation technology, and certain climate related aspects, such as precipitation, atmospheric circulation, solar radiation etc.

## 2. ENVIRONMENTAL CONTEXT

The Aghireș mining area is situated in the southwestern part of the Someșan Plateau, comprising the hillside area of Căpuș-Nadăș and representing the interface between the Plateau himself and the pre-mountain area of Apuseni Mountains. The landscape is hilly, with coastal type slopes and altitudes between 400 and 500 m, crossed by the Nadăș Valley, where most villages are located in the region. The surroundings consist of pastures, farmlands and meadows of poor quality.

The natural environment in this area is quite well structured, but the natural factor which caused the biggest economic changes was the geology of the region. Thus, in terms of geological system of beds, in the area we can find Paleocene-Eocene and Oligocene formations, within which a deposit of quartz-kaolin sands has been developed. This deposit belongs to the Oligocene sequence on the western side of the Transylvanian Depression. At Aghireş, the sands in question were opened by quarrying, but the complete stratigraphic sequence became known only through bore-holes. Through these drills, within the sequence of sands there have been identified a series of shale breaks, which bear foliar imprints and pollen-spores (Petrescu et al., 1997).

Noteworthy in this respect that in Aghireş area were conducted several paleobotanical research studies from which one of the richest Oligocene floras of Romania has been collected over more than 15 years.

Regarding the perimeter of the quartz-kaolin sands deposit, this is located about 29 km north-north west of Cluj-Napoca Municipality, laying out on the territory of Aghireș and Gârbău villages (from Cluj County), and Cuzăplac village

(Sălaj County), at about 3 km north-north east of Aghireș-Fabrici and 300 m west of Cornești (Figure 1).

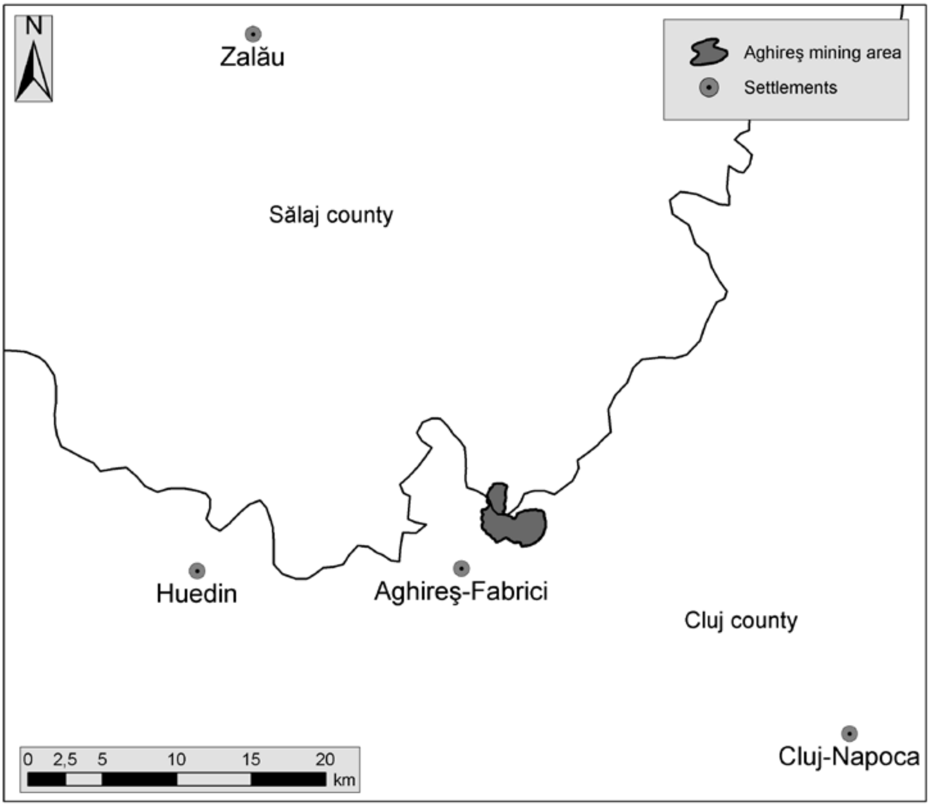


**Figure 1.** ***Geographical location of the mining area***

Since it is located on the outskirts of Cluj County, a particular feature of the investigated perimeter is its relative isolation, which is particularly manifested on the transport infrastructure, the access to the area being quite difficult, especially in winter.

In terms of possible methods of exploitation, for Aghireș deposit it has primarily been selected the underground mining, but due to the high costs, low productivity and unsafe geological structure, the underground exploitations have not continued very long. Therefore, in the second half of the twentieth century, the open-cast mining has been implemented, an exploitation method which ensures high productivity and minimal losses of useful minerals (Şerban et al., 2009).

To be more precise, at present the exploitation method for the quartz-kaolin sands deposit is *quarrying, on stages with downward progress, dislocation through drilling-blasting, mechanical loading of the dislocated material, and inner or outer tailing dumping* (MINESA ICPM, 2010).

The perimeter has two sectors, namely *Aghireș-Cornești* and *Stoguri*, where all the quarries are located (Figure 2). The total surface of exploitation area is 2.467 square kilometers, of which 1.473 square kilometers in Aghireş-Corneşti sector and 0.994 km in Stoguri sector. The exploitation perimeter also includes the areas occupied by buildings, facilities, quarry roads, dumps etc. (MINESA ICPM, 2010).

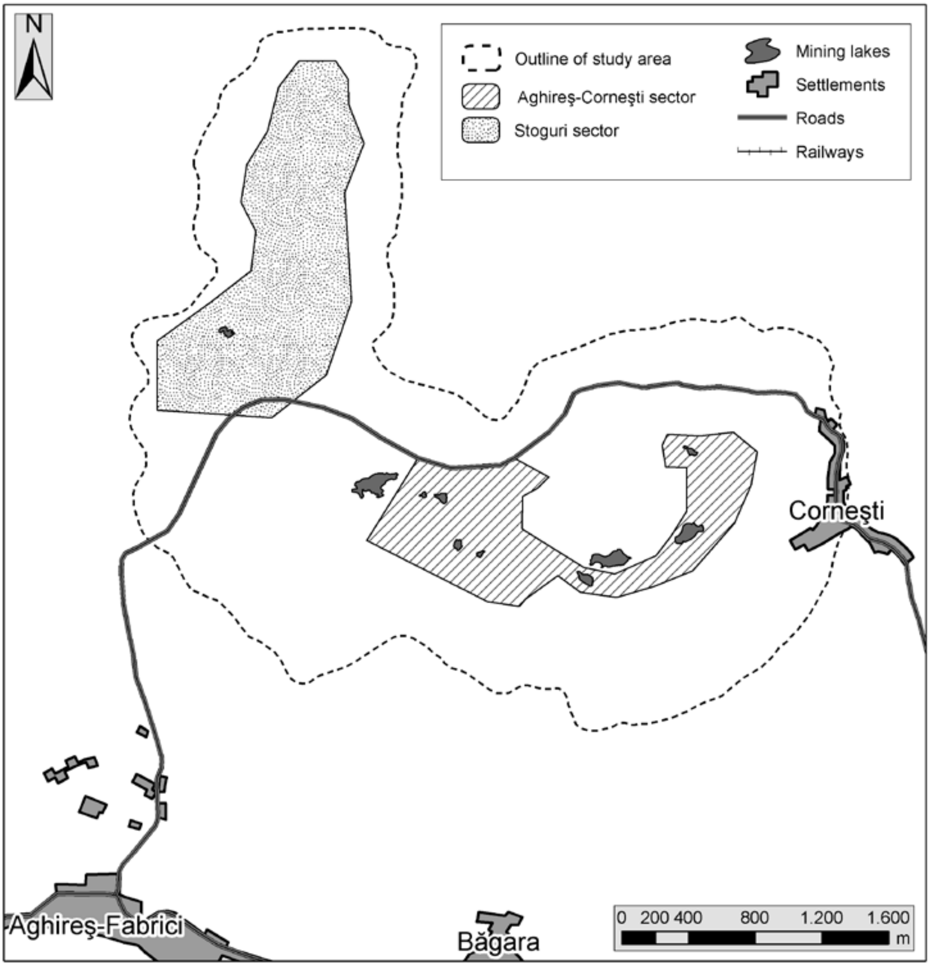


**Fig. 2** ***Mining sectors of the Aghireș area***

## 3. MINING LAKES - GENESIS AND EVOLUTION

Given that lakes in general have particular ecological, environmental and socio-economic functions, artificial lakes and reservoirs should fulfill those functions as far as possible (Schultze et al., 2010). This paper deals only with artificial lakes in former and current open-cast quartz-kaolin mines. For simplification, these lakes are generally called *mining lakes* in this paper.

When investigating mining lakes, in order to determine the responsible factors for their genesis and evolution, one should take in consideration the following: the human activities that generated the lacustrine basins, the groundwater level, the surface water sources, climate and precipitation inputs, erosion and weathering.

With regard to the first aspect, the human activities, in Aghireș area situation is quite clear: as a result of human intervention on the substrate, in the area emerged a number of aquatic units. However, the precise way in which the water has been accumulated in lacustrine basins remains imprecise. And to clarify this aspect, the other factors must be investigated.

In what concerns the groundwater, the hydrostatic level is situated under the useful formation, which allowed normal operation without any problems in terms of water. The determined water flows from hydro bore-holes are very low, around 2.1 cubic meters per day. Therefore the former active quarries were dry, without water (MINESA ICPM, 2010). However, due to the removal of the impermeable coverture by mining, after the exploitation cessation, the groundwater started to re-ascend at the surface, leading to the flooding of the open-pits.

Passing to the surface water sources, it is noted that in the surroundings the hydrographic network is made up of valleys with torrential character and streams with irregular flow, determined by the variations of annual rainfall. However, in the investigated perimeter there are no permanent sources of water, like streams for example, which could constantly fill the mining lakes.

Regarding the climate, due to its position, the region where the quartz-kaolin sands deposit is located, benefits from a moderate continental climate. As a result, in winter the sea-polar or sea-Carpathian penetrations from northwest prevail, and in summer the warm air from the southwest.

On rainfall, the month with the lowest amount of precipitation is February, and the month with the largest amount of precipitation is June. The snow falls from the second decade of November. It seems that in addition to re-ascending groundwater, the precipitation is the second cause for the genesis and evolution of mining lakes.

In short, in our study area, mining lakes resulted from the infilling of mine pits by rising groundwater and additionally by precipitation after the cessation of underground and open-cast mining operations.

## 4. MORPHOMETRY OF MINING LAKES

Water storage of a lake and its variations are fundamental quantities for the lake environment. Precipitation can control flushing, and evaporation strongly affects heat budget of a lake. Together with the investigation of these two exchange processes with the atmosphere, knowing the morphometric parameters of lakes, along with subsequent observations of surface area changes, depth and volume of stored water, one is able to provide valuable information about their evolution and their specific environmental state (Boehrer et al., 2010).

The investigated mining lakes have irregular shaped depressions, and as a very interesting fact, it has been noted that in some cases the lakes communicate with each other through the former underground galleries. This aspect attracted many adventurers who had the courage to explore the deep waters, activity that unfortunately has proven to be fatal for some of them (Şerban et al., 2009).

Due to the extremely friable substrate and the surrounding unconsolidated sterile dumps, the lacustrine depressions have a special dynamics in space and time, which may lead, in a relatively short period of time, to the disappearance of certain lakes and the emergence of others (Sorocovschi and Șerban, 2010).

At present, the water accumulates over the banks and layers of quartz-kaolin sands, creating a unique landscape.

Among the investigated mining lakes we primarily notice the lake known as Laguna Albastră (Blue Lagoon). The unique color of the lake (see Figure 3), from which derives its toponym, is given by the water's rich chemical cargo in dissolute compounds from the exploited rocks (Şerban et al., 2009).

**Fig. 3** ***Laguna Albastră (Blue Lagoon) (photo V. Măcicășan)***

The water volume of Laguna Albastră lake has been evaluated to 50,000 cubic meters, and the maximum depth has been calculated to 7 m, a significant decrease from the past, according to Pandi et al. (2009, cited by Sorocovschi and Șerban, 2010).

Alongside with Laguna Albastră, for this study there have been taken into consideration nine more mining lakes, which are noted by the fact that the water maintains from one year to another (Figure 4). But also, depending on the amounts of rainfall, throughout the exploitation also arise some ephemeral aquatic units which disappear over time, as we mentioned just above.

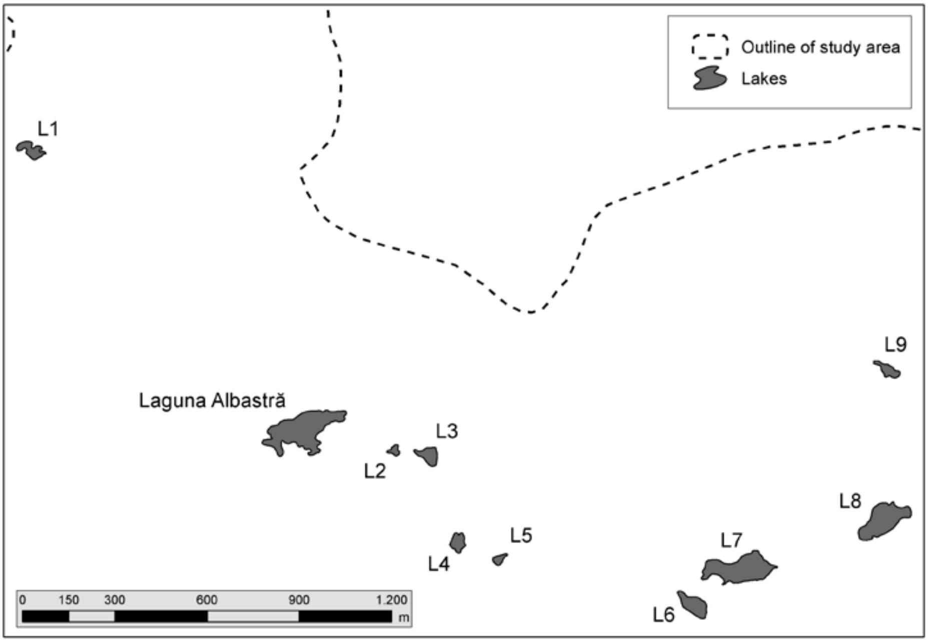


**Fig. 4** ***Aghireș mining lakes***

Regarding the permanent aquatic units from Aghireș, among the numerous morphometric features of the lakes (surface area, depth, length, width, volume, perimeter, sinuosity coefficient etc.), for the present study there have been taken into account only the surface area and length (Table 1). In order to calculate these features, we resorted to GIS technology, which involved using particular software by which the mining lakes were digitized from the orthophotomap, and then the surface areas and lengths were calculated.

**Table 1.** ***Morphometric parameters of Aghireş mining lakes***

| **Lake** | **Area** ($m^2$) | **Length** (m) | **Lake** | **Area** ($m^2$) | **Length** (m) |
|---|---|---|---|---|---|
| Laguna Albastră | 19,859 | 292 | L5 | 943 | 51 |
| L1 | 2,787 | 95 | L6 | 4,523 | 121 |
| L2 | 835 | 42 | L7 | 14,646 | 242 |
| L3 | 2,707 | 84 | L8 | 11,373 | 191 |
| L4 | 2,238 | 67 | L9 | 2,109 | 94 |

As shown in Table 1, with exception to Laguna Albastră, high levels of surface area and length are not characteristic of investigated mining lakes. This shows that they are in a close relationship with recorded precipitation during the year, which means that their surface varies quite significant.

## 5. CONCLUSIONS

In our area of investigation, underground and surface mining for quartz-kaolin sands generated a series of new artificial lakes (mining lakes), which are an important part of the local environment, because they fulfill ecological as well as socioeconomic and landscape functions.

As surface waters, mining lakes are dynamic systems and are characterized by a high degree of heterogeneity in space and time.

In Aghireș area, due to their current use, the sustainable management of the mining lakes is an important environmental and socioeconomic factor.

In general, typical functions of lakes in a given environment are as habitat for aquatic organisms, as water source for wildlife, as geochemical sink and as providers of sites for human use, e.g. recreation, fishery, aquaculture etc.

The mining lakes of the Aghireş area fulfill these functions widely, as indicated by their use. And given that the major use of the mining lakes is for recreational purposes, the concern related to the endangerment of human health needs to be well investigated.

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