Ph.D. thesis abstract: Natural dam lake Cuejdel from Stânișoarei Mountains. Limnogeographical study.
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The achievement of a limnological study of a "simple lake" represents a scientific enterprise that is more complex that it appears at first sight. This fact derives from integrated monitoring concept of an aquatic open system and comes as a reaction of scientific research that have enforce on modern Limnogeography. Even if the research direction is geographical, the great number of investigation analysis and methods often concerns an interdisciplinary approach.

Natural dam lake Cuejdel represents an almost unique hydro-geomorphological entity in the landscape of the Oriental Carpathians. The number of lacustrine units from this genetic category is small, perhaps the most well-known of these being the Red Lake, formed in 1837, on Bicaz Valley (Hășmașul Mare Massif. But more often than not, the accretions formed by deluvial dam have a passing character, and often these disappear in a short time, provoking negative hydrological events (flood, flash flood and overbank flow).

The methodological premises from which the present study has started have been initially identified in the speciality literature. Subsequently, the idea of achieving a program of integrated monitoring, based on modern methods of investigation started from the availability of the technique instrument used in limnogeographical research and which has been provided with the kindness of the administrative personnel at the Laboratory of Geoarchaeology (Leica System 1200 - Total Station Leica TCR 1201 & GPS 1200, Valeyport Midas Ecosounder, GPR System - Malå Ramac X3M – Antena de 100 mHz, Multiparameter - Hack Lange type, Benthic dredge- Van Veen type; Trilaminate diving equipment for temperate and cold waters- NAUI Pic. No. 30056 & Pic. No. 30060 License, ecological engine boat).

In this circumstance, the chosen subject of research has as a main purpose the achievement of an interdisciplinary study of Cuejdel's lacustrine basin, by triple integrating investigation areas characteristic to research direction, and also by analyzing the specific physico-geographical area (zonal relief, the reception basin of the lake), the lacustrine biotope (lacustrine basin-sediments-water) and aquatic and palustrine biocenosis (vegetation, fauna).

On the territory of Romania there is a relatively big number of aquatic units that brings together the terms mentioned in the definition of the lakes that is universally accepted. Even though, the lacustrine basins formed by natural processes are rare, and they are often anthropically modified. The highest frequency of natural lakes occurs in the area of Carpathian Mountains and Subcarpathia, in the Danube Delta and rarely in the highland and plain area.

The natural dam lakes correspond to a special genetic category, due to the processes and phenomena that include them in the landscape. In most of the times these are considered a consequence of the hydro-geomorphological processes, and their formation in the dwelt areas can represent a risk factor for the human society. In the world, based on the genetic category and nature of the obstructive dam , have been identified the following types: volcanic dam lakes (Nicaragua, Snag, Rio Magdalena), lakes formed by landslides (Earthquake, San Cristobal, Spirit, Yamaska, Addergoole Bog, Goatswater), moraine lakes and ice dams (Gapshan-Shyok, Nostetuko, Rio Plomo), fluviatile dam lakes (Pepin, Tung-ting, Tulare, Lacul Albastru - California, Old River), aeolian dam lakes (Moses), former lagoons blocked by barrier beach (Eureka, Razim-Sinoe), organic dam lakes or formed by animals (Okeechobee, Beaver).

The best represented category on the territory of Romania is the one of natural dam lakes formed after landfall and landslide processes. The most favourable conditions for their formation are found in the Oriental Carpathians, Subcarpathians of Curvature and Moldavian Subcarpathians, but also in some isolated areas from the Moldavian Plateau. The highest susceptibility is the carpathian flysch area where the formation of lacustrine accretions behind the diluvium is frequent. The best-know examples are: Red Lake (Hășmaș Mountains-Bicaz), Mocearu Lake (Buzău Mountains-Buzău), Bălătău Lake (Carpathians of Curvature- Zăbala), Balătău Lake (Ciucului Mountains-Trotuș), Betiș Lake (Maramureșului Mountains- Ampoi), Iezer and Bolătău Lakes(Feredeului Mountains-Sadova), Tăul Zânelor Lake

(Bârgău Mountains-Colibița), Izvorul Măgurii Lake (Bârgău Mountains- Ilva), Evil Lake (Nerei Canion-Nera).

Natural dam lake Cuejdel, also known by the hydronym Cross Lake, situated in the south-east part of Stânișoarei Mountai, constituent part of Oriental Carpathians central group, is registered in the speciality literature as one of the newest natural aquatorium (23 years old). The present lacustrine depression has been forming in the superior basin of Cuejdiu river (left affluent of Bistrița river) at cca. 1.5 km upstream Cuejdel brook (left affluent of Cuejdiu river). Its origin is based on a large dimension landslide (surface: 67.74 ha) that has disjointed the rock in the summer of 1991, on the left flank of Muncelu crest (a subunit of Neamțului Mountains, relative altitude of 1 077m).

Physico-geographical conditions analysis from Cuejdel Valley and their role in forming Cuejdel Lake dignifies a number of factors that has lead to the destabilization of the flank and slide complex production. It is worth mentioning the role of the factors: geological (flysch layers with clay deposits, argillaceous marl and tough sandstone), relief (relief energy >300m, declivity 30-50°), precipitation regime (pp. cumulate 05-07.1991=741.4 mm) hydrography (order IV- Horton Strahler classification) and valley structure (transversal/longitudinal on the general direction of lithologic layers), bioedaphic cover (broadleaf, coniferous and mixt forests- 9.2%), and last but not least, the role of anthropic factor (the density of forest exploitation road network 10.67 km/km²). The list of factors that have led to landslides can be completed by the earthquake from 1990 (5.4° Richter).

The first measurements in the lacustrine basin of Cuejdel Lake were taken in 2011 when a high precision echosounder (Sonar Valeyport Midas Ecosounder), and a GPS for topographic correction (GPS Leica System 1200) were used. Morphographic and morphometric parameters determined in the same year were indicating the following values: altitude of water surface 661 m, surface of lacustrine bottom 13.95 ha, max. length 1. 004 km, min. width 19.25 m, med. width 138.8 m, max. width 282.6 m, perimeter pf 2.8 km, max. depth 16.45 m, med. depth 5.6 m, volume of $92.53x10^4$ m³. Based on the results, Cuejdel Lake confirms the superlative of the largest natural dam lake in Romania overtaking both as surface and maximum depth, the dimensions of Red Lake from Bicaz Valley (surface 12.1 ha, max. depth 10.5m).

The second stage of measurements was taken during the winter of the year 2013, this time using GPR technology (Ground Penetrating Radar) with the help of Gpr Malå Ramac X3M device and a 100 mHz antenna. Because this method of bathymetric scanning of alluvial deposits requires an outright plan and also a frozen surface, the dimensions of morfomethic parameters of the lake have been reduced comparing to previous ones, but normal for the cold season. The results of bathymetric scanning were put across by the reconstruction of initial basin and draw up of the lacustrine sediments thickness map. Therefore, the aquatorium dimensions in the year of 1991 have reached the following maximum values: altitude of water surface 665 m, surface of lacustrine bottom 16.22 ha, max. length 1.17 km, min. width 24.1 m, med. width 138.6 m, max. width 341.2 m, perimeter of 2.95 km, max. depth 18.8 m, med. depth 7.5 m, volume of $122.3x10^4$ m^3 . The values were confirmed both by the internal structures identified on GPR profiles interface and the limit of maximum levels left on the arbors found in the water mass.

The regressive evolution of lake levels that took place during the 23 years, indicates a decrease of cca. 3.5-4 m, that determines the medium withdraw of the surfaces with 0.1 ha/year. The main cause is represented by the sinking of the drainage channel from the obstructive dam surface, due to flash floods subdued by the lake. The lake volume presents a descending tendency, being reduced per total with 297654.77 m³, from which, according to GPR measurements, 103988,87 m3 were replaced by alluvial deposits transported in lacustrine depression by the tributaries.

The map of sediments thickness distribution indicates a discrepancy between 0.1-3.6 m, from which the interval 0.1-1.0 m covers 8.552 ha (60.7%), the interval 1.0-2.0 m about 4.676 ha (33.32%), and the interval > 2.01 m, the rest of 8326.5 m² (5.93%). The sedimentation rate is included on different sectors, between 1-16 cm/year, and the medium rate of terrigenous sediments accumulation is situated around the medium value of 4521.26 m3/year. This value, related to the surface of reception lake basin (8.95 km²) and to an effluence rate of 33% determined by the level of vegetation cover, indicates a medium production of sediments in the basin- cca. 4.33 t/ha/an. Therefore, it can be estimated that the natural dam lake Cuejdel will clog, keeping its hydro-geomorphological balance for 247 years from now.

The monitoring program of Cuejdel Lake has also included an analysis of biotic conditions, regarding the description of physic-chemical parametes (T°, pH, LDO101, CDC401), water quality index

(WQI), trophicity level determined by chemism and nutrients (DO2, CBO5. KMnO4, NO3-, NO2-, NH4+, PO43-, P total). In situ measurements were taken every season (4 times/year), using a Multiparameter - Hack Lange type with a real-time display and the investigations from the laboratory have persuaded standard methods of water analysis.

Hereby, under a thermal point of view, Cuejdel Lake is acting like a dimictic aquatorium, with direct thermal stratification in the summer (T° - epilimn. 22-23°; hipolimn. 4-5°), spring (T° - epilimn. 16-17°; hipolimn. 4-5°) and autumn (T° - epilimn. 12.5-13°; hipolimn. 4-5°), but reversed in the winter (T° - epilimn. 0-1°; hipolimn. 4-5°). The dissolved oxygen quantity (LDO101) drops on the vertical inversely proportional with the strandard conductivity of the water (CDC401), indicating a euxinic stratification, induces by the vertical currents absence. The pH value follow the same tendency on bathymetric landing, presenting a lightly alkaline environment, specific to mountain waters (med. pH 0-8.3). Due to these physico-chemical conditions, at whici we add the medium transparency od 1.8-2.0 m, Cuejdel Lake presents a productive environment only in the epilimnion zone (0-3m).

Water quality chemical index (WQI), determined based on the nutrients: nitrates (NO_3^-), phosphates (PO_4^-), ammonium ion concentration ($NH4^+$), at which it has been added the dissolved oxygen quantity (DO_2), biochemical oxygen consumption (CBO_5), and the pH, indicates a score of 86%, this valeu being equivalent for quality class I. Also based on the nutrients determined in laboratory samples, Cuejdel Lake belongs to mesotrophic aquatorium category, where the trophicity conditions resemble the ones from volcanic crater lake Sfânta Ana or the ones from anthropic accretions Brădișor and Izvolrul Muntelui.

The determination of trophicity level of aquatic limnosystem Cuejdel is based on ecological bioindexes found in the water mass. The interdisciplinary reasearch in colaboration with a series of bilogist experts has taken shape by identifing the following categories: algal communities (phytoplankton- cca. 50 taxons), vertebrate aquatic fauna (cca. 17 species) and invertebrate aquatic fauna (over 150 taxons), from which is worth remembering the insects (over 100 taxons), zooplanktonic communities (cca. 14 taxons) and benthic macroinvertebrates (cca. 7 taxons). From all the species found, some of them with a higher density and others very rare, 72 taxons presented, due to dominant or specific valence, an indicating saprobic value. Therefore, based on ecological bioindexes from the mass of the water, Cuejdel Lake iss defined as an oligotrophic aquatic system with mesotrophic tendencies in the warm season.

The transition from a simple sector river specific to mountain area with medium altitudes from eastern Oriental Carpathians to an aquatorium of this range, has determined, as it was exected, the increase of biodiversity. Hereby, have been identified 11 aquatic and palustrine phitocenosis, which represents benefic habitats both for the already existing species, but for new ones. It has been made reference to 9 bird species, 3 amphibians species and one reptile existent on the list of the Habitats Directive (92/43/CEE) and Birds Directive (79/409/CEE), indicating the fact that protected area statute (IUCN IV.40 Cuejdel Lake), is not enough for their protection. Because of this reason, it is considered that Cuejdel Lake area gathers all the legislative conditions to constitute a site of community importance (SCI), a special area of conservation (SAC) and/or a special protection area (SPA).

The final conclusion of the present study, achieved based on the investigations that regarded both the biotope description (lacustrine basin- sediments-water), but the aquatic and palustine biocenosis, indicates the fact that the natural dam lake Cuejdel represents an aquatic entity with multipli valences of uniqueness in the landscape of Stânișoarei Mountains. The preservation of the aquatorium must represent a priority for the competent authorities (Gârcina commune City Hall, Neamț County Council, Romanian Waters National Administration ”Siret” – Water Management System from Neamț, ROMSILVA National Forest Administration, Ministry of Environment and Climate Change) and also for the local population, direclty involved in conserving the largest natural dam lake in Romania.