# IMPACTS OF DEWATERING OF AMYNTEON OPEN LIGNITE MINE ON THE AQUATIC ENVIRONMENT OF LAKE CHIMATIDIS, WEST MACEDONIA, GREECE

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**ABSTRACT**

*Lake Chimaditis lies about 1,5 km far from the Amynteon open lignite pit, west Macedonia, Greece.*
*For the protection of the lignite mine from groundwater, 1500 $m^3/h$ are pumped out, creating a cone of depression in and around the mine.*
*In order to identify the impacts of the dewatering on the aquatic status of lake Chimaditis, an extended geological and hydrogeological research was carried out, which led to the following conclusions:*
*The aquatic environment of the lake will not be practically affected by the dewatering of the mine.*
*The present amount of leakage of lake Chimaditis is approximately 20.000 $m^3/yr$. This is expected to increase in the future, due to overpumping, up to 70.000 $m^3/yr$., but it will not disturb the aquatic status of the lake.*
*That leakage from the lake's bottom supports essentially the preserve of a low depth hydraulic level of groundwater, in the surrounding area of the lake, preventing in that way the self-combustion and destruction of the turf- soil of this area.*

## INTRODUCTION

Lake Chimaditis lies west of the lignite field of Anargiri — Amynteon, 12 km southwest of Amynteon, west Macedonia of Greece (Figure 1). The closed hydrological basin, which supplies it, has been artificially joined with the small adjacent lake of Zazari, which accepts the flooding of Sklithron basin and overflows towards lake Chimaditis. Its northeastern side has joined with the central drainage trench (Kalinski, 1961) of the former Chimaditis swamp and its water overflows towards the dewatering trench and through this to Petron lake.

According to the plans of lignite exploitation, the open pit is expected to approach about 1,5 km from the eastern side of Lake Chimaditis. In order to make safe the exploitation the mine is obliged to carry out an extended dewatering, that is to lower the water table of the overburden and, if necessary to depressurize the underburden, creating thus a cone of depression around the mine (Figure 2). Today 1500 $m^3/h$ are pumped out from a network of peripheral and in pit water wells, for the protection of the mine from groundwater, the amount of which — according to the research — is expected to increase to 2200 $m^3/h$. Simultaneously, multiple quantities of groundwater are extracted from the Amynteon basin for the agricultural needs mostly.

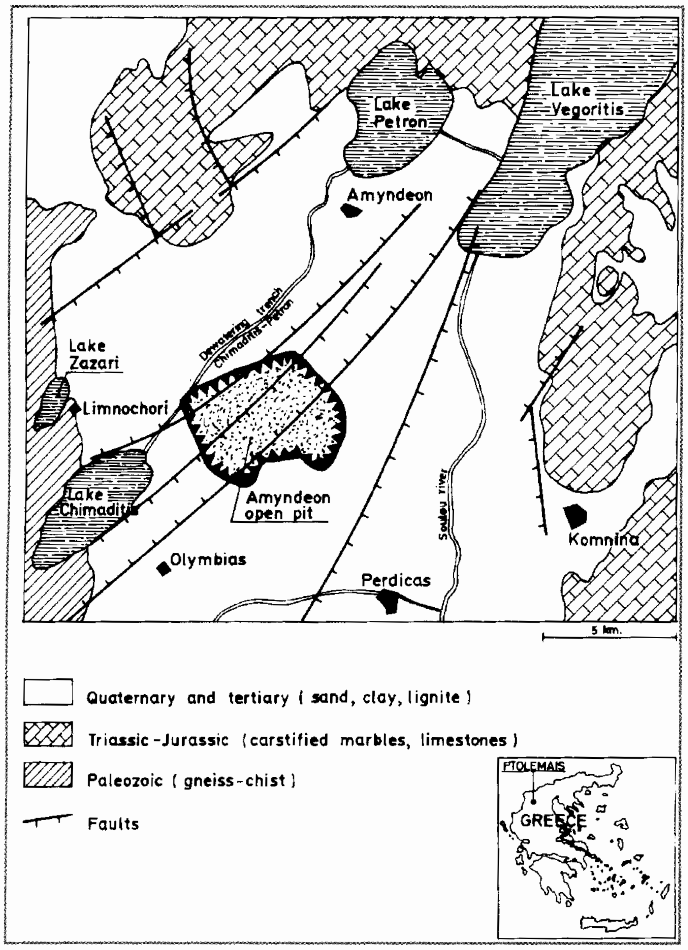


Figure 1. Simplified geological map of Amyndeon basin.

This report offers a brief reference to the geological and hydrogeological conditions of the region and presents the results of the researches conducted during 1994 — 95 by D.E.I. (Koumantakis, 1995) for the impacts of the dewatering of the open pit and the exploitation works on the aquatic environment of lake Chimaditis.

## NEW RESEARCH PROJECTS

In the area of the lignite field, "D.E.I." or other organizations, for the hydrogeological research of the basin have conducted drillholes, water-wells and geophysical researches. In order to get a better picture of the changes of the lithological combinations in both vertical and horizontal dimensions and also of the behaviour of various lithological groups concerning the permeability, in relation to the depth of the immediate environment of the lake, a new, more detailed geological research has been scheduled.

The research program included 8 drillholes of continuous sampling, at a diameter of 98 mm, during which permeability tests of unsteady piezometric head (MAAG) were conducted, every 3 m. In some cases undisturbed samples were taken.

The MAAG test was chosen because of the expected low hydraulic conductivity (K) and also for the necessity of constant casing of the drillholes, due to the collapsing of the walls of the water-wells. The deepest water-well (102 m) was done in the middle of the northeastern bunk, south of the overflowing position of the lake, towards the central drainage trench of Chimaditis — Petron (Figure 3) and 7 more, 30 m deep, at the eastern border of the lake.

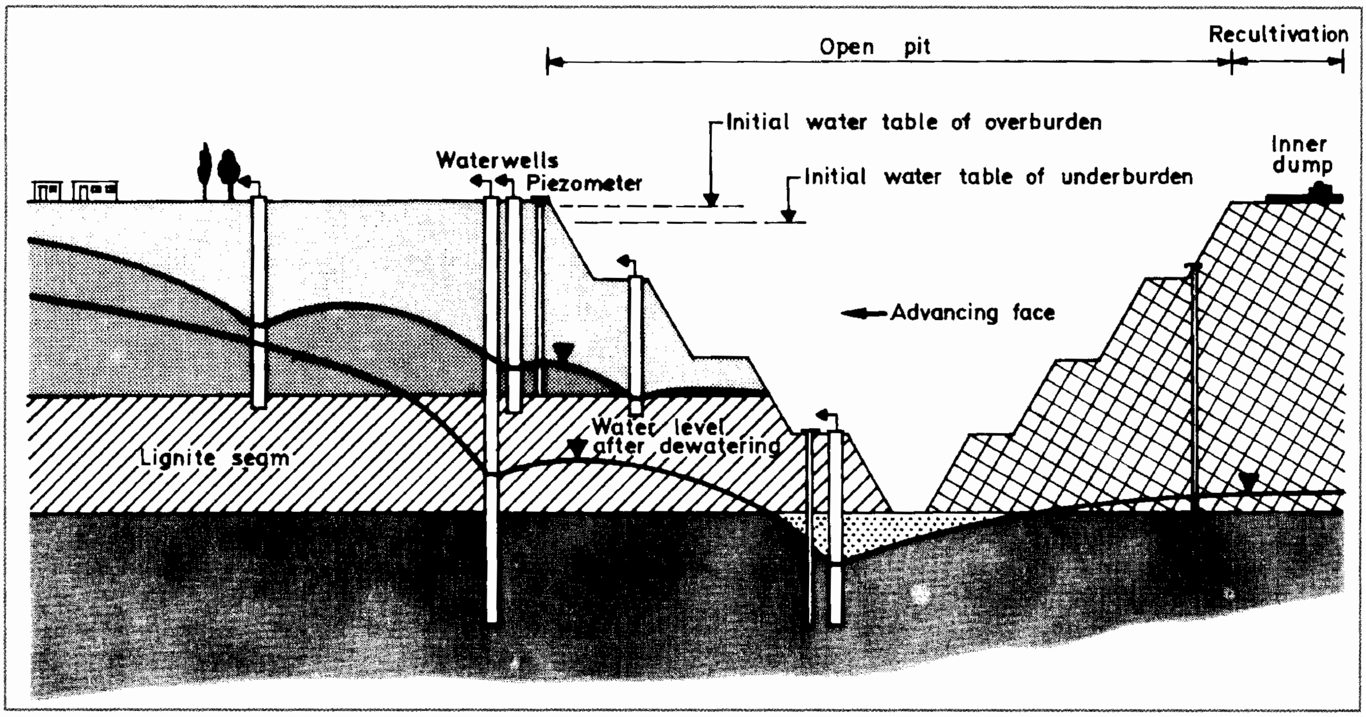


Figure 2. Schematic diagram of dewatering of open pits.

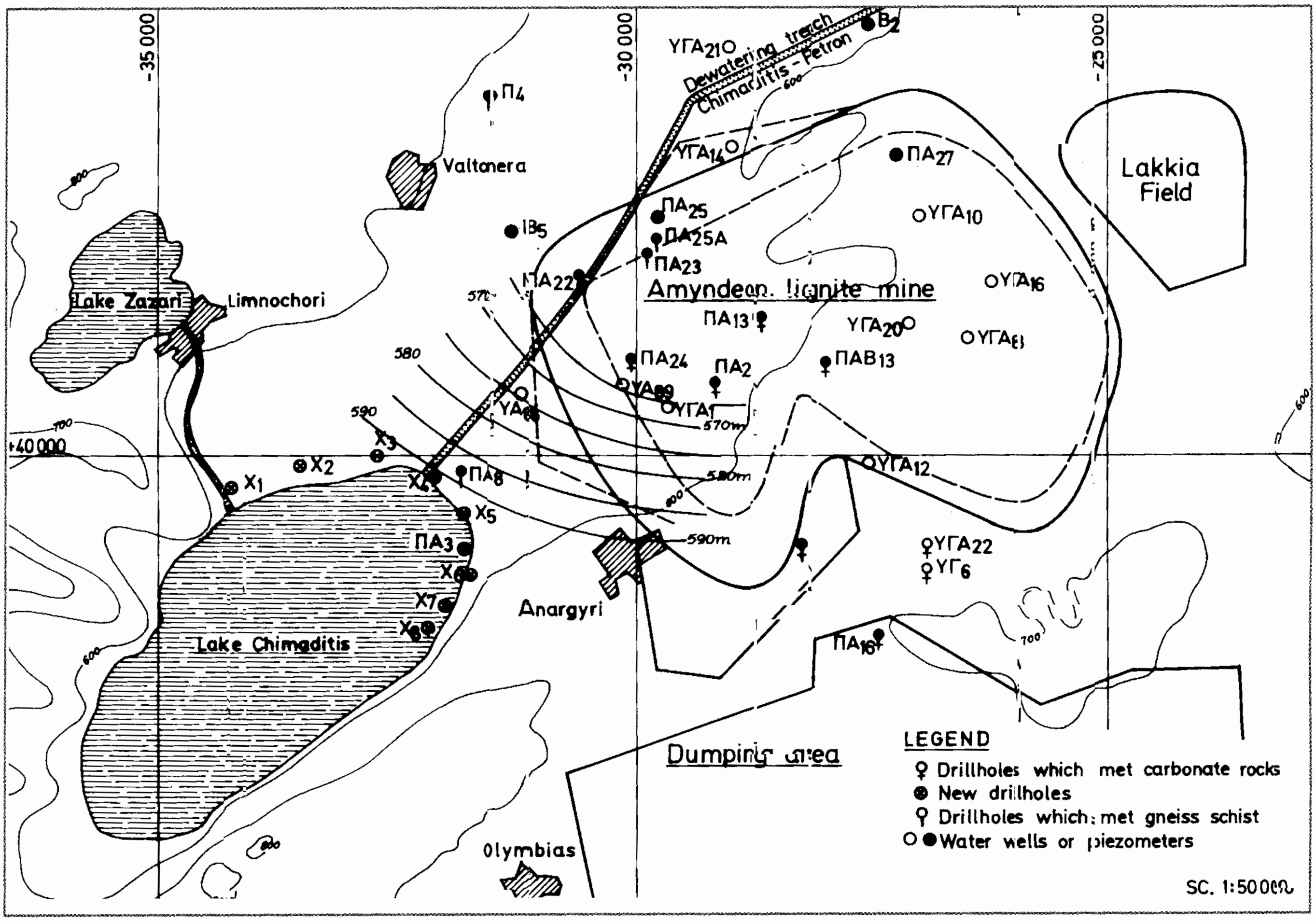


Figure 3. Piezometric map of July 1995.

After the sampling and the permeability tests were conducted, these wells turned to piezometres. In these piezometres as well as in a number of others selected in the surrounding area, various measures of the level of groundwater were taken.

Following are the results of the research and conclusions of the study.

## RESEARCH RESULTS

### Regarding the geology of the region

- The substratum of lake Chimaditis of the south, southwest and northwest part consists practically of impermeable gnessious — schists, which form the general older bedrock of the whole region. Their presence has been certified with drillholes in various positions and depths and also from geophysical searches in depths bigger than 400 m (PA22, PA23, PA25A, fig. 2).
- East and northeast of lake Chimaditis, below the Neogen accretions carbonate rocks of the Mesozoic are met, in depths ranging from 130 m to 435 m. These rocks are normally found over the crystalline schist.
- Between the impermeable substratum and the bottom of the lake sedimentary materials are found, created by the weathering of the surrounding mountain area. They have been deposited during the Pliocenic and Plistocenic eras and are still accumulated. These Neogen formations, consist of clays, sands fine-grained to silts, gray and ashy-green being the predominant colors.
- The surfacial layers surrounding the lake consist mainly of organic silts, clays, turf, turf-soils and finely grained sands. Often, these materials are found in mixtures of various concentrations and it is hard to distinguish them from the subjacent Pliocenic formations. The deposition of these sediments was and is still done under river-torrential and partly lake swamping environment, which is why their layering varies so much and their grain size differs even in very close positions. The deposition has taken place in the form of Lens — shaped mostly, layers.
- The domination of fine grained to very fine grained fractions in these sedimentary materials is obvious in the substratum of the northeastern littoral zone, where the construction of the investigation water-well was concentrated, due to the fact that the groundwater flow as well as the flow of leakage from the lake takes place in that direction.

- The domination of the fine grained materials, is expected to be similar in the largest part of the bottom of the lake. Coarse grained material has been deposited laterally on the lake at its half southwest, but it has been covered by very fine grained materials (clays and silts) of the recent sedimentation of the lake.
- The total thickness of the sedimentary materials that interfere between the rocky gneiss-schist substratum and the bottom of lake Chimaditis, varies from a few meters, at the southwestern tip of the lake, to 400-500 m at its northeastern section.
- On top of these materials, turf has been deposited, which has its main expansion towards the northeastern section and thickness that may reach 6 m (position X2, Figure 3).

### Regarding the hydrogeological characteristics of the formations

Inside the turf and the very fine grained sands, a phreatic aquifer is formulated with a piezometric surface that varies from 0,1 to 1,5 m. It has an impermeable clayey substratum 10 to 15 m deep. This aquifer is supplied from the leakage of lake Chimaditis and from the direct but poor infiltration of the rainfall. The aquifer's water has a very small velocity and it flows towards northeast, with a hydraulic gradient of 1%. The average permeability of the turf and the fine grained sands was found, after conducting permeability tests, 10-7 m/sec at an average thickness of 9 m. The leakage of this aquifer at the northeast part of the lake has been estimated, through a section of 3 km long, to be 8000 $m^3$/year. These quantities are moving very slowly towards the northeast and their affects on the lake can be ignored. Nevertheless, in the adjacent area to the lake, due to high piezometric head, which approaches the ground surface, in some periods, problems of oversaturation maybe caused, as well as swamping or periodical constrain inundation in the lower parts. The periodical swamping takes place in a narrow zone parallel to the low dyke, which was constructed along the northeastern shore of lake Chimaditis. The dyke's length is 1300 m and its width is 50-70 m, or even bigger in some places. It begins from the overflower of the lake towards the central drainage trench and continues 1300 m towards the Limnochori village. In that stripe, the soil altitude is lower than the lake's (590,4 — 591 m), which overflows at 591,2 m. Except from this lower, comparing to the lake zone, swamping conditions are being observed also at the rest of the zone which is adjacent to the lake, up to the trench area that joints lakes Chimaditis-Zazari, although the ground altitudes in that area are slightly higher than the level of lake Chimaditis. The over-saturation and swamping of the grounds in these two zones are caused by their composition and by the co-existence of: high piezometric surface, bad conditions of surface runoff and underground drainage, the rise of the capillary zone up to the soil zone and by the constant supply of the shallow aquifer from the lake. In the region of expansion of the turf morphological irregularities of the ground surface due to differential settlings are met. These settlings were created by the decrease of the volume of the turf due to the burning caused by self-reflection, when the groundwater level was lowered because of the drainage works, in the past. If alterations that could cause a new drawdown of the hydraulic level take place in the region, it is possible for them to cause new self-reflections of the turf, destruction of its deposits and the cause of more settlings.

Under the shallow aquifer and its impermeable claylly substratum there are layers of sand which have a total average thickness of 8 m, in the zone of 15-30 m depth, while in the zone of 30-100 m depth, the total thickness of the sands is 10 m or even less. Simplifying we accept that these layers of sandy material have a poor hydraulic connection, forming a confined aquifer. The average permeability coefficient and the hydraulic gradient of the fine-grained silty sands were estimated to be, 5x10-8 m/sec and 1%, respectively. Taken into consideration the above mentioned results of the research, the annual discharge of groundwater through a cross-section of the ground up to the depth of 100 m, parallel to the piezometric curves, under the 3 km northeastern bank, was estimated to reach the amount of 8500 $m^3$.

## IMPACTS OF THE MINE ON THE AQUATIC STATUS OF LAKE CHIMADITIS

Due to overpumping for the protection of the mine and the significant drawdown of the piezometric level, the worst scenario that could be expected in the future, is that the hydraulic gradient is going to rise and will cause an increase of the discharge of the confined aquifer.

This discharge as well as the one of the shallow aquifer, is created by the leakage of the lake through materials of low permeability at the bottom of the lake. The annual leakage is estimated to be about 16,500 $m^3$, under the present aquatic environment and is expected to reach the amount of 67,000 $m^3$/year.

Although these quantities are very small and could be ignored, they are sufficient for the maintenance of the level of the phreatic aquifer at a small depth 0,1 - 1,5 m (Tsiouris, 1996), as well as for the maintenance of the piezometric surface of the deeper confined aquifers. These confined aquifers are sometimes supplied from the poor aquifers of talus, whose piezometry is higher the lake's. For that reason automatic artesian flow of groundwater has been observed at the ground surface in 4 wells whose piezometry was higher than the lake's (PA3, YGA1, PA8, X6).

## CONCLUSIONS

A general conclusion that can be obtained from the research is that the present amount of leakage of lake Chimaditis is very small, less than 20,000 $m^3$/year. The leakage is expected to increase in the future due to the cone of depression which will be created by the overpumping for the protection of the mine from groundwater, but will still remain small (approximately 70,000 $m^3$/year) and is not expected to disturb the aquatic environment of the lake.

That leakage from the lake's bottom not only supplies poor aquifers, but also supports essentially the preserve of a low depth hydraulic level of groundwater, in the surrounding area of the lake. In that way, the turf-soil of Limnochori, which is threatened by self-combustionand will be destroyed if the piezometric surface of the shallow phreatic aquifer is lowered, is sustained. Simultaneously, the swamping conditions of a soil stripe of 200 - 300 acres are maintained, which under the present status cannot be used for agriculture.

According to the above conclusions of the research, various acts have been proposed, not of course for the protection of the lake from the mine affects since it has been made clear that there will be no disturbances in its aquatic environment, but for the protection of the turf of Limnochori, dealing with the swamping of the narrow stripe at the northeastern side of the lake, facing more general subjects of increasing the water resources in the vast area (e.g. small rise of the water level of the lake), and for the protection and sustainability of the environment.

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