Hydrogeological Conditions in Amynteon Open Lignite Mine and Design of Dewatering Measures

D.Dimitrakopoulos [a)] J.Koumantakis [b)]

[a)] *Public Power Corporation of Greece, Kifisou & Dirahiou, 10443, Athens, Greece.*
e-mail: ddimitrakopoulos@gmail.com, tel: 0030-2105192269
[b)] *National Technical University of Athens, Iroon Polytechneiou 9, 15780, Zografou, Athens.*

Abstract

The hydrogeological conditions of Amynteon open lignite mine, West Macedonia, Greece, are very complex and sensitive. They are characterized by the existence of four lakes, the presence of quaternary and Pliocene unconsolidated sediments, above the lignite seams, which contain highly permeable sandy aquifers and a huge aquifer in the carstified bedrock of the basin.

Based on numerical ground water simulations of Amynteon basin, a dewatering scenario has been developed. The pumped out water is distributed to the consumers of the area, in order to eliminate inevitable environmental impacts.

Introduction

Amynteon basin is located at the northwestern part of Ptolemais Trough, West Macedonia, Greece (fig. 1). As early as 1973 a geological exploration based on 4 drills detected a lignite deposit in the basin. This deposit was the thoroughly explored during the next 15 years.

A mining study conducted by Goergen 1979, demonstrated that it was technically and economically possible the exploitation of the lignite reserve for supply of two power plants totally 600 MW. The geological investigation revealed also the existence of extended aquifers in the overburden and underburden of the lignite and in the carstified bedrock. The water level of the overburden was at +600 m a.s.l., near the ground surface. The piezometric surface of the karstic aquifer was at +510 m asl, 200 m higher than the bottom of the mine, which is at 350 m asl. So exploration was not limited only to geological conditions but hydrogeological and geotechnical conditions were also investigated.

The simplified map in fig.1 provides an impression of the geological setting of the area.

The following paragraphs summarize the investigation carried out in the frame of the doctoral dissertation (D. Dimitrakopoulos, 2001)

Hydrogeologic environment

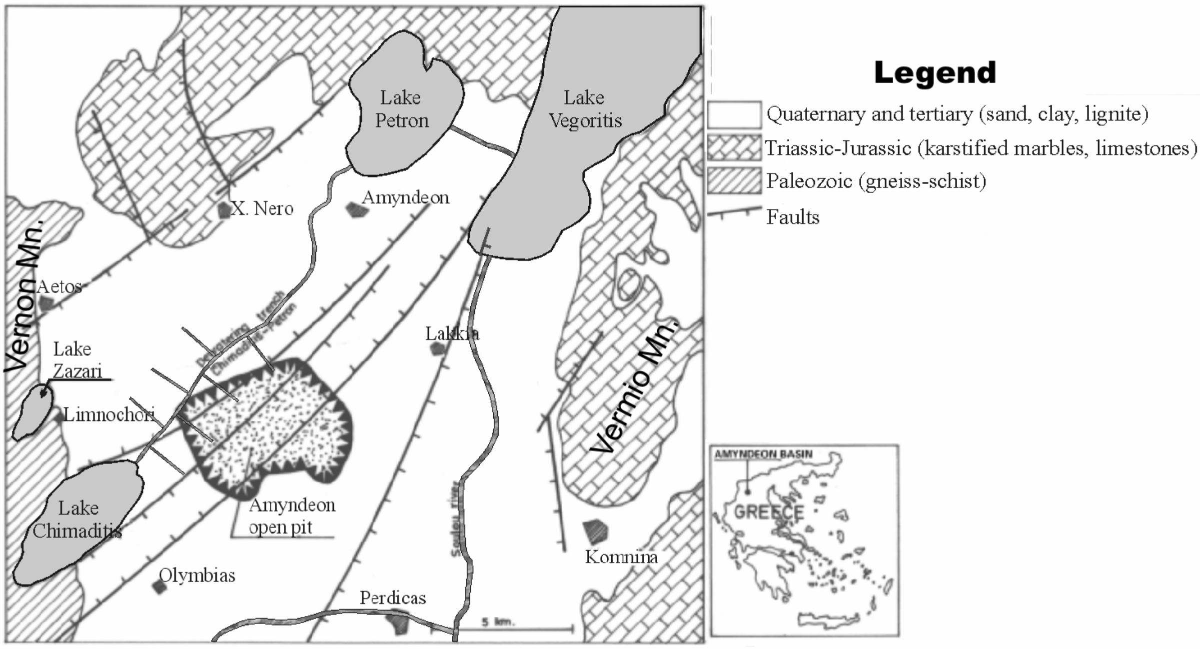
The Amynteon basin is surrounded by mountains:

- the Vernon mountain to the west, is consisted of crystalline impermeable rocks (granites and gneisses-schists)
- a mountainous area to the north above the line which is defined by the fault Aetos – Lake Petron consists of highly carstified marbles and limestones. This is a recharge area for the system of the aquifers of the basin fill.

The aquatic environment of Amynteon basin is rather complex and sensitive.

1. It is characterized by the occurrence of four lakes (fig. 1), which are hydraulically connected. In that way any interference in any of them has impacts on the others downstream.
2. Two major hydrological axes determine surface, and to some degree, also ground water flow patterns. The first axis runs in a SW-NE direction and connects Lake Chimaditis with Lake Petron. The second axis has a S-N direction and is characterized by the wide valley of the Soulou stream, which discharges into Lake Vegoritis. Both axes form the centerline of wide valleys. The escarpment of Lakkia-Perdikas, a flexural upward of the basin sediments, separates these from each other.
3. A stream and a network of drainage ditches connected to this stream, link hydraulically Lake Chimaditis and the swamplands downstream of it, with Lake Petron, forming a principal hydrologic axis between these two lakes. Some of the drained water is lost by evaporation.
4. The existence of the lakes, streams and swamplands near the lignite mine is a significant factor, which influences the planning of the exploitation.

__Figure 1__ Simplified geological map of Amynteon basin and environs (Rheibraun Consulting, 1988)



5. The sensitiveness of the aquatic environment, even to small changes, is due to the fact that the lakes contain a small volume of water. The depth of lakes Chimaditis, Petron and Zazari is up to 1 m and only in a small area it reaches 5-6 m. Under these circumstances even a small fluctuation of the level of the water, influences major part of every lake.

Ground water modeling

The first attempt to simulate the above described hydrogeological conditions, based on 4 pumping tests only was done by RE, 1988. But it was obvious from the early stages of the exploitation that the dewatering measures were overestimated, due mainly to inadequate data. So it became necessary to extend the investigation and re-estimate the dewatering process.

Logs of approximately 300 exploration drill holes, data from 39 pumping tests, monitoring of many piezometers and more than 50 chemical analysis served to develop a relative accurate conceptual model of the ground water situation. This model provided then the basis for developing a numerical ground water model.

At Amynteon basin three main hydrogeological units have been identified.

- Aquifer of the overburden (Pliocene and quaternary)
  The overburden series consists of a number of permeable unconsolidated and slightly cemented strata such as sand and gravel to conglomerate, clay and silt. This system of lensoid beds, with intercalations of low permeability layers, was simulated as a unique aquifer. Transitivity of sands and gravels derived from pumping tests covers the range $2,1*10^{-5}<T<1,3*10^{-2}$ m^2/sec. Thickness varies between 20-150 m. The thickness and the transmisivity in every model node reflect the accumulated thickness and the mean transmisivity. But anyway it is believed that the overall aquifer was properly simulated.
  The average precipitation of the area is 580 mm/year and recharge is estimated 12.3% (D. Dimitrakopoulos, 2001).
- The second aquifer of the fill of the basin is composed mainly of silty sands, is expanded under the lignite strata and is confined.
- A third hydrogeological unit has been identified at the bedrock of the basin, which is composed of highly karstified Triassic-Jurassic marbles and limestones.

A clay layer 20-200m thick below the lignite seam acts as a barrier to a possible inrush of water in the mine. Consequently these two aquifers were not included in the simulation.

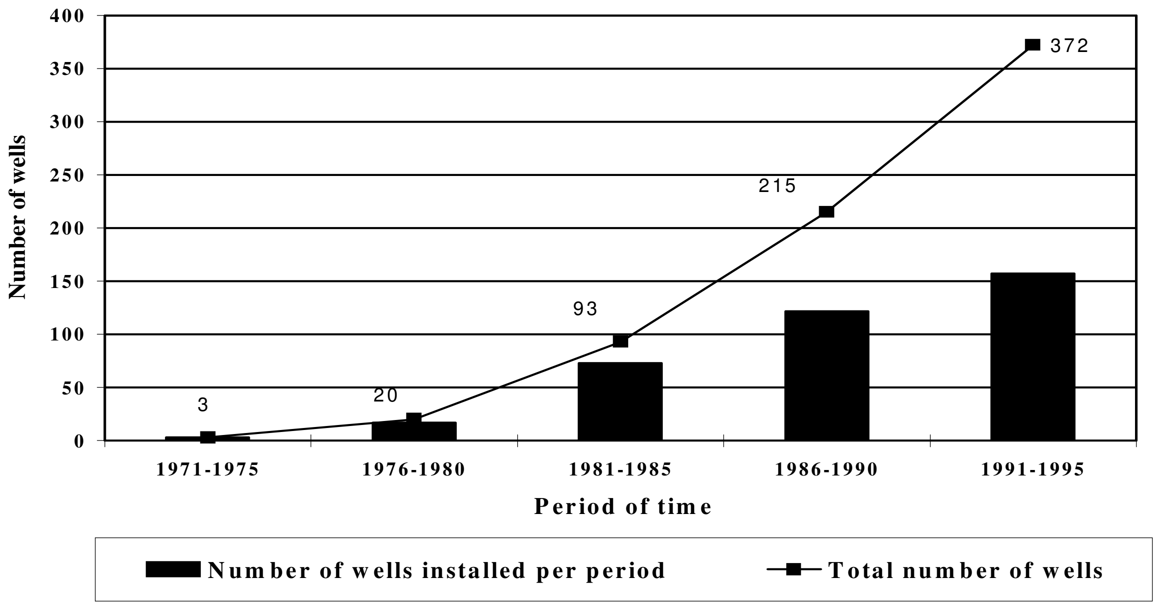
Dewatering measures

Ground water control measures were simulated on a basis of 4 mining positions covering the lifetime of the mine, until it reaches its deeper part, approximately 250 m below surface level.

Dewatering simulations with S.O.R model (Rushton, K. Redshaw, S. 1979), showed that the number of active wells had to be increased from about 20 at the beginning of the mine (year 1), to approximately 43 in year 10, and afterwards will remain in the same order for the next 15 years. The total rate of discharge will accordingly increase from 1200 m^3/h to 2600 m^3/h, approximately 50% less than the initial approach.

Today 13 years after year 1, the pumping rate for dewatering is 2500 m^3/h. On average 25-30 wells located in the periphery of the mine, are used. A substantial percentage, 30-50% of this volume, comes from surface sumps on the benches of the mine, as ground water seeps through the slopes. The number of water wells for irrigation and consequently the volume of the pumping quantities have drastically increased during the last years (fig. 2). Taking into consideration the increase of the pumping rate for irrigation in the vicinity of the mine, it is estimated that the actual total rate of discharge is in the order of the simulation. Nevertheless it is without saying that the rate of discharge from dewatering wells has to be increased.

***Figure 2** Number of wells for irrigation at Amynteon Basin*

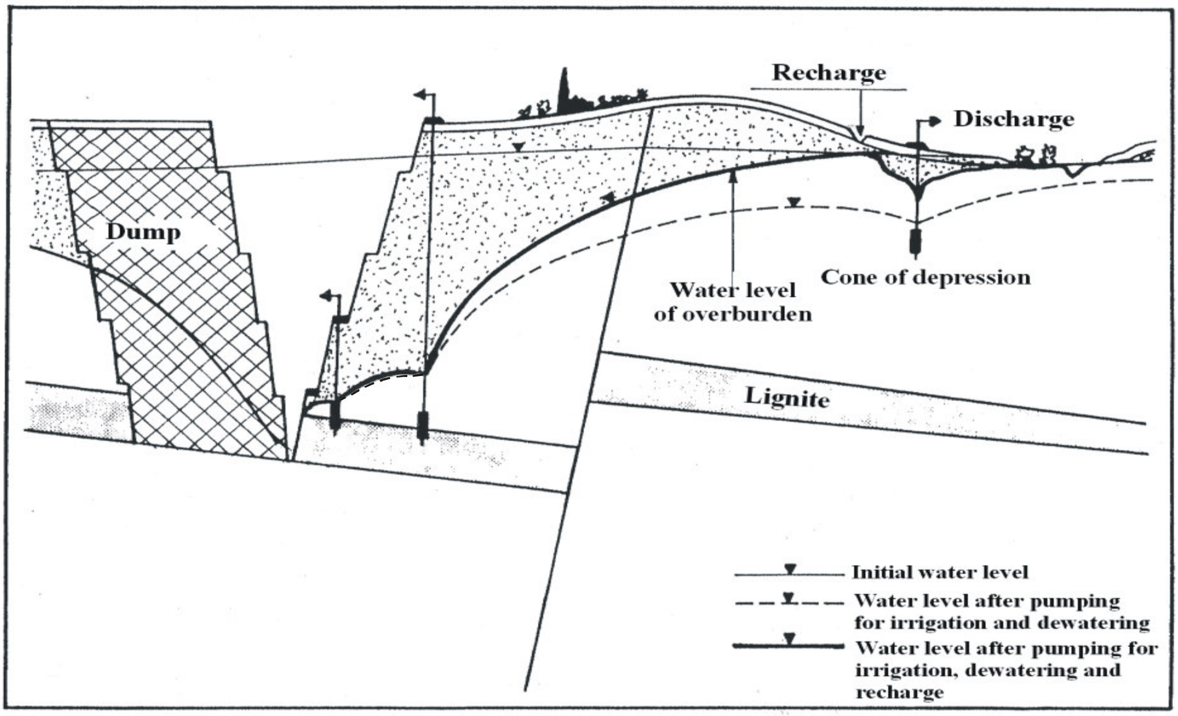


Water management system

In order to protect the environment, to maintain an acceptable aquatic environment and to minimize impacts on the sensitive system of the lakes, PPC has adopted a water management system, the main points of which are the following:

- Installation of an automatic recording system. A series of automatic recording stations have been placed in the lakes of the basin, in selected water wells and piezometers, in Soulou stream and in the trenches connecting the lakes.
- Pumping of the groundwater before it enters the excavation and be mixed up with the water coming from the sump stations inside the excavation, which has poor quality.
- Distribution of groundwater coming from the dewatering for agricultural and domestic use and in nearby ditches to eliminate the cone of depression (fig. 3).

Figure 3 *Recharge of the aquifer with water coming from the dewatering wells (Boehm B., Trumpff H., 1988)*



Conlusions

A conceptual model and reliable data are more important than a sophisticated numerical model when simulating complex hydrogeological conditions, as the case of dewatering of Amynteon lignite mine. The use of water, coming from dewatering, in the frame of a water management system is necessary in order to minimize impacts on the aquatic environment

References

Boehm B., Trumpff H., (1988). "Measures of water management for the protection of marshland north of lignite mining district" Wasser + Boden, March 1988, pp. 118-121.

Dimitrakopoulos D., Grigorakou E., (2001)."Water resources management at the Amyndeon basin, West Macedonia, Greece" 6th international symposium continuous surface mining. Freiberg 20-22 june 2001

Dimitrakopolulos D., (2001). "Hydrogeological conditions of Amynteon basin. Problems related to the groundwater" Doctoral dissertation. National Technical University of Athens.

Study financed by PPCDimitrakopoulos D., Voigt R., 1996. "Post mining water management problems in Ptolemais-Amynteon lignite district. Macedonia Greece" Geocongress Grundwasses und Rohstoffgewinnung, Proceedings Volume I, p. 49-54, Freiberg, Germany.

Goergen H., (1979). "Open cast mine Amyndeon preliminary report A, B". Study financed by PPC

Greek Biotope/Wetland Centre (EKBY), 1996. "Specific managemant plan for the site Chimaditida-Zazari" study financed by Hellenic Ministry for the Environment, Physical Planning and Public Works.

Koumantakis J., (1993). "Investigation of the possible impacts of Amynteon lignite mine exploitation on the aquatic regime of lake Chimaditis" Study financed by PPC.

Rheinbraun Engineering, 1988. "Dewatering study for the Amynteon lignite open cast mine, Ptolemais district" Study finances by PPC.

Voigt R., (1997). "Mine water handling at the proposed Thach K`11he iron ore mine, Vietnam" Braunkohle, Surface Mining.Vol. 49, pp 233-239.