Environmental Effects of Dewatered Open Pit Mines

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ABSTRACT

Before the initial burden removal and the beginning of coal mining it is necessary to drain the water bearing sand layers that can be found on the roof of the coal seams planned to be mined and also to affect a partial or total stress relieving of water bearing layers that can be found under the mined coal seams. Naturally, the dewatering or stress-relieving of water bearing layers causes a decrease in the saturation of semi-permeable or impermeable layers. The change of the saturation or hydraulic pressure causes a decrease in natural stress which is accompanied by an increase in effective stress. It causes the compaction of the layers and, in consequence, land subsidence appears.

The paper presents the environmental changes caused by the concentrated water withdrawal used in the territories of two Hungarian opet pit mines on the basis of data processing of water level decreases and land subsidence.

GEOLOGICAL AND HYDROGEOLOGICAL FEATURES OF THE BROWN-COAL TERRITORIES OF MÁTRAALJA AND BÜKKALJA

The underlying bedrock of the Upper-Pannonian brown-coal seams consist of sand, clay and other loose deposits with a mixed granulometric composition. The clayey-ligneous brown-coal seam can be found between them with regular bedding and accompanied by clayey coal and coaly clay layers. In the territory of Mátraalja 12, in the territory Bükkalja 37 elementary brown coal layers were discovered.

The Upper-Pannonian sedimentary complex thickens quickly in the direction of the lowland basin beds of coal measures dip by 2 - 3° down towards the SE direction. The coal seams become clayey at the boundaries and develop a divergent structure in the direction of the lowland basin.

The deposit developed in the Quaternary period and its surface has since been eroded. As a result Pleistocene fluvial deposits lie unconformably on coal sequences. The river valleys flowing from the mountain-sides and the southern and south-eastern part of the brown-coal areas are covered by Holocene sedimentary silt, sand and gravel. In the flow, and pressure conditions of the permeable settlements of the coaly block, the basin peripherical feature of the layers dominates.

It is a decisive hydrogeological condition that the basin settlements end off on the basin side in the order of succession of their slope, so the aquifers of the territory have a positive pressure distribution. Their water supply originates from local and infiltrating precipitation on the mountains through their outcrops.

Figure 1 shows an example of the geological and hydrogeological structure of this territory.

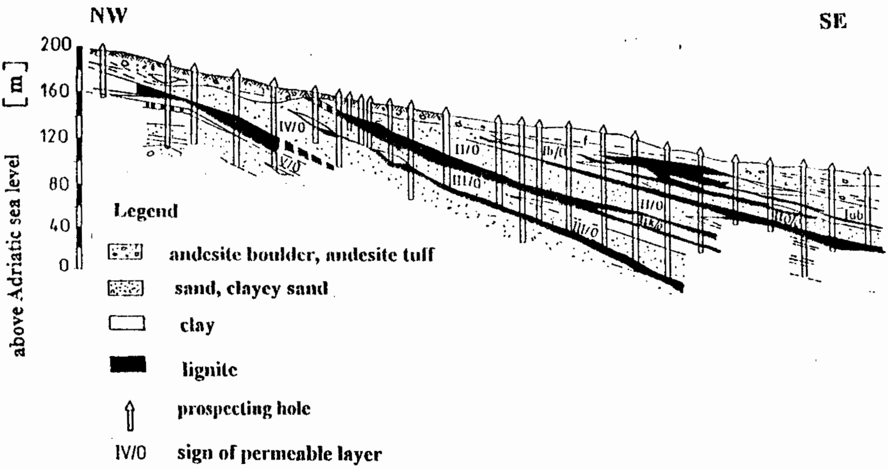

Figure 1. Geological cross-section brown-coal area named Mátraalja

The drainage of the territory of Mátraalja began in 1961, the dewatering of the territory of Bükkalja has been taking place since 1984. 460 million m^3 of underground water was extracted from the territory of Mátraalja. 14 million m^3 of water was extracted from the territory of Bükkalja by the end of December 1993.

DIRECT EFFECTS OF THE DRAINAGE

1. Lowering of the water table at the surface is as a result of the uppermost aquifer. The magnitude of the effect depends on the hydrogeological relationship between the soil layer and the deeper aquifers. This depression may be caused not only by the drainage but also by the meteorological conditions and the utilization of resources of the area. Depression can be observed not more than 100 m from the dewatered open pit mine in the form of water level decrease of dug wells and soil water wells of small depth. It is postulated that this is related to mine dewatering. For example, the water level of observed dug wells which can be found within a distance of 200 m from the open pit mine in the village of Visonta did not change after draining for seven years.

As the cultivated agricultural land has its own water balance independent of soil water the mining induced drainage causes agricultural damage only in the immediate vicinity of the mine. During the operation for three decades of the open pit mine of Mátraalja agricultural damage originating from drainage was negligible.

2. The lowering of underground water levels of deeper aquifers is locally severe. The scale of the problem depends on porosity and permeability of the aquifers as well as the intensity and duration of the drainage. This damage appears in the form of decrease of yield capacity or drying of springs and wells in the territory with a cone of depression. The radius of the cone of depression was 17 - 20 km in the mining territory of Mátraalja by the end of 1993.

Figure 2 shows an example of the depression developed in the aquifers of the territory of Bükkalja.

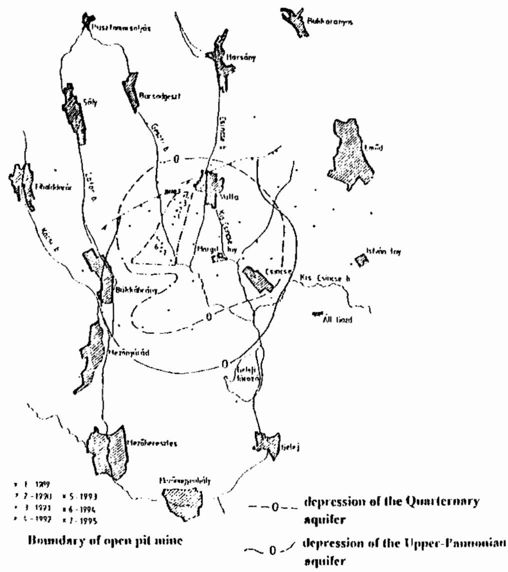

Figure 2. General plan

3. The damage to standing and fresh surface waters can appear depending on the quality and quantity of the insitu mine water. The cross-section, regulation, maintenance works, forms of the slopes of the receptive river-bed have to be modified on the basis of yield of mine water placed into the river. The quality of mine water influences the utilisation of receptive surface water.

The standard of water quality pumped from the area of Mátraalja and Bükkalja is drinking water, so the majority is utilized. The mining waters within surface water cause neither qualitative nor quantitative damage.

INDIRECT EFFECTS

1. The modification of seepage conditions of the depressed area causes changes in the movement circumstances of the aquifers. Increase of seepage rate, entrance of new supply areas can cause changes in the water quality, direction, ratio and amount of supply of the exploited aquifers and the changes can modify the utilisation of the ground waters.

In the territories of Mátraalja and Bükkalja neither the change of seepage rate nor the modification of supply area cause demonstrable changes in water quality.

2. The surface movements caused by decrease of water level are the results of concentrated water yield from the confined aquifers. The water yield is accompanied by a decrease in water pressure, which causes modification of the stress conditions. As a result of the increase of effective stresses compaction of layers begins. The combined effects of the consolidation process take place mainly in the compressible impermeable layers of the water bearing system and appear as land subsidence. The magnitude of the land subsidence varies with area and can cause damage or ruin of various technical surface facilities (roads, railway tracks, pipes, buildings).

Figure 3 presents an example of the chronological order of average fall in water level and the associated land subsidence observed as an indirect effect of water level changes. The data originates from the central region of the Mátraalja subsiding area.

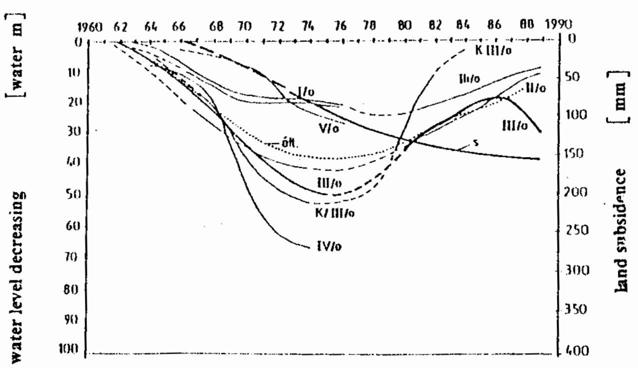

Figure 3. Chronological data of water level decreasing and land subsidence

In Figure 4 a map of predicted land subsidence by the year 2000 can be seen. It was made by using numerical computer models taking into account mining, technical and draining plans in the mining territory of Mátraalja.

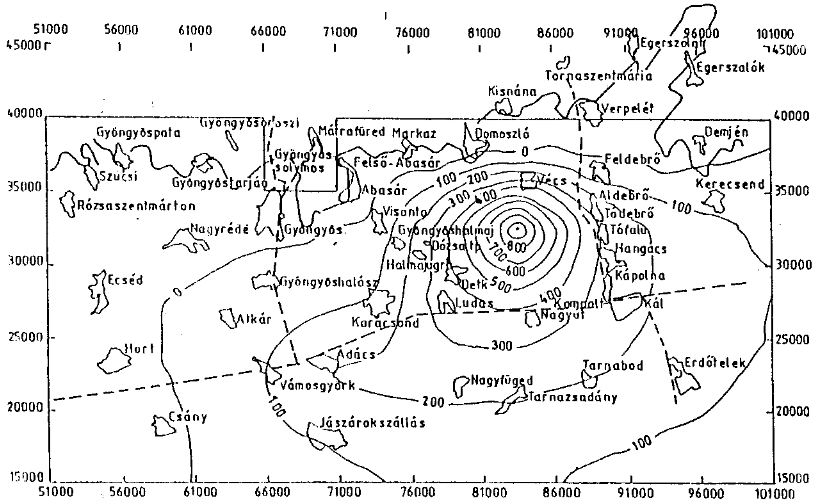

Figure 4. Land subsidence 2000 (mm)

PREVENTION AND REDUCTION OF ENVIRONMENTAL DAMAGE

The theoretical possibilities of reduction of environmental damage caused by ground water withdrawal are as follows:

- reduction of the amount and duration of the decrease in pore pressure,
- preparation of the technical facilities to tolerate the environmental effects,
- relocation of the technical facilities,
- replacement of water works used for drinking water utilization,
- utilization of mining water.

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