HYDROGEOLOGY OF AN OPEN PIT MINE IN HUNGARY

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ABSTRACT

In the Vadna lignite area representing part of the East Borsod lignite basin in NE of Hungary /Fig. 1/, the lowest seam, i.e. seam V. has developed out of the five seams charateristic of the basin. Due to its shallow depth, open pit mining is envisaged to work the deposit in two stages. Hydrology and hydrogeology of the area and a proposal for the protection against surface and ground waters in stage I. of the open pit mine are discussed in the paper.

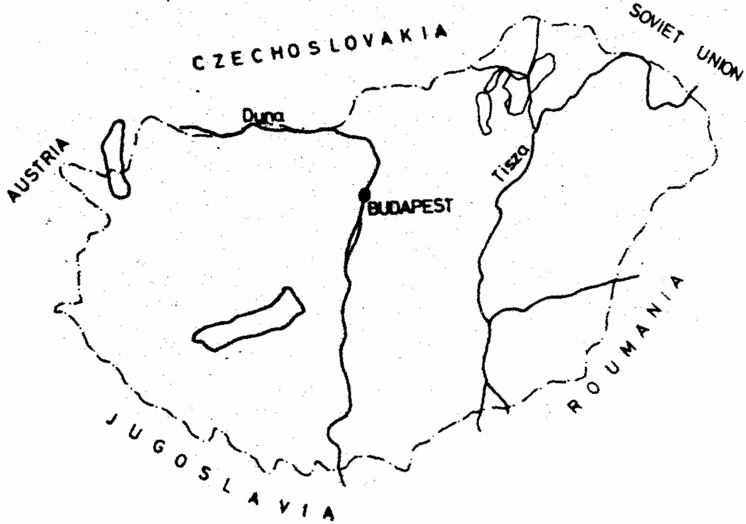

Fig. 1.
Geography of the Borsod lignite basin

GEOLOGY, STRATIGRAPHY

The basement rock and the basement of basin of the Tertiary lignite area in the Sajó valley are made up by new Palaeozoic-Mesozoic Bükk limestones, dolomites and slates as well as old Plaeozoic crystalline limestones and graphiteous slates.

The basement rock in the area prospected consists of Carboniferous limestone though one of the prospecting boreholes produced sericitic slate. The surface of the basement rock is indented, in the SE side of the Bán valley it lies lower.

The loosely cemented coarse-grained sandstone layered on Palaeozoic basement rock with an erosion discordance, can be regarded as the erosion product of Eggenburgian sediments.

The lower rhyolitic tuff and tuffeaceous clay with a general lithology forming the direct floor formation of the coalbearing sequence is 5 m thick in general but it is of varying thickness in the surrounding areas.

In the Vadna area - due to denudation - only the lowest, i.e. coal seam V. is known out of the five seams /Juhász 1958, Juhász 1961/ characteristic of the East-Borsod lignite basin, therefore the thickness of the Ottnangian coal-bearing sequence does not exceed 15-25 m. The upper, 1.5-3.5 m thick bed of the 6-8 m thick, multiple-bed seam V. is workable.

The average thickness of the overburden of seam V. is 21.6 m in the area of stage I. of the open pit mine.

A 6-8 m thick compact, water-tight siltstone and a clayey sand with poor permeability are layered on the coal seam. Higher, a light grey, loose, permeable sand has been found. The permeable sand sequence is divided into two water-carrying levels by water-tight or poorly permeable, fine-grained sediments over a considerable part of the area.

The sediments in the overburden of the coal-bearing sequence can be identified with the formations between coal seams V. and VI. of the East-Borsod lignite basin. Pleistocene sediments above them are represented by bouldery, gravelly sand and the terrace sediments of the River Sajó which is probable to belong to the upper Pleistocene due to its stratigraphical position and lithology.

From structural point of view the area in the Sajó valley is a graben structure with a NE-SW direction. The beginning of the formation of its elongated elements can be put to the Savaen orogenic phase with multiple renewal in the Styrian phases.

GEOGRAPHY, MORPHOLOGY AND HYDROLOGY

The lignite area around the village Vadna was first prospected in 1960-62. Further geological and hydrogeological prospecting took place in 1985-86. Relying upon the findings of the prospecting, the open pit mine is planned in two stages /Fig. 2/, preparation of stage I. started in summer of 1986.

The surface of the area dips slightly from the SW to the NE, its northern part belongs to the flood plain of River Sajó and its parts in the S and SW are covered by hills.

The most important river in the area is the Sajó. One of its right-hand tributaries, the Bán Creek crosses the area in the middle while the side branch of the Bán Creek, called Vadna ditch flows to the East from the lignite area /Fig. 2./.

Flood protection has been carried out on the upper 17 km section of the Sajó only: there are no protecting dams in the area prospected thus the northern part of the open-pit-mine-to-be is an open flood plain. This requires solving the problems of surface water protection.

The outfall section of the Bán Creek affects the area of the future open pit mine on a 1 km length. The bed of the creek is regulated, its cross-section can carry a 10-per-cent-probability discharge. Its fluctuation has been damped by the flood wave controlling effect of the Lázbérc Reservoir commisioned in 1969.

The Vadna ditch has been built with respect to 10-per-cent-probability dicharge outside the village and 1-per-cent-probability inside. At the outfall of the ditch to the Bán Creek a pipe lock with a gate has been constructed which protects the village from being flooded.

The average of the rainfall over the area is 681 mm/year and the average evaporation amounts to 500-520 mm/year.

The terrace gravel of the River Sajó forms the ground water reservoir of the area with an open water table except for the high-level spring hydrological period when certain spots become pressurized. The depth of the ground water below surface is 3.0 to 3.5 m according to the data of borehole group No. 108 and the data gathered in the observation well in the village Vadna over a period of 35 years. The height of the ground water level follows the surface morphology. The maximum change in the ground water level amounting to 180 cm was observed in 1970.

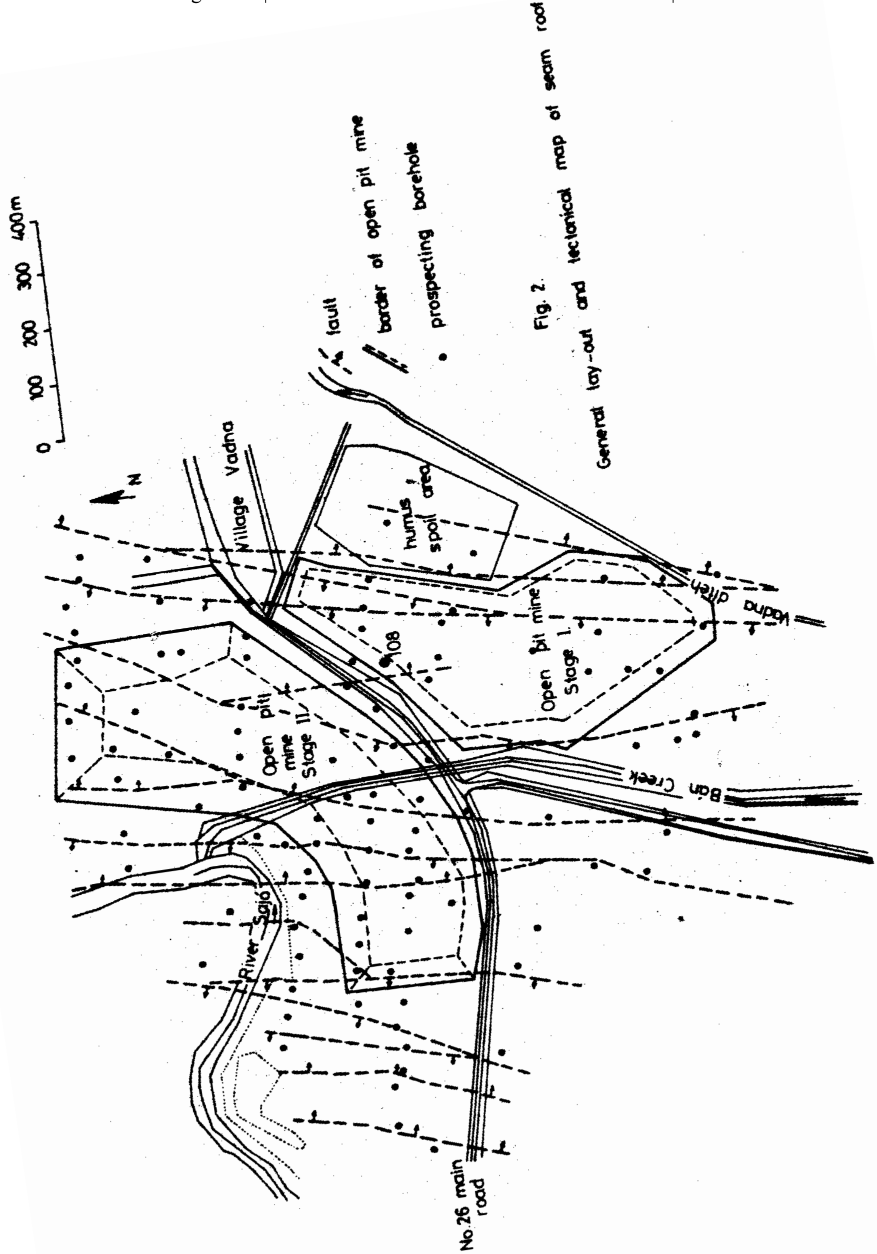

Fig. 2.
General lay-out and tectonical map of seam roof

Fig. 2. also illustrates the tectonical picture of the overburden of coal seam V. The throw of the faults varies between 2 and 10 m.

HYDROGEOLOGY

The upper water-carrying level is a Sajó terrace gravel which is 3.7 m thick in average and forms the groundwater reservoir of the area /Fig. 3./. The soil thickness averages 2.4 m. The coefficient of seepage of the Sajó terrace gravel was measured by pumping tests in the borehole group No 108 and has been found to be 24.2 m/d /2.8×10^{-4} m/s/. Its gravitational void volume has been accepted as $n_o = 0.15$ in designing water control.

Another water-carrying level in the overburden of the coal-bearing sequence is a sand sequence below the terrace gravel which has developed in one or two beds but can be considered hydraulically homogeneous. Its thickness is different /Fig.3/, the average being 9.8 m with values of 15 m in certain spots. In the E and SE parts of the area prospected the water-tight or poorly permeable formations between the sand and gravel layers have been denuded thus the young Sajó terrace gravel is layered direct on the water-carrying sand sequence. Thus the two water-carrying levels communicate also hydraulically.

The coefficient of seepage of the sand sequence-determined by pumping tests - has been found to be 0.6 m/d /6.9×10^{-6} m/s/, its gravitational void volume is $n_o = 0.1$ and the static water table coincides with that of the groundwater.

In the overburden of the coal-bearing sequence all prospecting boreholes have found water-tight formations consisting of siltstone and clayey siltstone with an average thickness of 7.5 m.

The average sedimentary sequence of phase I. of the open pit mine taken into account is illustrated by Fig 4.

Water-carrying formations in the overburden have their supply from the Sajó whose intensity has been found to be 15 l/s/km from the results of the well-group tests /Jeneyné-Szilágyi 1986/.

Considering the technical state of the bed of the Bán Creek and the experience of the Borsod Coal Mines gathered in the open pit mines in the Sajó valley /Borsod Coal Mines 1976, Borsod Coal Mines 1977a, Borsod Coal Mines 1977b/, the effect of drainage of the subsurface water reservoirs is regarded negligible. Water level reduction in the water-carrying layers is expected to cause no seepage from the strongly silted and colmated bed.

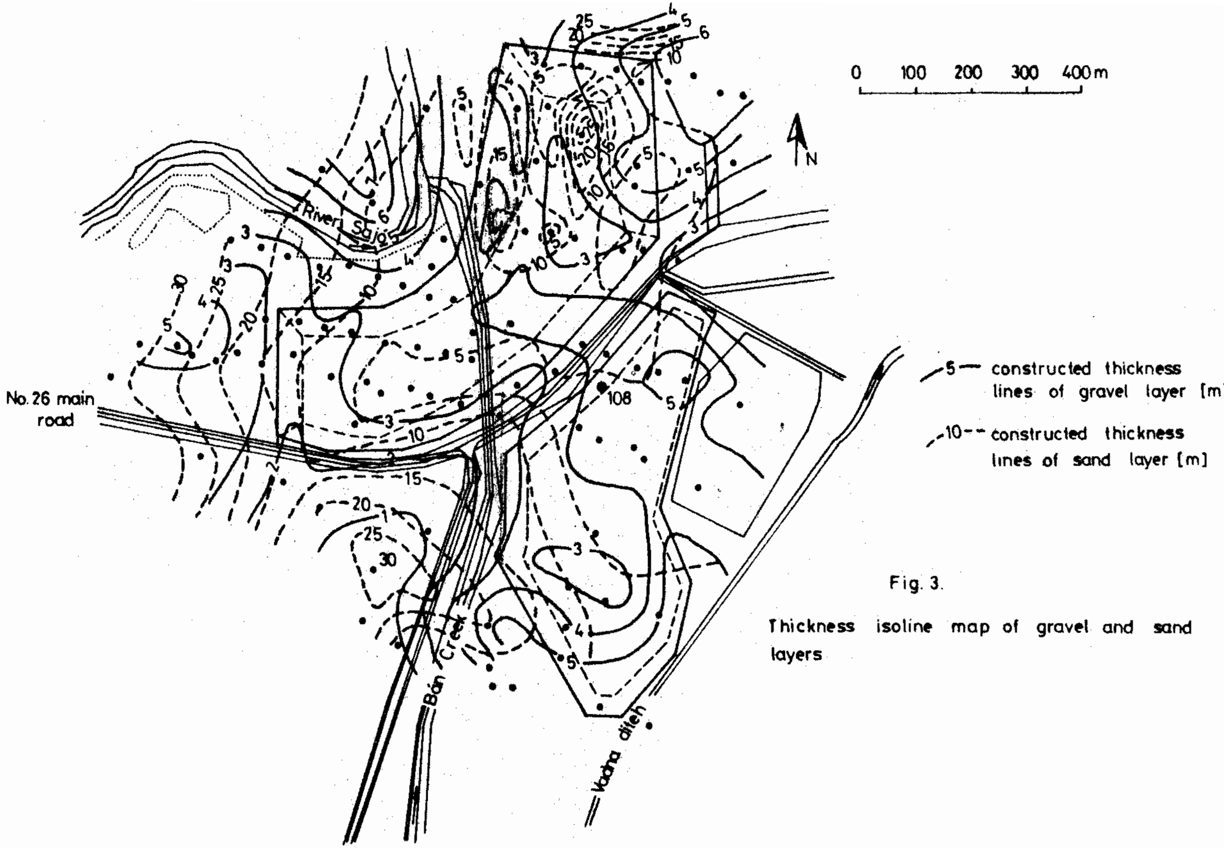

Fig. 3.

Thickness isoline map of gravel and sand layers

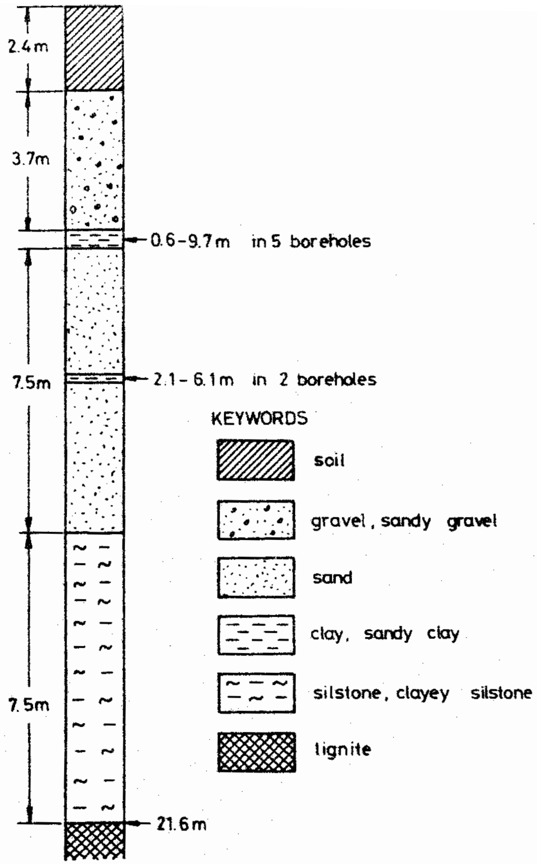

Fig. 4.

Average sequence of sediments of Vadna I. open pit mine

PROTECTION AGAINST SURFACE WATERS

The open pit mine will have to be protected in stage I. against rainfall in the area around it and inundation by the Bán Creek and the Sajó.

Water flowing down the surface of the hills surrounding the area from the S and SE is collected and carried to the Sajó by the Vadna ditch.Its bed is suitable to safely collect rainfall over the catchment area.

The design flood level of the Bán creek /$Q_{1\%}$/ is higher than the surface in the section beyond the bridge of the No 26 main road, thus a protection dam will have to be built on the W side of the open pit mine to protect it. The crown level of the protection dam has to be 1 m higher than the 1 %-probability flood level with a length of 650 m. The section 0+000 starts from the No 26 main road and its final section joins the Vadna ditch /Fig.5/.

On the NW side, the No 26 main road serves as a protecting dam against the floods of the River Sajó on a length of 240 m. To protect deep areas of the open pit mine in the N, NE and E against inundation by the Sajó a 630 m long protecting dam has to be built. 3.0 m crown width is suggested for the protecting dams with a slope inclination 1:2.

DRAINAGE OF OVERBURDEN RESERVOIRS

In oder to protect the open pit mine, both water-carrying sequences in the overburden of the coal-bearing sequence have to be drained. Discharges to be pumped in the water control are /taking into account hydraulic parameters, depth of layers, distance from the River Sajó and the area to be kept open/:

Layer	Discharge to be pumped /m^3/min/	
	Opening trench	Total area
Gravel	1.4	3.2
Sand	0.5	0.6
Total	1.9	3.8

The discharge calculated for the total area represents a theoretical maximum since the worked area to be kept open at a time is always smaller than the total area.

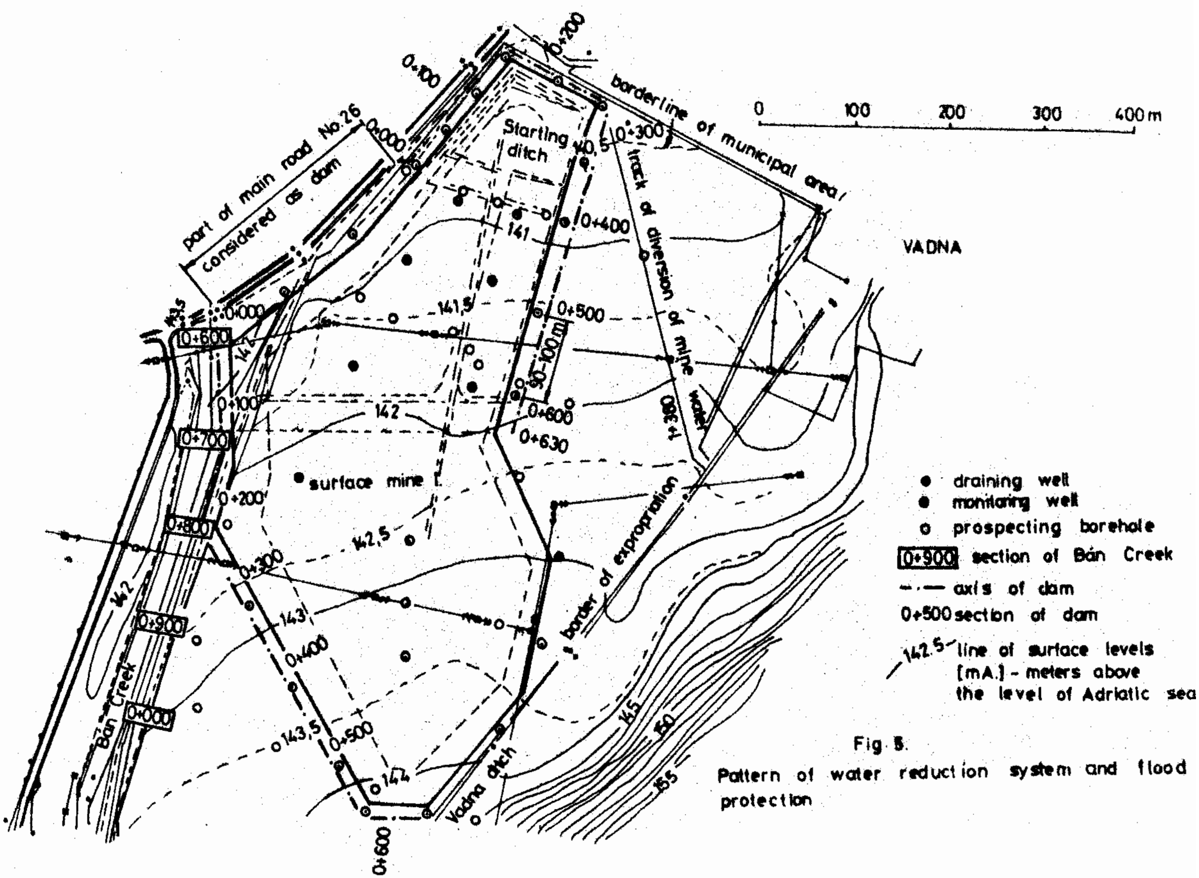

Fig 5.
Pattern of water reduction system and flood protection

The capatiy of the wells can be expect ed to be 210 l/min in gravel and 40 l/min in sand according to hydraulic tests. Thus the maximum capatcity of wells fitted with filters crossing the total water-carrying sequence will be around 250 l/min. Calculating with a 20 % safety 10 wells will be needed to protect the opening trench and a minimum of 19 to protect the total area. The pitch of the wells with a uniform pattern along the slope will be 57 m around the opening trench and 96 m around the total area.

A regular well pattern may be modified by the following aspects:

- to make use of layer and seam dip, wells have to be arranged in a denser pattern in the W border of the open mit mine;
- the floort of the sand layer is not plane due to tectonical reasons, thus non-drained "trenches" may remain using a regulst well pattern which have to be drained by specially arranged wells;
- the sand layers grows thin or wedges away around the E border of the open pit mine, here the working pit can be promine, here the working pit can be protected by draining the gravel layer.

To ensure an efficient protection, the following aspects have to be taken into account:
- The wells have to be fitted with filters both in the gravel and in the sand layers because a low discharge from the sand layer would cause trouble in the operation of the pumps.
- The capillarily retained water column in the sand layer amounts to 3.0 m. Therefore, to make protection in the open pit mine more efficient, the sand layer is to be removed in a separate slice with a minimum 10 m ahead of the removal of the direct overburden of the coal seam. Thus the water leaving the sand can be collected and carried away in ditches without disturbing cutting operations.

  To monitor efficiency of water control along the borders, a minim um of 4 monitoring wells has to be arranged so as to allow observation of the two layers separately.

The suggested water table reducing and monitoring system is illustrated in Fig. 5.

EXPECTED ENVIRONMENTAL EFFECT OF MINE WATER CONTROL

The distance of effect can be estimated for 1.5 to 2.0 km at the end of a 2.0 to 2.5 years period of time of the mining activity. The measure of the water table reduction will be checked in 3 selected dug wells in the village Vadna.

The expected measure of surface subsidence due to drainage has been calculated using compression modul determined on core samples from the area. The subsidence is expected to be 7 to 8 mm in the line of No 26 main road corresponding to total drainage - using strata paranteres measured in laboratory and taking static water level of 3 m below the gorund. Taking into account the average sequence of sediments in the Vadna I. open pit mine and the average thickness of the formations over the area, a layer compaction of 10 to 12 mm belongs to the total layer drainage.

The surface subsidence estimated around 1 cm can be regarded as an absolute maximum since it belongs to the complete drainage of the reservoirs which, however even if the wells operate ideally, is limited to a few dm surrounding of the filter wells. At greater distances from the working pit the value of surfance subsidence logaritmically decreases.

The Borsod Coal Mines will refills the working pit of the open pit mine by the waste of stage II so as to level with the original surface and will reclaim it to be suitable for agricultural production.

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