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DRAINAGE OF MINING DEVELOPMENT IN A NEOGENE LIGNITE DEPOSIT IN HUNGARY

Mrs Jeney dr R. Jambrik
Technical University of Heavy Industry

ABSTRACT

The neogene Borsod lignite basin of 620 sq. km extension is in the north-east of Hungary, to the North of Miskolc. The Dubicsány lignite deposit is its NW district explored by drillings /Fig.1/. An inclined shaft is under construction, its sinking started in 1984. The inclined shaft crosses 3 water-bearing sand seams forming separate closed-table water reservoirs. Possible solutions of the drainage of the inclined shaft are dewatering or depressurizing and dewatering the reservoirs. The study deals with the geology, tectonics, hydrogeology of the area, as well as the hydraulic and rock physical parameters of the reservoirs and suggests a double-stage draining system.

Fig. 1.
Geography of the Borsod lignite basin

GEOLOGY OF THE AREA

The oldest formation of the Dubicsány lignite deposit forming the basement of the basin is a dark grey cristallic limestone and sericitic slate and has been formerly considered of Carboniferous /Juhász A., 1961/ lately, however, of Devonian. This limestone and sericitic slate can be found in the SE of the area on the surface too and it limits in this direction the expansion of the coal-bearing seam series and their overburden formations. On top of it Miocene /Eggenburgian/ rhyolitic tuff /"lower rhyolitic tuff"/, tuffaceous clay, tuffeaceous sand, slay, siltstone, rock fleur-sand sand are stratified. These formations form the underlying of the Ottnangian coal-bearing seam series.

The coal-bearing seam sequence is montonous because neglecting a few exceptions /the presence of a thin coal seam IV/ coal seam V has only developed of the five coal seams characteristic of the Borsod lignite basin - in some places in two beds. A sedimentary sequence of siltstone, clayous siltstone and clay stratified on seam V with a thickness varying between 0 and 30 m and averaging at 8.1 m, forms the protective seam in the roof of seam V. The water-bearing seam sequence above it is separated into two sand groups in a part of the area while on other parts it forms a communicating water reservoir creating a hydraulically unified system over the whole area. Exploring drillings in the shaft axis have found an average thickness of 55.3 m for the water-bearing seam sequence above coal seam V /Fig.2./.

The coal-bearing Ottnangian and Carpathian seam sequences cannot be found over the whole area, their upper part is denuded. The Badenian seam sequence stratified with an erosional discordance on the denuded area is built of rhyolitic tuff, rhyolitic tuffeaceous clay, siltstone, clayous siltstone, sand and sandy clay. Due to the Presarmatian denudation, the Badenian formations are thin while in certain places they are fully denuded.

The fairly plainly denuded surface is covered with a Sarmatian basis gravel of varying thickness and good permeability, followed by an andesite tuffeaceous, agglomerateous seam sequence interstratified with clay, siltstone, sand and gravel beds.

The thickness and areal expansion of Pliocene and Pleistocene formations are rather limited. Their basic material consists of coarse particles /gravel and conglomerate/ covered with clay siltstone, sand, gravel seams and their intermediates. Their expansion is limited, they reach their maximum thickness in the northern part of the area.

The whole area is covered with a 0.5-2.0 m thick Holocene soil cover.

TECTONICS

The area of the Dubicsány lignite depost has been explored with geologic and hydrogeologic drillings in detail. Using geologic profiles drafted from the exploration results, the structural features of the area can be summed up as follows;

- The area is divided by successive faults into grabens and horsts. The average inclination of fault is 62-65^o .
- The direction of strike of these longitudinal faults is NNE-SSW with an angle of 25-32^o with the northern direction. Transverse faults could not be found with the given drilling density-though faults with smaller throw cannnot be excluded.

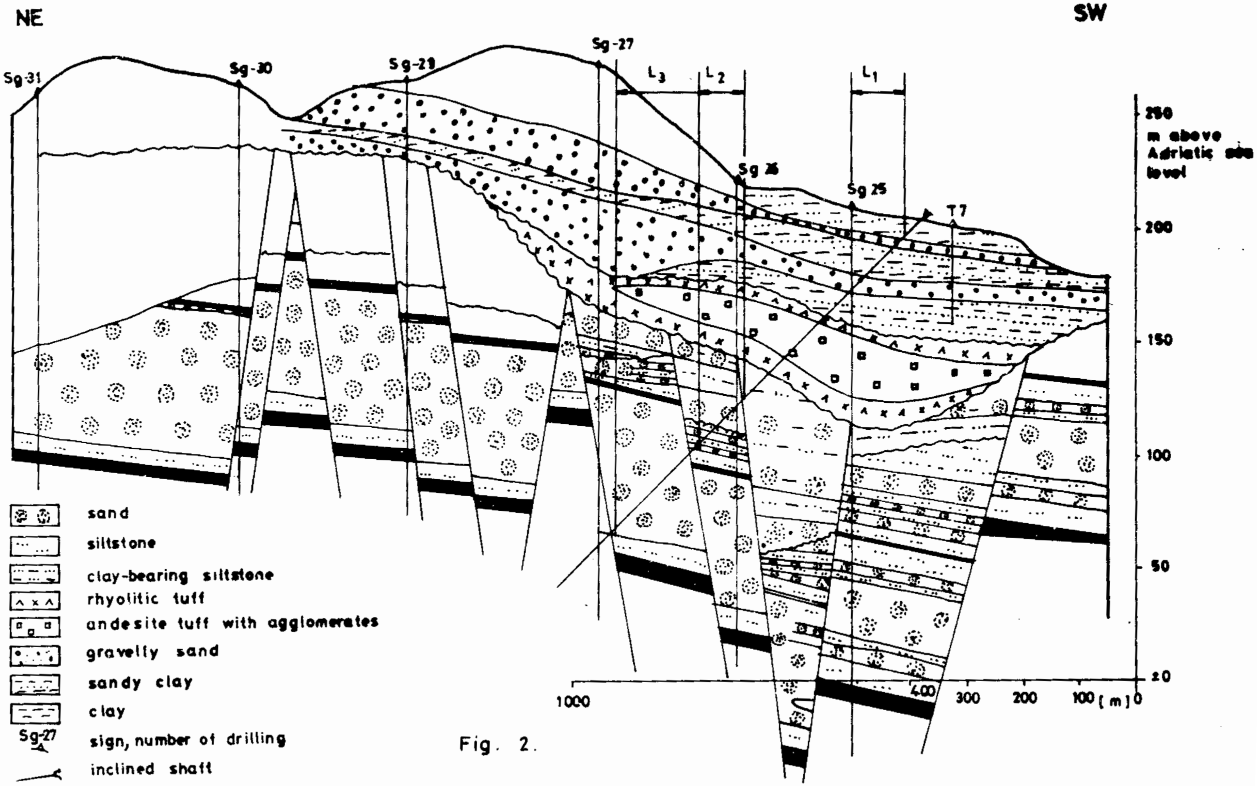

Fig. 2.

Geological profile in the shaft axis

- The throw of the faults varies between 10 and 100 m with a most frequent value of 20-25 m.
- In the NE of the area a group of faults can be found.
- The coal-bearing seam sequence dips at 2-5° towards the SE.
- The structure of the area may have developed in 3 phases of motion /Mrs Jeney R. Jambrik, 1982/;

1. crust motion of Premiocene epirogenic character preforming the basis mountain that created the area of sediment formation;
2. crust motion after coalification but still in the Ottnangian-Carpathian probably in connection with Old-Styrian orogenic motions;
3. Prepannonian crust motion affecting the Sarmatian seam sequence too.

The structural sketch of the lignite deposit is shown in Fig. 3.

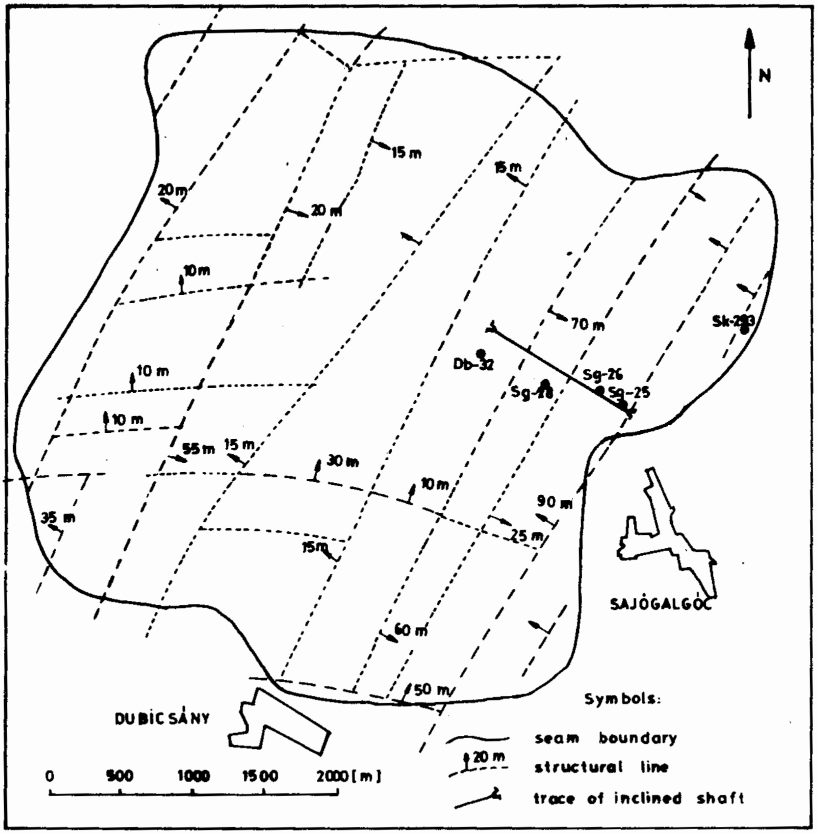

Fig. 3.
Structural sketch of the Dubicsány lignite deposit

HYDROGEOLOGY

In the Dubicsány area only seam V developed in workable thickness of the five coal seams characterizing the Borsod neogene lignite basin, seam IV is very thin /a few decimeters/ or can be found in traces only.

The water-bearing layers in the Miocene underlying of coal seam V store pressurized water but mining experience in the Borsod lignite basin has shown that these reservoirs do not cause any hazard concerning mining in seam V /Juhász A., 1966/.

The most important formation of the area from the hydrogeology point of view is the water reservoir of great thickness in the roof of seam V endangering mining directly. The thickness of this seam sequence averages 30.4 m over the area and though it is disturbed by siltstone and clay formations, tuffeaceous interbeddings and sand stone beds, hydraulically it is a communicating unity. Particle size distribution, clay content and degree of classification of the inhomogeneous seam sequence varies both horizontally and vertically. For the particle size distribution, rock physical and hydraulic parameters, pressure conditions and layer connections of the water-bearing formations affecting development and mining operations, data have been obtained from laboratory analyses of core samples of geological drillings /particle size analysis, permeabimeter seeping test etc./ and from in-situ measurement in 7 hydrogeological drillings. The effective particle size d_m lies between 0.08 and 0.2 mm, the unequality modulus u falls into the range of 2.0-5.0 indicating certain deliquescence tendecy in some portions of the seam series. Therefore, the drainage and crossing with developing mining excavations of the water-bearing seam sequence have to be carried out with special care.

Another hydrogeologically important Miocene water-bearing formation is bedded in the roof of seam IV and is a Badenian and Sarmatian gravelly, sandy, tuffeaceous, agglomerateous sequence of sediments of heterogeneous permeability with finegrained interbeddings.

The coarse conglomerate of the Pliocene-Pleistocene formations stores ground water. Their role is, however, because of the small thickness and restricted areal expansion, rather limited.

The average values of the rock physical parameters determined by laboratory measurements and characteristic of the water reservoirs in the area, are displayed in Table 1.

The static water level of the various water reservoirs measured in places as indicated in Fig. 3 is shown in Table 2.

The following conclusions can be drawn from static water level data;

- All of the three water-bearing seam sequences contain pressurised water, the pressure increases from top to the bottom /0.1; 0.5 and 0.9 MPa/.

- The Pliocene reservoirs are hydraulically independent of the older reservoirs, therefore a separate draining system is needed to drain them.
- The reservoirs in the roof of coal seams IV and V form one hydraulic unit, their depressurization and the reduction of their water reserves can be made by a combined draining system.
- The vertical pressure profile is negative, the absolute values of the static pressure stay below the hydrostatic ones. From the hydrogeological data no conclusion can be drawn as to any supply takes place. This means that no problem can be expected if only the stored reserves are taken into account in designing the draining system.
- Since the static head in the water-bearing sequence above coal seam V hardly varies, this proves that the faults disturbing the area failed to produce hydraulically separate seam systems around the inclined shaft.
- This statement cannot verified for the whole lignite basin; the water level in drilling Sk-293 indicates a hydraulic independence of the surroundings of the drilling from that of the inclined shaft.
- The pressure on the roof of seam V, depending on the lithology, varies between 0.9 and 1.5 MPa i.e. the protection in the roof is nowhere satisfactory over the area.

Table 1.
Rock Physical Parameters of the Main Water-Bearing Sand Sequences

Water-Bearing Sand Sequence	d_m [mm]	u $\frac{d_{60}}{d_{10}}$	n [%]	k [m/day]
Seam V, roof	0.15	3.4	36.7	1.60
Seam IV, roof	0.24	2.8	37.2	8.19
Pliocene- -Pleistocene	0.79	6.2	34.8	19.62

Table 2.
Static Water Level of the Main Water-Bearing Sand Sequences

Drilling N^o	Water-Bearing Sand Sequence	Static Water Level m /above Adriatic sea level/
Sg - 25	Pliocene	+191.60
Sg - 26	Seam IV, roof	+175.73
Sg - 26/A	Seam V, roof	+175.23
Sg - 28	Seam V, roof	+166.32
Sg - 28/A	Seam V, roof	+166.32
Db - 32	Seam V, roof	+167.64
Sk - 293	Seam V, roof	+144.18

In the hydrogeological drillings three-stage pumping tests, absorption tests and recovery tests have been carried out. The permeability and storage parameters determined from in-situ measurements and accepted for the calculation of water level reduction and dewatering, are displayed in Table 3.

Table 3.
Basic Data for Designing Water Table Reduction

Water Reservoir	Geometric Parameters			Permeability and Storage Parameters			
	ρ_e [m]	H^{max} [m]	M [m]	h_k [m]	k [m/day]	a [m^2/day]	n_o [%]
1	27,4	22,3	20.0	0.6	8.50	483.84	20
2	23.7	86.0	18.0	1.6	0.52	62.21	15
3	40.0	166.0	60.0	1.3	0.78	311.04	15

PROTECTION OF THE INCLINED SHAFT

In the drainage plan of the exploring inclined shaft to be constructed in the Dubicsány lignite district at an inclination of 200 per mille, three levels can be distinguished /Fig. 2/; Pliocene gravelly sand 1, sand 2 above coal seam IV and water-bearing sedimentary sequence 3 above coal seam V.

Because of the position of the inclined shaft a two-stage water level reduction is suggested. Stage one is performed from the surface preceding the actual shaft sinking. Water level reduction will be carried out by submersible pumps in wells at 2.5 m distance from the future cross-section of the inclined shaft.

Stage two is carried out from the inclined shaft following its advance. It has to reduce water tables remained after stage one and continuously protect the inclined shaft. Data used in designing water table reduction are displayed in Table 3.

Data of the surface-based draining system planned with 165/155 mm filters can be seen in Table 4.

Table 4.
Data of the Surface-Based Draining System

Water Reservoir	Draining System		Wells			
	Flow Rate [m^3/day]	Time of Operation [day]	Number [piece]	Flow Rate [m^3/day]	Max.Well Depth [m]	Filter Length [m]
1	5710	30	8	715	40	12
2	2360	90	10	236	130	12
3	4440	90	10	444	210	15

The layout of the draining system for the Pleistocene reservoir /length L_1 in Fig.2/ is illustrated in Fig.4, that for reservoirs above seams IV and V /length L_2-L_3 in Fig.2/ can be seen in Fig.5. As indicated in Fig.5, one pair of wells should suitably be fitted with filters draining sands both

above coal seam IV and V. To ensure continuous shaft sinking, the dewatering of water-bearing sedimentary sequence above coal seam IV should be simultaneously carried out with the draining of reservoirs above coal seam V.

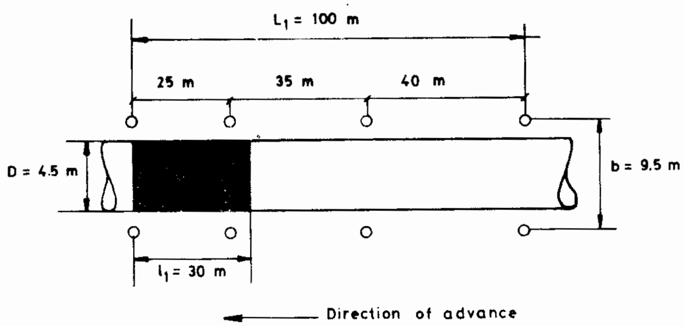

Fig. 4.
Pattern of the draining system in the Pleistocene reservoir

Considering the geometric properties of the inclined shaft and the change of the water table due to the interference of the wells, the distance of the wells has to be reduced in the direction of inclination.

During the surface-based drainage, the heads of residual water due to hydraulic well resistance, capillarity and the shape of depression curves between wells in the lowest parts of each shaft section in the water-bearing reservoirs, as well as shaft lengths to be drained by drillings from the face, are displayed in Table 5 and indicated in Figs. 4 and 5.

Table 5.
Data of Stage Two of Drainage

Water Reservoir	Head of Residual Water [m]	Shaft Length to be Drained from the Face [m]
1	5 - 6	30
2	10 - 11	45
3	8 - 9	40

Stage two of the water table reducing system has to be commenced from the inclined shaft in all three reservoirs. Its elements are Kassai-Halász's filters to be sunk by flushing whose flou rates can be expected for 130-170 m^3/day in the Pliocene reservoirs, 100-140 m^3/day in the reservoir above coal seam IV and 70-115 m^3/day in the reservoir above coal seam V, calculated with a draining time corresponding to the time requirement of continuous shaft sinking.

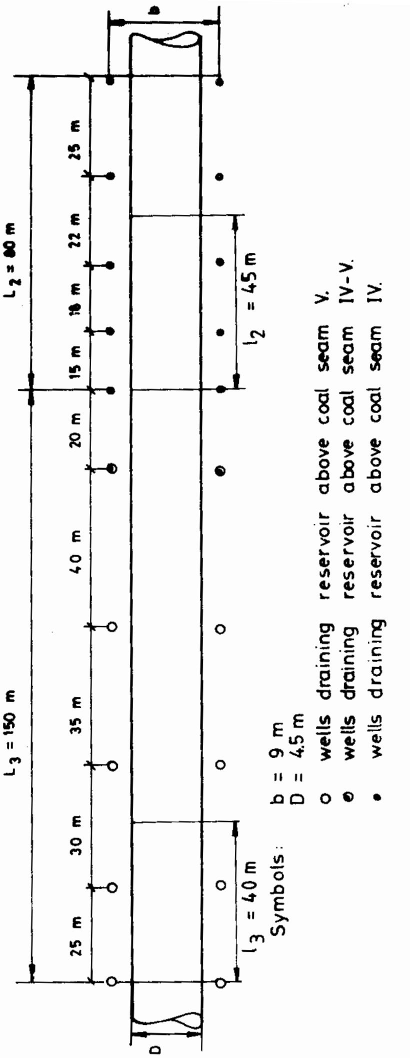

Fig. 5

Pattern of the draining system in the reservoirs above coal seams IV. and V.

Their suitable pattern is illustrated in Fig. 6. The head of residual water above the impermeable layer will be probably reduced belon 1 m due to their effect.

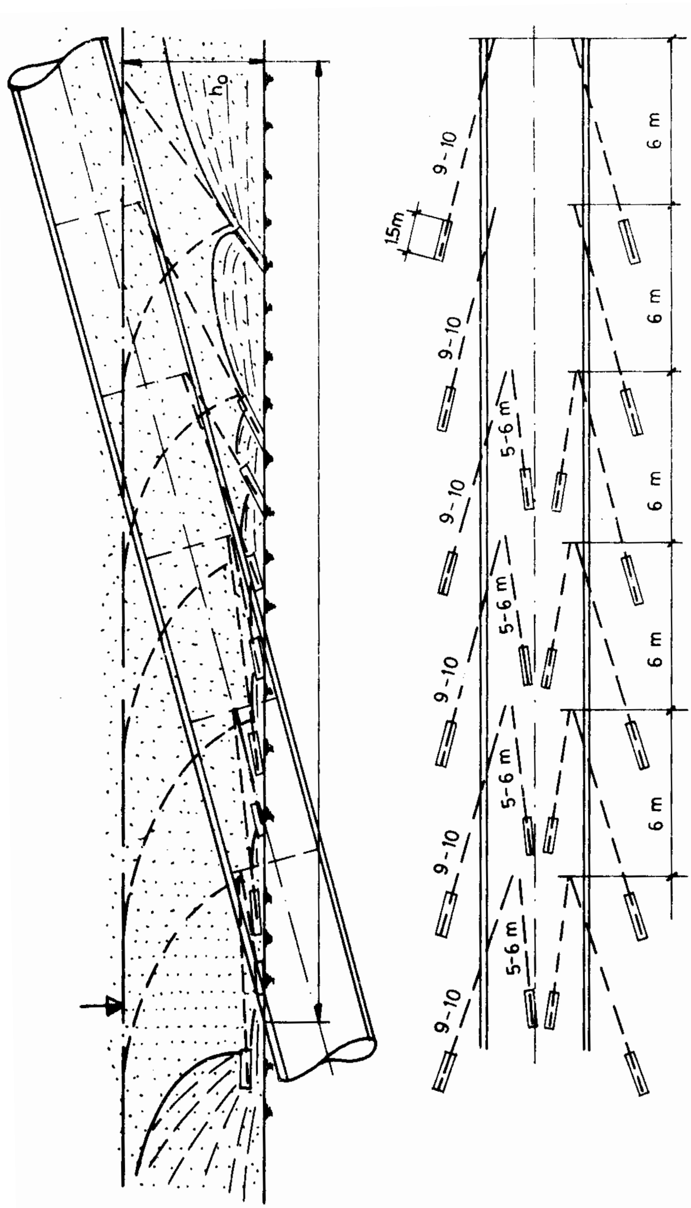

Fig. 6.
Pattern of stage two of the draining system

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