HYDROGEOLOGICAL SURVEY WORKS AT LIGNITE DEPOSITS IN THE SLOVAK PART OF THE VIENNA BASIN

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ABSTRACT

In the development of the Upper Miocene of the Vienna basin two megacycles of transgressive nature have been discovered, starting in both cases by lignite formation and ending by clay material sedimentation. The first megacycle is characterized by the occurrence of Kyjov seam /E-Panonian zone/ up to clay-sandy series of strata /E, zone/. It is known from the South-Moravian lignite basin. The second megacycle begins by the development of Dubnany lignite seam on the Pontian basis /F zone/ and it ends by calcareous clays of the Upper Pontian. The present paper deals with hydrogeological conditions at lignite deposits of Dubnany seam, Slovak part of the Vienna basin.

INTRODUCTION

Systematic lignite survey in the Slovak Part of the Vienna Basin began on the basis of oil prospecting structural survey results. The basic geological and tectonical structure of the basin was determined by these works. Although archives material of oil counterflush boreholes described lignite layers of variable thickness without qualitative data, yet it became the standpoint for lignite deposit estimation.

The survey works were concentrated chiefly in the surroundings of Gbely, Kúty and Sekule villages /Kúty graben/, later between the villages of Štefanov, Letničie and Dojč /Koválov graben/ and then to the surroundings of Závod, Studienka and Lakšárska Nová Ves villages. Besides the mode of occurrence and tectonics attention was paid to the quality, thickness of lignite seam as well as to gaining of knowledge about hydrogeological conditions. As in all described areas there are lignite deposits in the same stratigraphic-zonal position, it is possible to gi

ve the common petrographical description. The seam zone itself is indicated in the single areas by typical signs, i.e. seam structure, depth of position, number of intercalations, etc. These differentials will be stressed later.

BRIEF GEOLOGICAL CHARACTERISTICS

Neogene substratum of the Slovak part of the Vienna basin is formed by Triassic carbonates, Jurassic limestones and clayey limestones of the Upper Cretaceous. Paleogenic flysch development may be ascribed to the BieleKarpaty /White Carpathian/ unit. In neogene filling the sediments of Eggenburgian, Carpathian, Badenian, Sarmatian, Upper Miocene /Panonian-Pontian/, Pliocene and Quaternary are described. Our characteristics will be dealing with the sediments which are near to lignite seams, i.e. Upper Miocene, Pliocene and Quaternary sediments. As it was mentioned above, lignite deposits of Dubnany seam occur on the basis of Pontian sediments.

Underlying sediments are represented by Upper Pontian beds /E_3 and E_4 zones/ according to R. Jiríček's classification, 1975. They are represented by clays, sandy clays with positions of fine-grained to powder sand of variable thickness. The small underlying lignite seam with a Jumachelle is the most important horizon that is developed almost at all localities investigated. From hydrogeological point of view the fine grained sands have the important rôle for they are in direct connection with lignite seam or may be separated from it by less thick clay layer. The sands are aquifers which form several subconfined aquifers. They are indicated by numbers from the seam towards substratum during the survey works.

Coal-bearing formation /F-Pontian zone/ is noted for the fact that on its basis lignite seam of industrial importance was deposited. Its name is derived from the village Dubnany that lies in nearby South Moravian Lignite basin. The coal-bearing formation is moreover built by clays, sandy clays, medium-to-fine-grained sands and lignites. Lithological character of these sediments made possible forming of several subconfined aquifers /5-7 or more/, one upon another. Water-bearing capacity of these aquifers depends on particle size distribution, geometrical shape and space reach of single sandy sediments. Ground water aquifers are indicated by numbers from the seam up to the overlying rock. The thickness of all coal beds is variable and it depends on tectonic position. The seam zone of Dubnany seam itself is formed by lignite with clay and sand intercalations of variable thickness. The thickness of lignite is chiefly 4-6 m. In the southern part of Kúty graben seam zone homogeneity is considerably disrupted by seam disintegration into lignite sheets with the thickness of about 1,0 m and positions of clays, less of sands. Such structure is high as much as 35 m, just several sheets have economic thickness. From genetic point of view lignites are indicated as humites of paralic type and autochthonous origin.

Variegated coal beds /G/H - Dakian -Lower Pliocene/ are at all parts of the deposit represented by varicus clays with sand lentils. Clay material is noted for aboundance of calca

reous conglomerations. From hydrogeological point of view this complex may be considered for a ground water aquitard. Transition to Quaternary, where is no Rumanian, is usually formed by plastic clays with abundant calcareous conglomerations.

Rumanian occurs in this part of the Vienna basin just sporadically. It is decribed from the north-western part of Kúty graben on both sides of the river Morava. It is represented by gravel-sandy sediments with local occurrence of rewashed lignite.

Quaternary sediments are represented by alluvia, wind-blown sands and deluvial sediments. Thickness and particle size distribution depend on the intensity of sedimentation, i.e. on activity of tectonic lines in Quaternary. Kúty depression is an important ground water reservoir for there were formed relatively great thicknesses of Quaternary sediments /max. 42 m/.

Simultaneously with the deposit exploration hydrogeological survey works are also carried out. They are aimed at the total determination of hydrogeological structure, ground water circulation and regime, function of boundary conditions which limit individual areas of lignite occurrence. The works were also concentrated to verification of hydraulic properties of ground water sandy aquifers which occur in proximity of the lignite seam. At present most knowledge is collected about ground water aquifer properties of Gbely area - one section of the deposit - the easternmost part of Kúty graben where opening mine workings are driven now. The knowledge from other parts of Kúty and Koválov grabens are at the first stage of survey works.

Gbely Deposit Section

lies in tectonic closure of Kúty graben. It has the shape of unequilateral triangle. It is limited by Farské dislocations from the northern side, by Jánsky fault from the eastern side and Čársky fault from the western part where it is joined to Kúty section of the deposit. This section is noted for the most homogeneous development, without significant intercalations. Lignite seam thickness is 3,50 - 5,60 m. Position depth is in the southern side from 4,5 m close below the surface, in the central and northern section of the deposit up to 250 m. General seam dip is from south to north at an 8° angle. In the southern part where the seam outcrops below Quaternary there occurs phreatic surface and direct recharge of rainfall waters into the deposit. In the northern direction along with the seam dip ground water takes on an artesian character. In the whole deposit clays and sands, sandy clays and clayey sands vary both in horizontal and vertical direction.

Regarding Dubňany seam position we divide water-bearing Gbely beds analogically into the following complexes::
- Quaternary sediments
- variegated bed sediments
- coal bed sediments
- substratum sediments
- deep substratum sediments

Quaternary sediments occur at the whole area of Gbely deposit. Major part of them is formed by wind-blown sands and clayey sands. In the easternmost part of the deposit there occur clays and sandy clays. The average thickness is 4 - 6 m, max. 9 m. Ground water level is 1 - 1,5 m below the surface and during higher atmospherical rainfall is up to the surface.

Sediments of variegated beds occur in the main part of the deposit directly below Quaternary. They are formed by clays and sandy clays. Permeable layers are created by sands, though they are strongly clayed. Sandy layers have lentical development. Variegated beds have an important rôle at forming the whole deposit geological structure because they prevent infiltration of Quaternary waters into coal beds. With coal seam falling the thickness of variegated beds grows preventing so the interconnection of single aquifers.

Coal bed sediments may be subdivided in reference to seam to:
-upper overlying rocks
-second overlying ground water aquifer /n_2/
-first overlying ground water aquifer /n_1/

Upper Overlying Rocks

Coal beds are 90 - 100 m thick. Between the second overlying aquifer and variegated beds there occur even n_3 - n_5/n_6/ ground water aquifers. They are separated one from another by clayey and clayey-sandy positions. Aquifer thickness is 5 - 7 m, except for n_3 aquifer which is 15 m thick. Upper overlying aquifers will not be dangerous for exploitation itself for they are more than 30 m above the seam. They will be dangerous for driving of vertical mine workings /shafts/.

Second Overlying Aquifer /n_2/

has not been regularly developed in Gbely deposit. It is lacking in marginal parts or it is connected with n_1 aquifer. Clay position which separates aquifer n_2 from n_1 is varied, in central block 3 - 6 m in northern difection it grows up to 16 m. Average n_2 aquifer thickness is 3 m. Coefficient of permeability was determined to be $1,81.10^{-5}$ $m.s^{-1}$ by means of pumping tests that were carried out using methods of non steady flow.

First Overlying Aquifer /n_1/

occurs on the whole deposit directly above seam or it is separated from it by clays. Aquitard thickness above the seam varies very much and it is usually not greater than 1 m. In the main part of the deposit n_1 aquifer is in contact with the seam zone. Aquifer thickness is 12 - 15 m, in marginal parts up to 30 m. Standing level of ground water body was 160 - 167 m. n_1 aquifer pressure to the roof of seam zone was 0,1-2,6 MPa.

Substratum Sediments

The first substratum aquifer /p_1/: is developed at the whole

area of deposit and it is contacting except for small exceptions directly with the seam bottom. Thickness of aquifer is variable though in average 8 m. Standing level was settled similarly as at overlying aquifer at 160-167 m. Aquifer pressure to seam bottom was in the range of 0,1-2,7 MPa.

The second substratum aquifer /p_2/: is separated from the first one by a clay layer, the thickness of which is 6-16 m. It does not contact directly with the seam zone. The average aquifer thickness p_2 was determined to 7 m. Coefficient of permeability amounts to 2-3.10^{-5} $m.s^{-1}$.

Deep substratum: Deep substratum aquifers will not be dangerous directly for seam exploitation as they occur more than 30 m below the seam bottom. Several difficulties may arise at tectonic dislocations where aquifer is connected with the seam.

On the basis of existing survey hydrophysical parameters of aquifers n_1 and p_1/simplified solution according to Jacobs/ were determined as follows:

	n_1 Aquifer:	p_1 Aquifer:
Coefficient of Transmissivity T /$m^2.s^{-1}$/	$2{,}95.10^{-4}$-$8{,}9.10^{-5}$	$1{,}56.10^{-4}$-$9{,}16.10^{-6}$
Storage Coefficient S	$1{,}46.10^{-4}$-$5{,}93.10^{-4}$	$1.86.10^{-3}$-$5{,}43.10^{-6}$
Coefficient of diffusivity /$m^2.s^{-1}$/	0,11 to 4,83	0,04 to 0,03
Coefficient of Permeability kf /$m.s^{-1}$/	$2{,}03.10^{-5}$-$5{,}54.10^{-6}$	$1{,}86.10^{-5}$-$1{,}3.10^{-6}$

These parameters are comparable with the ones of presently exploited sections of the South Moravian Lignite basin. Individual tectonic limitations of the deposit are characterized by means of long term pumping tests and regime observations of ground water level which have been carried out from 1972 up to the present.

Drainage of Gbely Deposit

is carried out by two ways: pre-drainage by means of surface wells and additional dewatering from mine areas.

Pre-drainage by Surface wells - is carried out in order to depressurize aquifers n_2, n_1, p_1 and p_2. The surface wells are carried out in 2 systems /Fig 1/. The first system provides pre-drainage in tracks of driven mine workings /21 wells/ and the second one /6 wells/ provides drainage in the form of the barrier from the deepest parts of the deposit. The 27 wells mentioned above were performed in the years 1978 - 1985. Each well has 2 aquifers built up in the seam roof and 2 aquifers in the seam bottom. Well pumping rate varied from 100 to 600 $l.min^{-1}$. The depth of wells is from 50 up to more than 300 m. There are gravel filters on metal frame with gravel packing Well diameter is 300 mm. The wells are drilled by Salzgitter RC-81 and Wirth-B2A drilling rig.

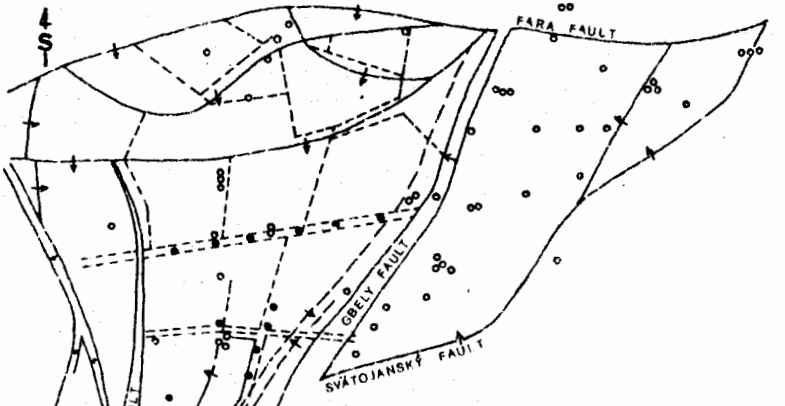

Fig.1. THE MAP OF TEKTONICS, PROSPECTING AND OPENING WORKS

De-watering from Mine Areas - Mine boreholes are carried out into the seam roof and seam bottom as surface boreholes do not provide total depressurization in the aquifers n_1 and p_1. Boreholes into the roof are drilled to the distance of cca 15 m and to the bottom in 30 m intervals on an average. The borehole length is 7-8 m. The boreholes are installed by the method of drilled filters with filter length 0,15-1 m. Two layer gravel filters on a perforated pipe serve for intake freely flow into well. Presently V-shape filters of "Johnson" type are successfuly used. Drilling rigs EBGP-1 /USSR/, WD-02/E /Poland/ and UVS-150 /Czechoslovakia/ are used for drilling. The boreholes are drilled through cemented seal. Roof borehole yield is 20 - 60 $l.min^{-1}$ and bottom borehole yield is 2 - 10 $l.min^{-1}$.

Present State of Deposit Drainage

The driving of survey workings was conditioned by lowering of ground water pressure in the roof and bottom aquifers. Before beginning of drainage in 1978 ground water pressure was 0,15 - 0,20 MPa in the southern part of the deposit and 2,5 - 2,7 MPa in the northern part of it. Ground water level was lowered by gradual dewatering by wells downward dip entries /1976 - 1982/ and chiefly by dewatering by means of barrier wells /1984 - 1985/. In 1978 ground water level was 162 - 168 m above sea level and at present it is lowered at 20 - 30 m above sea level, it means, it has been lowered by more than 140 m /Fig 2/. In the area of existing mine workings ground water pressure in aquifers n_1 and p_1 is even minimal and it varies between 0,0 - 0,2 MPa, in the deepest parts of the deposit at Farské dislocations and Gbely fault cca 0,8 - 1,0 MPa. In northern direction gradual driving the wells in their tracks lose their function and pumping from barriere wells is used as the main dewatering system. They are given pumped water amounts from 1978 for illustration: 25 100 m^3 from mine areas and 45 000 m^3 from dewatering wells, i.e. totaly 70600 m^3 of ground waters. On the other side, in 1985 the total amount of pumped water was 305 224 m^3 from mine and 873 545 m^3 from dewatering wells /together 1 178 769 m^3 of ground waters/.

Inrush Prevention

Inrush prevention measures were established for the safe mine working driving. They consist of passive and active prevention. The basis of passive prevention consists in leaving of protective impermeable layer in the seam roof or bottom. The impermeable layer is lignite laser and clay rocks. Maximum pressure value upon 1 m of the protective layer is 0,1 MPa of ground water pressure. The basis of the active prevention is systematic surface dewatering, chiefly mine dewatering, evaluating the passive and active prevention it is possible to perform mine workings in the area from mine borings in the southern part up to 2 - 2,5 km northwards. In this area the prevailing part of n_1 aquifer is formed by sands with ground water with phreatic surface. Under this aquifer there is certain pressure increase but it is in the range of safe protection.

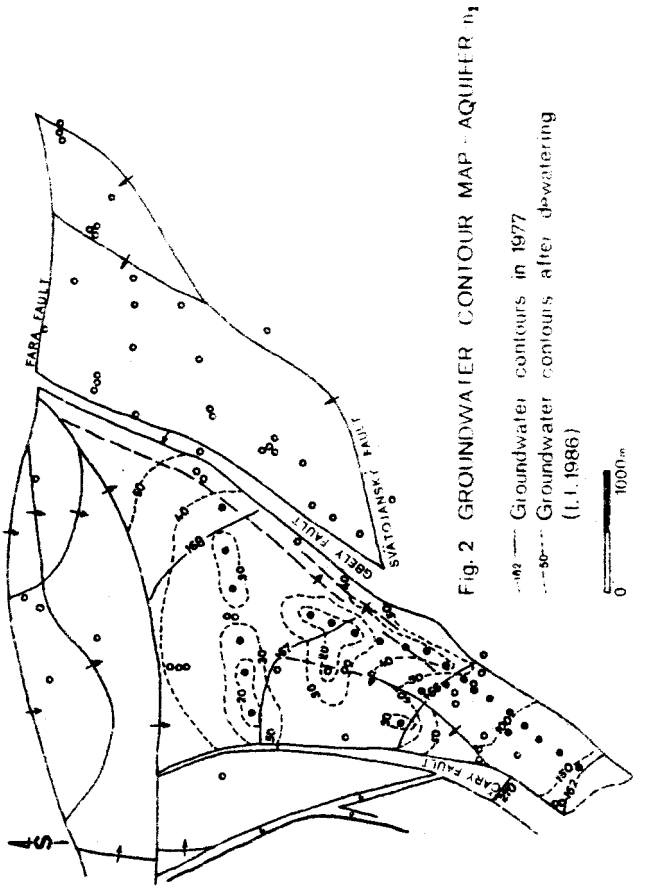

Fig. 2 GROUNDWATER CONTOUR MAP - AQUIFER n1

— Groundwater contours in 1977

--- Groundwater contours after dewatering (1.1.1986)

by performing of survey hydrogeological works and chiefly by systematic pre-dewatering at Ohely deposit conditions were created for a wide-spread mine survey. This survey is the basis of investment opening development. Investment opening at the deposit would begin in 1987 and the first exploitation in 1995.

Kúty Deposit Section

includes the area limited by Čársky fault in the east /where it borders Ohely section/, Farské dislocations at north and it is tectonically limited also at south-east by Jánsky fault. At western side the seam zone continues to Austria. The deposit itself is affected by tectonic faults of Carpathian direction which divide the deposit into several blocks. Though in the northern part lignite seam is divided by 1 - 2 2-25 cm thick intercalations, in the southern direction there are 5-8 or sporadically more of them, their thickness increasing up to 2 - 3 m. The seam disrupts into several lignite benches and the seam zone reaches up to 35 m. Lithological character of deposit beds enabled forming of several subconfined aquifers one upon another. The majority of artesian aquifers has standing level close below the surface and several aquifers show positive standing level above the surface. Zoning of artesian aquifers that corresponds to flowing in artesian structures was confirmed by special radio-isotopic measurements carried out by workers of Charles University in Prague. Holocene age was ascribed to the ground waters of the first overlying aquifer and Pleistocene age was ascribed to the ground waters of the first underlying aquifer. More intensive hydrogeological survey is carried out from 1984. Sandy sediments in proximity of lignite seam are built by hydrogeological wells. They are built up by filters with conical openings and the proper pumping tests are performed and evaluated by the methods of nonsteady flow.

Štefanov Deposit

is localized in Koválov depression. It is characterized by the development of two lignite benches, which are joined in the southern part /5,6 m/ and the intercalation thickens up to 10 m in north-east direction. The upper bench is 1,3-2,6 m thick and the lower one is 1,55 m - 2,55 m. The deposit is markedly tectonically limited and it is divided into ten blocks of prolongated shape. Tectonical structure of the area is determining for forming of hydrogeological structure. While in the southern part of the deposit where the seam zone is deposited next below Quaternary sediments water table aquifer is found, in northeastern direction the ground water obtains artesian character simultaneously with the lowering of the seam zone to 120 m below the surface.

Hydrogeological conditions at the deposit were classificated as difficult ones on the basis of the first survey works performed. The difficulty is caused by the character of underlying and overlying rocks in relation to lignite. Here there are fine grained sand aquifers with relatively low coefficient

of permeability - 1,46.10^{-5} to 3,88.10^{-7} m.s^{-1}. The ground water pressure on the seam roof was calculated to 0,34 - 0,36 MPa and on the seam bottom 0,122 - 0,32 MPa. From the point of view of deposit exploitation it is a drawback that the lignite seam does not reach such a thickness and homogeneity as it is in Gbely section of Kúty depression.

Lakšárska Nová Ves - Studienka Deposit

The knowledge about geological structure and quality of Dubnany seam is from 1960. Lignite has a wood-earthy character and thickness of 2 - 3 m in the northern part. In the southern part it is divided into several positions by clay and coal-clay intercalations. The deposit is divided by tectonical lines, too. The important fault is the cross Leváre fault of jump height above 100 m dividing the deposit into the northern and southern part. In the northern part the lignite seam is developed relatively well. At the western side it wedges out below Quaternary sediments where there occurs probably infiltration area of ground water. At this deposit special hydrogeological survey has not been carried out yet. But the survey concerning underground gaseing of lignite has been carried out. Five ground water aquifers with artesian level have been distinguished.

CONCLUSION

At conclusion all the lignite survey areas in the Slovak Part of Vienna basin may be charcterized as artesian basins, markedly tectonically limited in which there occur ground water bodies with prevailingly negative ground water level. It is posssible in all structures to distinguish probable infiltration and transition areas. The structures may be characterized as semi-confined to confined hydrogeological structures with slowing change prevailingly with static ground water storage. Lignite seam is deposited in water-bearing sandy aquifers and so the knowledge of hydrogeological phenomena being one of the most important data for judging lignite economic importance and so for its economic use. Economic hydrogeological survey is very important both at survey works as well as during the proper exploitation of the deposit. Hydrogeological survey of the shallow water table aquifers will be of use at estimation of the influence of exploitation upon the environment.

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