HYDROGEOLOGY OF THE DOLINA MINE BROWN COAL DEPOSIT AT VEĽKÝ KRTÍŠ

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ABSTRACT

In the subject paper, geological and hydrogeological characteristics applying to the Ipeľ Basin brown coal deposits as well as to the questions connected with dewatering and degasification of those are discussed.

INTRODUCTION

The South Slovakian Coal Basin (the Dolina Mine Coal Deposit) is situated in the southern part of Central Slovakia, in the SE one of the so-called Ipeľ Basin.

It was since 1945 that geological survey operations beginning with prospection made by the Dionýz Štúr Geological Institute (Geologický ústav Dionýza Štúra) Bratislava and By the Coal Geological Survey (Uholný prieskum n.p.) Turčianske Teplice have been in the South Slovakian Coal Basin carried out. Brown coal mining started here, however, by the end of the XVIIIth century but industrial exploitation began in 1955 only.

The problem of dewatering has been there known from the very beginning of mining operations performed and is still questionable until now.

Some questions appying to hydrogeology, dewatering, degasification, exploitation and mining methods as well are subject to study by Mining Research Institute (Banský výskumný ústav) Prievidza, Geological Survey (Geologický prieskum n.p.) Spišská Nová Ves and the Dolina Mine Mining Company proper in Veľký Krtíš at the present time.

BRIEF GEOLOGICAL OUTLINE OF THE DEPOSIT

The whole Ipeľ Basin area is formed by Tertiary sediments. From tectonic point of view it is divided into several horsts and grabens. The brown coal deposit proper lies in the socalled Stračina Upthrown Blocks.

The wider vicinity of deposit is constituted by sedimentary rocks of Paleogene and Miocene age being emplaced on the basin Pre-Tertiary Basement and on pyroclastics referred to the Krupina Range.

The brown coal deposit proper is created by the so-called Producing Zone i.e. sands comprising three coal seams named in sense of mining practice as the first (Upper), the second (Middle) and the third (Lower) Coal Seam.

The deeper-seated base of this is formed by Egerian sediments of sandy nature. Overlying those, there is a sequence consisting of aleuritic-clayey and sandy beds alternating with some thinner conglomerate layers being overlain by a thicker marly clay one. The uppermost part of Egerian is composed of sands alternating with clay and consolidated sandstone layers. These sediments mentioned are about 600 m thick.

The bottom of the Lower Coal Seam is formed by sediments of Lower Ottnangian age represented by frequent alternations of variegated marly clays, sands and conglomerates with tuff and tuffaceous sand intercalations.

This sequence is typical of rather irregular thickness and in some parts of the deposit is not developed at all. Since sediments are there not present as continuous ones, they are presumably filling the irregular surface of the Egerian Beds. Upper Ottnangian sediments are represented by sands referred to the Producing Horizon involving coal seams and they are overlain by a grey-coloured clay complex being there known as Overlying Clay.

The Producing Beds are deposited on the Upper Ottnangian Beds of irregular development, in some places lying directly on the

Egerian Beds. They are represented by fine to medium-grained sands with some smaller sandy clay intercalations. The base is there formed by sandy clays to clayey sands of grey green colour overlain by the Lower Coal Seam. Somewhere it rests, however, on the Lower Ottnangian Beds. Overlying this, there are sandy clays to fine-grained clayey sands up to 10 m thick passing upwards into fine, medium to coarse-grained sands. The Middle Coal Seam lies some 15 to 25 m (in average) above the Lower one and the Upper Coal Seam is situated 25 to 30 m above the Middle one. Overlying the Upper Coal Seam, there is a 5 to 10 cm thick sand layer reaching some 20 m in width in the northern part of deposit.

In the SE marginal part, sands overlying the Upper Coal Seam are 15 to 20 m thick almost reaching the surface and in some places they are cropping out from beneath the surface. The mutual distance between the Upper and the Lower Coal Seam (these two are considered as the most extensive ones) is increasing from S to N to 30 up to 55 m, in rare cases even up to 70 to 80 m. The average thickness of the Upper Coal Seam is 2,3 m, in case of the Middle one it does 2,7 m while the Lower Coal Seam is considered to be (according to drilling survey) about 4 m thick. They all are generally dipping 3^{o} to 5^{o} to NW.

The average thickness of Producing Horizon in the deposit involved is varying between 45 and 55 m increasing up to 90 m in N and NW direction.

The Overlying Clays deposited on the Producing Beds are strongly eroded in the southern part and in some places they are completely absent. In the western part of deposit, their thickness is varying between 100 and 150 m in southern and eastern direction being of decreasing tendency. They are composed of monotonous grey to greenish grey pelites in the basal part being of sandy nature and mostly corresponding to montmorillonitic pelite from mineralogical point of view. From hydrogeological point of view, however, these Overlying Clays are considered as conspicuous aquitards.

In the northwestern part of deposit there are Carpathian Sands deposited on the Overlying Clays and may be apparently vertically divided into Rzehakia Beds, Sandy Beds (the so-called Manganese Sands) and Marly-Clayey Beds laterally replacing one the other.

The Rzehakia Beds are formed by very fine-grained marly sands, the Manganese Beds are composed of non-calcareous sand layers comprising typical manganese dioxide concentrations and the Marly Clays of typical schlieren-like disintegration are frequently of sandy nature comprising some sand layers.

Badenian is represented by a volcanic-sedimentary complex constituting the Krupina Hills and forming the natural boundary of the Ipel' Basin on the north.

From among Quarternary sediments, alluvia, river terraces and debris of relatively low thickness are in the brown coal basin present. For geological situation see Fig.1.

BRIEF HYDROGEOLOGICAL CHARACTERISTICS

In this chapter, a brief outline on the hydrogeological conditions with respect to the questions connected with brown coal exploitation in the Dolina Mine will be presented.

On the basis of impermeable layers existing in the vertical profile of the brown coal deposit Tertiary sediments, the aquifers may be divided into several hydrogeological units characterized by different conditions of groundwater quality, quantity and regime formation. These are, as follows:

- Egerian groundwaters
- groundwaters referred to Lower Ottnangian Sediments
- groundwaters in the Upper Ottnangian Producing Beds
- groundwaters referred to Rzehakia, Manganese and Marly-Clayey Sands of Carpathian
- groundwaters of the Badenian Volcanic-Sedimentary Complex, and
- groundwaters referred to alluvia of the Ipel' River and its tributaries as well.

They are the Rzehakia, the Manganese and the Marly Sands of Carpathian overlying the Producing Beds, which are considered as the nearest aquifer being divided from those by a 150 m thick sequence of the Overlying Clays. That is why this aquifer does not influence mining activity.

The aquifer formed by the Producing Bed Sands belonging to Upper Ottnangian is the largest one extending over the whole Dolina Mine area. It is constituted by fine to medium-grained quartzy sands characterized by rather variable grain size distribution within short horizontal and vertical distances where passing into clayey sands and sandy clays is not rare.

On the basis of analysis performed on several sand samples collected from various parts of the mine field (Fides, 1961), the average porosity value has been stated as 38%.

In spite of the fact that the Producing Beds are divided by coal seams (including shale and clay layers) into several partial aquifers, one aquifer of close hydraulic continuity may be there virtually taken into consideration. It applies to the beds overlying the Lower Coal Seam. In the southeastern sections of the Dolina Mine, where the Producing Bed Sands are cropping out from beneath the surface, the aquifer is of unconfined nature. Towards the west or nortwest, respectively, where it is covered by younger Tertiary sediments, this unconfined aquifer is gradually passing into confined one the hydrostatic pressure on the Upper Coal Seam bottom in the Modrý Kameň area varying between 1,6 and 1,9 MPa.

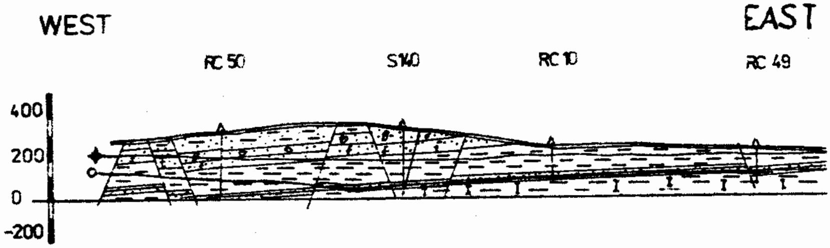
On the basis of hydrodynamic study carried out, the following hydrophysical parameters have been under the conditions of one-phase regime flow determined:

- coefficient of transmissivity $T = 5.7 \cdot 10^{-4}$ to $1,9 \cdot 10^{-3} m^2 s^{-1}$
- coefficient of permeability $k = 2,3 \cdot 10^{-5}$ to $4,2 \cdot 10^{-5} m\ s^{-1}$
- storage coefficient $S = 1,5$ to $2,0 \cdot 10^{-4}$

Infiltration areas have not been satisfactorily defined until now.

As to stratigraphic division, the Producing Bed Sands underlying the Lower Coal Seam are reffered to Upper Ottnangian, from hydrogeological point of view, however, there is an isolated aquifer involved remarkably differing in salinity and piezometric groundwater level as well.

Fig.1. SCHEMATIC GEOLOGICAL GROSS - SECTION



EXPLANATIONS

0 100 500 1000m

1. OUARTERNARY - SANDY LOAM
2. CARPATHIAN - SANDY MARLY CLAY
3. CARPATHIAN - MANGANESE SAND
4. OTNANGIAN - RZEHAKIA BEDS
5. OTNANGIAN - OVERLAYING SAND
6. OTNANGIAN - COAL SEAM
7. OTNANGIAN - PRODUCING BEDS-SAND
8. EGERIAN - UNDERLYING SAND

◆ INITIAL STANDING LEVEL
o DYNAMIC LEVEL (1986)

Groundwaters contained in the Producing Beds may be characterized as those of calcium-magnesium-bicarbonate type of a total salinity varying between 0.5 and 0.7 $g.l^{-1}$ (only in rare cases more in places where water is enriched in carbon dioxide) while waters coming from the Lower Coal Seam base are considered to be as calcium-magnesium-bicarbonate ones of a total salinity exceeding 4.0 $g.l^{-1}$ being enriched in CO_2 throughout the whole Dolina Mine area. Piezometric groundwater level is 40 to 60 m higher than in case of the aquifer overlying the aquifer overlying the Lower Coal Seam.

During research works performed, the following hydrophysical parameters have been in the subject aquifer ascertained:

- coefficient of permeability $k = 1.6 .10^{-6}$ to $3.2 .10^{-5}$ $m.s^{-1}$
- storage coefficient $S = 1.0 .10^{-4}$ to $2.0 .10^{-4}$
- coefficient of transmissivity is of considerably variable va-

lue depending on the sandy bed thickness being rather variable as in lateral as in vertical direction.

In the deeper-seated sandy layers of Egerian age underlying the Lower Coal Seam, three aquifers of a salinity exceeding 5 g. l^{-1} and of a higher pressure than in case of sandy layers referred to Producing Beds directly underlying this Lower Coal Seam have been proved until now.

On the basis of recent knowledge, however, these aquifers mentioned do not influence the Upper and Middle Coal Seam mining and the future exploitation of the Lower Coal Seam is expected to be locally influenced by the highest-seated Egerian aquifer only.

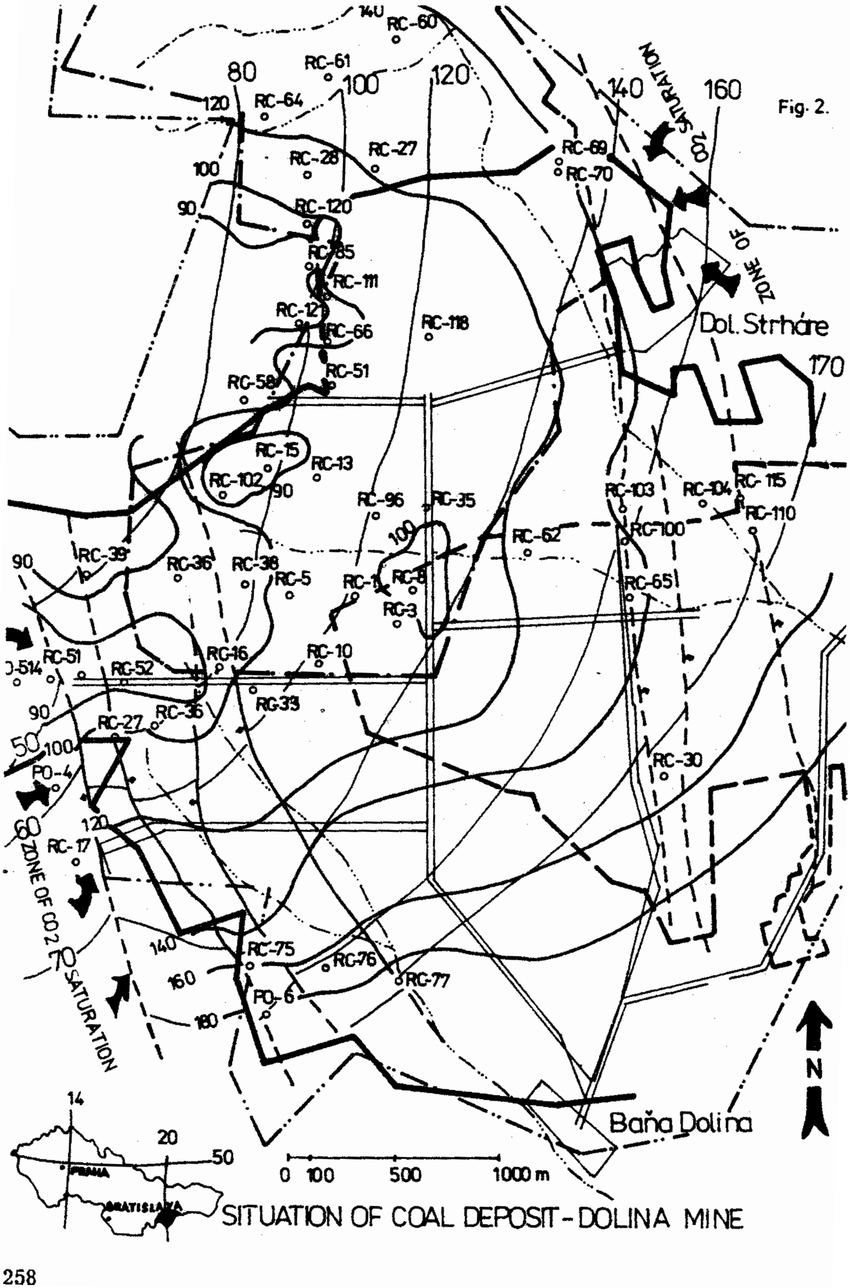
THE QUESTION OF DEWATERING THE PRODUCING BED SANDS

At the very beginning of coal deposit developing in the second half of fourties and at the fifties, hydrogeological conditions on the basis of geology have been concluded on. Because of unstable nature of the water-bearing sands (situated in the flat-lying marginal parts of deposit) encountered by underground workings, galleries have been mostly driven in the coal seam proper. It was also due to unfavourable physical-mechanical properties of clays to be found in the bottom of the Upper Coal Seam but first of all in the roof of the Middle one. In case of a low thickness resulting in removing the protective coal layer or when inevitably driving in sands, it had to be made by means of advance timbering using there hay as filtration material. In such a way, heading advance has been consequently low bringing about inadequately high expenses necessary for driving one metre of underground working.

When passing into greater depths, a continuous negative influence of increasing groundwater pressure has been noticed. That is why a systematic groundwater pressure lowering by surface pre-dewatering wells has been there performed.

Figure 2 presents the Dolina Brown Coal Deposit geology including groundwater contours of the Producing Beds related to the

Fig. 2 SITUATION OF COAL DEPOSIT - DOLINA MINE



EXPLANATIONS TO FIGURE 2

	mining BOUNDARY	RC-36	DRILLED WELL
	1st SEAM		PERENIAL STREAM
	2.nd SEAM		FAULT WITH DIRECTION OF DOWNTHRON SIDE
	3.rd SEAM		MAIN WORKING
-60	UPPER SEAM CONTOUR		
120	GROUNDWATER CONTOURS OF PRODUCING BEDS-SAND		

Upper Coal Seam position 30th June, 1986 .

The first attempts for using surface dewatering pumping wells started there in the half of fifties. By the end of those, drilling technology has been of higher level already due to setting up a Salzgitter drilling rig of PS-150 type having been resulted in systematic dewatering of the so-called Interjacent Beds, i.e. the Producing Bed Sands up to the Lower Coal Seam considered as unmineable that time.

Because of improving the dewatering well construction and mainly that of drilling filters by introducing gravel ones in the half of sixties, considerably better results have been in dewatering achieved from quality point of view. By the end of the sixties, it has been reflected in the exploitation, too, by introducing complex mechanization mining resulted in markedly increased mining and total output as well.

Some basic data applying to the amount of water pumped out from surface dewatering wells and underground workings as well as to the average inflows are shown in the following table:

Year	Water from Surface Dewatering Wells $m^3.year^{-1}$	Water from Underground Workings $m^3.year^{-1}$	Total Amount of Water $m^3.year^{-1}$	Total Output $t.year^{-1}$	Storage Coeff. $m^3.t^{-1}$	Total Inflow $l.s^{-1}$
1957	577120	2397752	2974872	422984	7.03	94.33
1960	1409984	1787286	3197270	549315	5.82	101.11
1965	2661824	1578065	4239824	714807	5.93	134.45
1970	2207217	1675838	3883055	715678	5.43	123.13
1975	3244908	1536972	4781880	912952	5.23	151.21
1980	4437139	2166399	6603538	979628	6.74	208.82
1985	4024449	1527947	5552396	1013319	5.48	176.06

Surface pre-dewatering cost converted to 1 tonne of extracted coal has been varying between 2.05 to 3.42 Kčs in the period mentioned with the exception of 1975, when it did 6.70 Kčs/t. There are costs involved having been expended for performing surface dewatering wells including water pumping but without expenses necessary for that of underground workings.

For underground working drainage, shallow small-diameter boreholes into the roof and wells up to 400 mm in diameter into the bottom are used. In conclusion it may be said that dewatering is nowadays of good quality and without extraordinary difficulties but rather expensive in comparison with some other deposits characterized by better hydrogeological conditions and lower water-bearing capacity.

PROBLEMS CONNECTED WITH DEGASIFICATION

The subject brown coal deposit is typical of intricate and remarkable hydraulic conditions but it is especially interesting because of the presence of CO_2 bringling about local groundwater enrichment in carbon dioxide resulting in **making** some parts of the deposit hardly accessible for exploitation.

On the basis of the results obtained by drilling carried out, some so-called CO_2 zones could have been in the second half of the fifties distinguished said later on as CO_2 accumulations (Gazda, Choma, 1968).

At the eastern margin of the Dolina Mine, there is the so-called Strháre CO_2 Accumulation and in its western part, behind the so-called Modrý Kameň Fault, the so-called Modrý Kameň CO_2 Accumulation is to be found (see Fig. 2). In the Ottnangian Producing Beds they are associated to marginal fault zones limiting a conspicuous structural-tectonic unit - the Stracina Upthrown Blocks. From the results obtained (Gazda, Choma, 1968) it follows that the subject CO_2 accumulations are directly related to young volcanic activity being considered as post-volcanic exhalations coming from primary magma chambers.

It is the fault zone of NE-SW strike mainly bordering the SE margin of the Šahy Elevation which is considered as primary passageway for juvenile CO_2 ascending from the depth. It is at the crossing of cross fault systems of NW-SE direction (the so-called Modrý Kameň and Strháre Fault Zones) with the zone mentioned above that the maximum dynamic CO_2 inflows occur. When encountering these passageways by drilling, active gas blowers origenate producing several ten thousands m^3 of CO_2 per day up to 150 000 m^3/day.

Recently (in 1980), a production of 200 000 m^3/day of CO_2 has been in borehole D-11H noticed. After liquidating the accident and sealing the borehole mentioned, the pressure measured has been close to 1.0 MPa.

Due to a horizontal migration of carbon dioxide from the passageway into the aquifer in ascending direction, secondary CO_2 accumulation takes there place. In both of two cases there are not dry CO_2 accumulations involved but gas-saturated waters of different stage negatively acting on the pumping capacity of dewatering wells due to gas congestion but first of all because of a conspicuous decreasing of the aquifer permeability due to bi - phase flowing.

On the basis of the recent geological survey works performed, dry CO_2 accumulations forming gas caps (which would be more favourable from degasification point of view) have not been ascertained. In comparison with the Producing Bed Sands overlying the Lower Coal Seam, groundwater of uniform carbon dioxide enrichment has been at the base of this noticed being present virtually in the whole deposit area including the deeper-seated Egerian aquifers, too.

Due to the presence of CO_2, there were several unpleasant accidents underground, too, remaining fortunately without human victims until now. When driving development workings in the Strháre CO_2 Zone area in June, 1976, gas-saturated water inrush took at the face place. The initial water inflow noticed was about 1000 $l.min^{-1}$ and the amount of CO_2 released did cca 50 $m^3.min^{-1}$. This accident resulted in temporary stopping of mining operations. Gas-saturated water inflows lasted one year and CO_2

exhalation has been decreased up to 25 $m^3.min^{-1}$. After thirty months, the CO_2 production noticed was about 8 $m^3.min^{-1}$.

It was in May, 1980, however, that the highest CO_2 exhalation took there place when driving an inclined opening drift (No.415) of northern direction in the Overlying Clays to the coal seam behind the so-called Modrý Kameň Fault. Fortunately, there were no people at the face situated up to 10 m above the Upper Coal Seam roof. In sense of measuring performed two hours after the accident, CO_2 production has been about 130 $m^3.min^{-1}$ at a negligible water inflow of 0.5 $l.s^{-1}$ only. Carbon dioxide production was gradually but relatively rapidly decreasing. After ten days it was 58 $m^3.min^{-1}$ and after two months it did about 27 $m^3.min^{-1}$.By the end of 1980, the CO_2 production measured was 7 $m^3.min^{-1}$. In 1981, it was falling to 5 $m^3.min^{-1}$ and in June, 1982 only a 2 $m^3.min^{-1}$ production has been noticed. At the present time, gas exhalation is varying between 1.5 and 2.0 $m^3.min^{-1}$.

Nowadays, a new opening drift of east-west direction is under driving being situated some 400 m to the north from the place of the above mentioned CO_2 exhalation. The subject drift was horizontally passing from the Upper Coal Seam through the Modrý Kameň Fault into the Overlying Clays. Behind the fault mentioned, it continues as an inclined shaft. Driving is supported by safety boreholes being 25 to 50 m far one the other. Since in August, 1986, presence of CO_2 has been by such a borehole noticed, a further safety borehole has been in November 1986 performed having been drilled up to the bottom from the drift situated some 20 m above the seam. This borehole encountered an 80 cm thick clayey sand layer situated some 14 m above the seam mentioned the gas pressure being there 0.47 MPa. Directly overlving the Upper Coal Seam, an about 0.5 m thick water-saturated sand layer with carbon dioxide enrichment giving a pressure of 0.47 MPa has been found. It is necessary to note, however, that the present situation seems to be much more favourable already due to degasification effect of several exploration-exploitation wells performed. In 1983, borehole PF-7 has been some 700 m to the west from the drift mentioned above carried out. When pumping out 3.3 $l.s^{-1}$ of water from, CO_2 exhalation of an initial volume of 50 $m^3 . min^{-1}$ has been there successfully induced at a dynamic level of 182 m below the surface. At the hermetic well mouth, a maximum static CO_2 pressure of 0.90 MPa has been measured. Following two months, gas production fell to 12 $m^3.min^{-1}$ and after nine months to k,4 $m^3.min^{-1}$. After the next four months, this pressure was and still is (December, 1986) 1 $m^3.min^{-1}$.

The total volume of CO_2 exhalation from borehole PF-7 up to January, 1986 did about 2.9 million m^3 while to 1st December, 1986 it was less than 3,4 million m^3 of CO_2. Though the further wells performed did not reach the PF-7 borehole production, they contributed, however, to certain degasification of the coal deposit in question, too.

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