PRELIMINARY POSSIBILITIES OF WATER LEVEL LOWERING UNDER THE GRAVEL BENCH OF THE SAJÓ RIVER BY APPLYING AERIAL METHODS

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ABSTRACT

A shaft of the Borsod Coal Mines the "Szeles akna", which is one of the most hazardous ones from the point of view of the water inrush is described by the study. Here from the early 197o-s more and more intensive investigations have been done and then water level lowering was also realized by applying aerial methods in order to define the optimum protection against the stratum waters. As a result of the investigations the full scope of the hydrogeological and waste water problems could be clarified including the leakage parameters of the different strata, the additional supply provided by the live watercourses and precipitation, the approximate range of the broken and fissured zones due to mining activities, etc. The possibility of the further progress is given: The aerial water level lowering is possible and thus the lifted water can be economically used. The rentability of this solution is economically proved. The investigation, experimental operation and the development of further plans are all based on calculations where the different equations and calculation methods discussed by the literature were naturally applied. However just because these equations and methods are so well known from the literature, here they will not be discussed. The aim of this study is to discuss a specific waste water protection problem and the solution of the given problem.

INTRODUCTION

An age old problem of the brown coal mining in the Borsod area is waste water protection. Earlier only the crossing of a fault or watered sand layer could mean transitional or perhaps final obstacles. Beside this problem caused by the water appearing on the spot could be overcome by the tolerance of the manpower employed there. Now however, when the economic efficiency is of primary importance, it simply cannot be permitted that complex production equipments of several hundred million forint values could be used at their optimum capacities on the longwalls only for fragments of their working time. It is essential to find the waste water protection methods for every site.

SZELES AKNA /SZELES SHAFT/ AND THE WATER HAZARDS

As Fig. 1. shows the mining operations in the Szeles akna take place under the flood plain of the Sajó river. At the north-west side of the area explored by now another watercourse, the Szuha can be found. The coal production is done in longwalls of 6o-1oo m widths with runouts of 3oo-5oo m. The range of the mining activities is defined by the tectonics. The thickness of the cultivated layer IV. is 1,5o m. At the longwalls locomotive cribbings is applied and the breaking is done with cutting cylinders.

Layer IV, that is suitable for mining is already exploited to a great extent /Fig. I./. According to our long range plans the mine can be worked for another ten years period yet. The planned production for 1981 is 243,5 thousand metric tons and in the coming years, considering a gradual decrease, the produced quantity will by cca. 2oo thousand metric tons as an average.

The geological structure of the area is simple. The upper part of the miocene layers containing the brown coal, due to the erosion caused by the watercourse, was denuded. On the surface, partly pebbly, flood plain sediments of 6-15 m width can be found. Figure 2. shows the large-scale tectonics and inclination relations of the region and the layers truncated by the wearing. It also shows that how the layers among the coal deposits can be classified as permeable and impermeable layers. The layers belonging to the first class are sands and dwaks, while those belonging to the second class are aleurites and loamy aleurites.

Figure 3. shows that part of the area in block section form where the comprehensive hydrogeolocal survey and the experimental aerial water level lowering took place [9;1o]. It can be clearly seen that the upper sand layer above layer IV /H 42/ can be divided into five independent benches, separated from each other by impermeable, or at least hardly permissive rocks. The layers meaning the most important water hazards are just the benches of H 42 into which the broken-fissured zones, that developed because of the mining, intersect. The flood plain sediments, and occasionally its gravel layers may be in

contact with the sands of the coal deposit layer /Fig. 2. and 3./. On Fig. 1. the area, where one of the benches of H 42 gets additional gravel supply is outlined.

The geological-hydrogeological situation discussed above explains that the Szeles shaft is a mine of great water hazards from the beginning. The thickness of the specific protective layer calculated by specification [1] of the "Safetey regulations" never reaches the ϑ = 2 m/bar value.

In spite of this the waste water hazards in the Szeles shaft mean only very rarely life-danger or significant danger for the equipment. During the 2o years of the shaft however several damages, and transitional and constant decreases in the production have taken place [12] due waste water inflow. Experiments and measurements in the mine show that water conducting breaks occur on the longwall face as well if the speed of the mining drops under the daily value of 3,5 - 3,6 m/day. In contrary cases water appears with the ripping.

A decrease in the production speed cannot be hindered even because of the days of standstill. Measurements indicate that each heading results in a water inflow of 1,o - 2,5 m^3/min, which due to the increasing number of the ground breakings in the territory decreases to o,5 - 1,o m^3/min [12].

From the mid-197o-s on the demand for a more solid water protection method is becoming greater and greater. After a short time experiment period in the mine we found that the small boundary depth makes the application of the aerial method possible. To study the possibilities provided by this method we made several experiments and did also experimental production.

RESULTS OF THE EXPERIMENTAL WATER LEVEL LOWERING

Primarily our studies aimed at defining the water-hazardous formations, their parameters, and the phenomena accompanying the live workings. Analysing sand H 41 with the help of pressure gauges placed in roof wells in the mine we found that it does not contain waste water of stressed water plane even in its primary state, so as a water hazard it can be excluded. On the above discussed basis the role of the benches of H 42 is obviomsly significant from the point of view of the waste water hazards.

The gravel bench of the flood plain area was examined in several ways. Most data were obtained from test pumpings from the observatory wells, from water level measurements during the floods, from direction finding measurements of the flows, and from undermining experiments [4, 8, 13].

It was found that the gravel layer receives a regular though not continuous additional water supply from the Sajó, Szuha and the precipitation. The yearly average value of this addition is

$$Q_u = 1,3 \cdot 10^{-6} m^3 s^{-1} m^{-2}$$

A part of this water gets into the neighbouring sand benches.
The parameters of the layers considered to be water hazardous were subjected to several examinations. The permeability coeffcient was determined with test pumpings from observatory wells, from backflow curves, with laboratory measurements and from grain-size characteristics [10;12]. Tables 1. and 2. show the expected values of the permeability coefficients of two examined layers and the limits of errors.

Pressure ratios of the different layers are clearly given. The gravel bench is always influenced by the momentarily give water levels of the rivers Sajó and Szuha. The sand benches H 42 were examined together.
Its primary pressure surface is situated at 8-10 m under the land surface and it is at 2-4 m under the level of the gravel bench.

Being aware of the geological-hydrogeological structure of the area an experimental water level lowering plan was prepared which take the given special circumstances into consideration. We wanted to make use of the fact that H 42 can be divided into independent benches and no pressure relief occurs among them. Thus the upmost benches which are in contact with the gravel layer and the gravel layer itself can be excluded. Water level lowering can thus be realized with the help of the well system created this way, already in the sand benches, theoretically free of additional water supply [9].

Though it is excluded by the calculation possibilities related to the height of the broken-fissured zone caused by minima activities [1;3;5;6;7] that water from the sand benches of upper position and from the gravel bench may flow into the developing fissures, we kept this possibility in mind. The emptied sand benches provide protection for this case as well, since the water flowing downstairs must first fill up the empty reservoir space, the sands, and a greater scale inflow into the abandoned mining space can occur only when a homogenous water level develops in the sands. This may happen however only after the passing away of the mining activities from that spot, because water-lifting in the wells is continuously done.

Just from the point of view of the realization of its main purpose, concerning the lowering of the water level to the required extent, the experiment was not complete. The main reason for this was the much less than required time

/much less capacity for the execution of the experiment than it was planned, due to emergency reasons some mines had to be started earlier, etc. /In fact 3o-4o per cent of the water level lowering as compared to the necessary quantity could be realize. That is why, following the experiment, there is still water in the mine, even if in a smaller quantity than it would correspond to the primary pressure.

The answers for our theoretical questions are however convincing:

1. The material balance type comparison of the water quantity lifted from the wells and mine respectively /V = 662 thousand m³/ and the consolidated exploitable water supply calculated for the area /V max = 671 thousand m³/ shows that there is no additional water supply. Supposing however that there is an error of 2 % in both the measurement and the calculation but with a different sign, then the difference indicates an additional supply of 18 thousand m³ /3 %/, that is quite insignificant. Thus the conclusion, that the sand benches with additional water supply can be excluded in the practice as well, can be drawn.

2. The definition of the height of the broken-fissured zone /x tr/ is one of the key problem with regard to the planning of the future water level lowering systems. In Table 3. we suumarized the values which were calculated by using the equations offered by different authors [1;5;6;7]. As it can be seen, there is quite a large range dispersion among the values. It is also well known that in Várpalota and in the Velenje mines /Yugoslavia/ the broken-fissured zone of the protective layer on the hanging, defined by experimental and analytical methods as well, does not exceed the 15-25 m [3]. All these, depending on the thickness of the mining section, on the number of the sections, and on the rock strength suggest that x tr = 2o-4o m. In the Szeles shaft area however Salaginov's calculation method gives the best approximation that is also proved by experiments.
Fig 4. shows the behaviour of our wells in the course of the water level lowering process, and in the course of the mining activities' passing away, respectively. Bench H 421 was observed with the help of pressure gages placed in roof wells in the mine. It was found that due to the depression impact of the mining it gradually became unstressed and got unwatered. In the surface wells, in case of approaching with mining, the lowering of the producing water level acclerated due to the rock displacement. Because of a certain consolidation of the broken zone the waterflow turns into opposite direction in the well, because the upper, and it is easy to prove now, intact sand benches with their greater supply are able to fill up the well.

The new production water level obtained in this way set in however at none of the wells above bench H 422.

To exclude the direct contact of the near surface layers and the broken-fissured zone theoretically as well we determined the depth of the surface broken zone as well [6;7]. This value, according to the calculations, is z = 3 m, and so our hypothesis was correct.

THE PROTECTION SYSTEM TO BE DEVELOPED

The waste water protection activities are determined by the fact that the mining activities are spreding deeper and deeper in the inclination, so they get farther and farther from the sand benches that are in contact with gravel bench /Fig. 2./, and at the same time the measurable pressure in the water hazardous layers increases.

The geological-hydrogeological structure and the after-mining behaviour of the protection layer on the hanging prescribes that in each sand layer and at each bench the water level lowering work summarized in Table 4. must be done. Fig. 6. shows the most rational way of forming the well in accordance with the data of Table 5., and which way also offers several other advantages.
Its essence is that separate wells are deepened into the benches to be relieved of pressure, and into the benches to unwatered.

Other advantages:

- no common pressure surface is created for all the five benches,
- the benches to be unwatered are surely isolated from possible dynamic supply,
- the unwatering requiring a greater period of time and the comparatively quick pressure relief can be done at comparatively long time intervals,
- the water exploited in the upper benches can be brought to the surface with a smaller lifting height requiring less energy, etc.

According to our calculations the optimum solution providing the protection during the shaft life is the combination of a fixed and a moving system. The first element of the combination, the fixed system is essentially a well gallery embracing the whole mine area.
/Fig. 1./ The moving system consists of linear well galleries, the tapping elements of which are connected to the fixed system. Development of the moving system preceeds the mining activities on the given field with two years.

Not differentiating between the pressure relieving wells and those ones which are used also for unwatering, the water level lowering in the given field requires altogether

280 wells. Their average production rate will be 90 m^3/day and they will be operated for 600 days.
Control of the water level lowering activity will be done by observatory well network.

WATER SUPPLY, WATER UTILIZATION

Calculating the exploitable water supply of the area by Juhász J. [2] we obtain the data of Table 5. Considering the probable errors with each data, of which so far we have only mentioned the permeability coefficient, at a probability level of 95,5 % an error of ± 11 % is obtained for the water supply calculation. As a result of the water supply calculation we learn that for the remaining ten years of mining activities in the area we have to prepare for a water production of 3600-4400 m^3/day.

Beside realizing the water level lowering the idea of water utilization also occurs. The solution is even more obvious, since the mine is situated in the Kazincbarcika region, in the neighbourhood of the greatest industrial and communal consumers.

Table 6. gives most important values of the analyses of the water samples taken from the surface wells, and the mine, respectively, but both kinds of samples are basically taken from the same layer. The chemical differences between them may be due to the contaminations of different sources. The comparison of the data series indicates that in case of proper treatment the potable water quality can be reached. In case of proper water quality the North-Hungarian Regional Waterworks is willing to acquire any quantity.

As for the economic aspects of the water level lowering, on the basis of real data, a simple comparative analysis can be done [11]. If the costs protection is compared with the return from sales lost exclusively because of hydrogeological reasons for the experimental water level lowering area we receive the following data:

Return from sales /total loss/	+6,1 million Ft
Erection and operation of water level lowering system	-4,7 million Ft
Profit	1,4 million Ft

This should be completed with return from sales of the water utilization and its costs /total investment, operation calculating with the one year cost of water production; the price is planned to be 5 Ft/m^3 /:

- Total loss in return from the sales	+6,1 million Ft
- Price of the water sold	+7,3 million Ft
	+13,4 million Ft

- Erection and operation of water level lowering system:	- 4,7 million Ft
- Erection and operation of the water producing system:	- 1,5 million Ft
	- 6,2 million Ft

The total profit is 7,2 million Ft and this is not negligible from the aspects of company financing. This advantage is however incomparable with the fact that we may succeed in realizing mining without waste water hazards, that would increase the safety of production and would secure more favourable conditions for the manpower.

Essentially the complex mining-hydrological interests, that together are already a rather significant sphere of the national economy, serve as economic background for the water level lowering at the Szeles shaft.

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Table 1.

Examined layer	Number of examination /samples, tests/	Expected value $\bar{X}$ ms^{-1}	Expected value $\bar{X}$ logarithm	Corrected deviation $\bar{D}$ logarithm
Flood plain gravel	19	$1,2 \cdot 1o^{-3}$	-2,92	-2,87
H_{42}	255	$2,4 \cdot 1o^{-5}$	-4,61	-5,o3

Table 2.

Probaility of occurance %	Error of "k" factor /± %/	
	flood plain gravel	H_{42}
45,1 68,3 95,5 99,7	68 113 227 34o	23 39 77 116

Table 3.

Method of Calculation	Heitht of broken-fissured zone /x_{tr}/ m
ÁBBSz. Chap. XIII.	37,5
Salaginov	63,5
Staron	25,5
Somosvári	20,0

Table 4.

Sand bench		Required extent of water level lowering
sign	situation	
H_{41}	in broken-fissured zone	-
H_{421}-H_{422}		Unwatering
H_{423}	above broken-fissured zone	Unwatering.
H_{424}-H_{425}		stress-relieving
sands in higher situation		-

Table 5.

Type of supply	Potentially exploitable supply - total Mm^3	Supply to be exploited
Consolidated	7,2	7,2
From water level lowering	4,4	2,2
From elastic expansion of water and rock	-	-
From dynamic additional supply	52,1	5,2
Total	63,7	14,6

Table 6.

Component		in wells	in the mines
Total hardness nk°		15-35	18
CL^-	mg/1	2o-55	65
SO_4^{2-}	mg/1	25-25o	9o-1oo
NH_4^+	mg/1	much	0
NO_2^-	mg/1	varied	0
NO_3^-	mg/1	0	0
Fe 3+	mg/1	o-3,o	0

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Fig. 5. Density functions of the permeability coefficients
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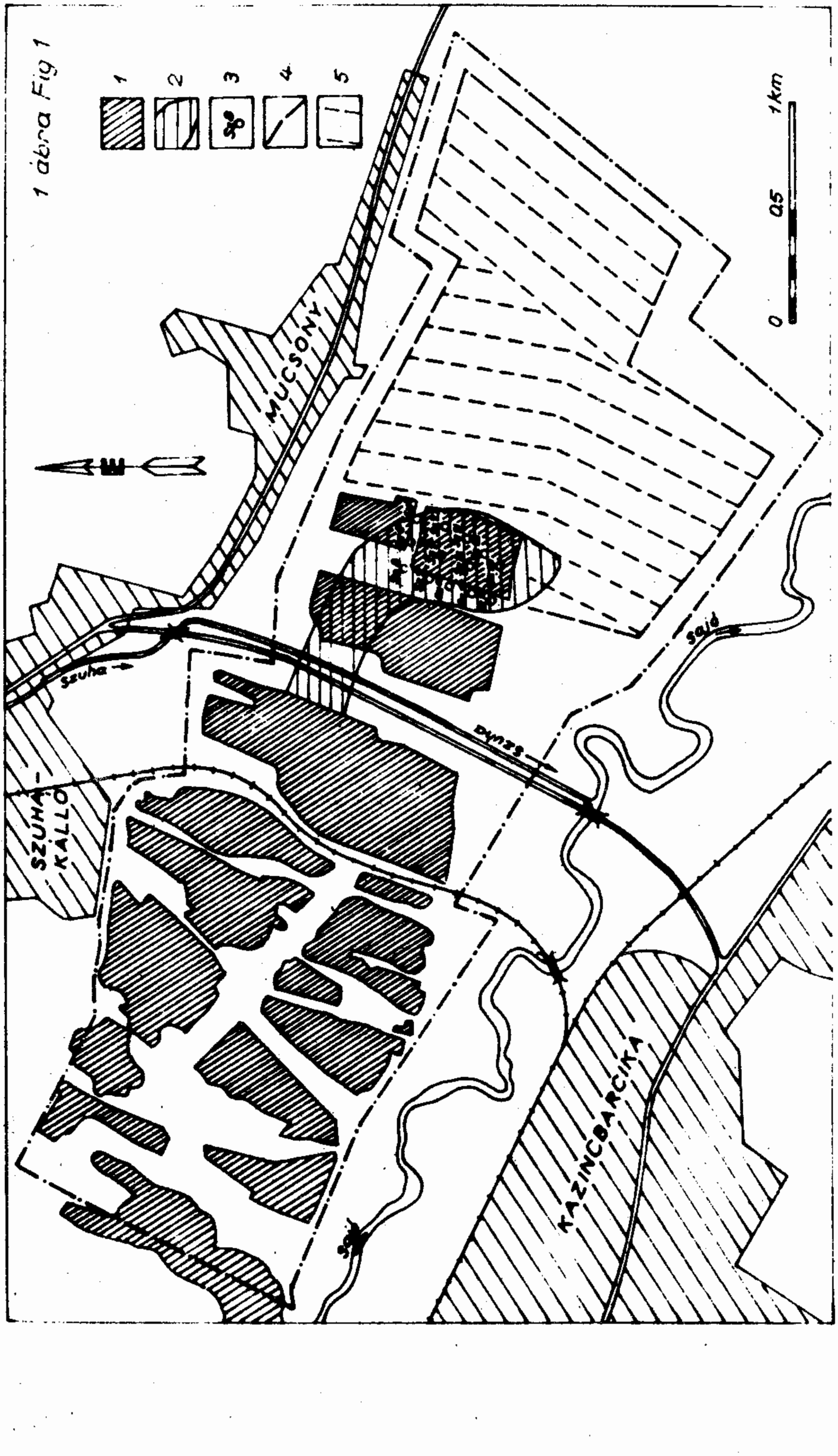

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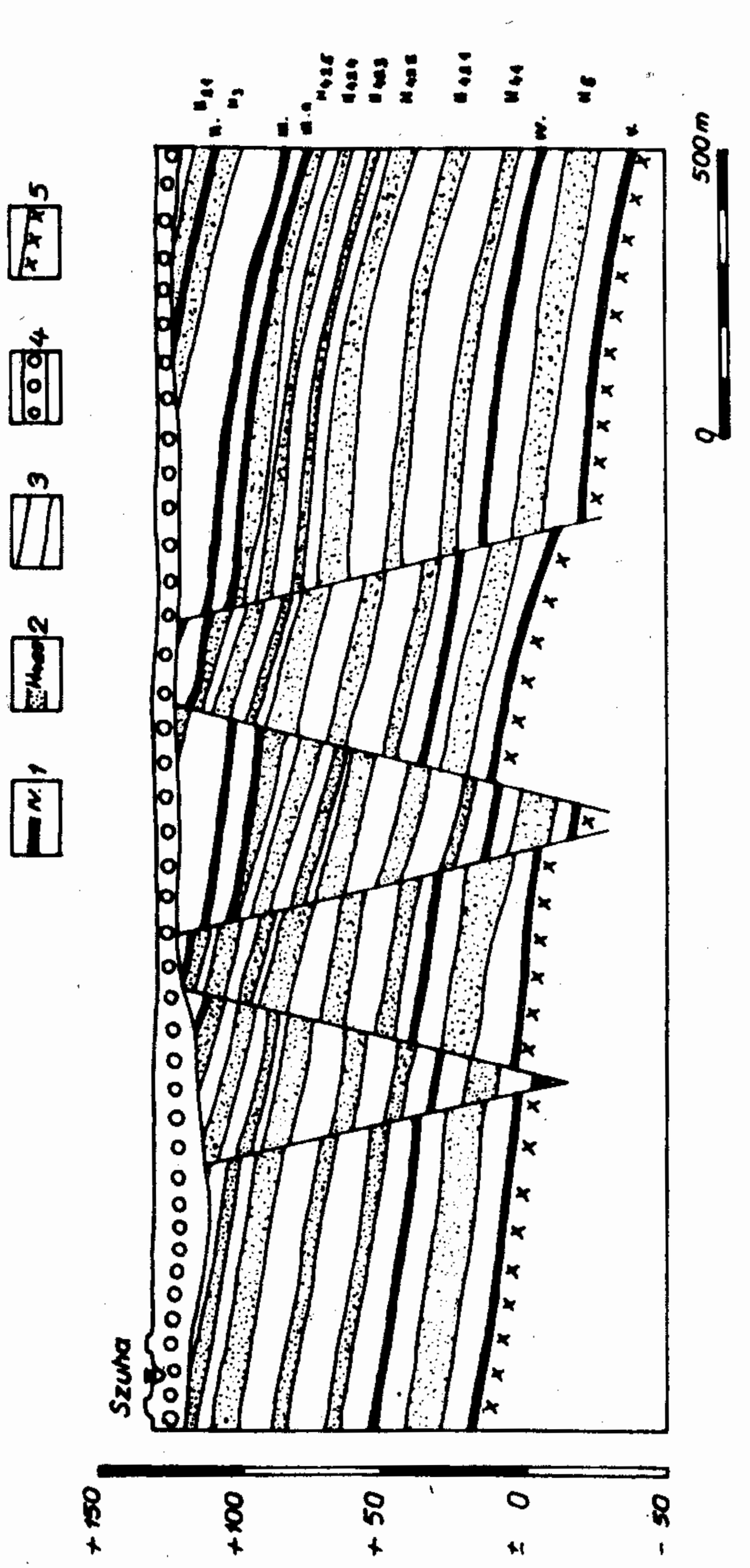

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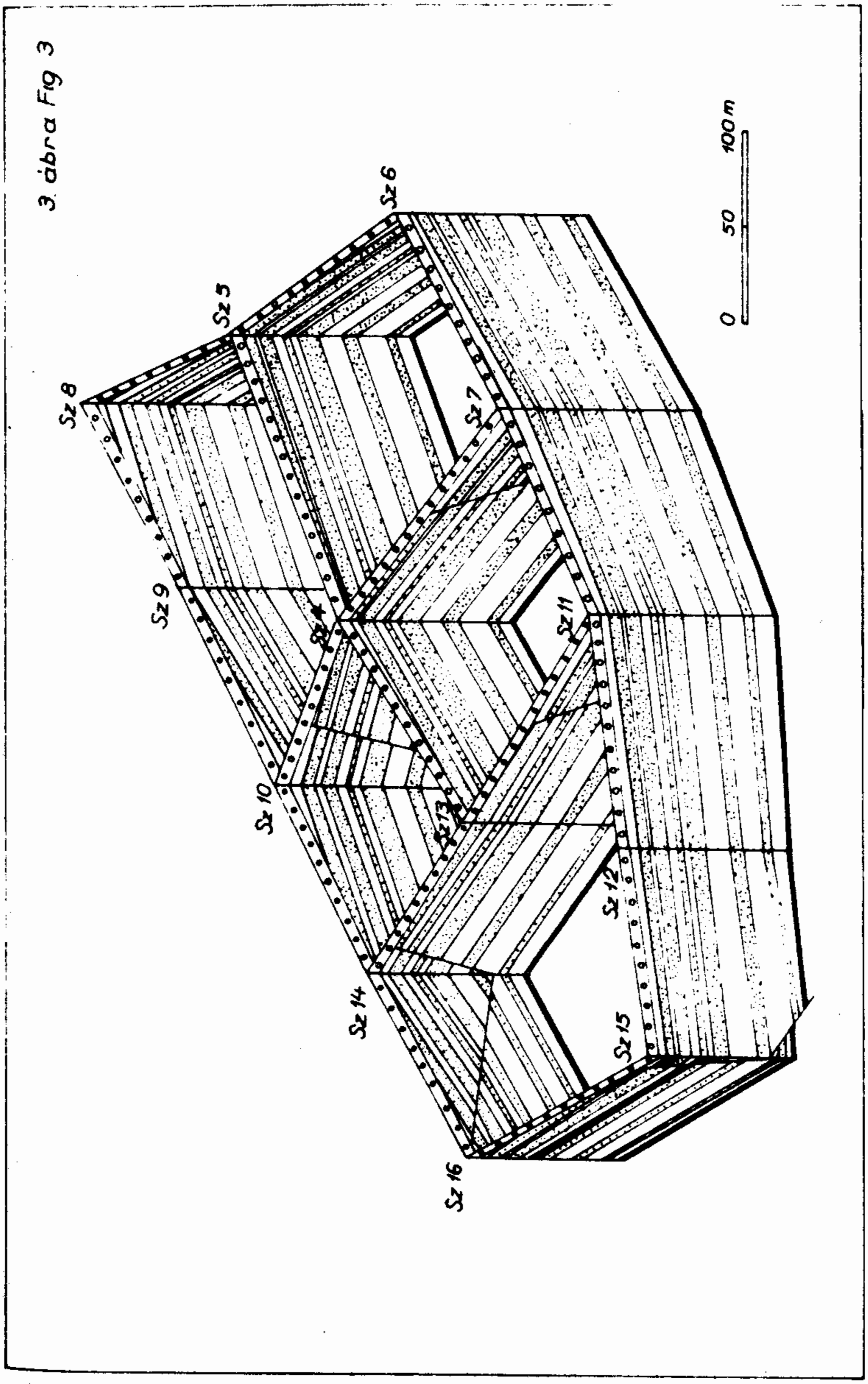
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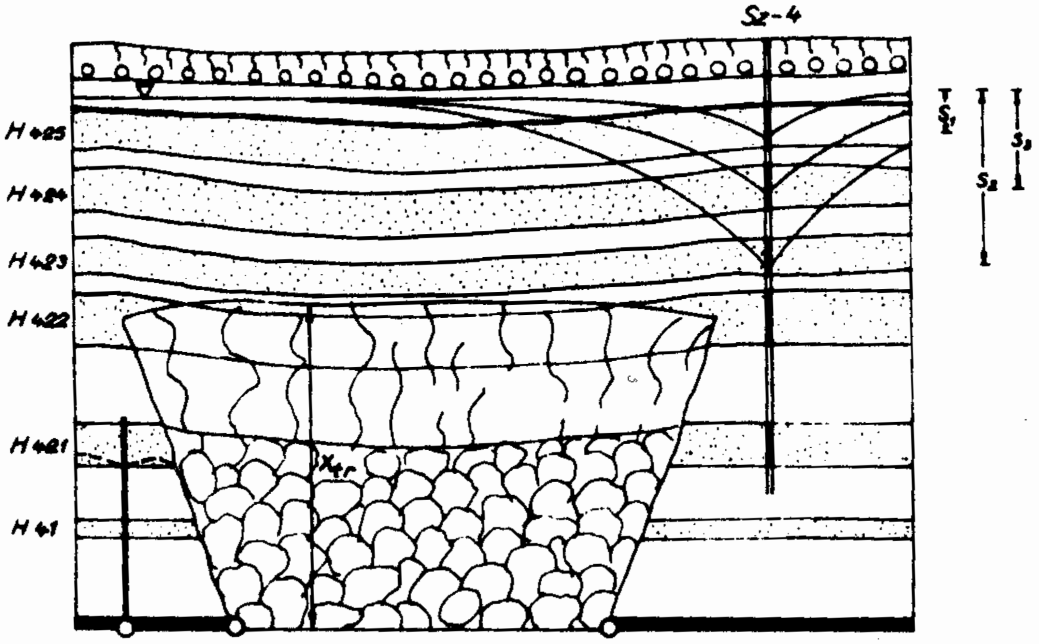
3. ábra Fig 3



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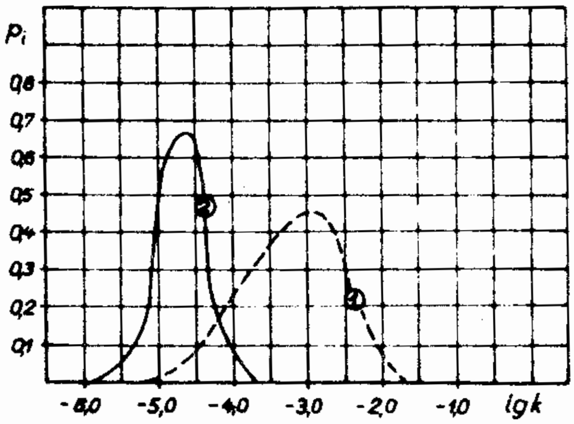

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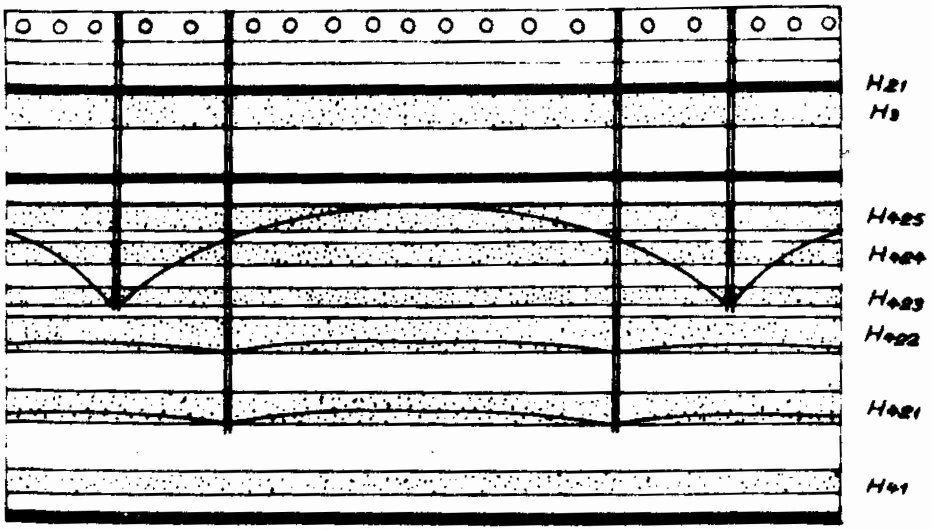

6. ábra Fig. 6.