THE EFFECT OF LITHOLOGIC HETEROGENEITY ON THE TRANSMISSIVITY OF SANDY LAYERS AMONG LIGNITE SEAMS

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SUMMARY

Quasi-homogeneous structure of sandy layers is generally assumed for the dewatering design of open-pit lignite mining. However, borehole log data and open-pit slope samples show such a degree of heterogeneity of sandy layers that bears on the efficiency of dewatering. The variation of transmissivity can be detected mostly from electrical surveying curves. Experiments have been performed in 12 boreholes over a lignite exploration area of 8 km^3 located in the northern edge of the Hungarian Great Plain. In the vicinity of this exploration area lignite has been open-pit mined for two decades and dewatering problems of this mine have prompted this investigation. Median of transmissivity within the sandy layer was 15 m^2/day with a range of -87 % and +160 %, the mean and maximum of standard deviation were 9 and 26 m^2/day resp.

PROBLEM DESCRIPTION

Method and conditions of the investigation

Such boreholes from the area have been considered where the sandy aquifer could safely be interpreted and electrical surveying curve pertained to the same parameters.

The selected sandy layer is located between two lignite seams. Its thickness is 20-22 m and it inclines in 5° to SSE together with the Pannonian lignite seam. The sand consists mostly of quartz and vulcanic particles originating from the denudation of an ancient vulcanic mountain.

The sandy layer was partitioned to sections of different transmissivity by the help of the whole series of electric surveying curves.

The 20 m thick layer was partitioned in the boreholes to 5-17 sections of 0,4-4,0 m thick. Vertical partitioning of the sandy layer is illustrated in Fig. 1. Thickness distribution of the sections within the 20 m thick layer is as follows:

$\leq$1 m : 36 %
1-2 m : 41 %
2-5 m : 22 %
>5 m : 1 %

After this partition, seepage coefficients /k/ for the sections were determined by the help of natural radioactivity curves /Ra - γ/ in the following manner:
Seepage coefficients were calculated from particle size distribution by the Bayer method at places of minimal and maximal intensities at the curve Ra - γ referring to a section considered within the sandy layer. Then, seepage coefficient was calculated as

$$k_x = \frac{K_1 - K_2}{I_1 - I_2} \cdot I_x + k_o \quad /m/day/ \qquad /1/$$

where: k_x - is the unknown seepage coefficient;

K_1 and K_2 - seepage coefficients pertaining to minimal and maximal intensities and calculated from particle size distribution;

k_o - parameter of the estimated linear function $k = f/I/$;

I_x - intensity of natural radioactivity at place X

I_1 and I_2 - minimal and maximal intensities /A/kg/.

Thus, graphical linear interpolation was used for estimating seepage coefficients. The effect of vulcanic particles on increasing radioactivity intensity was accounted for by the help of the electrical surveying curves. This approximating process was checked by the help of calculated seepage coefficients pertaining to particle size distributions of average soil samples of 2-5 m /Fig. 1. part B/. Distributions obtained by the two methods are quite similar. The higher ratio for small k and the smaller ratio for high k reached by the radioactive method, can be attributed to the effect of vulcanic rock fraction.

Though this numerical calculation of seepage coefficient may be incorrect in some places, conductivity variation can be properly characterized for the sandy layer formerly assumed as quasi-linear.

EXPERIMENTAL RESULTS

Variation of section transmissivity calculated by multiplying seepage coefficient k and section thickness M is shown in Fig. 1., part A. Transmissivity profiles are highly variable even within this 2 km section in boreholes located 500 m apart. Transmissivity distributions in boreholes for the given section are shown in Fig. 2., part B. Note the high variance of the distributions. Continuous distributions are drawn but in reality jumps can be present due to sudden particle distribution changes along section boundaries.

Variability of the sandy layer, even in a horizontal sense, as characterized by borehole data, is illustrated in Fig.3. Statistical parameters such as modus, median and standard deviation calculated from empirical distributions /Fig.2., part B/ are also given.

Conductivity variation of the sandy layer over the area of 8 km^2 can be characterized by the following numbers:

	Mean	Max.	Min.	Deviations from the mean	
	m^2/day			%	
Modus	18	63	1	-94	+265
Median	15	39	2	-87	+160
Standard deviation	9	26	1	-87	+189

CONCLUSIONS

The following conclusions for practical mining can be drawn from this investigation:

1. There is great vertical and horizontal variability in the conductivity of sandy aquifers to be dewatered.

2. This variability is greater than one order of magnitude for different sections of the 20 m thick sandy layer investigated, within the probability domain higher than 10 %.

3. Zones of max. and min. transmissivity within the layer are not continuous but have lense structure.

4. Due to this lense variability of transmissivity, efficiency of well dewatering can be insufficient in some places. This could result in "pore pressure zones" leading to slope sliding during subsequent mining operation.

5. As a result of the transmissivity variation, the dewatering system must be either overdesigned or optimized using statistical methods based on the outlined measurement data.

6. It is not recommended to consider some average transmissivity even for the various sections but the whole partitioned transmissivity profile should be accounted for.

LIST OF FIGURES

Fig. 1: Permeability profiles /A/, and permeability distributions /B/ calculated from radiological surveying and pore sire distribution by the Bayer method
1 - lignite
2 - sand
3 - clay
4 - symbol and unit of permeability

Fig. 2: Transmissibility profiles /A/, and transmissibility distributions /B/ in boreholes of a section directed in a bending angle
k - permeability
M - layer thickness
Me- median
D - standard deviation

Fig. 3: Statistics of transmissibility in boreholes over the investigated area
Mo - modus
Me - median
D - standard deviation
R - direction of bending angle
1 - indication of drilling

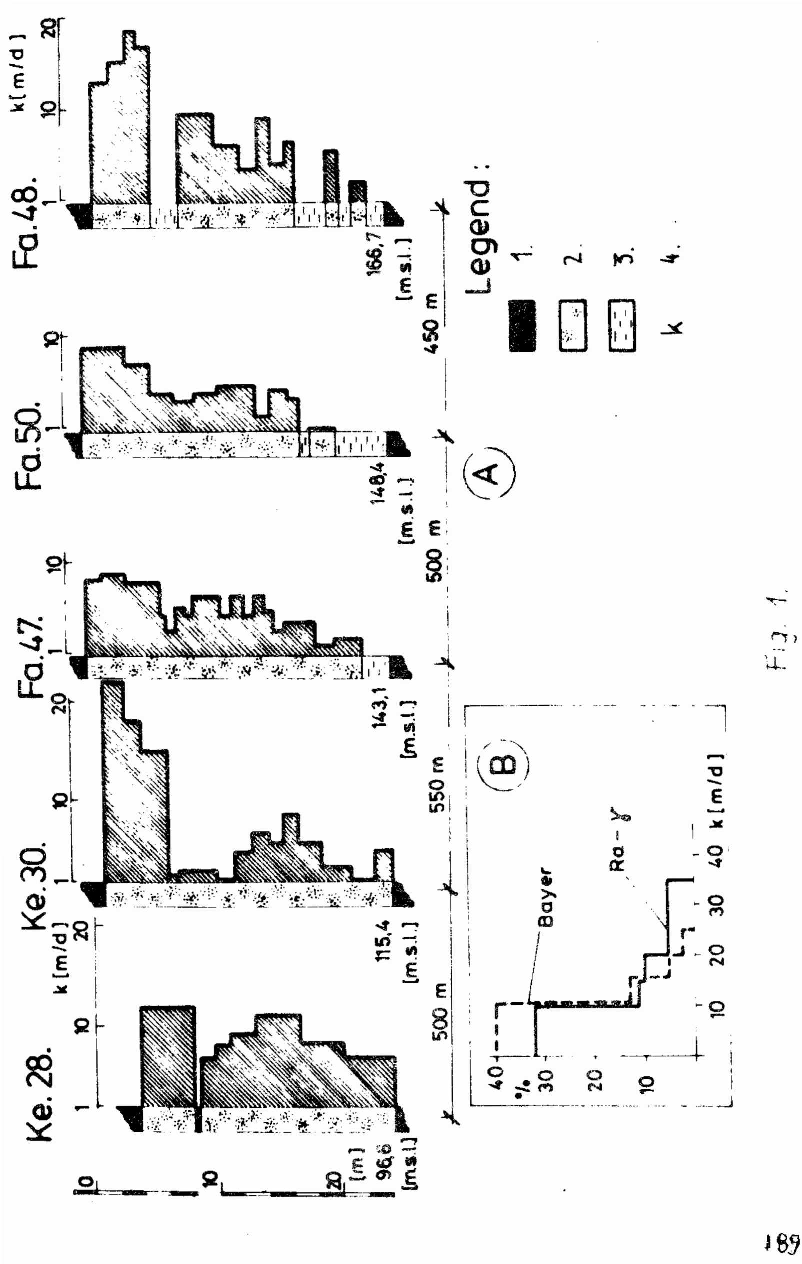
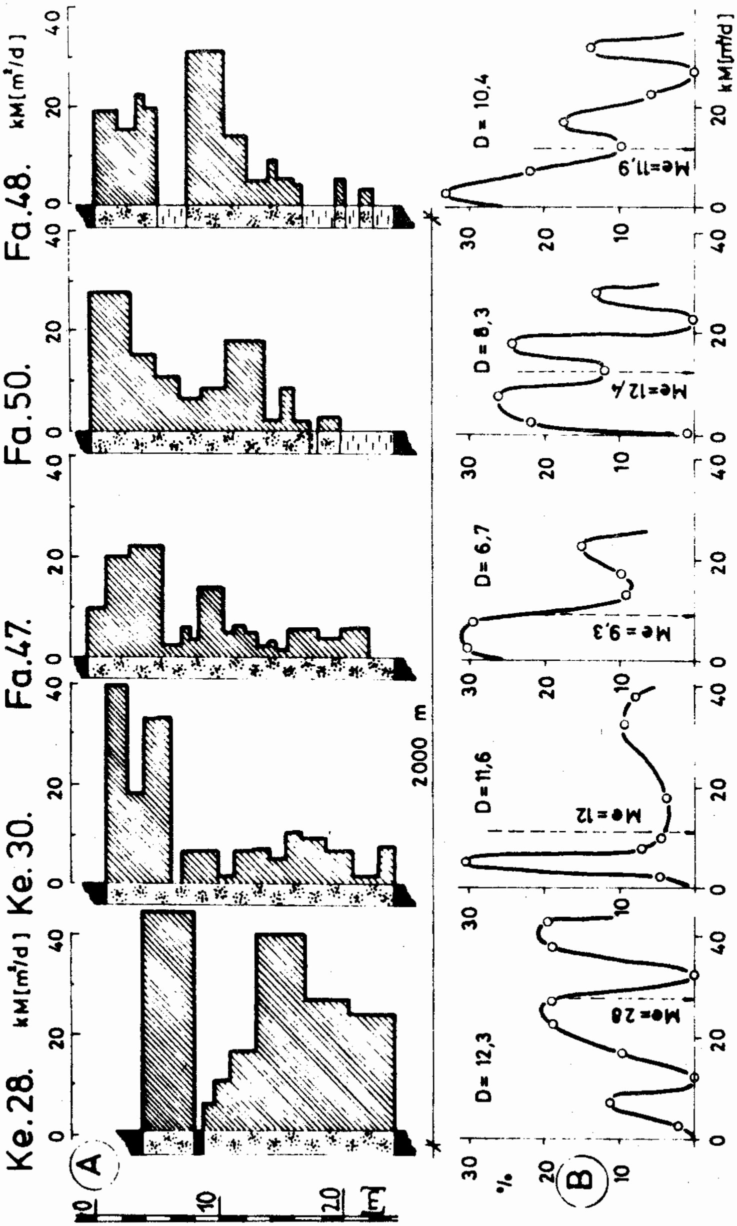

Ke. 28.
Ke. 30.
Fa.47.
Fa.50.
Fa.48.
k [m/d]
96,6 [m.s.l.]
115,4 [m.s.l.]
143,1 [m.s.l.]
148,4 [m.s.l.]
166,7 [m.s.l.]
[m]
500 m
550 m
500 m
450 m
Legend:
1.
2.
3.
k 4.
A
B
Bayer
Ra - γ
%
k [m/d]

Fig. 1.



A
B
Ke.28.
Ke.30.
Fa.47.
Fa.50.
Fa.48.
kM[m²/d]
2000 m
m
%
D= 12,3
Me= 28
D=11,6
Me=12
D= 6,7
Me= 9,3
D= 8,3
Me=12,4
D= 10,4
Me=11,9

Fig. 2

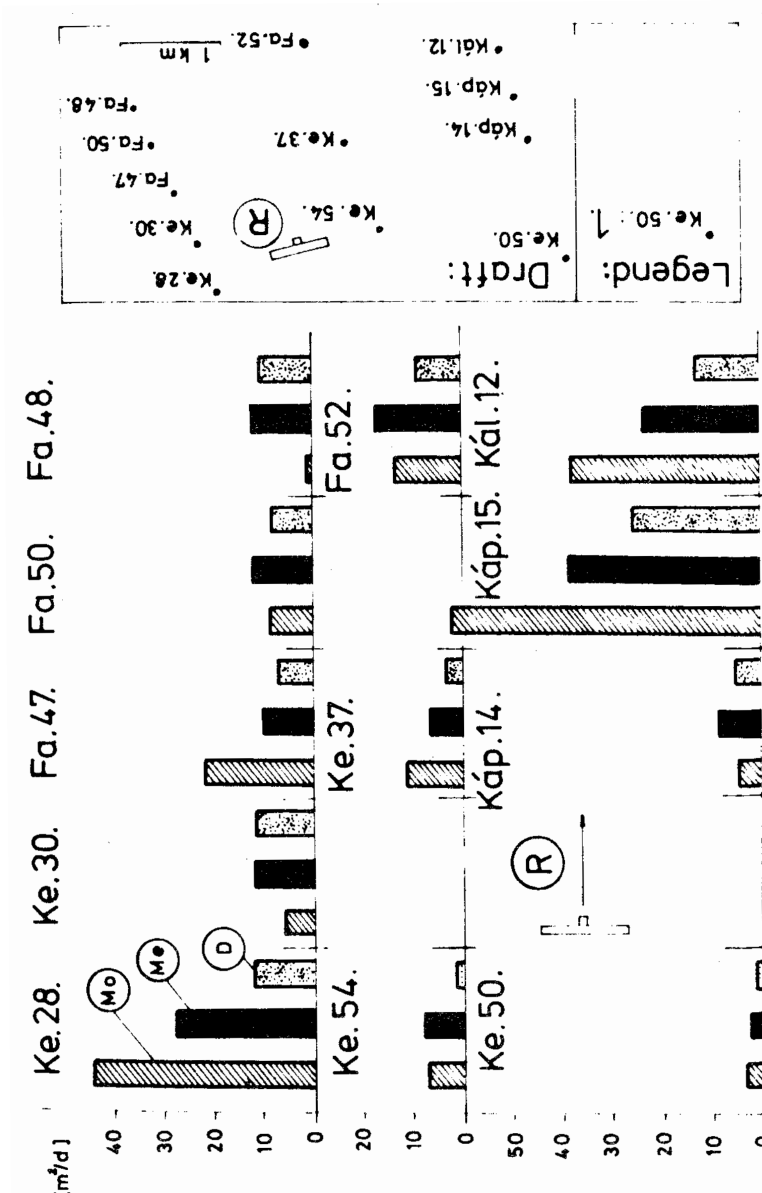

[m³/d]
40
30
20
10
0
20
10
0
50
40
30
20
10
0
Ke.28.
Ke.30.
Fa.47.
Fa.50.
Fa.48.
Ke.54.
Ke.37.
Fa.52.
Ke.50.
Káp.14.
Káp.15.
Kál.12.
Mo
Me
D
R
Legend:
Ke.50. : 1.
Draft:
Ke.50.
Ke.28.
Ke.30.
Ke.54.
Fa.47.
Fa.50.
Fa.48.
Ke.37.
Káp.14.
Káp.15.
Kál.12.
Fa.52.
1 km

Fig. 3.

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