ROOF WATER CONTROL IN EXTREMELY STREAMFUL HIGH ROOFS

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SUMMARY

Under the area investigated Miocene coal is mined by longwall method in a depth of 80-120 m.

Groundwater is stored near the surface, in a coarse gravel bed of a thickness of 8-15 m supplied also by a river. The coefficient of seepage of the gravel bed varies between $3x10^{-4}$ - $3x10^{-3}$ m/s. Under the gravel, a Helvetian sand bed lies that continues in fine silt and rock flour down to the upper coal seam. Altogether five coal seams are in the area, the four lower ones are mined. Sand beds are also stratified among the coal layers their coefficients of seepage being 10^{-7} - 10^{-6} m/s. The sandy layers are separated by siltstone.

The floor of the coal layers consists of heaving, softening green clay with a breaking strength of 1.0-1.2 MPa.

The siltstone providing partial protection in the roof, often fractures up to the gravel bed due to the mining activity and conduct water to the mine thus soaking the floor. The gravel bed being in connection with rivers on the surface and having a coefficient of seepage greater than that of the roof by several orders of magnitude, can provide practically unlimited supply.

The miner has to face two problems due to water hazard:

/a/ in course of the passive protection against water hazard, a great amount of water has to be raised to the surface under conditions far from optimum rendering mining difficult and expensive;

/b/ the water brings about floor heaving and reduces carrying capacity, consequently, supports sink into the ground and working becomes difficult or even impossible.

The optimum solution to the first problem is a limited-range drainage restricted to the necessary area and a suitable winning method that reduces roof loosening to a minimum thus preventing it from reaching the gravel bed.

The second problem can be solved by arranging pseudo-horizontal roof-filters in a herring-bone pattern. The roof-filters have to be driven from the longwall drifts at an angle of 45° and with an inclination of 5°. Two roof-filters lined by PVC pipes should be fitted in each cross-section.

If the longwall advances in the direction of dip, a few floor-filters also have to be installed in the goaf.

Roof-filters can drain the longwall and they can also be used for dewatering purposes in combination with other drainage methods. Longitudinal floor-filters collect water from the goaf, mainly in inclined workings.

Under the area investigated, bituminous coal is mined by longwall method in a depth of 80-120 m. In a Pleistocene terrace bed on the surface a few rivers cross the area providing unlimited water supply towards the mine.

The working area of Szeles Mine of the Borsod Coal Mines has been studied in more detail. The mine lies in the Sajó Valley in Northern Hungary /Fig. 1/. The surface is smooth, water is supplied by the creek Szuha and the river Sajó. Built dams ensure protection against floods exept for the southern region flooded by the Sajó twice a year. Apart from the rivers, smaller lakes, e.g. Lake Udránszki, lie in the area.

Based on the data of VITUKI /Scientific Research Institute of Water Economy/ over a long period, the characteristic water outputs of the Sajó and Szuha are:

	Sajó	Szuha
Maximum	390.0 m^3/s	16.00 m^3/s
Mean	22.2 m^3/s	0.70 m^3/s
Minimum	0.7 m^3/s	0,01 m^3/s

Characteristic sections of the Szuha and the Sajó are shown in Fig. 2. The map showing them can be seen in Fig. 5. The Sajó cuts deeply into the Pleistocene terrace gravel-bed that stores groundwater. Since the water table is 1-1.5 m below the bottom of the river, the Sajó can supply groundwater at any water-level. But while supply comes only from the river at low and medium levels, water also seeps from the surface if it is flooded.

The creek Szuha flows in an artificial bed over the area. The bottom of the Szuha lies higher than the roof level of the gravel bed, consequently, the creek Szuha does not supply groundwater or utmost to a very small extent.

The bituminous coalfield of Szeles Mine belongs to the Miocene bituminous coal-basin in East Borsod. Its geologic boundaries are the Rudabánya Mountains and the Gömör Karst to the north and the Paleozoic rocks of the Bükk to the south. The basin is open towards E-SE, and the strata gradually dip into greater depth along a set of parallel faults. The coal seams are layered on the border of the Uppony Mountain, their floor consisting in all probability of Carboniferous limestone and limestone conglomerate. The basement of the basin is probably composed of Devonian limestone and sericitic slate. The upper Oligocene strata may contain considerable amount of clay. The area has not been explored by drillings.

The Eggenburgian stage of the lower Miocene is composed of schliery, clayey products while the Burdigalian stage consists of rhyolitic tuff and its weathering products viz. tufite and tuffeaceous clay forming the direct floor of coal seam V.

The coal-bearing sedimentary sequence of an approximate thickness of 200 m, with five known Helvetian main seams, dips generally towards SE and becomes more complete in this direction.

Sandy and siltstony beds are layered among the coal seams /s. Fig. 3/.

The roof of the coal seams consists of sandy beds separated from the Pleistocene gravel layers by a 3.0 m tichk siltstone but there are places where the two beds are in direct contact.

The characteristic stratigraphy of the area investigated is displayed in the following table /the thickness data are calculated as arithmetic means of the data acquired from berehole logging/:

Epoch	Thickness /m/	Stratum
Holocene	1.50	soil
Pleistocene	4.00	gravel
Helvetian	18.00	siltstone
	4.00	sand
	1.22	bituminous coal seam II
	5.00	siltstone
	6.00	sand
	13.00	siltstone
	0.63	bituminous coal seam III
	8.00	siltstone
	0,60	bituminous coal seam III/a
	26.00	sand /N° 2/
	23.00	siltstone
	9.00	sand /N° 1/
	22.00	siltstone
	1.50	Congeria bed
	1.54	bituminous coal seam IV
	7.00	siltstone
	4.00	sand
	23.00	siltstone
	0.54	bituminous coal seam V
Burdigalian	?	green, tuffeaceous clay

The roof of seam V layered on the green tuffeaceous clay is siltstone and sandy siltstone in average 23 m thick. A 4 m thick aquiferous sand bed lies above the siltstone. Because seam V is not worked, this sand bed can be ignored from the water hazard point of view.

Another siltstone bed, 7 m in thickness, and a greenish brown clay follow the latter being the floor of seam IV and of tuffeaceous and sandy composition in some places. This rock in the floor heaves if it gets in contact with water which results in difficulties concerning the mining activity. A few physical and soil mechanical parameters of this rock have been determined: $W_F = 57.5$ %; $W_p = 33.9$ %; $P_p = 17.5$ %; $I_c = 1.35$; $\gamma_n = 19.1$ kN/m^3 ; $\gamma_o = 14.3$ kN/m^3; $Sh_L = 6.5$ %. These parameters show that the floor is a high plasticity clay with a considerably great linear shrinkage. Exceeds the water content of this clay 40-45 %, its strength decreases to a great extent.

The direct roof of seam IV is a 1.5 m thick Congeria siltstone. An approximately 22 m thick siltstone is layered above it. The output of water flowing through this bed into the worked and worked-out areas amounts to 2.2 and 5.8 m^3/min the corresponding areas being 236,000 m^2 and 600,000 m^2, respectively. Assuming that seepage is brought about by the pressure difference in sand bed N° 1, the average coefficient of seepage is $3.23-3.2\times10^{8}$ m/s i.e. 0.003 m/day. This value exceeds that of the own coefficient of seepage of the intact siltstone and reflects the craqked state of it.

The coefficient of seepage of the sand bed above it is greater by approximately one order of magnitude. A few physical parameters that are important from the water hazard point of view have been measured: $W_F = 43.9$ %; $I_p = 12.3$ %; $W = 16.3$ %.

The measured water content shows that the siltstone in the roof is not soaked thus it provides partial protection. Water can only pass through fissures formed by fracture in the roof when the siltstone cracks up to the sand bed. The sand bed above the siltstone is regarded by many authors as a sedimentary sequence consisting of two sand beds. This stratigraphic distinction is verified by hydrogeologic considerations. The sand beds are separated by siltstone beds from each other and seam IV, the upper sand bed being the direct floor of seam III/a. The lower sand bed, called <u>sand N° 1</u> is 3-9 m thick and has a varying lithology. Sand, gravelly sand and sandy siltstone alternate here. The sand is fine-grained and it yields its water with difficulty; the amount of gravel particles, 0.5 - 2.0 cm in diameter, is negligible and does not influence the hydrogeologic properties of the layer. Flow conditions have been analyzed with the help of data obtained from drilling M-222 and boreholes in the mine. The coefficients of seepage calculated with various methods are displayed in Table I.

The static water level is at 103.0 m above the /Adriatic/ sea level. Previous studies predicted water outputs of 100 l/min a well in this layer. But taking into account a posibble depression of 83 m and an average coefficient of seepage, an approximate water output of 60 l/min can be expected from a well which can increase to 70-80 l/min with an increased equivalent well radius.

The upper sand bed, called <u>sand N° 2</u> is 26 m thick in average and is composed of fine-sandy rock flour with scattered gravels according to the grain size analyses. Lenticular sandy siltstone beds cause variations in the lithology of this layer, making the identification difficult in many cases. Hydrogeologic investigations of this bed were carried out also in drilling M-222 and in hydrogeologic drilling Sz-1/V in 1971. The coefficients of seepage for sand N° 2 are also displayed in Table I.

The satatic water level of this layer is at 106.0 m above the /Adriatic/ sea level. With an average value of the coefficient of seepage and a possible depression of 36 m, the water output of a well can be expected to be 250 l/min that can increase to 300 l/min in case of an increased equivalent well radius.

The area of supply for the beds between seams IV and III/a or in the roof of seam IV, is illustrated in Fig.4. It can be seen that the area of supply from the south, i.e. the Bükk Mountains is far away, a supply from the north-east, The Szendrő Mountains is insignificant because of the permeability of the limestone there. The only supply of greater importance is from the north-west and from above, the aquiferous Pleistocene sandy gravel.

The map showing the areal distribution of the delivery coefficient of the beds above seam IV, is illustrated in Fig. 5.

Between seams III/a and III siltstone can be found, there is no sand bed here.

The roof of seam III is a 10-15 m thick siltstone and the floor of seam II is also siltstone, 5 m thick in average. There is a 3-7 m thick sand bed between the siltstones. In some places clayey sand replaces the siltstone and sand below seam II.

The roof of seam II is a loose sand. A siltstone bed is layered on it, followed by the Pleistocene gravel bed.

In January, 1971 water analyses were carried out on samples taken from aquiferous sand N° 1 above seam IV, the results of which are summarized in Table II.

Results of analyses performed two days later, allow the conclusion that the sand bed N° 1 obtains supply within a short time from sand bed N° 2 and the terrace gravel above it, but separated by a siltstone layer. This statement can be proved by the fact that the data obtained on 5th January indicate the presence of groundwater while those of 7th January refer to subsoil water or to that of mixed character. Further parameters of groundwaters are displayed in Table III.

Since the coal seams dip towards E, SE, four Helvetian layers can be found below the Pleistocene gravel due to later erosion. These layers are identical with those among the seams.

Groundwater is stored in the main by the Pleistocene terrace gravel over a great part of the area. Its material is slightly eroded and consists mainly of quartz, andesite and limestones of Gömör type. The binding substance is clay, clayey sand and sand. Its thickness varies between 1.0 m and 9.0 m, the average being around 4.0 m. It is generally filled with water.

To determine the direction and rate of the water flow in gravel terrace, a "large well" was constructed on the mining field Edelény I in 1967 and it was surrounded by 14 monitoring wells. Salt solution was added to the water in the large well and the appearance of the salt solution was detected by measuring the electric resistance of the water in the monitoring wells. The rate of the water flow has been found to be 2.5 m/day and the direction of flow approximately coincided with that of the Sajó and Szuha, i.e. NW-SE. The water table is 4-5 m below the surface, both above the area being worked and that already mined out. This observation proves the good isolation capability of the siltstones in the roof of seam IV.

On areas where the seams above seam IV were denuded, the gravel bed is layered in the main directly on the upper sand bed above seam IV, the subsoil water and groundwater being in direct sontact with each other.

In December 1976 hydrogeologic investigations were carried out in the gravel bed at Szeles Mine. The river Sajó was just flooding during this period therefore the test pumping was performed before and after the flood. The rate of rise of the water table during the flood was also used to calculate the coefficient of seepage. The results of this test and the coefficient of seepage calculated from the test pumping in drilling Sz-1/V are displayed in Table I.

The area in question is in connection with the rivers flowing over it, the water supply of the aquiferous layers depends on the output of the rivers. The saturation of the gravel bed varies within a wide range as an effect of the Sajó and Szuha, but the full saturation of the gravel is brought about by only the increase of the water level of the rivers.

The subsoil waters in the area contain a high percentage of sulfates. Table IV summarizes some water-chemical data.

Above the Pleistocene gravel bed Holocene flood-plain mud, clay and soil are layered.

The groundwaters of the basin have their supply partly from the surface, partly from older water-bearing rocks /Fig. 4./. To the north, upper Carboniferous limestone blocks outcrop from below the Miocene strata containing coal seams. It is even very probable that these limestones occupy a much greater area in form of an extension of the Szendrő-Edelény island mountain.

The coal seams dip deeper in the eastern part of the basin, thus water supply cannot be expected from this direction.

The coal seams are supported from the south by the Mezozoic limestones of the Bükk, consequently, the groundwater of the karst - in case of direct contact - can enter the porous sand beds.

The karst water table of the Bükk is higher than the static level of the groundwaters of the coal basin.

On the eastern part of the southern margin of the basin the coal seams are separated by thick Rupelian clay beds from the limestone, preventing an exchange between the karst water and the groundwater.

The coal seams outcrop on the western side of the basin or they are covered by a gravel bed only. From this side the beds among the seams can obtain water supply directly from the surface.

The natural water supply is, however, only of minor importance for the mine. While the natural water supply of the two sand beds above seam IV is 250 l/min and 600 l/min, respectively /assuming the drainage to the depth of sand N° 2 and N° 1, respectively/, the mine removes a water output of 8,000 l/min, i.e. more than twelve times the supply from the side. The caving method brings about roof fractures of an extent that the main supply of water comes from the rainfall over the area of the mine and from the floods of the rivers which have access to the seams through the water reservoir stored in the terrace gravel.

This terrace gravel have to be considered in practice an infinite, unlimited reservoir because its coefficient of seepage differs by more orders of magnitude from those of the other layers.

The tectonic features of the area can be characterized by normal faults, i.e. diplacement occurs along fault surfaces downwards. The angle of dip of the faults varies between 36° and 76°, their direction of strike is NNE-SSW and the transverse faults are perpendicular to that. Numerous minor faults with a throw of

0.5-1.0 m can be found crossing the major faults.

The structural forms of the basin are the type of successive faults. Grabens and horsts alnernate in the area. Tilting along fault surfaces is also frequent. The faults are of gravity type and their angle of dip varies between 65-75° according to observations gathered from mining operations. Apart from the acting forces, compaction due to the drainage of the sediments plays also an important role in forming the structural shape of the basin.

The working advances in Szeles Mine from west to the east. The area can be divided into two parts; the western worked-out panel R and the eastern panel M being mined. A constant drainage takes place also in the worked-out panel to ensure free passages for escape routes in the old drifts.
In December, 1975 a water-inflow of 5.8 m^3/min was measured in panel M and 11 m^3/min in panel R. The pumping plants of the panels pump the water into a 10-12 m deep lake in the site of a surface mine the layers below which are, according to experience, in connection with the drifts of the worked-out area. The level of the lake is kept by constant pumping 1-2 m below the groundwater--level in the surrounding soil. This measure reduces the amount of water entering the "old man" from 3 m^3/min to 600-700 l/min.

There are no facilities provided for dewatering purposes in the mine or on the surface to protect panel M worked by caving longwall method. Bibo pumps are used for draining the longwalls and even they pump water in the main from the goaf.

If the longwall advances upwards in the direction of dip, water from the goaf does not cause much problem. However, if the working travels downwards in the direction of dip, the soaking of the floor arises considerable difficulties. Fairly good mining conditions can be expected until there is no fracture in the roof. But if the roof fractures because of the caving method, the fractures can extend e.g. in case of the 100 m deeply bedded seam IV up to the gravel terrace resulting sometimes in "water inrushes" of 250-300 l/min at the 70-m longwall. To prevent the roof from fracturing, a 10-20 cm thin coal bed is left in its place.

At low rates of advance and on holidays the amount of water entering the mine can reach an output of 150 l/min. If the longwall advances more rapidly, the amount of water is less, and if the rate of advance achieves 3.5-4.0 m/day there is no more problem due to water. The faults in the coal had no effect on the amount of water. Efforts made by the miners to remove water from the area, have failed until now. According to experience, about 70 % of the water entering the mine becomes steady. The mine water is generally clean, it does not contain deposits.

It is not the amount of water that causes problem for the mine but the fact that the green clay of 1-1.2 MN/m^2 breaking strength in the floor heaves, becomes plastic and the supports sink into the ground. The floor becomes soaked to a depth of 1 m according to estimations.

The southern part of panel M being worked lacks the water-tight Congeria siltstone in the roof. In this part of the mine the longwall has been systematically soaked for many years.

Experience proved that in the drifts of the new panels, to the east from the Szuha at a rate of advance exceeding 3 m/day, the seeping-down water reaches the seam by 10-15 m behind the face, but at 2 m/day the water soakes the floor. In the drifts driven until 1976 with a total length of 4000 m, 500 l/min have been drained. A drilling directed upwards from the dead end of the drift produced a water output of 20-30 l/min.

The main problems the mine has to face, are:

/a/ in course of the passive protection against water hazard a great amount of water has to be raised under conditions far from optimum rendering mining difficult and expensive;

/b/ the water entering the longwalls brings about floor heaving and reduces the carrying capacity in the clayey beds, consequently, the supports sink into the ground and working becomes difficult or even impossible.

The mine presently applies posterior protection against the water hazard. The water that entered the drifts, longwalls and the goaf, is collected and pumped to the surface by two pumping plants. The total water output of the mine amounted to 15 m^3/min in 1977. This amount can be reduced if the area to be drained at a time is decreased and/or the supply is cut off.

The possibility of reducing the area to be drained can be found in the fact that the posterior protection extends not only to the worked panels but water is also drained from a great area already worked out to maintain a considerable part of the drifts. The drainage of the worked-out area could be stopped if escape routes would have been arranged in an alternative way. Since water seeps in the main nearly vertically from the gravel terrace, the amount of water to be raised changes as a function of the ratio of the worked and drained areas. By abandonding the old mine, the area to be drained would be considerably reduced.

Water supply can be cut off by two methods:
/a/ by maintaining the protection capability of the protection layer above the bituminous coal seam;
/b/ by reducing the area of supply.

The first method applies a new technology of working that prevents the roof from loosening and fracturing up to the water-bearing gravel, thus it allows for the 22 m thick siltstone bed in the roof of seam IV to provide partial protection. This kind of working can considerably reduce the amount of water entering the mine.

The main feature of the second method is a partial closing of the Pleistocene sandy gravel bed in order to reduce the supply. The terrace gravel has two principal sources of supply, viz. the rainfall and the rivers. To cut off supply from the rivers, the protection area determined by the angle of fracture above the mining operations should be fenced round. The perimeter of this area would amount to 9400 m. The depth of the wall to be constructed should be 7 m in order to ensure a reliable contact with the siltstone or sand bed N°2 below the terrace. A closing wall of 66,000 m^2 total surface ought to be constructed to achive its aims.

If the closing wall extends as far as 1 m in the Miocene siltstone being the floor of the terrace gravel, and the width of the wall equalling 40 cm; the rate of water seeping through a 1 m section of the wall becomes /assuming previous rock physical parameters/ $q = 4,8 x 10^{-6}$ m^3/sm and the total flow rate for the whole 9400 m length is $Q = 4.5 x 10^{-2}$ $m^3/s = 2.7$ m^3/min.

The rate of water seeping through an injected wall is $q = 2.0 x 10^{-6}$ m^3/sm if a careful execution is assumed; the total flow rate can be expected for $Q = 1.13$ m^3/min.

If only an area on the surface were drained that corresponds to the panel worked within a year, the amount of water would be only 70 % of the previous one. The water has to be raised through wells inside the surrounded area, ensuring for the total amount of water to be removed.

The gravel bed, however, cannot be drained with a high efficiency.

Consequently, the reduction of the area of supply is extremely expensive and complicated. Water output can be reduced to one half or one fourth of its original value by this method. The construction costs, however, considerably exceed those of pumping and a concentrated investment is needed to meet the financial requirements while pumping costs incur over a long period.

To keep longwalls dry, drainage by horizontal filters in drifts perpendicular to the longwall /haulage way, entry etc./ seems to be the suitable method.

Longwalls advancing upwards in the direction of dip are soaked if roof fracture approaches the rock in front of the longwall. These fractures lie in inclined surfaces and are parallel to the longwall. Roof water is led through them to the floor where they soak the green clay containing a certain amount of volcanic tuff which causes especially much problem.

The siltstone in the roof - even in a cracked state - is of low permeability. It can be, therefore, effectively drained if draining elements of sufficient great surface are used, possibly near the coal seam. Filters arranged at angles of 45°, directed backwards in the roof of the coal seam and having an inclination of 5° can handle drainage problems most suitably /Fig. 6/. The filters are made of PVC to prevent damage to winning and other machines in the longwall due to contact with them during their operation.

The herring-bone pattern of the roof filters ensures for the water flowing down the fractures, to be led to the drifts near the longwall, even if some of the filters are broken due to rock fracture. The filters in the goaf break automatically thus they gradually cease to collect water.

The efficiency of the filters can be considerably increased by applying vacuum technique.

The filters have to be arranged at distances ensuring for all possible fracture surfaces to be crossed by a pair of filters. For the given geometric arrangement and a 70 m longwall length, a filter distance of 17.5 m would be needed. In practice 20-m distances are used on most occasions.

The length of the filters is 50-60 m, corresponding to the 70-m length of the longwall. Each roof filter can provide a water output of 5.5 l/min, which is ensured by 3-in or 2 1/2-in perforated pipes lined with 40/60 synthetic sieve cloth.

Since the beginning of the intensive inflow of roof water coincides with roof fracture, no pre-drainage has to be taken into account.

To drain the goaf, perforated steel pipes can be laid on the floor simultaneously to the advancing of the longwall.

The water drained by these longitudinal filters at distances of 14 m, can be collected in a water drift driven in the deepest line if the longwall advances upwards. If the longwall travels downwards, flexible hoses can collect the water in the goaf. In this case the collecting pipe has to be removed and fitted newly to the next filter pipes. The floor filters can be made of 2 1/2 - 3 in scrap steel pipes, the perforation consisting of 5 mm dia holes or 2x200 mm slots, their total free area amounting to 12 %. For this purpose steel pipes are needed because they have to resist sudden and high loads due to caving.

Based on the investigations, it can be stated that making use of the partial protection capability of the protecting layer is the best method of water control for mining under a streamful high roof. The heaving and softening of the rock in the floor can cause further problems. Water control has, therefore, to remove even small amounts of water from the mine. Roof filters seem to be suitable to meet this dual requirement. They can be combined with other methods of water control or can be used on their owns. Longitudinal filters can drain the goafs of workings advancing both upwards and downwards in the direction of dip.

In the investigated Szeles Mine, a combined application of roof filters and longitudinal floor filters seems to be the most suitable method of water control.

Table I.

Coefficients of Seepage in m/s Calculated with Various Methods

Stratum	Porsche's analysis	Pumping	Grain size distribution	Back-filling	Average taken into account
Sand N° 1	1.22×10^{-2}	1.4×10^{-6}	8.4×10^{-5}		1.1×10^{-6}
Sand N° 2	1.6×10^{-7}			2.6×10^{-6}	4.5×10^{-6}
Pleistocene terrace gravel		8.7×10^{-4} 1.2×10^{-3} 1.28×10^{-4}	2.8×10^{-4} 2.19×10^{-4}	3.5×10^{-3}	5.0×10^{-4}

Table II

Chemical Data of Water Samples

Date of sampling		5 January 1976	7 January 1976
Alcalinity ml 1 n HCL		21.7	9.9
Carbonate hardness $^{\circ}$		80.76	27.72
Non-carbonate hardness $^{\circ}$		-	-
Total hardness $^{\circ}$		24.68	13.64
Calcium, Ca^{2+}	mg/l	111.49	67.18
Magnesium, Mg^{2+}	mg/l	39.09	23.45
Chlorine, Cl^{-}	mg/l	112.87	45.73
Sulfate, SO_4^{2-}	mg/l	-	-
Oxigen cons. O_2	mg/l	8.0	24.0
Ammonium, NH_4^{+}	mg/l	0.05-0.02	0.05-0.2
Iron, Fe^{3+}	mg/l	0.5 -1.5	0-0.1

Table III

Place of origin of the samples	Mucsony, Drilling N° 222			Szeles III Main line 6 right airway at longwall	Mucsony Kossuth str.73 welled up water
	Outflowing from 81–89 m	Groundwater from 51 m	Outflowing from 51 m		
Time of sampling	5 Jul 1971	20 Jul 1971	20 Jul 1971	5 Dec 1968	30 Oct 1980
Water temperature °C	15.4	16.0	16.0	–	–
Alcalinity W°	42.28	24.8	23.4	18.3	10.0
Carb. hardness °	118.38	69.44	65.52	51.24	28.0
Non-carb. hardness°	0	0	0	0	33.88
Total hardness°	14.91	23.85	17.26	13.8	61.8
Calcium mg/l	45.61	125.94	76.93	68.56	383.66
Magnesium mg/l	36.76	26.8	27.98	18.37	36.76
Chloride mg/l	272.0	188.0	138.0	47.0	360.0
Sulfate mg/l	123.17	168.75	123.17	77.24	258.88
Ammonium mg/l	2–5	1–2	2–5	0.5–1.0	above 5
Nitrite mg/l	0	0	0	above 0.5	0.03–0.1
Nitrate mg/l	1	0	0	–	1.0
Iron mg/l	1–2	1–2	0.5–1.0	0.1–0.5	above 2

Table IV

Place of origin of the sample	Mucsony E.Szuha gravel terrace	Mucsony Soil mechanical drilling N° D3	Sajó terrace gravel	Drilling M-217
Time of sampling	24 Jul 1967	13 Apr 1971	8 Sep 1966	4 Apr 1971
Alkalinity N°	5.30	6.0	2.06	3.0
Carbonate hardness °	14.84	12.48	5.77	8.4
Non-carbonate hardness °	20.78	23.49	43.67	15.68
Total hardness°	35.62	35.97	49.44	24.08
Calcium mg/l	172.52	160.1	245.07	130.59
Magnesium mg/l	49.40	61.0	65.19	26.08
Chloride mg/l	92.0	60.0	60.0	52.0
Sulfate mg/l	636.74	1094.3	919.14	1210.86
Ammonium mg/l	2 - 5	above 5	0	0.05-0.3
Nitrite mg/l	0	0	0.03-0.1	0.03-0.1
Nitrate mg/l	2	0	0	17
Iron mg/l	1.2	0	0	0

LIST OF CAPTIONS

Fig. 1. Topographic map of the surface
Pl_1 Gravel, sand clay, bituminous coal /1/
$Ms-Pl_1$ Limestone, quartz and crystallized slate gravel /2/
λMs Upper rhyolitic tuff /3/
αMs Pyroxene andesite, p roclastic rocks and veins /4/
Ms Brack-water clay, sand, rhyolitic tuffite, marsh clay and bituminous coal /5/
Mt Foraminifera white clay with middle rhyolitic tuff and Lajta limestone /6/
λMt Middle rhyolitic tuff /7/
^{h}Mh Clay, sand, sandstone, gravel, bituminous coal /8/
Mb Gravel, sand, sandstone, sandstone conglomerate, colourful clay and gravel /9/
Fault /10/

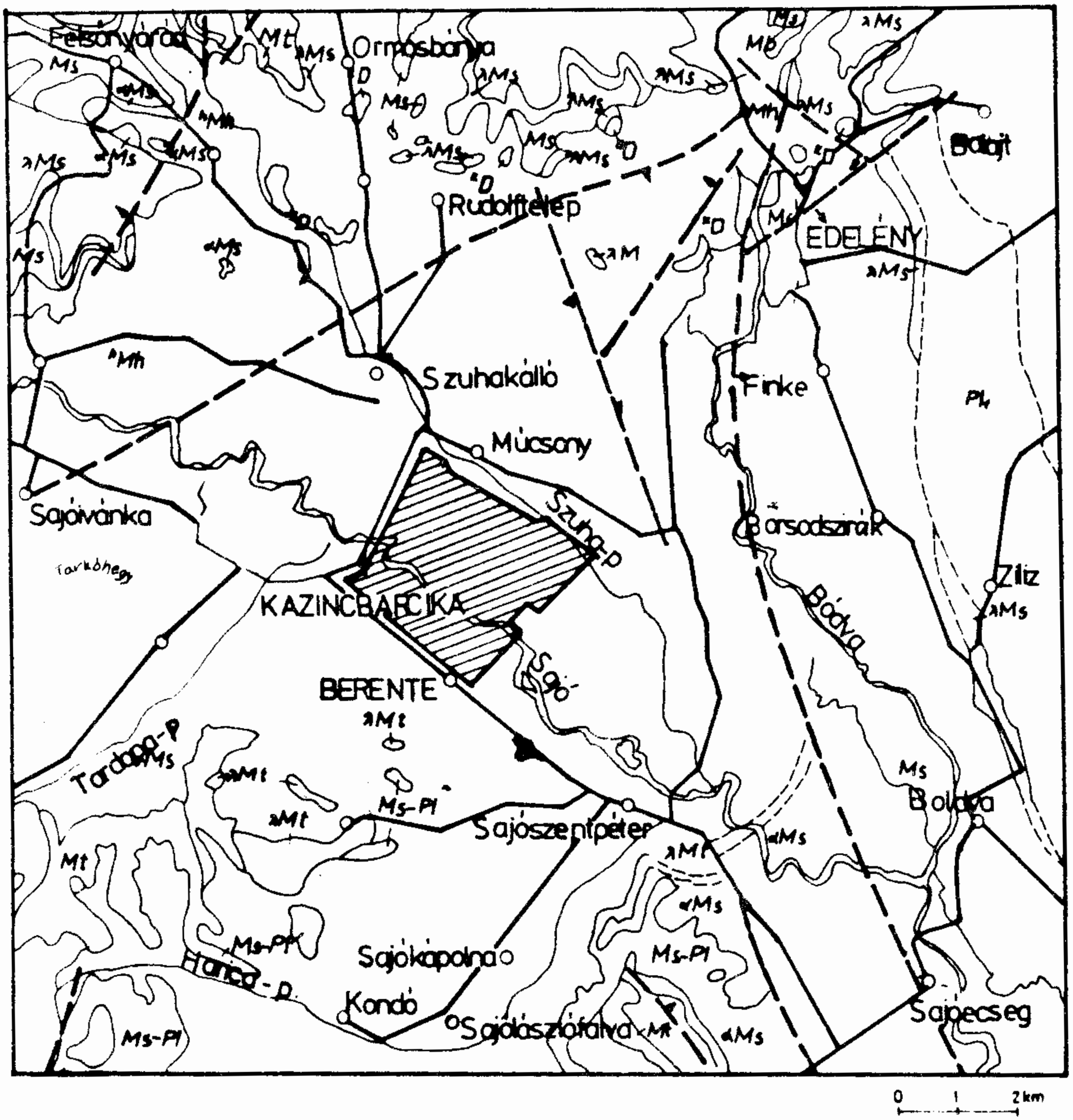
Fig. 2. Connection between Rivers and Groundwater
m.A.f. = above /Adriatic/ sea level
DDNY = S-SW
EEK = N-NE
ENY = NW
DK = SE
LNV = high water
KÖV = middle water
LKV = low water
Átl.talajvizszint = Average water table

Fig. 3. Geological Section NW - SE
soil /1/ } Holocene-Pleistocene
gravel /2/
clay, siltstone /3/
sand /4/ } Miocene
bituminous coal /5/
rhyolitic tuff, tuffeaceous clay /6/

Fig. 4. Filtration Areas in Rocks of Various Age
triász = Triassic
miocén = Miocene
devon = Devonian

Fig. 5. Delivery-Coefficient Map of Beds above Seam IV in Area of Szeles Mine
average delivery coefficient in m^2/s /1/
section across the Sajó as shown in Fig. 2. /2/
section across the Szuha as shown in Fig. 2. /3/

Fig. 6. Arrangement of Roof Filters
Fronthaladás = Direction of Longwall Advancing
A-A szelvény = Section A-A
1 Roof of Longwall
2 Roof of Longwall Drifts
3 Roof Filter
4 Goaf
5 Floor Filter

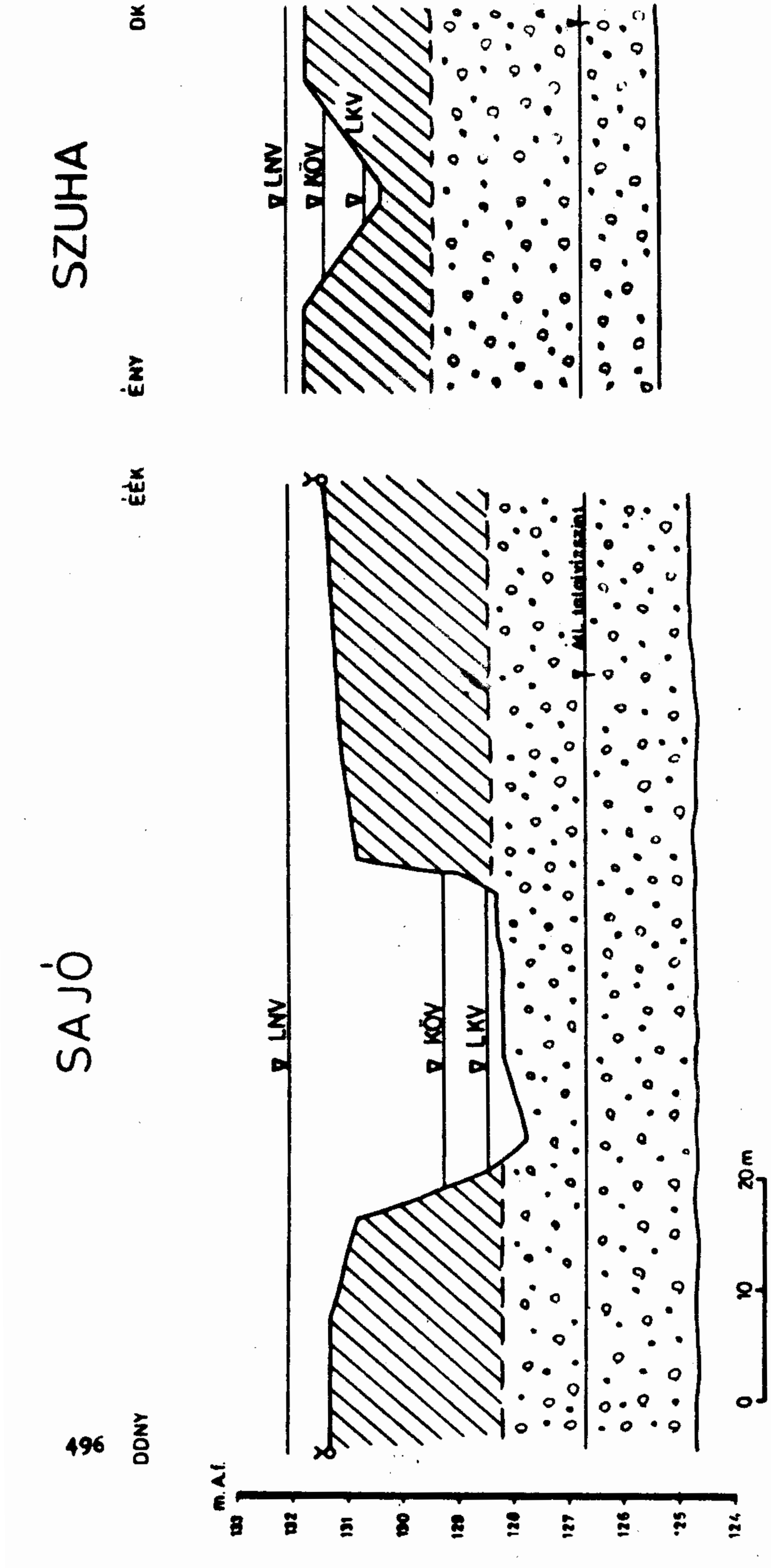


JELMAGYARÁZAT

Felszíni földtani térkép

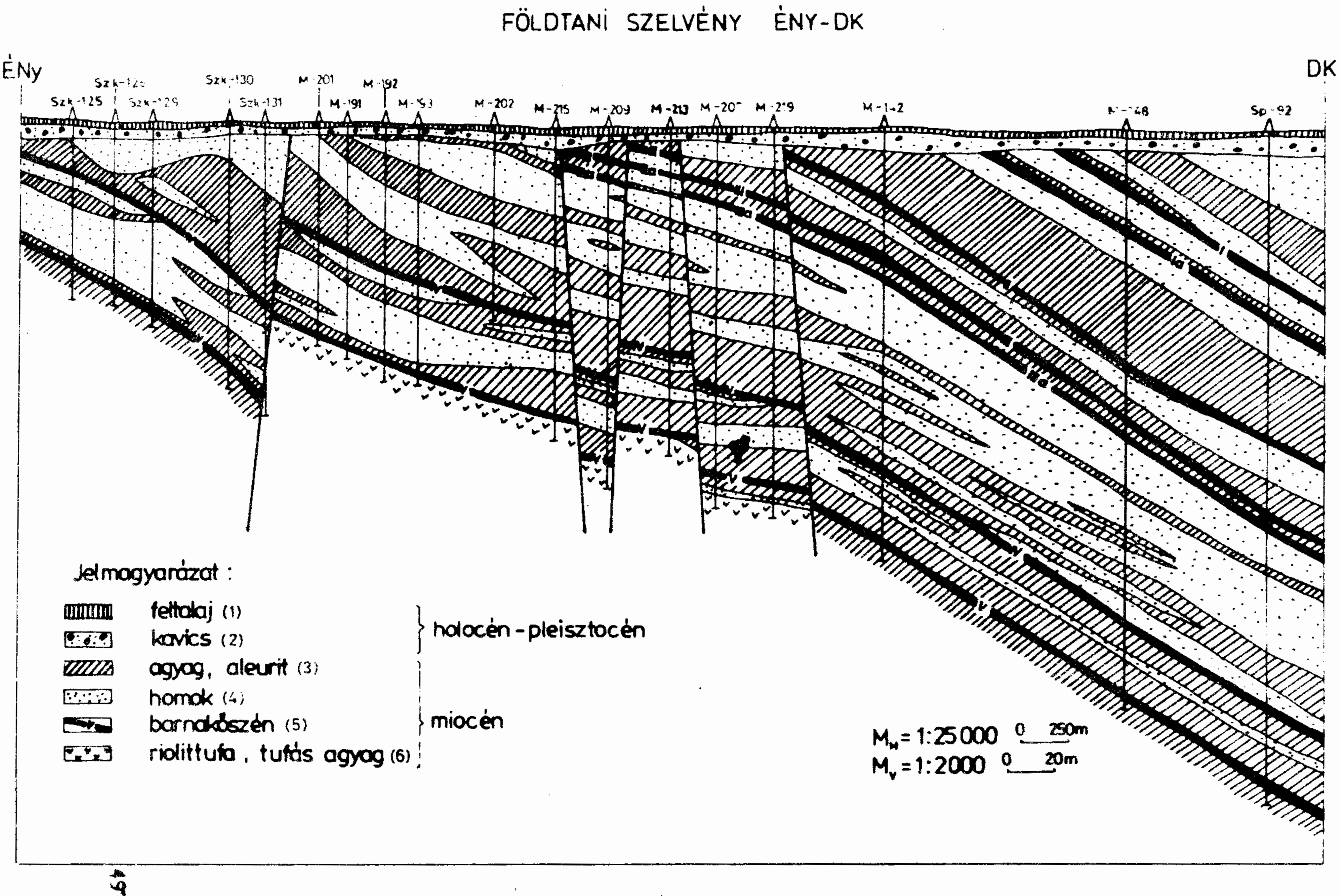
Pl_1	Kavics, homok, agyag, barnakőszén (1)	Mt	Foraminiferás fehér agyag helyenként középső riolittufa és lajtai mészkő (6)
$Ms-Pl_1$	Mészkő-, kvarc-, és kristályospala kavics (2)	λMt	Középső riolittufa (7)
λM_s	Felső riolittufaösszlet (3)	Mh	Agyag, homok, homokkő, kavics barnakőszén (8)
αM_s	Piroxénandezit-piroklasztikumok és -telérek (4)	Mb	Kavics, homok, homokkő konglomerátum, tarkaagyag és kavics (9)
M_s	Csökkentsósvízi agyag, homok, riolittufit mocsári agyag és barnakőszén (5)		Vetődés (10)

1. ábra

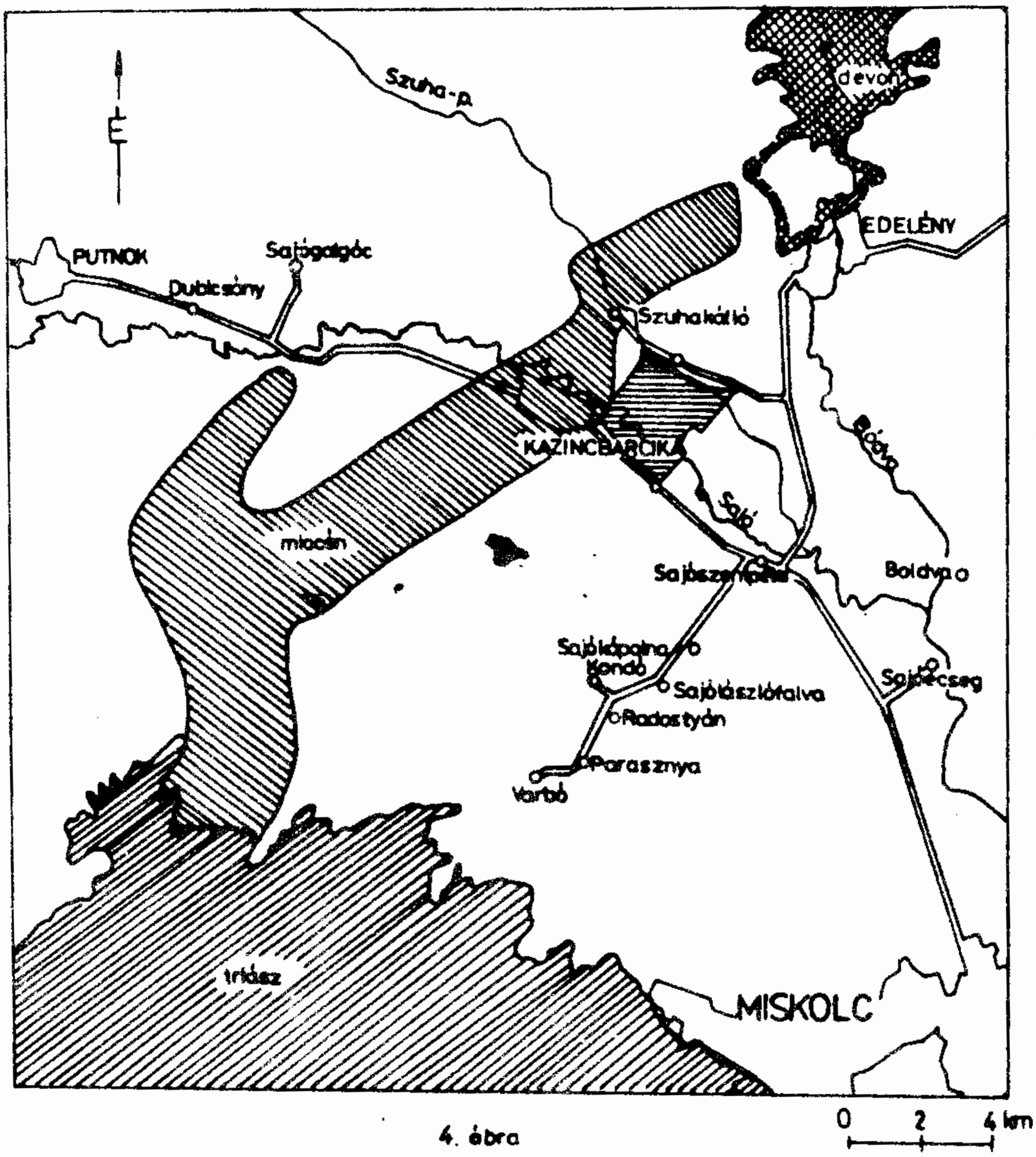

SZUHA
ÉNY
DK
LNV
KÖV
LKV
SAJÓ
DDNY
ÉÉK
LNV
KÖV
LKV
Ál. talajvízszint
0
10
20m
m.A.f.
133
132
131
130
129
128
127
126
125
124

2. ábra

A FELSZÍNI VÍZFOLYÁSOK ÉS A TALAJVÍZ KAPCSOLATA



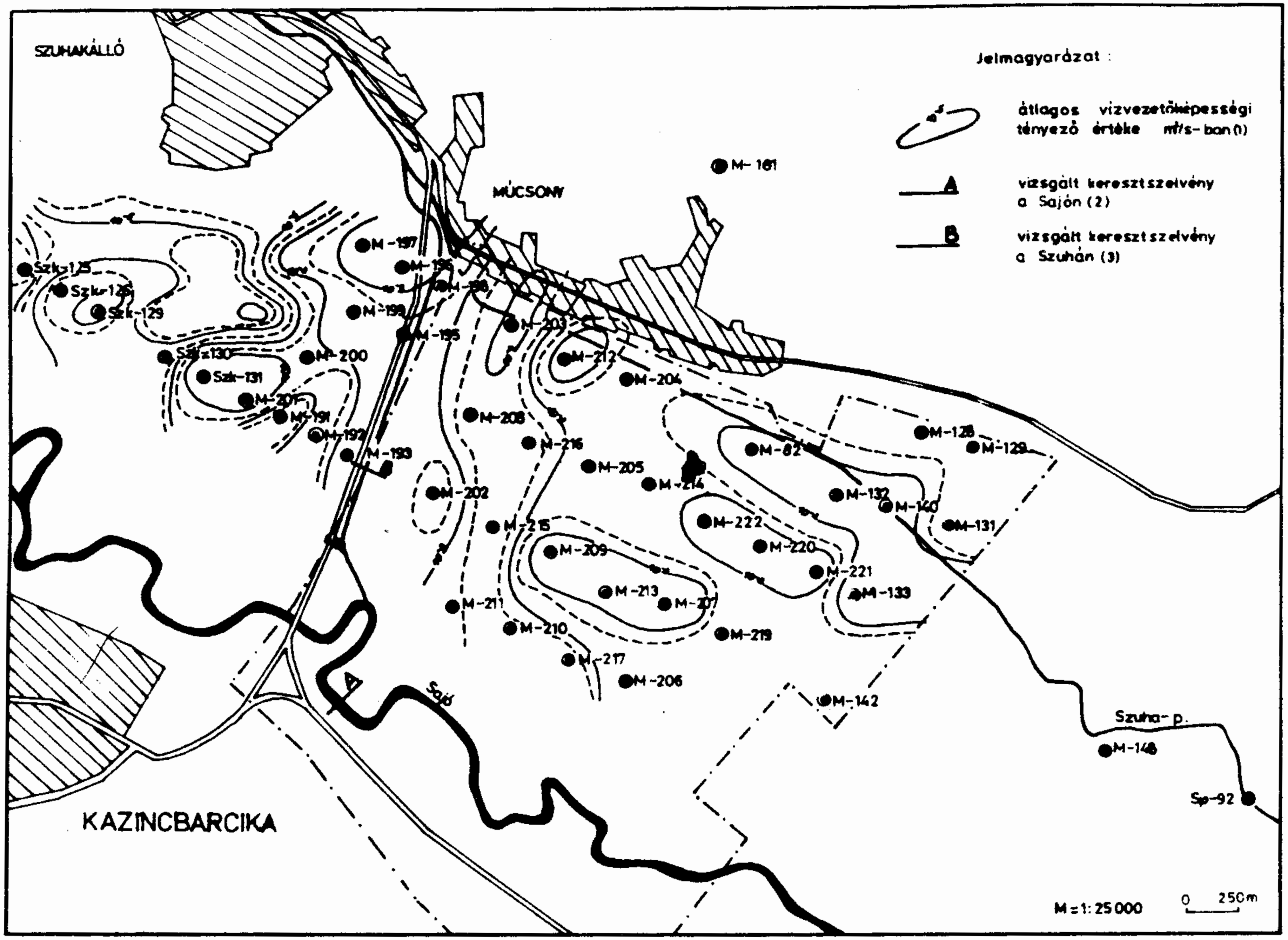
3. ábra



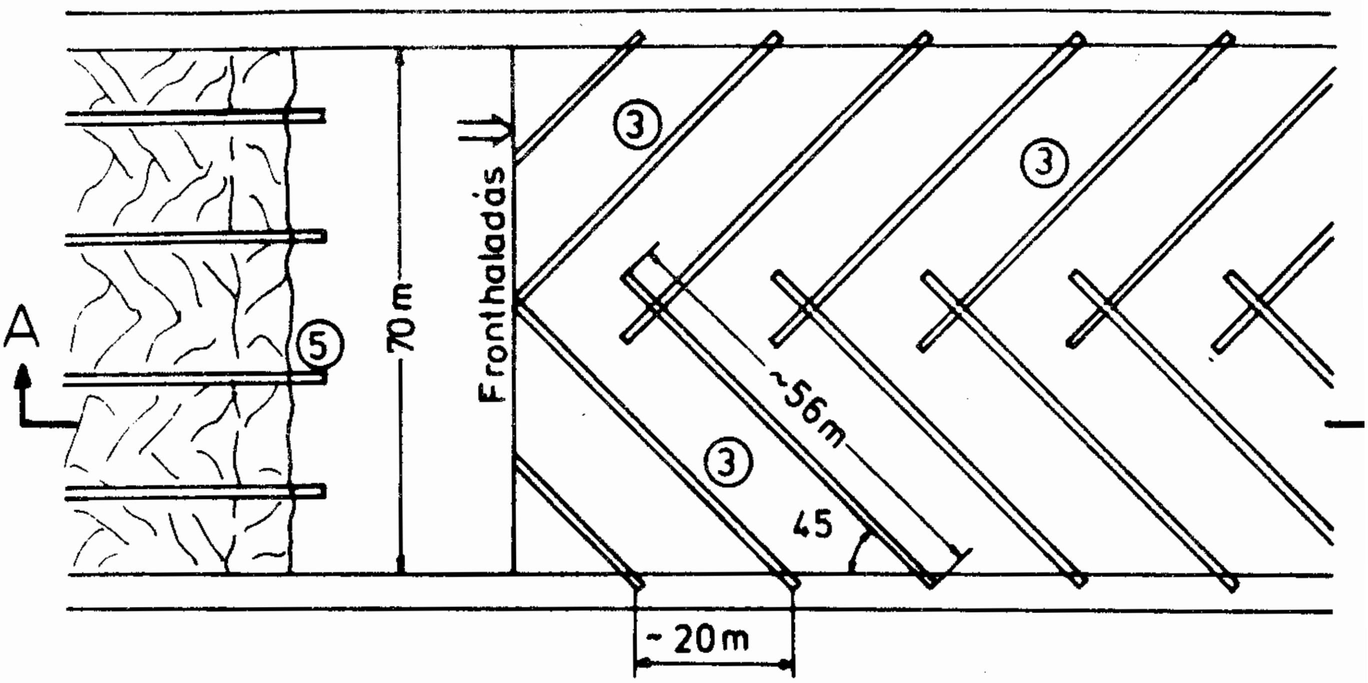
4. ábra

Beszivárgási területek
különböző korú kőzeteken

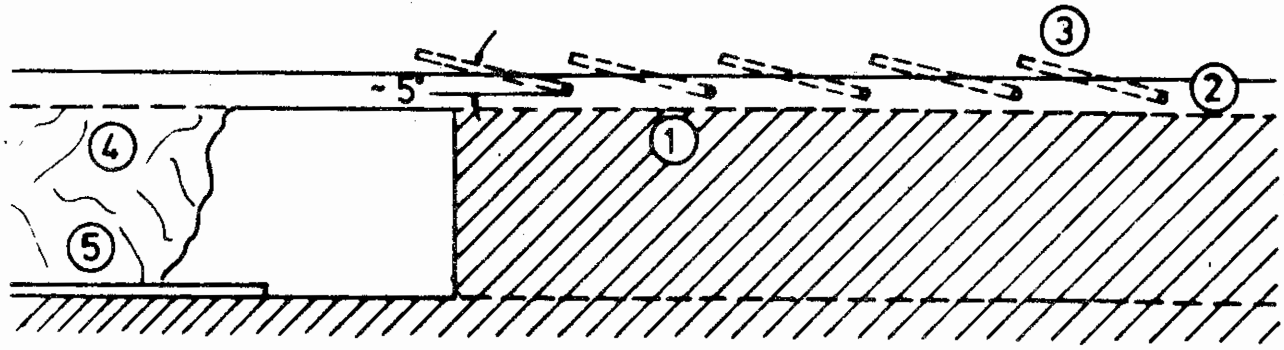
A IV. TELEP FELETTI RÉTEGEK VÍZVEZETŐKÉPESSÉGE
A SZELESAKNAI TERÜLETEN



5.ábra



A–A szelvény



① Front tető

② Frontkisérő vágat tető

③ Főteszűrő

④ Omlás

⑤ Talpszűrő

6. ábra

A főteszűrők elhelyezési vázlata