Hydrogeological Aspects on the Origin of "Borsod Mineral Water"

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ABSTRACT

In 1958, carbonic water inrushes with heavy salt concentration occurred at bed I exploration of Edelény mining district of the Borsod Miocene brown-coal basin, located in NE Hungary, which were considerably different in composition from the usual water of Miocene water-bearing layers. The water was specified as "alkali hydrogen carbonate and sulfate mineral water with calcium and magnesium content", and since 1968, it has been bottled for commercial purposes as "Borsod Mineral Water." The latest mining explorations produced carbonic water inrushes, respective CO_2 jads from the sand layer above the coal bed IV. This presentation discusses the origin of the mineral water and summarizes the results of our research on the origin.

INTRODUCTION

In January 1958, in eastern part of the Borsod brown-coal basin, located in NE Hungary, occurred base water inrushes in bed I supply gallery of Edelény mining district I. (see Fig. 1). These appeared from No. E-137 coal exploring drilling of 1953 (see Fig.2.). The quality of water was different from the usual one explored from earlier "lay" water of Miocene water-bearing layers. It was also different from the quality of "aging water" filling the abandoned spaces. On the basis of examination made in 1959, the water was qualified as "mineral water related to group of alkali hydrogen carbonate and sulfate water with calcium and magnesium content". From the same drilling, during exploration of bed II, there were mineral water inrushes too. These later springs occured in some locations around the mining coal bed II. The No. E-137 coal exploring drilling could not be used as a producing well, so at the beginning of 1968, a 310 m deep well was drilled (drilling No. Sp-109) in the pillar of the south shaft of Edelény mining district IV. In this well the water was filtered from the aquiferous layers above the coal bed IV, as well as, between coal beds III/a and IV. This mineral water contains less solute than the springs of No. E-137, but exceeds 4000 mg/l. The Borsod Coal Mines Co. began to bottle it in 1968. Today the mineral water bottling reached a 10 million bottle/year capacity.

Simultaneously, the mining areas of the immediate neighbourhood indicate the presence of additional mineral water with high hydrogen carbonate content which increases significantly the bottling operation. There are mineral water inrushes accompanied by CO_2 jads in eastern part of Edelény mining district in the "slope drifting" from bed II of exploring bed IV (see Fig. 2).

On the other hand, on the "hanging side" of the mainway of the East major opening of the bed IV of the Szeles mining district (bordering the Edelény mining district on the west), there are mineral water inrushes and CO_2 jads without water afflux.

The existing and planned protection of the water basin above the mining bed IV makes the search for the origin of mineral water and the possibility for further exploration extremely interesting.

GEOLOGICAL, STRUCTURAL AND HYDROGEOLOGICAL SURVEY

The East-Borsod brown-coal basin is the area between Bükk, Aggtelek, Rudabánya and Szendrő Mountains (see Fig.1). The supporting base is of old and new Paleozoic, Mesozoic Oligocene and Miocene deposits, Pliocene, Pleistocene, Holocene detrital sediments. Five coal beds are known with secondary beds in structure of Miocenic coal beds. Numerical identification of beds is in a downwards sequence. These were falling (stripping of) today resp. were already partially fallen. Clayey-aleurolitic-arenite, aquiferous resp. impermeable formations can be found between the beds (see Fig.3).

The cases of coal bed structure of the basin have granulometric composition generally classed among fine sand group, are well graded and can be characterized by little modulus of irregularity - so they are susceptible to swim. Their lay functional scheme is usually of negative mirror and they store "lay-water" in compression.

The structure of overlain mountains' formation is characterized by ruptured, fault elements. The strike of faults is NNE-SSW resp. dominantly N -S. Their trouble heights are between 1 - 80 meters, most frequently 1 - 15 meters.[6,7]

THE THEORIES ABOUT THE ORIGIN OF THE "BORSOD MINERAL WATER"

Borbély, S. and Juhász, A.[1] in their paper of 1961 stated that "water raises not directly from arenous layer found under the level of bed I, but from lower level". They have calculated with 18 m/°C geothermic gradient and came to the conclusion that the water rises from aquiferous layer between beds II and III.

They stated that Ca^{++}, Mg^{++}, HCO_3^- contents of the mineral water originates from limestone substratum and alkali comes from clay.

Juhász, A. and Kerényi, B.[(6)] in their lecture given in 1968, considered that the origin of the mineral water: "the inrushes occur along fault, shift or from coal exploring drillings countersank previously".

Borbély, S.[(2)] has written about the origin of the mineral water on the basis of analysis of the geohydrological conditions:

"We must suppose the origin and supply from the basin support".

"The basin support is only at its edge in such position that the water could spill over from its ruptures to the superimposed porous layers".

"The alkalinity of the water is higher in standstill conditions than during the outtake of the water."

In accordance with the remarks of Juhász, A., offered at the meeting discussing the possibilities of utilization of mineral water of Edelény shaft I: "It is certain that the mineral water originates from basin support. It is proved by its temperature which is 5 - 6°C higher than the temperature of the lay water. The mineral water rises from the basin support along the fault and mixes with lay water. In case of removal of lay water, the water temperature will rise".

To summarize the discussion of the researchers about the origin of the mineral water, we have written down the following: It is certain that the mineral water originates from the basin support, falling along the faults or along the stressed belt of the basin edge into a water-bearing layer mixing with lay water.

THE MOST RECENT PRESENCE OF THE "BORSOD MINERAL WATER"

Until present, only the brown-coal bed II was mined in the Edelény mining district. The bed IV is planned for mining in the near future (see Fig. 2). To secure this area of Edelény shaft IV southward of the vertical shaft, in 1985, deepening of slope has begun from level of bed II to level of bed IV. During this operation, the arenite water-bearing structure between beds III/a and IV needed to be bound.

The slope has passed through upper beds of arenite structure without any problems -- under active water protective measures - then it has received an aquifer sand inrush approximately 25 m above bed IV which filled the slope in a length of 40 m. The samples from the water inrushes showed high alkaline, hydrogen carbonate content and high $NaHCO_3$ content. On the basis of alkalinity, total hardness from the seeming hardness, the water has mineral water characteristics. It is most interesting that the examined water has a low temperature in comparison with its bedding depth. Based on calculation taking in account 26 - 35 m/°C geothermic gradient for 170 m bedding depth (-140 m below Adriatic sea level), the temperature should be higher. From the low temperature, we can conclude that the water supply is not at all from below, it is rather from above - from water of the pebble bed, its temperature is closer to neutral temperature.

In May 1989, a vertical drilling was deepened from the slope which burst after 24 hours standstill during inserting of a drill rod. 700 liters/min water, much drift and CO_2 in large amount streamed into the deepened drilling.

At our suggestions, continuous water sampling and water quality analysis was performed and nodules of drilling were processed continuosly. In accordance with previous experience, the water of highest content of alkali hydrogen carbonate, CO_2 inrushes of highest concentration have originated from the layers of roughest granulometric composition of aquiferous structure.

Shaft Szeles, in which mining area the coal bed IV is mined for many decades, is bordering on Edelény shaft IV in the West. Mining practices use passive protection. The cases of the cover structure are connected hydraulically with the pebble bed of the river Sajó. During passive protection, lay water is pumped, which is characteristic to the basin in general. There is no record about the occurrence of mineral water in the area of shaft Szeles until most recently and there is neither any CO_2 occurrence in the form of concentrated inflow.

Placing longwalls in shaft Szeles procedes continuously to the East. In this way, it arrived to the East main line, has been drawn at coal face where water inrushes and CO_2 jads occured in 1985 and since the water inrushes and CO_2 jads developed in addition in three places (see Fig. 2: Sz-1, Sz-2 and Sz-3 marks).

In accordance with the evaluation of the results, water rising from the sand above bed IV is similar to "Borsod Mineral Water". Still, the lately occurred CO_2 jads indicate that water of the area has free CO_2 content of considerable quantity, beside the compounded CO_2 in form of hydrogen carbonate.

Geohydrological analysis of the area, where the water inrushes and CO_2 jads occurred, shows that the part of sand structure above coal bed IV is the roughest granulometric composition of layer structure. It is connected hydraulically with the water of the pebble bed of the river Sajó. From this condition, we have drawn the conclusion that the mineral originated water supply is furnished in form of high solute and hydrogen carbonate content water from the substratum. Chemical composition of water suggests that the mineral water is an intensive supply of CO_2 gas of high pressure from the basin support. The CO_2 gas in best conductivity layers - even besides dilution by continuously supplied water - results in forming high solute content.(5)

Although the possibility of water supply from basin support can be not be precluded, we consider it s quantity less significant in forming the mineral composition of Miocenic lay water - supplied moisture from above is also negligible in the examined area.

In order to determine age and CO_2 origin of water accumulated in water-bearing layers of coal bed structure, we have had to establish the $\sigma^{18}O$ isotope displacement and the $\sigma^{13}C/^{12}C$ isotope ratio of mineral water in the area of Edelény and Szeles. For this reason, the $\sigma^{18}O$ isotope displacement - in 15 places were water taken water samples. In order to determine (organic or inorganic) the origin of carbon dioxide solved in mineral water, gas samples were taken in 5 places (see Fig. 2).

In examination $\sigma^{13}C$ values of CO_2 are related to PDB standard, $\sigma^{18}O$ values of water samples are related to SMOW.

Hertelendi, E.(4) valued the measuring results as follows:

"The $\sigma^{13}C$ value of carbon dioxide is related to its inorganic origin".

"On the basis of the $\sigma^{18}O$ values of water samples, it can be proved that the examined water is of moisture origin, its age is of several thousand years."

CONCLUSION

On the bases of geohydrological water quality examinations, the following statements can be made:

(1) The water of water-bearing layers of coal bed structure is not contemporaneous Miocenic lay water, but essentially younger than Miocenic water. This proves that the cases of coal bed structure have a moisture originated supply. The decisive portion of the supply comes through the pebble bed of river Sajó to the cases of the coal bed structure.

(2) The moisture originated supply Ca-Mg-hydrogen carbonate water comes to cases, and the present hydrogen carbonate water quality is caused by transformation after seeping through. The water quality changing is caused by the getting of CO_2 in large quantity into the water. Varying concentrations, depending on local changes of CO_2 enrichment, alkali hydrogen carbonate and sulfate, creates the existing water quality.

(3) The CO_2 is of inorganic origin, its forming is independent from the coal forming. The inorganic CO_2 could be formed during volcano activities or by metamorphosis. Considering

that sings of volcano activities can not be traced in the area, the inorganic CO_2 could be formed during metamorphosis of carbonic substratas. It has been accumulated in broken zones of substratum.

(4) The mass of CO_2 of high pressure in gas form travels upward through broken, cracked, porous formations and reaches the permeable-aquiferous, water-bearing layers of roughest granulometric composition of the coal bed structure. It dissolves in lay water and causes high aggressivity of the water.

(5) In accordance with our assumption written about what has occurred before the cases of coal bed structure got water of high CO_2 content, a thin layer of sediment structure, between the coal bed structure and the tectonic substratum, can be found. Alkali hydrogen carbonate water is characteristically spreading in large areas and in good aquiferous cases. In the examined area, the deepest bedding of such layer is the sand structure between the coal beds III/a IV. From this, we can expect, most probably, to get mineral water.

(6) Although on the basis of evaluation of water quality, we can not prove unambiguously its quality, we can draw conclusions that alkali hydrogen carbonate lay water can be found also in other areas of coal basin, especially in coal bed structure of East-Borsod brown-coal basin. Instead of the present exploration, by draining from the planned bed IV mining,the mineral water can be brought to the surface in other locations of the basin.

References

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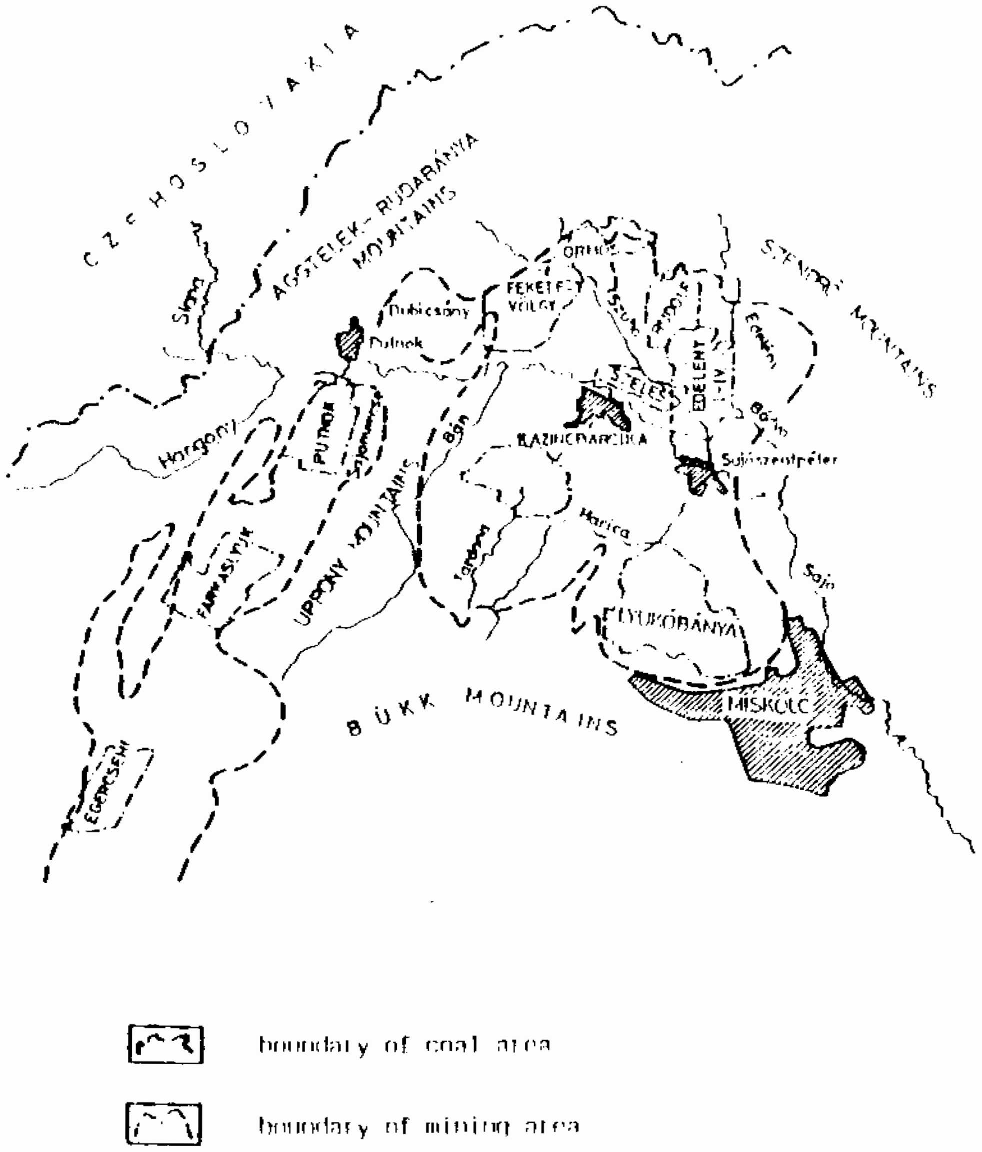

Fig. 1.
Map of Borsod coal basin

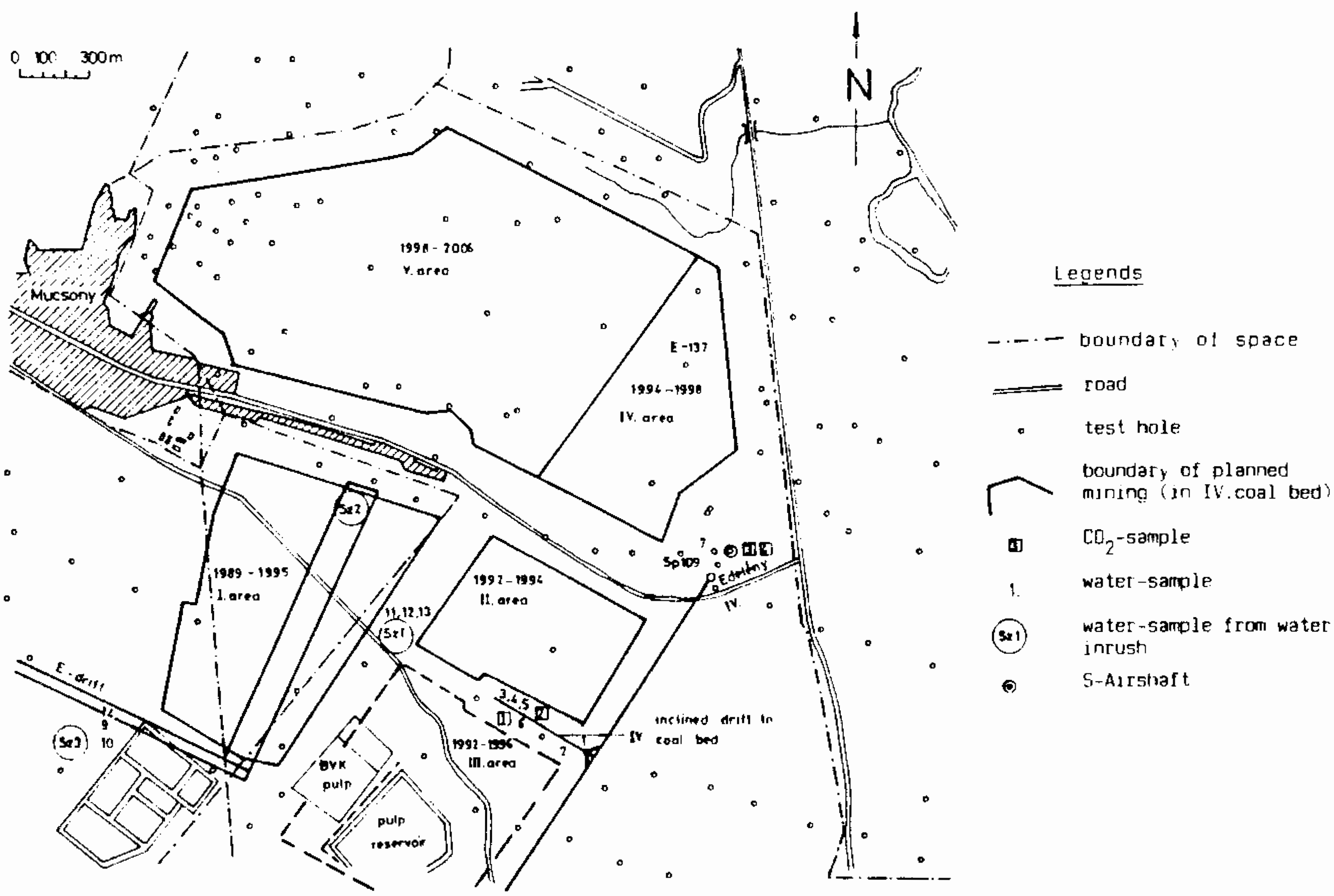

Fig. 2.
Map of Edelény mining territory

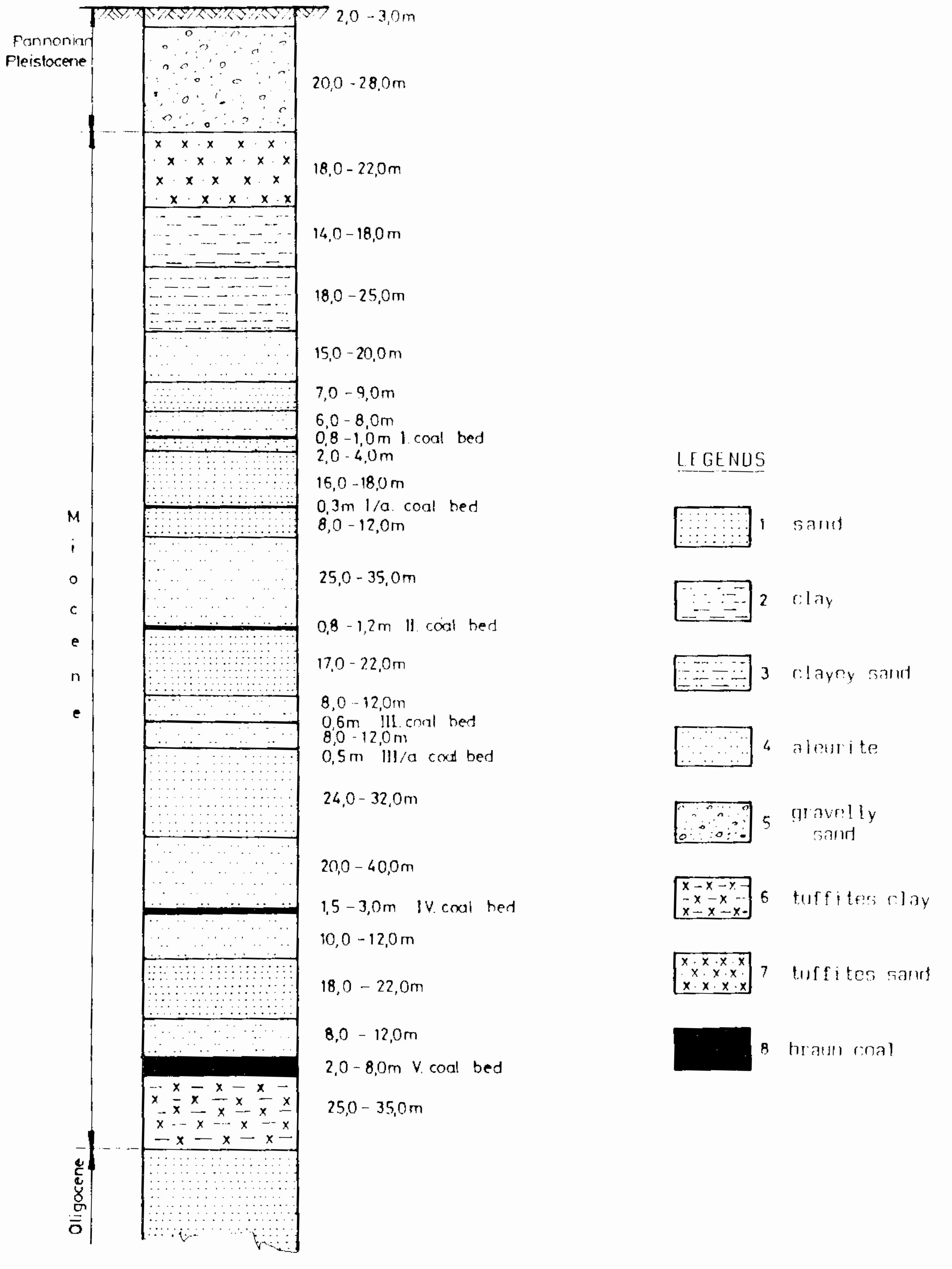

Fig. 3.

Average geological profile of Edelény mining territory