EFFECTS OF COAL MINING TO THE ENVIRONMENTAL CONDITIONS OF THE EAST BORSOD BASIN

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Abstract: To the NE of Miskolc city in the hilly foreground (East-Borsod coal basin) of the Bükk Mountains made up mainly of Miocene molasse sediments, Ottnangian-Karpathian brown coal deposits have been under exploitation for almost 200 years *(Fig. 1)*. Therefore we tried to estimate the spatial extent of surface subsidence induced by headings and to measure environmental effects of the waste heaps. As a conclusion we can state that the effects of the waste heaps are not so considerable but the subsidence endangers the unstable surface.

Geological conditions of the research area

At the East Borsod Basin a Cenozoic molasse sediment series was deposited enclosing an Ottnangian-Karpathian coal bearing formation *(Fig. 2)*. The barren material of the coal strata is mainly of fine sand and clayey aleurit, in which tufogene clays, variegated clays, drying duricrusts, gypsum seams, limonite, black metals, lumachella and ostrea layers equally occur. The average sulphur content of the coals varies between 1.5-4%. In the reductive environment certain elements often condensed due to bacterial effects.

The recent geomorphology of the hills was formed extremely mosaic-like by Quaternary events. The less consolidated sediment series was also formed near by linear erosion by derasional processes and mass movements. The various solidity, swelling capacity and hydrodynamic character of the clayey sediment series caused the formation of sliding planes and collapses along the bassets.

Research methods

More than 100 samples were collected for chemical, polarisation microscope, SEM, microprobe, DTA and X-ray examinations.

To observe the possible emission effect of the re-mineralization processes we carried out dissolution by distilled water with varying time scale (*Sütő, et al. 2001*). Surface and groundwater samples were also taken in the directio of possible pollution moving away from the bottom of the heaps. The element content of the samples was determined by ICP-MS atomic absorption mass spectrometer.

In the knowledge of the low degree of surface stability we laid emphasis on the examination of surface subsidence and plotted the map of tunnels of the area. We estimated the dimension of the surface movements with the help of the following equation: **S=(T+M)-AT** (*Nir, 1981*), in which **'S'** refers to the sinking of the surface, **'T'** to the thickness of the overlying beds, **'M'** to the thickness of the coal-seam and **'A'** to the coefficient of average volume increase of the coal-bearing sediments. On the basis of the information about mining activity and with the help of Geomédia and Idrisi GIS softwares we set the degree of surface subsidence and sketched out the borders of the endangered areas by this formula for each hectares *(Fig. 3)*.

Impacts of the heading and coal waste heaps

The surface movements caused by headings are concentrated to the tributary valleys of the Sajó River. These regions mainly coincide the temporally stable slope with landslides and the areas of gardens in which the degree of built up is increasing therefore, the above mentioned territories appear as sources of high danger.

The dimension and the form of the subsidence and the time during which they reach the surface all depend on the length of the period of the mining activity, the dimension and deepness of the worked layers, the structural and the hydrogeological conditions of the region, the lithological characters of the overlying beds and the mining method. On the territory of the coal basin the overlying beds can be generally characterized by a low strength coefficient. Furthermore, the thickness of the beds rarely exceeds 50 m on the terrain strongly dissected with valleys. Gardens, vineyards and woods can be found above heading surface in the model area near Kazincbarcika where the subsidence might reach about 2-3 m *(Fig. 3).* Where the stability is small the values of the subsidence may be 4 m above the headings.

The maturity of the waste heaps has to be determined for the reusing purposes of the territory *(Baros, et al. 2001).* However self-combustion and long-term burning occurred frequently in the coarsely dumped tips and it could have been continuous for 20 years. Hydrothermal, low pressure, pneumatolytic and thermo-contact microenvironments occurred simultaneously. The domination of native sulphur and sulphates and also the occurrence of ammonium and organic material reflect the interaction between the volatiles and the tip rocks. However occurrence of certain rare minerals is associated with the geochemical characteristics of the basin and with the local burning conditions on the pit-heaps.

The pelitic barren rock of varying clay mineral content were burnt to a light brown and red colour, fissures formed corresponding to the original bedding. The partly re-melted internal parts are reminiscent of toadstone volcanic cinders and ferrum and/or sulphur rich melts were formed on their surface *(Sütõ 2000).* At the high temperature points (above 1000 °C according to DTA / X-ray control) isolatedly mullite and wollastonite occur. In the medium temperature zones *hematite* and *fluorite*, in the hydrothermal phase primarily sulphates (*barite, somolnocite, thaumasite, jarosite etc.*) and *rhombic native sulphur* are often formed, while in the presence of carbonates *calcite*, *aragonite* and *huntite* occur. In some places the re-crystallisation of carbonate fossil structures could be observed. In the course of burning, the greyish and white silicified coal pieces lost most of their organic material but retained their specific texture. In their segments dominantly cristobalite (80-95%), little silicagel and in their inner pores in subordinate quantity anhydrite, gypsum, sulphur and aragonite can be found *(Sütő et al. 2001)*.

Water contamination

Due to the mineralisation processes in the pit-heaps water pollution is detectable in the surroundings of the tips. The dissolvable element content exceeded moderate harmful effect on the natural surface and groundwater only in the case of a few components and indicated increase in dissolved As, B, Ca, S, Sr, and SO_4 content. The latter already reached the possible maximum (1400 mg/l) at the 1 hour dissolving, and then scarcely changed after this (1 hour, 1 day). Ca also displayed a short period of dissolution, and reached the solvable maximum within 1 week. As opposed to this B appeared in the 1 week dissolving, and reached a slight contamination after the 1 year dissolving.

All of the samples collected in the surroundings of the pit-heaps showed higher concentrations than the background. Due to the dilution-taking place in the given local environment these concentrations only increase above the tolerance threshold value in exceptional cases and temporarily. The surface and groundwater around the pit-heaps, which have diminishing activity, fall into the tolerable-good classification category (Hungarian standard) regarding Al content. Considering As, B, Cd, Cr, Ni, Pb, Cu content they are classified as excellent-good, while in the case of Fe, Mn and Zn they are found as polluted. The samples from springs near the foot of the tips display lower pH than the background resulting from higher HCO_3^- and CO_3^-.

In the region's artesian waters around 160 mg/l SO_4 content can be displayed while the SO_4 content of the springs at the foot of the pit-heaps moved around 4000 mg/l, and the total quantity of dissolved material was 7400 mg/l. The Ca, Cl, Fe and Mg values showed slight positive anomaly compared to natural conditions. At the foot of the pit-heaps NO_2 and NO_3 values exceed the tolerance threshold. However every valuables reduced exponentially moving away from the waste heap.

The spreading of this contamination is significantly influenced by the geological formations at or near the surface. The construction of our pollution-sensitivity map was based on the porosity of formations creating the surface, and the depth of the groundwater table *(Fig. 4).* Accordingly we separated good conducting (10^{-6}-10^{-5} m/s) and less good/poor conducting (10^{-6}-10^{-8} m/s) strata, and unsaturated and water saturated or periodically saturating strata groups. The specific pollution-sensitivity relating to acidic loading and the magnitude of natural buffer capacity are increased by the natural carbonate content of the sandy sediments of the coal bearing sequence (5-10%) and the aleurit horizons (>10 %) *(Sütő et al. 2001)*.

The basement of the pit-heaps is favourable for trapping chemical pollution, although varying stratification and increasing water conduction capacity in some places impede the localisation of the pollution. In determining the direction of further spreading, besides surface drainage conditions, the regional flow relations of shallow artesian waters also play a part. Here the strata dipping opposite to the surface downflow conditions are responsible for subsurface spreading of contaminants, the tracing and measuring of which can only be solved outside our examination area.

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Fig. 1: The main waste heaps and the mining object in the East Borsod Basin

Fig. 2: Geological map of the East Borsod Basin

Fig. 3: Heading map and the subsidence danger zone one of the model area

Fig. 4: Pollution-sensitivity map of the surroundings of East-Borsodian waste heaps and the main influencing factors

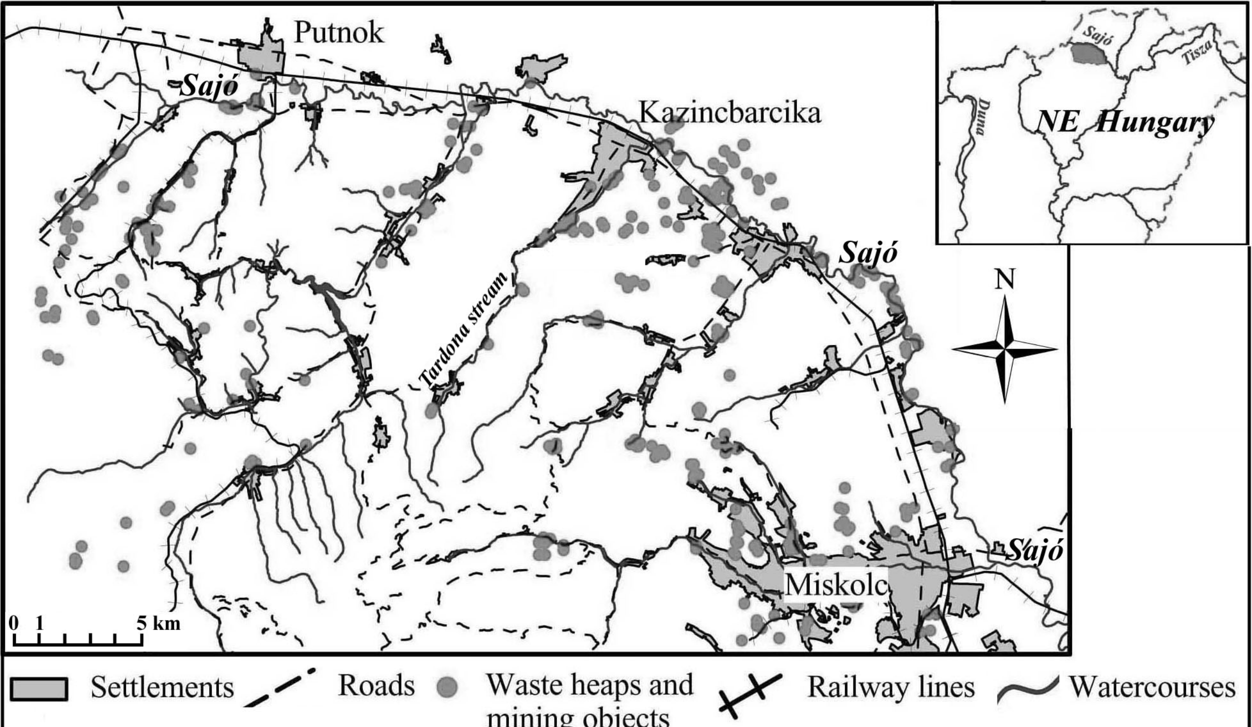

Fig. 1.: **The main waste heaps and the mining objects in the East Borsod Basin**

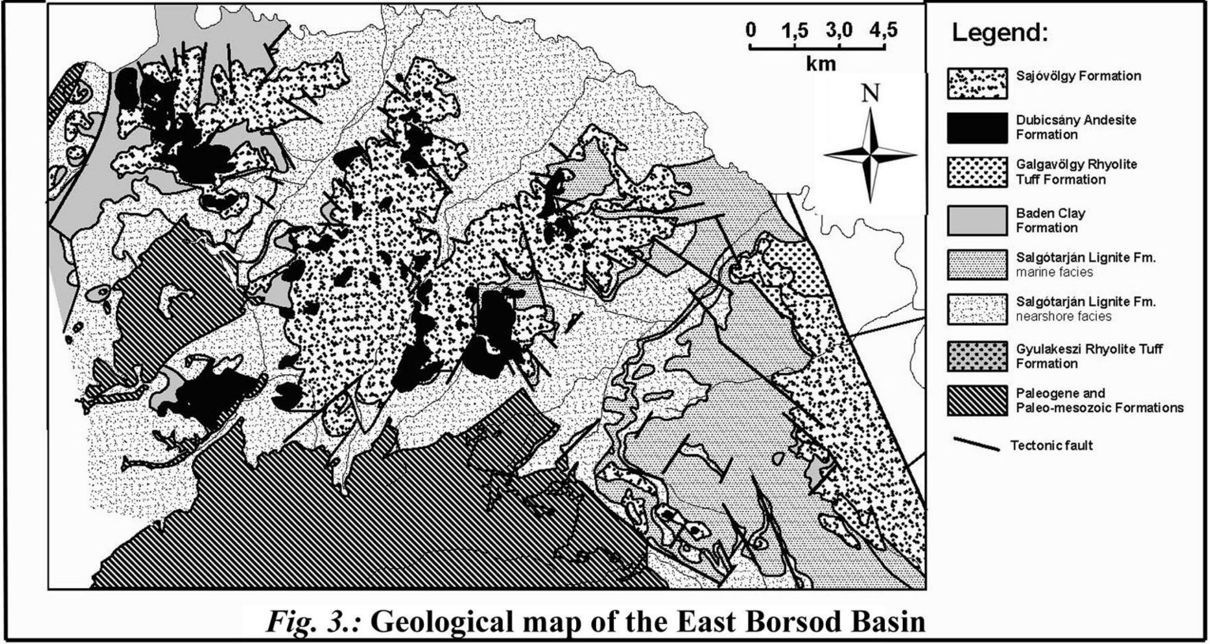

Fig. 3.: **Geological map of the East Borsod Basin**

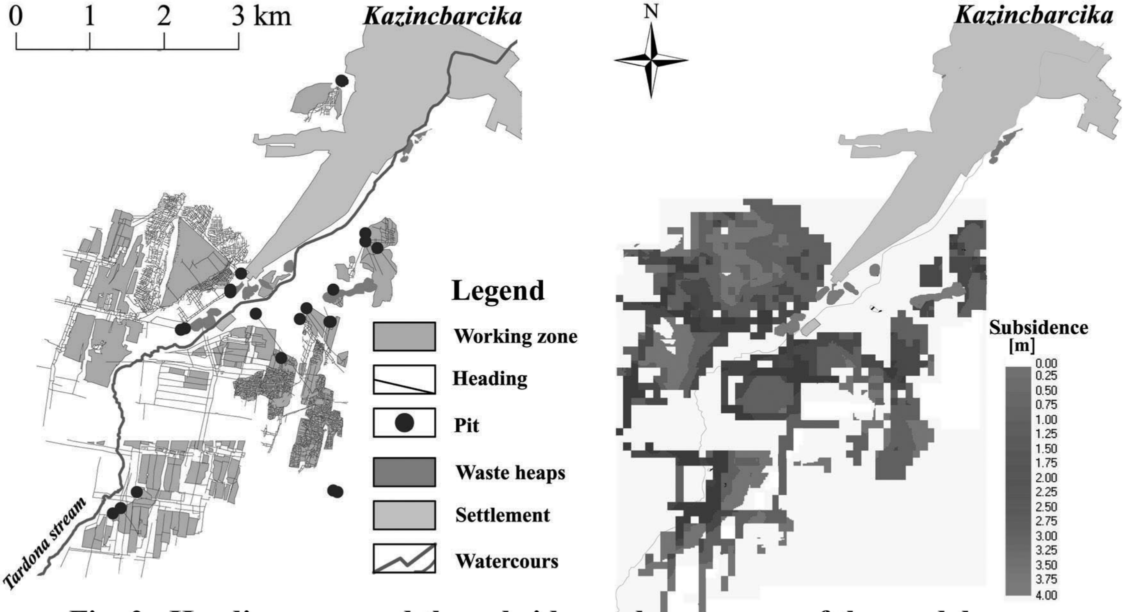

Fig. 3.: **Heading map and the subsidence danger zone of the model area**

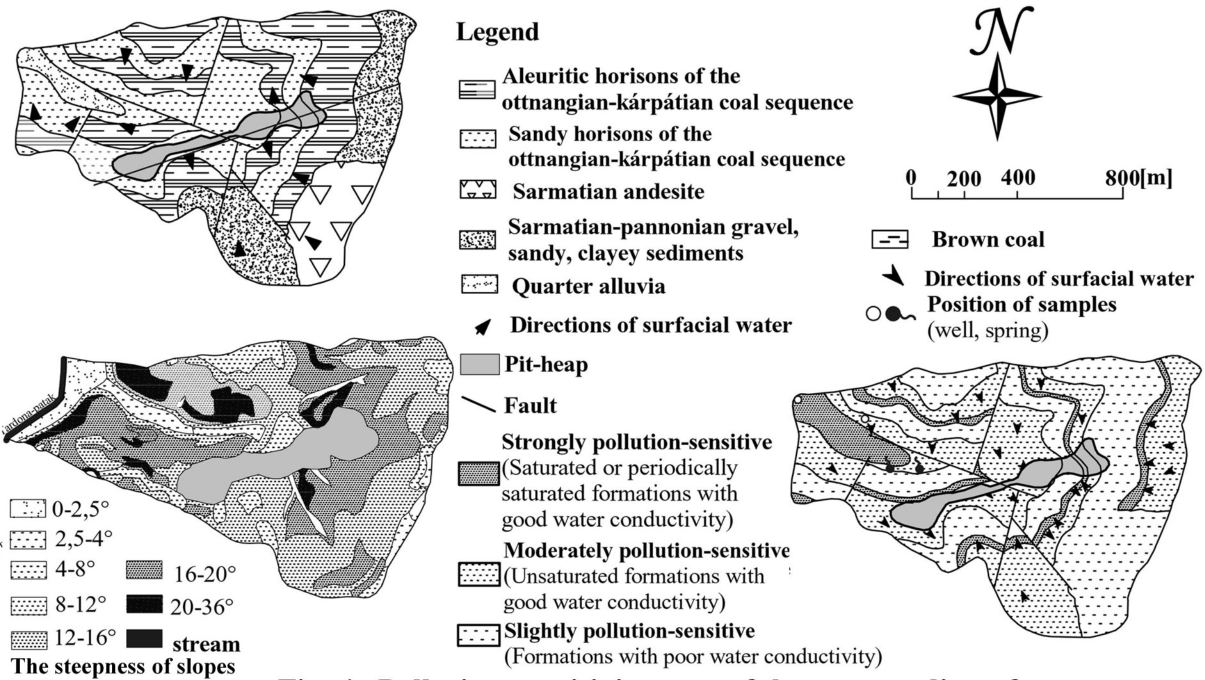

Fig. 4.: **Pollution-sensitivity map of the surrounding of East-Borsodian waste heaps and the main influencing factors**