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THE INFLUENCE OF MINING ON THE GROUNDWATER MINERALIZATION IN THE UPPER SILESIAN COAL BASIN

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ABSTRACT

The Upper Silesian Coal Basin covers the area of about 7500 km^2 and is comprised within the Variscitic intermontane depression. It has been mined since the second half of the 18th century. The average depth of mining is about 650 m. There is observed the increase of mine water mineralization with depth from 0.2 to 372.6 g/dm^3. The isotope investigations have given an indication about differentiated origin of waters and their location in the flow system. Mine pumping about 1 mln m^3/day has a great influence on the hydrogeologic conditions in coal basin. The artificial hydraulic interconnections created by mines activities and deep drainage cause changes in the natural regime of groundwaters. In these circumstances the atmospheric waters penetrate to considerable depth into Carboniferous deposits and frequently become mixed with relict brines. Taking into account these phenomena the mine water mineralization is lower than this which was observed before mining. The refreshing effect due to mining activity depends mainly on the depth of mining, drainage activity and geological conditions of the area.

INTRODUCTION

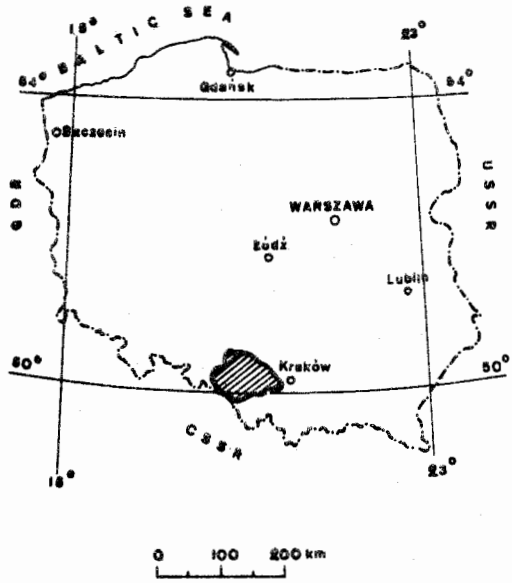
The Upper Silesian Coal Basin, the greatest coal basin in Poland, has been mined from the second half of the 18th century. This leads in effect to changes in the natural hydrogeological regime among other things to modification of the groundwater chemistry and mineralization.

GENERAL HYDROGEOLOGIC CHARACTERISTICS

The Upper Silesian Coal Basin covers the area of about 7500 km^2 and is located in the southern Poland /Fig. 1/. It is comprised within the Variscitic intermontane depression /Kotas, 1982/ whose geological development has been effected by the Variscian and Alpine orogenies. The thickness of the molasse sediments of the productive Upper Carboniferous reaches 8200 m. The Carboniferous deposits are covered with discontinuous series of permeable Mesozoic corbonate rocks in the

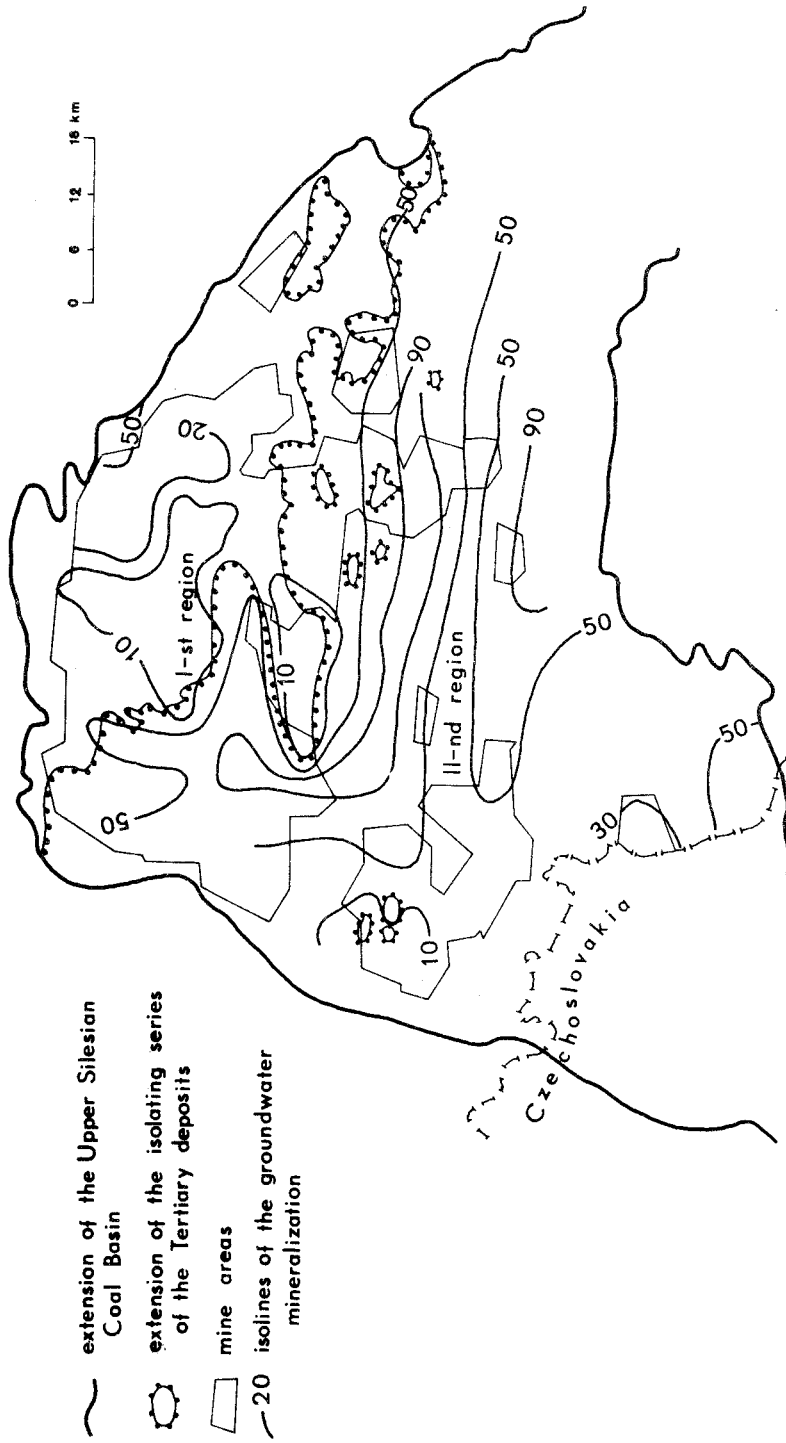
Location of coal basin

Fig. 1



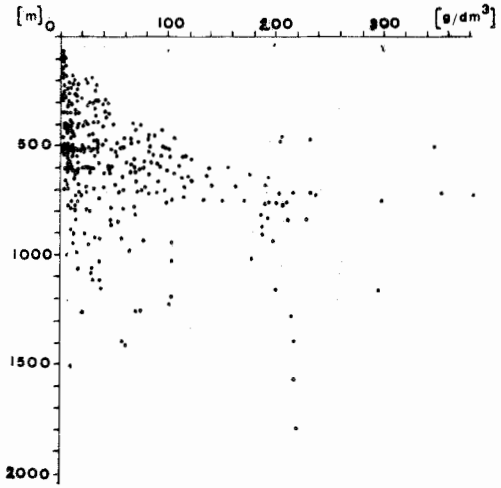
GROUNDWATER MINERALIZATION AT THE DEPTH 500 m

Fig. 2



Evolution of mineralization of waters in relation to depth of their occurrence

Fig. 3



northern and north-eastern parts of the depression and with clayly impermeable Tertiary rocks in the southern and western parts /Fig. 2/. The thickness of the Tertiary series in the Alpine depressions amounts to 1000 m.

The productive Upper Carboniferous includes sandstone, conglomerate, mudstone and siltstone as well as coal beds. The coefficients of permeability of the Carboniferous aquifers have changed from 10^{-5} until 10^{-10} m/s with depth, while the specific capacity has decreased from 16.6 to 0.002 $m^3/h/1$ m in the interval to 1800 m.

Taking into account the recharge conditions of the Carboniferous aquifers two hydrogeological regions may be differentiated in the Variscitic depression /I, II/. Their boundaries are delineated by the extent of the isolating series of Tertiary deposits /Fig. 2/.

Hydrochemical zonality recorded at present and marked by the sequence of chemical types of waters: HCO_3 - SO_4 - Cl, is the result of the interaction of the present gravitational and deep sedimentational hydraulic systems. There is observed the increase of TDS of groundwaters with depth from 0.2 until 372.6 g/dm^3 /Różkowski, Rudzińska, 1983/. This general trend is disturbed by the phenomena of hydrochemical inversion /Fig. 3/. The hydrogeochemical gradients vary from 8 to 25 g/dm^3 in the 1000 m interval.

ORIGIN OF MINE WATERS IN THE LIGHT OF THE ENVIRONMENTAL ISOTOPES DATA

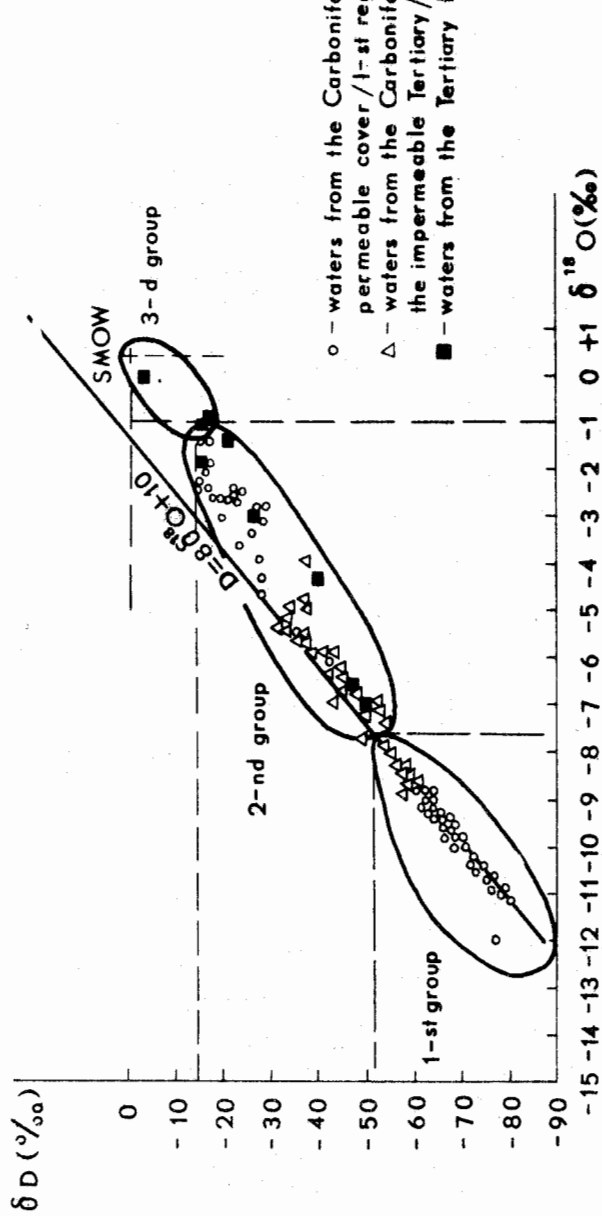
The environmental isotope studies of groundwaters in the Upper Silesian Coal Basin have been carried out to determine the sources and zones of waters inflows to the mine workings /Różkowski, Przewłocki, 1974/. The isotope investigations give also indications about the differentiated origin of mine waters and their location in the flow system /Przewłocki, Różkowski, 1984/. The results of the isotope studies allow to determine both the depth of groundwater freshening under the influence of mining as well as the extent of mixed water zone too.

Meteoric waters of the last infiltration stage recharge directly or indirectly Carboniferous aquifers in the whole Ist region and locally, through the hydrogeological windows in the IInd region. They also filter along down the formation squeezing out relictic waters or mix with them. This process illustrates the dependence between $\delta^{18}O$ and δ D /Fig. 4/. In the diagram at the background of precipitation line described by the equation: $\delta D = 8\,\delta^{18}O + 10$ one can distinguish 3 groups of waters: infiltration waters, mixed and synsedimentic ones varying among themselves in the frames of particular groups, determine their position in the dynamic systems of the Upper Silesian Depression.

To the Ist group /infiltrational/ belong the waters with the $\delta^{18}O$ values varying between -12.1 per mille to -7.8 per

GRAPH OF DEPENDECE OF $\delta^{18}O$ ON δD FOR GRUNDWATERS IN THE UPPER SILESIAN COAL BASIN

Fig. 4



mille, and δ D between -81.0 to -52.0 per mille. Measuring points fall at the precipitation line confirm infiltrational origin of these waters. Waters from the permeable upperlying Carboniferous have been sampled together with the natural seepages to the mining works in the Ist hydrologic region, locally in the IInd region. Total mineralization of those waters ranges from 0.2 to about 20 g/dm^3. Generally, they belong to the HCO_3 - SO_4 - Ca - Mg, SO_4 - Ca - Mg, Cl - SO_4 - Mg and Cl - Na type of waters. The total range of their appearance reaches 400 m. locally to 600 m. below the day surface. At the basis of the Tritium, ^{14}C and stable isotope data one can conclude that the waters belonging to the examined group are of Holocenian, Pleistocenian and Prepleistocenian age.

The second group of waters creating separate cluster at the precipitation line /Fig. 4/ $\delta^{18}O$ values range here from -7.8 per mille to -0.9 per mille and D from -52.0 per mille to -15.0 per mille. These waters were sampled at the depth 240 to 850 m., mainly below 400 m. The total mineralization of waters amounts from 14 to 229 g/dm^3. They belong mainly to the Cl - Na and Cl - Na - Ca type, locally Cl - SO_4 - Na type, of water. These waters are a mixture of relict and meteoric water of the last infiltrational stage as well as in the deeper part of Carboniferous formation they are the mixture of relict water of different ages.

The IIIrd group of waters separated at the precipitation line /Fig. 4/ contains Cl - Na brines, mineralized within limits 35 to 50 g/dm^3. They were formed as a result of compaction and dehydratisation of marine Tertiary clays. $\delta^{18}O$ and δ D values for this group of waters correspond to SMOW /Fig. 4/ which confirms their synsedimentic origin. Tertiary age of these waters was also confirmed by means of He/Ar factor for gases dissolved in brines. These waters can be sampled from the Tertiary sands on the depth about 600 m., during the shafts sinking only.

THE INFLUENCE OF MINING ON THE GROUNDWATER MINERALIZATION

The Upper Silesian Coal Basin has been mined since the second half of the 18th century. Recently the extraction of coal has been usually carried out by the longwall mining. The average depth of mining is about 650 m., while the maximum depth is 950 m.

Mine pumping about 1 mln m^3/day has a great influence on the hydrogeologic conditions in the Upper Silesian Coal Basin. The increasing depth of coal extraction affects the development of drainage influence. Both the surface and underground waters are drained by mines.

In the areas subjected to mining extraction the natural equilibrium of rock environment is severely disturbed. The artificial hydraulic interconnections created by mines activities and deep drainage cause changes in the natural regime of groundwaters. In these circumstances the atmospheric

waters penetrate to considerable depth and frequently become - mixed with relict brines. It causes the differentiation of groundwater chemistry and mineralization.

The decrease of the regional discharge level as well as the greater velocity of water turn - over time are observed under mining activity. Therefore the mine water mineralization is lower than the one which was recorded before mining.

The development of the groundwater mineralization on the depth of 500 m, under the influence of mining, is shown in Fig. 2. The mineralization ranges from 1.8 to 117.0 g/dm^3. There is a great variety of chemical types of waters with mineralization below 10 g/dm^3. Groundwaters with higher mineralization belong only to Cl - Na and Cl - Na - Ca chemical types.

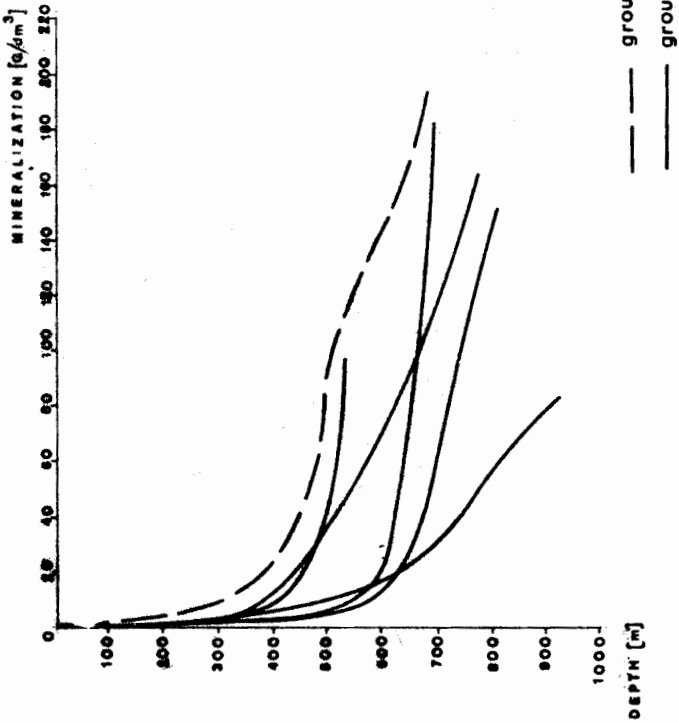
A close correlation among groundwater mineralization in the Carboniferous deposits and the permeability of the Carboniferous overburden as well as mine drainage activity are observed. In the first hydrogeological region /I/ where the Carboniferous deposits are covered with well permeable stratas and where the intensive coal extraction is carried out above 100 years the groundwaters mineralization on the depth of 500 m ranges very often from a few until ten g/dm^3 only /Fig. 2/. In the second hydrogeological region /II/, under a capping of the Tertiary clays, the groundwaters mineralization in the Carboniferous deposits varies from 70 to 117 g/dm^3. The re - sults of the hydrochemical investigations have shown that in the first region the groundwaters freshening process may exceed the depth of 500 m.

On the basis of the tritium investigation results it is possible to define more detailly the turn - over process of groundwaters in the mining areas. It was recorded that before the mining activity groundwaters with the tritium content above 5 $\pm$ 2 TU extented to the depth of 60 - 150 m. Recently mine waters with such tritium content have been recorded to the depth of 200 - 300 m. It indicates that the zone of young waters distribution, of age below 30 years, was enlarged about 100 - 150 m.

The influence of the coal extraction effects and the mine drainage on the groundwaters mineralization and chemistry differs in the I and II hydrogeological region. In the I region the long - time mining has made the rocks more permeable and has lowered the drainage base of the gravitational groundwater flow system. It enabled more effective infiltration of atmospheric waters by the permeable overburden in the bed - rock. The graphs of the groundwaters mineralization related to the depth, before and after mining, are shown in Fig. 5. The hydrochemical gradient of mine waters in the depth interval to 450 m varies from 0.9 to 4.4 g/dm^3/100 m, while before mining the average value of it was 8.8 g/dm^3/100 m. These e- nable to estimate the refreshing effect due to the mining activity. Taking into account the shape of these curves, the depth and the magnitude of the mine waters refreshing in the particular mine are different. It depends mainly on

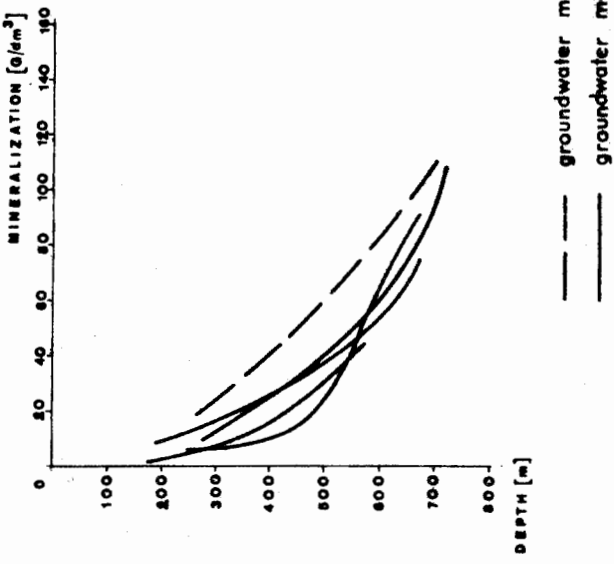
DEPENDENCE OF THE GROUNDWATERS MINERALIZATION ON THE DEPTH OF SAMPLING /1-ST HYDROGEOLOGICAL REGION/

Fig. 5



DEPENDENCE OF THE GROUNDWATERS MINERALIZATION ON THE DEPTH OF SAMPLING /II - HYDROGEOLOGICAL REGION/

Fig. 6



the depth of mining, drainage activity and the geological conditions of the area.

In the second hydrogeological region the coal extraction has been carried out for about 25 years only. It takes place in the Carboniferous stratas under the impermeable Tertiary capping. There are static - relict brines in the Carboniferous aquifers mainly. In this region the refreshing process of groundwaters due to the mine activity is also observed /Fig. 6/. This phenomenon is probably connected with the active drainage effect of less mineralized waters from the Tertiary deposits and from the upper link of the Carboniferous, too. The groundwater flow from the areas of the hydrogeological windows under the influence of mining drainage has also been taken into account. The distinct decrease of mineralization of mine waters in the case of coal extraction on the depth below 750 m has not been observed yet.

CONCLUSIONS

In the Upper Silesian Coal Basin the artificial hydraulic interconnections created by mines activities and deep drainage cause changes in the natural regime of groundwaters. In these circumstances the atmospheric waters penetrate to considerable depth and frequently become mixed with relict brines. It causes the differentiation of the groundwater chemistry and mineralization. The mine water mineralization is lower than the one which was observed before mining. The depth and the magnitude of the mine waters refreshing in the particular mine are different. It depends mainly on the depth of mining, drainage activity and geological conditions of the area.

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