The influence of open-cast lignite mining on adjacent ground water systems

U. Maiwald
A. Pekdeger

Freie Universität Berlin, Fachrichtung Rohstoff und Umweltgeologie, Malteserstraße 74-100, D-12249 Berlin

Introduction

This paper deals with the influence of water drainage in connection with open-cast lignite mining on adjacent ground water systems, illustrated by the situation at a former pit in the Mid-German Lignite District. Intensive water drainage is accompanied by dewatering of the aquifers overlying the exploited coal seam which causes a cone of influence in the surrounding of the pit.

Investigation area

The investigated lignite mine is located Southeast of Halle (Sachsen-Anhalt, Eastern Germany), a town in the south-eastern Hartz foreland. Between 1925 and 1968 lignite was mined, first by underground mining and in later decades by open-cast mining. In the region Permo-Triassic, Tertiary and Quaternary sediments can be found. The pre-Tertiary basement shows extensive disconformities and is characterised by an intensive block structure. The hydrological situation of the area is strongly influenced by open-cast mining, because intensive water drainage was necessary to mine the local seam. The water table was lowered to the base of the mined seam by about 45 m from a natural level of 95 m above sea level. Water drainage is still performed. At least five aquifers are distinguished in the investigation area: Two river gravel aquifers occur in the Quaternary sediments. Within the Tertiary sequence several preponderantly thin aquifers are differentiated, usually limited in their lateral expansion. Locally water bearing lower Triassic sediments occur whereas a karstic aquifer in Permian dolomite and anhydrides is regionally disseminated. The ground waters in Tertiary and pre Tertiary formations are generally confined. In the surrounding of the lignite mine ground water movement in all aquifers is directed towards the pit.

Methods

In the surrounding of the former lignite mine about 46 wells were installed in different aquifers. Here, the results from 26 wells in the vicinity of the pit are reported. The main point of this investigation was directed to the subjacent aquifers of the mined coal seam. Water samples were analysed for major constituents, minor constituents like K, Sr, F and also for some trace elements like Fe, Mn, Li, Al, As, Cd, Cr, Cu, Pb, Zn. Physico-chemical parameters were determined directly in field. Stable isotopes ^{18}O and Deuterium were analysed. To distinguish waters of different ages the Tritium contents were measured.

Results

Within the investigated area different ground water types occur. Deep aquifers in the permian and lower Triassic formations usually bear NaCl-brines containing total dissolved solids (TDS) between 66 g/l and 108 g/l. Within the Tertiary aquifers subjacent to the mined coal seam relatively low concentrated $CaSO_4$-dominated waters (TDS 1-4 g/l) occur besides NaCl-waters with different mineralisations (max: 96 g/l).

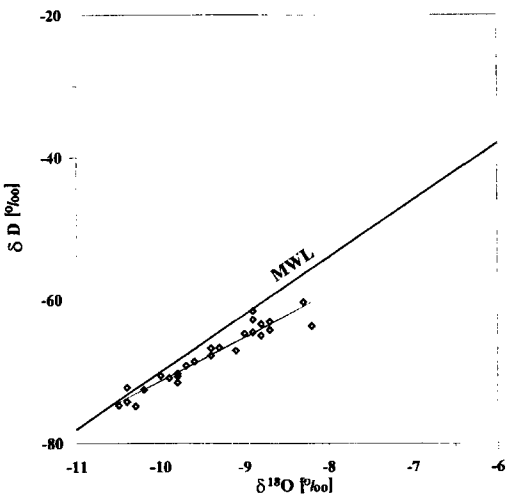

FIG. 1. Stable isotope composition of the ground waters in deep Tertiary and pre Tertiary aquifers.

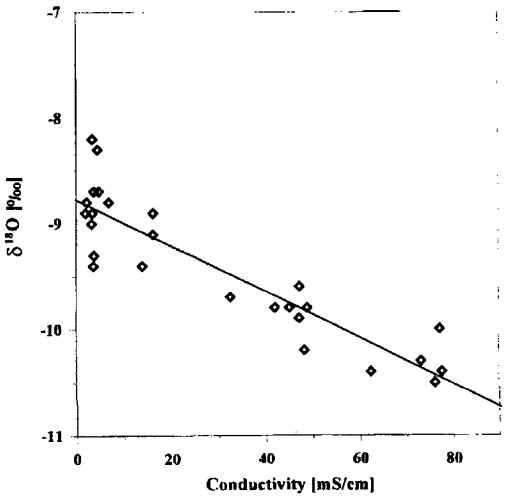

FIG. 2. Relationship between the conductivity and the $\delta^{18}O$-value in deep tertiary and pre Tertiary aquifers.

Waters of $Ca(Mg)HCO_3(SO_4)$-type with TDS of 0.6-1.8 g/l are restricted to the overlying Tertiary and Quaternary aquifers.

In their stable isotope composition the waters of the deep Tertiary and the pre Tertiary aquifers are plotting on a line below the meteoric water line (MWL) (Fig. 1). At first sight, this pattern might be interpreted as an evaporation line. In this case, enrichment of heavy isotopes should go along with an increasing TDS. As can be derived from figure 2, however conductivity and $\delta^{18}O$ are negatively correlated.

Therefore, the line has to be interpreted as a mixing line. Meteoric water enriched in NaCl by solution of Permian evaporites are mixed in different ratios with more dilute waters influenced by evaporation processes. This hypothesis is confirmed by the behaviour of the conservative element Li reflected in a relative constant Li/Cl-ratio. Mixing of ground waters of different ages can be deduced from the tritium contents of these waters with respect to their TDS. Waters from deep Tertiary aquifers are superimposed by NaCl-dominated waters from subjacent formations. Spatial distribution of conductivity, stable isotopes and tritium content show local differences in the influence of the brines (Fig. 3).

Conclusion

The open-cast mining and the depression of the ground water of about 45 m has led to significant changes in ground water quality. The ground waters directly subjacent to the mined coal seam show a negative relation between their conductivity and stable isotope composition. This has to be interpreted as a mixing of waters from different ground water systems. The salinity of deep Tertiary waters locally increased significantly caused by upward migration of deep saline waters. The NE-SW directed trend in the spatial distribution of conductivity, stable isotopes and Tritium content may reflect the influence of surface water from a close river system on the Tertiary ground waters in the SE.

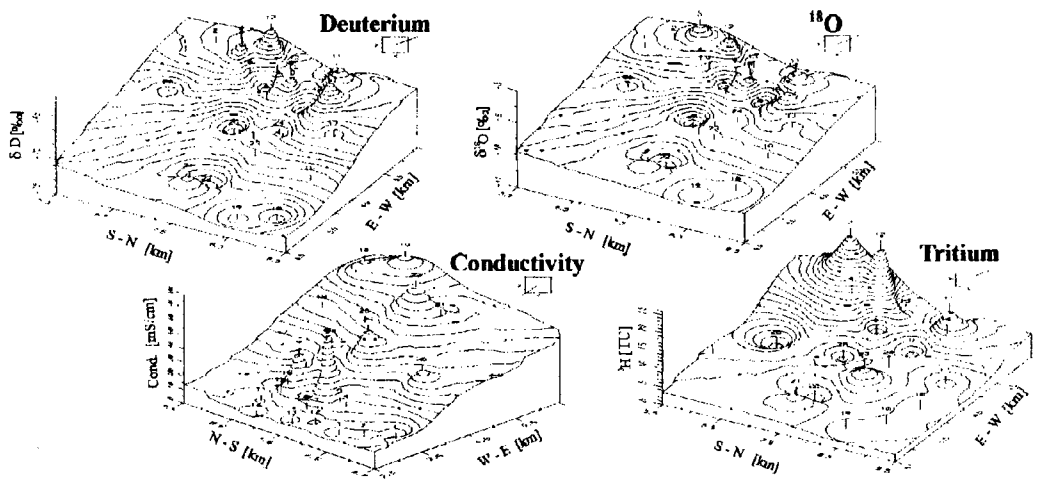

FIG. 3. Spatial distribution of conductivity, stable isotopes and Tritium content in deep Tertiary and pre Tertiary aquifers.