THE INFLUENCE OF HYDROGEOLOGY IN MINING ACTIVITIES

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ABSTRACT

The task of hydrogeology in opencast coal mining is to assist in the securing of measures for the geotechnical safety of the mine by excluding, to the highest degree possible, negative effects of ground and surface waters on the mining operations. In the central part of the North Bohemian Brown-Coal Basin, the fine-grained to silty sands should be drained by pumping holes in order to increase the stability of the mine and waste-tip slopes. The basic problem is the drainage of a discontinuous fracture aquifer of the Krusne hory crystalline massif. The solution of this problem becomes essential with the advance of the working faces towards the foot of the mountain slopes with exposure of slopes of the crystalline basement involved. Using the analyses of natural radionuclides, a model of groundwater circulation within the area has been developed.

INTRODUCTION

Any mining activity invariably disturbs the hydrological cycle of the region. Negative effects are produced by both ground and surface waters in both opencast and underground workings. Mining hydrogeology has been gaining increasing importance, particularly in recent years, as the mineral deposits with complex structural and hydrogeological conditions began to be exploited. A high level of knowledge regarding the hydrogeological conditions of a deposit is useful not only for securing adequate conditions for exploitation of the raw material but also for the study of changes in the ecology of the landscape. This factor is not negligible because groundwaters have become, at the present time, important sources of drinking water supply.

The hydrogeological investigation plays an important part in the development of brown-coal mining in the central part of the North Bohemian Brown-Coal Basin, between the towns of Chomutov and Most.

HYDROGEOLOGICAL CHARACTERISTICS OF THE BASIN

The North Bohemian Brown-Coal Basin was formed by infilling of the SW-NE situated graben during the Tertiary period. On the NW side it is limited by the morphologically clean-cut slope of the gneiss and granite massif of the Krusne hory Mts. These rocks form the basement of the basin sediments, which are of lacustrine and deltaic origin. At the contact of the basin sediments with the Krusne hory massif, a fault zone consisting of crushed and altered
rocks runs parallel to the axis of the basin. This zone is disrupted by transverse faults having a NW-SE strike. The rocks underlying the basin are strongly kaolinized.

From the viewpoint of brown coal mining, the following water-bearing conduits are the most important: the crystalline rock of the basement, sands underlying and overlying the coal-seam complex, the coal seam itself, and Quaternary debris and gravel. All of them are distinguished by a low coefficient of permeability of the order of $10^{-6}$ m.s$^{-1}$. The permeability of Quaternary sediments varies within $10^{-4}$ and $10^{-7}$ ms$^{-1}$, depending on their composition and the site of deposition. Debris deposits predominate on the mountain slopes, covering the contact of the basin sediments with the crystalline massif. Cones of proluvial loamy gravel developed in places where the streams emerged from mountain valleys. Of particular significance is the position of the coal seam, which in the past few years has been exploited in the areas at the foot of Krusne hory Mts. The mining activity has increased the primary permeability of the coal seam, which nowadays functions as a conduit draining the soaked-in water. The intake area of the Tertiary water-bearing conduits is delimited by the outcrops of individual rock complexes at the foot of Krusne hory slopes in the NW towards the SE margin of the basin. The mining operation in the central part of the basin disturbs the flow circulation by drawing off the mine water. The amount of pumped water ranged from 31 to 44 million m$^3$ per annum during the years 1979-1982; 60-68% of this amount being water drawn off from the opencast mines. The coefficient of water saturation for the basin is characterized by values of 0.46 - 0.64 cb.m/t, that of the opencast coal mine ranging from 0.32 - 0.48 cb.m/t. The overall increase of the proportion of water volumes drawn-off from the opencast mines is caused by both the collapse or closure of underground mines ahead of the advancing working faces of the quarries and by the development of drainage works.

THE INFLUENCE OF HYDROGEOLOGY IN COAL MINING

The prevailing opencast mining methods require a limitation of the negative effect of water on the operations, so as to ensure their geotechnical safety (Strzodka, Fischer, 1983). Hydrogeologically, this term implies the securing of stability of lateral and frontal slopes of opencast mines, waste-tip slopes, the prevention of water inrushes and floods, bearing capacity of working platforms on exploitation and stripping faces, etc. The geotechnical safety is also governed by the mining-technological conditions, by petrographical composition of rocks, and their geomechanical properties. The geotechnical safety of opencast mines is further controlled by structural, hydrogeological, engineering-geological, and geotechnical conditions of the deposit.

The basic prerequisite of the safe operation in an opencast mine is to gain control over the water inflow into the mine and the drainage of aquifers in its forefield. In the first instance, the common technical procedures of water management are involved. In the second case, the drainage works are directed to securing of the stability of frontal and lateral slopes, in order to reduce the negative effects of hydrostatic, flow, and pore pressures to the lowest degree possible. The mentioned tasks call for a wide
participation of hydrogeologists. Results of hydrogeological investigations within the confined area are processed with regard to requirements of planning the individual stages of mine development. The preparation and course of drainage works are an integral part in this stage, which is of much importance for further progress of operations, as the drainage works must be started well in advance. Every insufficiency is reflected in the decrease of geotechnical safety of the opencast mine, ultimately affecting the mining operations. It is not an infrequent case that deep-rooted ideas acquired exploiting coal seams under more favourable mining/hydrogeological conditions have to be overcome. Some manifestations of negative effects of water as, for example, sudden landslides of working faces, accentuated the importance of the mining hydrogeological service both before and during the exploitation operations.

Hydrogeological investigation, for example, enabled the steepness of stripping-face slopes to be increased after the drainage of water-bearing fine-grained sand, or to improve the safety of platforms on exploitation faces by reducing a high piezometric stress in the underlying aquifer. It should be realised that the rocks to be drained are of a low permeability, with fine-grained to silty sand fractions. Sand-bonded filters proved convenient against the washing out of the fine-grained sand fraction into the drainage wells (Hass, 1983).

The advance of exploitation towards greater depths calls for additional areas for waste dumps, which are not easily available. An effective preparation and execution of drainage of the waste dump bedrock is a basic requirement for the stability of the waste dump. This holds true especially for the internal waste-heaps situated in the exhausted part of the open pit.

The stability of slopes is, at the present time, a very urgent problem. The stripping and working faces approach the margin of the area at the contact with the slopes of Krusne hory Mts. The slopes are inclined at angles of up to 35° and those of crystalline complexes underlying the Tertiary sediments at 60-75°. By exploitation of coal reserves, a steep slope 250-300 m high will be exposed, which makes the solution of slope stability extremely important. One of the requirements is the drainage of the crystalline massif in order to increase its stability by 20% and more.

From the hydrogeological viewpoint, the mountain massif, which is built up of gneisses and granites, represents a discontinuous fissured water-bearing system. A high hydrogeological anisotropy of surroundings and the topographical position of steep slopes restrict the use of current investigation methods. It is therefore necessary to assess the feasibility and efficacy of drainage works by creating a model of circulation of the underground fissure water.

The Hezerka and Jezeri trial galleries, driven to lengths of 468 and 420 m respectively at the foot of the mountain massif, have shown that the water-bearing fissures are of a low capacity. The total inflow from each audit has steady values of 0.5 l s⁻¹ and 0.7 - 1.5 l s⁻¹ respectively. Higher concentrated inflows were met during the driving of drifts, but they lasted for one or two days only. From the analyses of tritium and ¹⁴C contents and
prospect hole results it follows that two circulation systems were formed in the set of fissures. The shallow circulation system is confined to the surface formations and depends on atmospheric precipitation. Groundwater accumulations do not develop in stony debris and gravel. These sediments function as a medium of passage, through which water infiltrates to the outcrop faces of Tertiary aquifers. The second system is of the deep circulation type. The circulation of fissure water is concentrated into deep-reaching fissures and fractures. It manifests itself by inflows of groundwater from the crystalline basement into the basin's sediments. The inflows did not exceed 0.5 l s\(^{-1}\). Nevertheless, a borehole situated at the foot of the mountain slope gave a constant overflow of fissure water of more than 1 l s\(^{-1}\) from the depth of 84 m. This finding reveals that preferred circulation paths of both regional and shallow depth are developed in the crystalline massif.

The inflows of fissure water which were intersected in trial galleries deep within the massif are of two ages. The \(^{14}\)C analyses give an age of 8 - 10,000 years and the tritium measurements 20 - 25 years. The determinations of \(^{18}\)O indicate a predominance of water infiltrated during winter seasons. This proportion prevails in the majority of established inflows and springs. Fissure waters overflowing from boreholes provide similar results. The inflows from trial galleries and/or boreholes do not drain only the static reserves of fissure water system but also water of the relatively contemporary circulation system. The impermeability of the surface zone at the margin of the Krusne hory was also checked by trial drifts. The drifts as drainage workings exhibit only a minimum drainage effect on the surrounding rock complex, as was demonstrated in the case of the Jezeri drift driven below the historical adit having a constant water inflow. During the driving and the routine measurements in the Jezeri gallery, no mutual influences could be proved.

The drainage of the crystalline mountain massif is, as far as the geotechnical safety of the mine is concerned, difficult to determine and its eventual results appear somewhat questionable. The successive accumulation of relevant information reveals that one should search for the preferred circulation paths, which will have developed in association with the fault lines of regional significance. This task is time consuming and demands the development of non-traditional methods.

The influence of hydrogeological factors on the slope stability in the marginal part of the opencast mine is investigated by using the hydrogeological monitoring facilities as a component of complex geotechnical observations.

CONCLUSION

The paper discusses the principal problems of opencast mining, in which the influence of hydrogeology is irreplaceable. The results of investigations are decisive in securing geotechnical safety of the mine. They are of decisive importance for the control of exploitation and for the prospecting in advance of working face in order to leave safety pillars with coal reserves. Hydrogeological information should unconditionally be respected especially in the foundation and piling up of waste dumps. The great
variety of problems makes the mining hydrogeology a very effective scientific discipline.

ACKNOWLEDGEMENTS

The author expresses his thanks to the management of the Institute of Geology and Geotechnics, Czechoslovak Academy of Sciences, for providing him favourable conditions to fulfil the task imposed. He is also obliged to his collaborators in mining and exploration works for their support.

REFERENCES

