CHANGES IN UNDERGROUND WATER REGIME AT AREAS OF THE USSR COAL MINING ENTERPRISES' IMPACT

V.M.Bankovskaya
All-Union Institute for Scientific Research
on Environmental Protection in Coal Industry
60 Ostrovsky St.,614600,Perm,USSR

ABSTRACT

Activities of coal mining enterprises, accompanied by pumping out of mine and quarry waters, deformation of rock mass and ground surface, result in significant changes in hydrogeological conditions at areas of surface and underground mining. These changes consist in underground water pollution, depletion of their storage, waterlogging of disturbed territories, dewatering and salinization of soil layer, that causes damage to national economy and necessitates a development and emplementation of special measures for water resources and soil conservation. In this connection by the USSR Ministry of Coal Industry comprehensive studies of changes in underground water regime as a result of coal mining activities,including special scheduled and stationary observations on test plots, are being carried out.

INTRODUCTION

Intensive development of the coal industry and the formation of high capacity fuel and power generating complexes lead to negative changes of the hydrogeological conditions, which predetermines the necessity of working out and implementing measures of protection. During the development of such measures of protection the decisive role belongs to the forecast of changes in underground water regime in the confines of coal deposits and in the adjacent territory.

The reliability of nature-oriented forecasts depends in many respects upon the fullness and reliability of initial information. The obtaining of this information is ensured by hydrogeological studies conducted in different stages of the development and operation of deposits.

HYDROGEOLOGICAL STUDIES

To obtain a forecast estimation of the changes of the hydrogeological conditions under the influence of the coal industry by the USSR Ministry of Coal Industry since 1978 comprehensive studies have been conducted including special scheduled observations on test plots of Podmoskovny, Dneprovsk, Donetsk and other basins of the country. Studies are carried out according to the common integrated programme by six leading branch institutes in co-operation with production amalgamations.

A considerable volume of field, laboratory and analytical work has been carried out during the study. It included :

1. The selection of base enterprises in the main coal mining basins of the country to study full-scale changes in underground water regime.

The base enterprises were selected judging the results of analysis of natural and mining-technical cinditions of the development of deposits, implementing reconnaissance route surveys of the surface of mine (quarry) fields, with account of the extent of knowledge of the geological structure of the area, the availability of hydrogeological drillholes, the time of operation of the enterprise.

2. The compilation of technical assignments for the equipment of experimental sections to obtain carrying out stationary observations.

An indispensable component of experimental sections is the network of hydrogeological observation drillholes. Unlike those existing at deposits which are sunk to ensure safe conduct of mining the mentioned network of drillholes should be permanently operating; built even at the stage of designing of the enterprise, and it should be located not only within the confines of the area allotted for the enterprise but in the adjacent territory at the distance of the probable development of the cone of depression of subterranean water.

3. Equipment of experimental sections, including: drilling and equipping hydrogeological drillholes for the observation of the level and chemical regimen of subterranean water; construction of temporary benchmarks to conduct observation over the deformations of land surface; equipping water measuring posts at rivers and water reservoirs within the confines of the deposit.

Experimental sections were set up with the assistance of production associations at some of the coal deposits in the Podmoskovny basin, at the Kimovsky quarry (24 drillholes and 9 water -measuring posts), at the Morozovsky

quarry in the Dneprovsky basin (17 hydroobservation drillholes), at the Kospashskaya mine in the Kizelovsky basin and in some other coal basins of the country.

During the construction of hydroobservation drillholes in experimental sections pilot-filtration operations had been carried out (bunch pumping tests, express pumping) to obtain information for the calculation of hydrogeological parameters, identification of the hydraulic relationship among water-bearing horizones and with the surface water, sampling to study the chemical composition of subterranean water.

4. Scheduled observations over changes in the levels and chemical composition of the main water-bearing horizons including ground water; deformation of land surface; volume and quality of subterranean water which is pumped by the mine (quarry) draw-off and the dewatering drillholes; the runoff and the chemical composition of surface water.

While studying the changes in hydrogeological conditions at experimental sections the following principles were adhered to:

- combination of local studies within individual sections with the study of changes of the natural medium as a whole for the coal basin;
- integrated nature of the conducted studies, which included observation over the water-bearing horizons, surface water, water influxes to mining areas, engineering-geological developments, meteorological conditions in the district;
- territorial approach to the study of changes in hydrogeological conditions by means of cooperation of studies with other organizations and administrations engaged in the territory of the studied coal basins (production associations, organizations of the Ministry of Geology of the USSR, of the State Committee for Hydrometeorology and Control of the Environment etc.)

5. Laboratory studies of the changes in the chemical composition of subterranean and surface water, the water-physical and agrochemical properties of rock in the aeration zone.

Changes in the qualitative composition of subterranean water were determined by a comparison of concentrations of chemical elements prior to the beginning of operation at the enterprise and during the working of the deposit at the moment of studies. In a number of instances comparison was conducted with permissible concentrations of indicators which are standardized by the State Standard No.2874-82 Pot Water. The chemical composition of natural water was determined on the basis of chemical and spectral analysis of water samples taken during the sinking of hydrogeological drillholes and during scheduled observations. The main indicators of the macrocomposition were analyzed in laborato-

ry conditions (Ca, Mg, Na, K, Fe, Cl, SO_4, HCO_3, pH, total ions, hardness, alkalinity, oxidation) and the following microelements: Al, Mn, Ni, Cu, Ag, Zn, Pg, Co, Be.

The changes in water-physical and agrochemical properties of rock on the disrupted sections were determined by comparing them with the rock in sections which have not been involved in mining operations. Sampling was made during the drilling of hydrogeological holes, during the sinking of prospecting shafts in loose deposits for the entire depth of the aeration zone. Field humidity, complete maximum hygroscopic and the least hygroscopic capacity, the specific weight and the volumetric weight, porosity, granulometric composition, the capillary rise were determined in laboratory conditions. As for agrochemical indicators the following analyses were made, that of pH, the sum total of exchange bases, hydrolitic acidity, alkalinity, chlorine, sulphates, calcium, magnesium, iron, aluminium.

CHANGES IN HYDROGEOLOGICAL CONDITIONS IN THE AREAS OF COAL MINING ACTIVITIES

Besides the field and laboratory studies, a complete inventory was taken of coal-mining enterprises in the studied coal basins covering the main mining-technical dimensions, hydrogeological indicators which has made it possible to summarize the information obtained at experimental sections, and identify the typical changes in hydrogeological conditions in the coal-mining districts. These include the lowering of the level and pressure of subterranean water, the change in the conditions of their feeding, movement and relief, the worsening of the qualitative composition of subterranean and surface water, the alteration of the stressed state of the rock mass, the disruption of land surface.

The formation of cones of depression and the lowering of the levels and pressures of subterranean water has been noted at all studied deposits. Thus, in the Dneprovsky basin, under the influence of opencast mining operations the levels of water in the above coal water-bearing horizon dropped by 18 m, and in the undercoal pressure horizon- by 43 m. The average annual rate of lowering of water levels in both water-bearing horizons comprised 4.5 m. The depressions have spread beyond the boundaries of fields of quarries. At the sections of the Dneprovsky basin where the area of the fields range from 4 to 8 km^2, the area of cones of depression reaches 30-40 km^2.

In the Podmoskovny basin, in the 14 years of exploitation of the East-Lyutorichesky section No.4 of the Kimovsky section the levels, owing to the pumping of water from the dewatering drillholes and residual water influxes in the areas of mining, dropped in the overcoal water-bearing horizones by 11 m, in the undercoal Upin horizon- by 30 m, given the average annual rates of lowering in the centre

of depression it was 0.5 m and 2.2 m, respectively. The lowering of the water level at mine fields was : in the Upin horizon from 11 to 40 m with the average annual lowering of 1.0-1.5 m; in the Tula horizon - from 2 to 13 m with the average annual lowering of 0.3 m; in the Mesoscic - from 0.5 to 40 m.

As the result of pumping of water from dewatering drillholes, draining during the draining of deposits, and as the result of mine-quarry draw-off there takes place a depletion of stores of subterranean water which tells unfavourably on the water supply of towns and rural communities. The disruption of the hydrodynamic regimen not infrequently is accompanied by changes of the chemical composition of subterranean water. The main source of contamination of subterranean water at coal deposits are sedimentation ponds, slag and silt accumulators, tailing dumps, rock dumps, the surface runoff from territories of production sites.

The greatest influence upon the chemical composition of soil and subterranean water comes from the waste dumps situated in the Podmoskovny basin, which are formed of toxic pyrite containing rock. This soil, at a distance of up to 50-60 m from the base of the waste dump, has a clear tendency to worsening. The content of iron here reaches 145-160 mg/eqv per 100 g, that of aluminium - 11-19 mg/eqv per 100 g of soil which surpasses the permissible concentrations by 3-4 and 1.5 fold, respectively, and attests to the toxicity of soil in that zone.

The ground water in the zone of waste dump influence is also characteristic of an increased content of iron (1.5 mg/l), sulphates (565 mg/l), aluminium (5.95 mg/l), manganese (1.52 mg/l), total hardness (15.5 mg-eqv/l) and total mineralization (1400 mg/l), which exceeds background values several fold.

Two zones of influence of mine waste dumps upon ground water are singled out. The first zone of intensive stable contamination of ground water is characteristic of increased values (up to 100 fold exceeding background values) of practically all indicators of the chemical composition and it is spread for 100-150 m away from the dump. The second zone of unstable contamination is that where the increased concentrations are characteristic of one-two chemical indicators and do not surpass background values by more than 2-3 fold. This zone may spread along the stream of ground water for several hundreds of metres.

CONCLUSIONS

Thanks to a range of field, laboratory and analytical studies it has become possible to identify the fundamental peculiarities of changes occuring in hydrogeological conditions at coal deposits, establish qualitative and quantitative indicators of the negative influence from mines and quarries

upon underground water regime. This has allowed to compile a standardization of coal deposits by the intensity of changes in hydrogeological conditions and go over to forecasting the changes for substantiating nature-oriented measures.

Thus, three types of changes in hydrogeological conditions in coal-mining areas have been distinguished: first type - weak changes; second type - medium (moderate) changes; third type - strong changes.

In case of weak intensity of changes the influence of coal-mining enterprises upon the underground water regime is insignificant, it does not call for any acute necessity of applying nature-oriented measures. Such changes have taken place at a number of mines of the Donetsky and Karagandinsky basins, at some sections of the Nazarovsky quarry of the Kansk-Achinsk fuel and power complex, at mines of the Kuzbass and Soviet Central Asia.

Given the average intensity of changes - the influence is substantial, but is done away with fully or partially by specific nature-oriented measures (by treatment of the effluent, by recultivation of land etc.). This intensity of changes is characteristic of a number of enterprises of the Podmoskovny and Pribaltiisky basins, of the quarries of the production association known as Sredazugol.

In case of strong intensity of the changes the exploitation of coal-mining enterprises might cause quite considerable and even irreversible changes in hydrogeological conditions and destroy natural resources. Strong changes occur at mines and quarries of the Pribaltiisky shale mining and Podmoskovny coal mining basins.

An indispensable condition of a successful and substantiated application of nature-oriented measures is the development of the monitoring over the state of the underground water in mining areas.