Drainage Systems for Stratified Deposits in Non-dislocated Rock Complexes

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ABSTRACT

Stratified coal and ore deposits often occur within water-saturated sedimentary complexes. The underground mining operations in these deposits are associated with drainage measures ensuring water flow interception, hydraulic head reduction in the mining area and safe mineral resources winning. The drainage procedure normally applied to such deposits is considerably complicated by the presence of low-permeability water-saturated rocks with a seepage coefficient in the range of $5.8x10^{-3}$ cm/s to $5.8x10^{-4}$ cm/s. The optimal dewatering effect is achieved by various methods, preference being given to groundwater displacement by compressed air in the mining district.

INTRODUCTION

Stratified manganese deposits in Ukraine occurring at depths over 50 m are mined by the underground method. The geological structure of the deposits considered depends on their location at the junction of Prichernomorskaya cavity and the South end of the Ukrainian crystalline massif. The manganese ore was formed during the Paleogenic period and the ore bed 1.2-3.8 m thick is ubiquitous in the region. The ore bed roof is composed of hard dark-green clays underlying sandy-clay rocks interbedded with isolated carbonate layers. Paleogenic sandy-clay deposits to be found at the mangenese bed floor separate the ore bed and the weathering crust of the crystalline foundation.

HYDROGEOLOGICAL CONDITIONS

Hydrogeological conditions of Bolshe-Tokmak deposit are specified by the presence of seven aquifers associated with loose sandy deposits and fractured crystalline rocks. In terms of mineral deposit fluid saturation the aquifers form two water-bearing complexes; those underlying and overlying the ore bed. The water-bearing complex underlying the ore bed is ubiquitous mostly in Paleogenic deposits. It includes pore and crack water under a head of up to 30 m. In the upper water-bearing complex water content in the mineral deposits depends mainly on the aquifers associated with the Neogenic Torton stage. The aquifers are distributed in Chokrak aquifer water occurs in fine-and medium-grained sands 3-5 m thick whose seepage coefficient ranges from $8x10^{-4}$ to $1\text{-}5x10^{-3}$ cm/s. The Chokrak sand roof and floor are composed of water-tight clays which determines the head regime of the underground water seepage. The hydraulic head on the saturated bed floor reaches 20-30 m in natural conditions.

The underground water present in Konk deposits is associated with irregularly distributed sands. The Konk sand seepage coefficient is about $8x10^{-3}$ cm/s. Under natural conditions the Konk deposit water is pressurized. The Konk water level coincides with that of the Chokrak aquifer.

THE EFFECTS OF MINE WORKING DEWATERING

The underground manganese mining is carried out by means of the panel - and - pillar method. The mineral being extracted by mechanized longwalling. The stoping is effected by complete roof caving which requires underworked saturated beds to be dewatered. The principal aim of the drainage operations is to eliminate inrushes of groundwater and/or sandy-clay pulp into the mine workings and to ensure safe winning conditions.

In the course of drainage technology development the following factor groups have been analyzed; hydrogeological structure mining technology and the present-day level of the drainage facilities effectiveness.

Mining operations that imply roof caving in the course of stoping require a high-degree reliability of the dewatering system performance. The drainage facilities design is made more complex due to facial and lithological variability of host rock and confining layer compositions. The level of drainage technique acquired suggests a wide utilization of vertical and inclined drainage raise wells.

The design envisaged the use of local dewatering systems ensuring groundwater control where mining operations were being carried out at the moment. In operating mines such systems were represented by linear rows of 6-15 m deep raise wells drilled with a spacing of 20-80 m in the entry roof. In Chokrak and Konk aquifers they are usually equipped with screens.

The experience with linear rows of raise wells has shown that the efficient drain system performance is to be expected only for water-saturated rocks with a seepage coefficient over $3x10^{-3}$ cm/s. In low-permeability grounds the dewatering period is greatly increased and it takes several months to prepare the panel for mining.

To cut the drainage period a method has been developed and tested that ensures intensification of the water-bearing bed drainage by means of compressed air pumping.

DEVELOPMENT OF THE NEW DEWATERING TECHNOLOGY

The compressed air technique used for dewatering relies on preliminary calculations carried out to assess the following parameters:
- the positive air pressure in the layer along the air feed hole;
- the air flowrate in air feed holes;

- the groundwater discharge from the drain wells;
- the number and distribution of air-feed holes and drain wells;
- the positive pressure distribution radius in the layer;
- the time required for the aquifer dewatering at a given section;
- additional loads on the mine working supports.

The calculations have shown that the most rational approach in these conditions would imply arranging the air feed holes and drain wells in rows inside the parallel entries of the panel. This pattern of the hole distribution creates air and groundwater linear flows with subsequent complete water displacement from the area to be drained.

The air-feed holes are connected with the mine air conduit (P 0.5-0.6 MPa) by means of special attachments. This rigging ensure the required regime of and control over the compressed air feed into the layer drained and prevent the ingress of rock pieces into the air conduit in case of pressure release. The drain hole months are equipped with gate valves and are connected with the mine drainage intercepting ditch. Water and air flows in the bed to be drained are controlled by means of the gate valves.

INTRODUCTION OF DEVELOPMENTS

The compressed air drainage technique has been tested at the mines of Marganetsky and Tavrichesky mining and processing enterprises.

The intensification technique was applied to the operating drainage systems including two linear rows of raise wells drilled in the parallel entry roofs. Test measurements of drain well discharge and residual fluid head on the panel roof were carried out previous to pumping compressed air into the water-bearing layer.

Part of the drain wells in one row were converted into the air-feed ones by virtue of their connection to the mine air conduit. Compressed air pumped into the bed to be drained gave a flatly parallel flow that led to water displacement by the air-"piston", its flowrate amounting to 24 m 3/h per air hole under a pressure of 0.4 MPa.

Drainage raise wells arranged in parallel entries were used for groundwater discharge. Compressed air pumping into the water-bearing layers was accompanied by the water table observations that typically include daily measurements of groundwater pressure, level and flowrate in raises wells and flowrate in raise wells and observation holes.

A zone of positive air pressure created in the bed to be drained led to an increase in the groundwater potential energy by 5-30 m of the water column. The drain well discharge capacity grew with the bed pressure the total water inflow from all the drain wells growing 2-3 times.

Air was pumped into the water-bearing bed during 20-30 days until compressed air began to issue from drainage raise wells in the second entry.

RESULTS

The efficiency of the compressed air procedure applied for dewatering and residual fluid head reduction in panel roofs was evaluated on the basis of groundwater table measurements in the ore bed roof. It has been shown that at the moment the air feed was interrupted the groundwater residual head did not exceed 10 sm, i.e. was several times lower than the required values (0.5-2.0 m). This allowed stoping to be commenced a few months before the schedule. In significant increase in the energy expenditure and capital outlays incurred by the procedure utilization were totally offset by the ore output growth.