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Achievements in Mine Water Management and Research GENERAL REPORT

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ABSTRACT

Seven papers included in Session 8 of the Third International Mine Water Congress under the heading "Achievements in Mine Water Management & Research" have been reviewed. Only one paper, a case study by Masters on biological treatment of inorganically polluted effluent, has any connection with research in the sense of seeking new, generally applicable knowledge which would advance the frontiers of mine water management. The remainder deal with various aspects of the management of mine water ranging from investigation of the geology of a specific aquifer system through operating dewatering systems to the management of specific effluent disposal problems.

INTRODUCTION

In relation to mine water the term 'management' can have connotations ranging from the restricted one of collecting and disposing of unwanted water which enters the workings to the general one of investigating and controlling water which affects or is affected by mining and associated mineral treatment operations. The term 'research' is also used to cover a wide range of types of investigation. These vary from fundamental scientific research aimed at producing generally applicable knowledge to particular investigations of specific problems of industry.

The broad aim of water management should be to allow mining to proceed with minimum water handling and treatment costs commensurate with satisfying environmental protection constraints. Examples of achievements in management are well represented by the papers presented to this Congress. The Congress papers cover many aspects of mine water management, from investigations at the project feasibility stage through operating dewatering and monitoring systems to the final treatment of mine effluent and disposal to the natural environment.

However, research into the various aspects of water in mining in the most general sense is not well represented by the papers.

Managers depend on research for the provision of new information, techniques and equipment to improve water management procedures. Unless research keeps pace with pressures applied by the environmental lobby and increasing utilisation of scarce

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groundwater resources, mining will become increasingly fettered by water constraints.

REVIEW OF PAPERS FOR SESSIONS

The papers included in this session are all related to mine water management and, with one exception, have little direct connection with research. The topics of the papers are spread across the full range of mine water management. In an attempt to introduce a logical order of treatment, the review commences with the paper by Bolger and Brumley since it is concerned with the investigation phase of a project and ends with the paper by Masters on final treatment of effluent water.

The paper by Bolger and Brumley describes the geological environment in which brown coal (lignite) is to be mined for Loy Yang power station in Victoria, Australia. The coal measures to be mined are up to 600 m thick, with individual seams up to 100 m thick. Sand and gravel aquifers occur throughout the sequence. Reduction of water inflows and pressures is required to keep the pit dry and limit heave and slope failures. Dewatering at the Morwell open cut, about 20 km distant, has already had an effect on piezometric heads at Loy Yang. The complex hydraulic connections between the units in the aquifer systems make the task of modelling the groundwater flow on both the scale of the aquifer and the scale of the open pit very difficult, but nonetheless necessary. Whether the detail provided by the geologists can be successfully incorporated into the model will be of interest. Unfortunately, the validity of the modelling is unlikely to be known fully until a large part of the depressurisation has been completed. The authors stress "the importance of evaluating the regional groundwater system in the planning and development of individual open cuts". It would be pertinent to add that the scale at which the geology should be viewed depends on the level of detail required in the distribution of groundwater flow and the non-linear effects ignored in the averaging assumptions inherent in assuming aquifer homogeneity. The abstract of the paper states that the "complex stratigraphy of the coal seam and aquifer/aquitard sequences at Loy Yang has been analysed and integrated with the hydrogeological concepts - - - ". Unfortunately no details of the integration or the apparent success of the model are given by the authors. The paper is restricted to the geology with a few comments on the hydraulic characteristics and interconnections between geologic units.

The paper by Mitchell sets out the legal framework in which mine water management must be accomplished in New Zealand. The author then describes the physical environment in which several coal mines must be operated near Auckland without having an adverse effect on one of New Zealand's many lakes. Details of problems and potential problems at specific mine sites are given. Emphasis is on treatment and disposal of mine effluent water to the tributary system of the lake. Suspended sediment and acidic runoff from waste dumps is discussed. Flooding caused by mine subsidence is also mentioned as is the possibility of adverse effects of mine dewatering on aquifers used by farmers. The paper provides a good example of the range of problems which may need to be solved in managing water on a regional scale in a mining area.

The paper by O'Brien and Sullivan on dewatering a trial pit in brown coal at Lochiel, South Australia, is, like the paper by Bolger and Brumley, concerned with depressurising

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sediments associated with the coal in order to stabilise the floor and walls. A brief description of the stratigraphy is given, followed by a description of the dewatering system. The system was designed with the help of computer programs to assess the effects of pumping. Pumped wells and vertical drains were incorporated into the system. Finite element modelling was also carried out to examine regional effects of the dewatering and assess the effects of boundaries. A commonly overlooked point which was investigated is the hydrological regime which will be established when the pit is disused and pumping has ceased.

The pumps and instrumentation to monitor the effects of pumping are described in the paper. Of particular interest are the comments on the performance of pumps and instruments. Poor performance of such equipment can often grossly impair the efficiency and add to the cost of dewatering. The paper would have benefited from a discussion of the actual versus computed effects of the dewatering system. The only plot given shows considerable discrepancies between actual and predicted pressures. Some data on the estimated costs of dewatering would also have been of interest.

Depressurising is again a main aspect of the paper by Hammond and Boyd. Later in this review some discussion will be provided to clarify the relation between pressure and flow and the use of the terms 'depressurising' and 'dewatering'. In the case of the underground coal mines of Collie Basin, south-east of Perth, Western Australia, considered by Hammond and Boyd both high water pressures have limited mining depths. The paper considers one colliery in this basin. The geology and hydrogeology are given as a background to the description of the hydraulic investigations aimed at determining piezometric heads and hydraulic characteristics (hydraulic conductivities and storage coefficients) of the sandstone aquifers above and below the coal seams. These seams are described as "generally behaving as aquicludes". Use of the data and computer models to predict pressure reduction and water inflows allowed a new mine plan to be formulated using "a balance of down dip and lateral development". A combination of surface and in-pit dewatering boreholes has been used with the in-pit holes producing about 75% of the total water. Management of "total mine water" is discussed. In this paper, the term 'management' in relation to mine water is used in the narrow sense of pumping water from the mine and disposing of it via settling ponds to the Collie River. Water being pumped is only 60% of that predicted but this is attributed to it being found that mining could safely proceed if roof aquifer heads were lowered to 30 metres rather than the 20 metres adopted for computer modelling. Unfortunately no data is given to allow the accuracy of the computer modelling to be assessed properly.

The third paper with the theme of depressurisation to reduce the risks of failure of the boundaries of excavations is by Dundon, Humphreys and Hebblewhite. The paper by Hammond and Boyd was concerned with overcoming water problems to allow the application of total extraction techniques. Dundon et al. deal with another underground coal mine in the Collie Basin and actual trials of total coal extraction following depressurisation of the roof aquifer. A combination of holes drilled from the surface and holes drilled from the mine workings was again used to relieve pressures. Useful details of the spacing and construction of holes are given. Brief mention is also made of the lower cost of dewatering through in-mine boreholes compared with dewatering from the surface. Unfortunately,

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again no data is given to allow the ability of currently available flow equations and computation methods to predict accurately the relationships between borehole patterns, water discharges and piezometric heads.

The last two papers reviewed are primarily concerned with what might be described as the end of the mine water management flow chart. The paper by Hallenstein and Bastias on the management of water at the Ranger uranium mine, Northern Territory, Australia, gives a brief summary of the water system but does not make it clear how surface water is collected and stored. Borefields "are available as a contingency source in times of drought". The objectives of the management system are set out as the provision of adequate water supply for the mine and mill and minimisation of the impact on the environment of effluent discharge. The main part of the paper describes water quality criteria for discharge of effluent and how water within the precincts of the mine is managed to achieve them.

The final paper covered by this review is that by Masters and deals with treatment of effluent which comes from an industrial treatment process. The ilmenite, which is converted to synthetic rutile in the process, may be mined but the water is not mine water in the true sense. However, the treatment concept is sufficiently original and of potential application in mining to justify its coverage in this Congress. Details are given of a biological filter used to reduce pH and the concentrations of metal ions at the end of the treatment chain. The 'filter' consisted of an area of shallow water populated by pre-existing and imported native plants. The paper has aspects of research, development and management and thus is the only one in the group reviewed which could justify the inclusion of the word 'research' in the Session description. In the section on "Future Investigations" the author recognises that to complement the work already done, there is a need for some fundamental research on the mechanisms involved in the purification process.

SUMMARY

Of the seven papers reviewed, four were mainly concerned with dewatering mines to achieve stability. This raises the distinction between dewatering and depressurising. The term 'dewatering' may be used to refer to removing water from a mine or from an aquifer in which a mine is situated. Without dewatering the mine will flood. 'Depressurising' refers to reducing hydrostatic pressures within the flow channels in the rock mass to increase structural stability. High pressures with low storage can cause rock failure. High pressures with large storage can cause failure and water inrushes. The consequences need no elaboration.

Dewatering will necessarily cause depressurisation to some extent since piezometric gradients will result from naturally occurring inflow to a mine or will be induced by pumping from boreholes. However, the relationship between piezometric gradient, flow rate and time depends on the permeability and storage characteristics of the aquifer. The steeper the gradients and the higher the velocities the greater is the need to consider inhomogeneity of the aquifer and non-linearity of the velocity–gradient relationship. Since instability problems are restricted to the zone of rock close to the roof, walls or floor of a mine, it is in this zone that the factors affecting permeability and storage need to be best defined.

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Unfortunately the level of detail in this zone is normally inadequate. As a result predictions of inflow rates and piezometric heads are frequently inaccurate. Since a knowledge of accuracy is very important in planning and operating mines it is a pity that the papers presented did not give detailed comparisons of actual and predicted results. Perhaps the lack of this information is an indication of a poor level of accuracy achieved.

The remaining three papers deal mainly with environmental concerns and the disposal of mine effluent. Clearly this is another area of concern in mining at this time.

Although the sample of seven papers reviewed is small, the papers probably reflect what may be the two main mine water problems in Australia – instability caused by high hydrostatic pressures and disposal of effluent. Unmanageable quantities of mine water, although a problem in some specific circumstances, do not seem to be causing much concern if these papers and the titles of the other Congress papers can be taken as an indicator.

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