Technology for Mine Water Management GENERAL REPORT

By C. R. LAWRENCE[1]

DEPARTMENT OF WATER RESOURCES
35 SPRING STREET, MELBOURNE
VICTORIA, AUSTRALIA

This session comprises six papers:

One paper is specifically on advances in drilling techniques, a paper presents a classification for water inrush rich with corresponding guidelines for protection, two papers are concerned with mining impacts in integrated catchment management - one from the quality viewpoint and the other from the quality viewpoint, and the final two papers are case studies of mine dewatering - one for an underground mine threatened by a karst limestone aquifer and the other of an open-cut mine threatened by interbedded sand aquifers.

The paper entitled, *Practical mine dewatering by means of surface drilled wells* by Sides is innovative in presenting the case for wells as cost effective and appropriate for a number of purposes including exploration, re-opening old mines, dewatering, grout emplacement and monitoring.

The ability to drill large diameter wells and ensure accurate alignment are seen as very important. In the case of air drilling systems the use of down hole hammers in the most suitable for hard rock. Wells up to 750mm are customarily drilled with good alignment being ensured by a heavy drill stem and correct placement of stabilisers.

In the case of fluid drilling systems they are often appropriate for open cut mines in unconsolidated sediments. Experience has shown that 1,000mm diameter wells can be drilled to 300m using reverse circulation methods. In a situation where there is ground movement steel casing is unsuitable because of distortion problems and asbestos cement lining has been preferable.

Drilling in the open-cut situation is also referred to as part of the paper by Woods, Sommerville and Gibson who whilst expressing similar views on the appropriateness of the reverse circulation rotary method also strongly endorse cable-tool drilling which they see as having the benefits of accurate sampling, requiring less development, and less risk of installations being hung of in the hole.

The second paper is entitled, *Water inrush prevention in Polish coal mines* by Rogoz. It is based on the experience of mining Carboniferous coal in three basins: upper Silesian, Lower Silesian and Lublin and presents a classification for levels of risk and guidelines of the appropriate measures which should be applied to each level of risk.

I have taken the liberty of presenting this approach in a simplified table as follows:

RISK LEVEL	CRITERIA	PRECAUTIONS
1.	. Impermeable rock separates mine workings from surface or groundwater . Pressure groundwater has been drained away	no special precautions
2.	. Surface water could infiltrate lead workings . aquifer above or below mineral deposit . transmission zone features faults or bores	. gate roads and exploring headings more than 50m ahead of the face . exploratory wells . emergency plan
3.	. Surface water bodies in close proximity . Fractured or cavernous aquifers above or below workings	. exploitation only where gate roads and exploring headings less than 50m ahead of the face . emergency plan

I found this paper innovative in that it developed a systematic approach towards a strategy for the prevention of water inrush in mines in a particular hydrogeologic province. Whilst there is scope for improvement by, for example, a more detailed classification it is to be hoped that others would also attempt to pursue this approach. It would be of assistance to individual mine operators and regulatory bodies.

In addition this paper also includes a methodology for the estimation of the dimensions of protective pillars, which should have broader application.

Two papers address the broader aspects of catchment management. Both are from China. One concerns the groundwater resource of a karst limestone aquifer and the related surface drainage system in a paper by Mujin entitled, *The karst water in Han-Xing district and the counter-measure in water management.* The other paper concerns quality of surface drainage and land with respect to mine waste water disposal in a paper by Longshui, Chunbao and Zhenchuan entitled *Management and Treatment of Wastewater in Hunan's non-ferrous mines in China.*

The former paper refers to an area with iron and coal potential but because of the presence of an extensive Ordovician karst limestone aquifer there are water problems for future mining combined with reconciliation with maintaining the current level of regional usage of the groundwater resources and the surface stream regime, to which the groundwater behaviour is intimately related.

Hydrogeologically Han-Xing province can be sub-divided into 2 sub-basins, the Baiquan sub-basin to the north and the Heilongdong sub-basin to the south. Regional groundwater flow is eastward away from the higher relief areas. Recharge varies seasonally, and is reflected by marked fluctuations in the water table; natural discharge is via the two spring centres at about $7m^3$/sec for the Baiquan sub-basin and $10m^3$/sec for the Heilongdong sub-basin.

The proposed water resource strategy is to dam surface water in the upper reaches of streams and intensifying infiltration in the middle reaches.

With mining development cognizant of the broader objectives of protecting the water resources it is proposed for the iron deposits, which are located away from the discharge area and hydrologically semi-isolated because of the presence of imperious igneous rocks and barrier faults, that it would be possible to dewater mines there without causing regional interference to the limestone aquifer; whilst for the coal deposits, which are not hydrologically isolated it may be necessary to grout in order to minimise groundwater depletion within the limestone aquifer. Reinjection is not mentioned.

The second paper also addresses external effects of mining, in this case quality aspects. In Hunan province there are 194 metal mines within the catchment of the Xiangjiang River. There has been a history of serious pollution to water and land from the disposal of 2 000 x 10^6 tonnes/yr of waste water from mines and related industry. The authors stress that it is essential that this serious environmental problem be addressed. Detailed in the paper are two mines (Bogang Copper Mine and the Moyang Copper Mine) where there has been successful treatment of waste water combined with reuse.

In summary it is concluded that water quality management in Hunan province needs

- co-operation of all levels of government
- effective monitoring of stream and mine discharge
- enhancement of research in treatment of mine wastewater
- levels of protection for sectors for streams and fining of the culprit if this is exceeded.

In commenting on both these papers I would say that it is highly commendable that they have taken a holistic view to water and land management: there is a need for some group to have this responsibility- no matter what the economic-political system. It would be of interest to know in terms of the various "players" what is the relationship and co-operation between the mine operators and those with responsibility land and water management. For example is there negotiation or is it entirely authoritative? Also, can the approach be transferred in its present form to other countries?

The final two papers are mine dewatering case studies. The first is entitled, *Application of shallow interception of groundwater in Fankou lead-zinc mine* by Baoyan, Jifan, Yongyu and Liangjing.

This mine is located in Guangdong province in China. The ore is in Lower Carboniferous to Lower Devonian sandshale overlain by Middle to Upper Carboniferous karstic limestone.

During the early history of the underground mining there were numerous groundwater inrushes and flooding whilst subsequent pumping of mine water leading to collapse and inducement of surface water into the mine.

The dewatering system used now comprises two galleries, each with draining adits and wells; one gallery at ± 0 m ASL and the other at -40 m BSL, both upgradient of the ore body to intercept groundwater. This dewatering began in 1965 and with withdrawal of approximately 28 000 m^3/d the cone of depression is stabilised with a maximum drawdown of about 120 m.

The other case study is entitled, *Dewatering and depressurisation of a multi-aquifer groundwater system at Loy Yang open cut, Victoria, Australia* by Wood, Sommerville and Gibson. In this case there is an open-cut mine excavating brown coal in thick seams interbedded with unconsolidated sand and silt.

The groundwater pressures need to be controlled to prevent excess seepage, heaving of the open-cut floor where uplift hydrostatic pressure exceeds the weight of the overlying material and instability of the batters.

Modelling results indicate that by the year 2010 850l/s would need to be extracted to control pressure resulting in a maximum drawdown for the cone of depression of over 120 m.

Dewatering of the sand aquifer underlying the floor of the mine is carried out by pumping wells that are screened and gravel packed. Drainage of the batters is through near horizontal drainage wells drilled perpendicular to the joints in the coal and at a slope of 3^0 - 10^0 for a length of nearly 200 m.

Comparison of these two case studies is revealing: both are generating cones of depression, but the one in the fractured rock situation is very irregular because of the influence of lateral impermeable barriers, unlike the flat-lying sedimentary coal-sand sequence where there were apparently no such barriers.

It would have been of interest to know how these barrier effects were accommodated in quantitative prediction and whether the observation groundwater pressures matched predicted levels.

By contrast the underground mine case has used galleries for dewatering compared with pumping wells in the open-cut case. In view of the cost of these galleries it would be of interest to know if there had been evaluation of the galleries in terms of their optimal position and dimensions for the full mine life; further, if pumping wells would have been of assistance.

Neither of the papers has addressed the broader impact on the environment, but it would have been of interest to know how this is handled technically and administratively; in particular:

(a) effect in regional groundwater resource
(b) whether quality of disposal water has or will be a problem
(c) whether there is quantitative prediction of collapse or subsidence.