Standards and Procedures for Release of Uranium Minewaters into a World Heritage Area: Biological and Chemical Aspects

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ABSTRACT

The Ranger uranium mine, situated within a UNESCO World Heritage Area of monsoonal northern Australia, accumulates a surplus of potentially contaminated waters during normal Wet seasons. Runoff from areas containing ore-bearing materials must be retained within a `Restricted Release Zone' (RRZ) and the Australian Government has insisted on strict controls on any release of RRZ water. A variety of strategies, including land irrigation, release through wetland filters and controlled direct release to a local stream called Magela Creek, have been proposed to dispose of surplus RRZ waters in an environmentally safe manner. In an effort to minimise any impacts on a significant wetland area the Australian Government has decided that any releases should only occur in extreme wet seasons, averaging no more than 1-year-in-10. To ensure the highest standards of environmental protection of wetlands downstream of the mine, the Australian Government has proposed the introduction of additional standards, including both chemical and biological criteria, to regulate any direct release of RRZ water. Most of the proposed chemical criteria, but not the biological criteria, are included in an existing Authorisation regulating RRZ water release. In the proposed revision, criteria for 12 chemical parameters are based on the natural variability of stream concentrations or published toxicological data. The flow rate of any discharge must not exceed a value based on the flow rate of the stream and the specified maximum allowable addition. In addition, the total load of specified constituents contained in releases from all sources must not exceed set values for annual load limits in Magela Creek. Biological criteria are based on chronic toxicity tests which were developed by the Office of the Supervising Scientist using local test species (fish, cladocerans, hydroids) in local stream water. The flow rate of any discharge should be limited so that the proportion of released water, when diluted with the stream flow rate, should not exceed one-tenth of the lowest No-Observed-Effects-Concentration determined by toxicity tests carried out on the water proposed for release.

INTRODUCTION

The Ranger uranium mine is located within Kakadu National Park, a UNESCO listed World Heritage Area, in monsoonal northern Australia (Fig. 1). It lies within the catchment of Magela Creek, a seasonal stream flowing into floodplains downstream of the mine. Until mining operations began, the area was remote and difficult of access. The waters of Magela Creek remain uncontaminated and by world standards are oligotrophic and contain unusually low concentrations of dissolved salts. Average phosphate (as P) and nitrate (as N) concentrations are about 0.005 and 0.014 mg/L respectively and average conductivity is about 15 uS/cm.

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Although the (20 y) average annual evaporation (2600 mm) considerably exceeds the average annual rainfall (1500 mm), the water management system at the mine faces difficulties in waste water disposal because the rainfall is nearly all concentrated within three months of the Wet season. Runoff from areas containing ore-bearing materials are required to be retained within a 'Restricted Release Zone' (RRZ) and the Australian Government has insisted on strict controls on any release of RRZ water. The strategies proposed to overcome the problem of excess water include irrigation on to land, release through a wetland filter and direct release to Magela Creek. Direct release is seen by the mining company as necessary in seasons of above average rainfall and a regulatory regime has been designed by the supervising authorities to ensure that water releases from the RRZ, if they occur, will not cause environmental detriment.

The basis for minimising any environmental impacts from mining was established in the Ranger Uranium Environmental Inquiry [1], which took place prior to the commencement of mining. This inquiry recommended that a water management system be set up that minimised the release of contaminants from the mine site, whether by runoff or by deliberate release, both during and after mining. If deliberate releases were to be made, they should be controlled in relation to the flow conditions in the local creek, the measured contaminants and the acute toxicity of the water to be released. These recommendations led to the development of the RRZ concept, and the creation of water quality criteria to regulate any releases of RRZ water.

The water quality standards have been made very strict because of the concern about releasing potentially contaminating mine waste waters into an area which is now a World Heritage Area and also the home of aboriginal people depending to a degree on hunter-gatherer methods of obtaining food. The OSS has responsibility to develop environmental standards and procedures and to ensure that the high standards of environmental protection required by the Australian Government are met.

The attached Appendix is a draft Authorisation which includes, as well as the existing physical and chemical criteria, the biological criteria for water release that the OSS has proposed for use in Magela Creek.

In addition to physical, chemical and biological criteria, a special criterion based on one or more social factors is included in the release Authorisation to restrict the timing of releases to a frequency of not more than once in ten years. Condition 3 in Annex W of the attached Appendix is intended to achieve this and is based on the statistical distribution of annual rainfall at the mine. This special criterion is discussed in another paper at this conference.

CHEMICAL WATER QUALITY CRITERIA

The regulatory regime is based on chemical and physical criteria for the maximum allowable addition and maximum annual loads (Table X1 and X2 in appendix A). These criteria were developed specifically for Magela Creek and are based on established standards or where no such standards exist, on historical values in the stream.

The chemical and physical water quality criteria for Magela Creek included in the

Appendix were set by the Northern Territory Department of Mines and Energy which has direct regulatory power over the Ranger mine. These standards were based on the data which were available at the time on Magela Creek water quality and on the OSS Research Institute criteria. Because of the variability of these data, and the prevalence of values below or close to the detection limit, maximum allowable values of parameters obtained statistically might from time to time be exceeded in Magela Creek, even without additions from the mine. It was therefore decided to base water quality criteria on maximum allowable additions to the stream rather than maximum allowable concentrations in the stream.

For some parameters, no suggested limits based on ecological, toxicological or human health considerations could be found in the literature. Since suitable data could take many years to acquire, it was decided to use a statistical procedure to generate values for the maximum allowable additions to the existing Magela Creek concentrations. The accuracy of the values derived from historical stream water data can be low due to the prevalence of values at or below the detection limits. To allow for this uncertainty the maximum allowable addition for those parameters not limited by known toxicity effects was obtained by taking twice the Standard Deviation of the historical values.

For parameters such as the radionuclides, the long term exposure is more important than the short term concentration. For these, additional criteria were included to limit the maximum annual loads that could be deliberately added to Magela Creek (Table X2 in Appendix).

Organic materials are not included in the water quality criteria because they are not expected to be present in significant amounts in the waste waters of the Ranger mine. The only substances of concern in the waste waters are inorganic ions especially uranium, radium and magnesium.

Because of the limitations of using a theoretical approach to develop standards, the literature was searched to determine whether the values obtained were realistic and would ensure a high standard of environmental protection. It was found that the limits suggested on toxicological, ecological or human health grounds were generally far higher than the mean (or maximum) concentrations occurring naturally in Magela Creek.

BIOLOGICAL WATER QUALITY CRITERIA

Biological testing is perceived as an appropriate and necessary supplement to chemical testing for the regulation of RRZ water discharges. The OSS has proposed that the flow rate of any released RRZ water, when diluted with the flow rate of Magela Creek, is controlled so that the concentration does not exceed one-tenth of the lowest No Observed Effect Concentration (NOEC) determined from the available toxicity tests carried out on the water proposed for release.

Although the Ranger Uranium Environmental Inquiry [1] recommended the use of acute toxicity tests to set minimum dilutions, concepts in toxicity testing have developed since that time (1977) and it is now appreciated that acute tests based on mortality are less sensitive and generally less accurate than tests based on non-lethal parameters. For example a substance which prevented reproduction or only affected juveniles of the test species might

not be detected by acute toxicity tests but could cause severe damage to a population. To maintain a conservative approach by using the most sensitive measures, the test battery proposed relies principally on sublethal (chronic) measures of effect. Following OECD guidelines, a battery of three separate toxicity tests is specified which uses test organisms from widely different groups.

The toxicity tests proposed determine the maximum concentration at which a waste water has no statistically significant effect on:

the population growth of *Hydra viridissima* ('green' hydra) or *H. vulgaris* ('pink' hydra) over a six day period of exposure [2],

the survival and hatchability of purple-spotted gudgeon (*Mogurnda mogurnda*) embryos over a 4-5 day period of exposure [3],

cladoceran (*Moinodaphnia macleayi*) reproduction rate and adult animal survival over a five day period of exposure [4][5].

The minimum safety factor has been set at ten to allow for statistical uncertainties in the tests, the almost certain existence of more sensitive species in the receiving waters and the uncertainties of translating laboratory results to the field.

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APPENDIX

DRAFT AUTHORISATION FOR THE RELEASE OF WATER FROM RANGER RRZ

Suggested Clauses for inclusion in the main schedule of the Authorisation

1. The owner or the Manager of the mine in which the mining hereby authorised is carried out may only transfer water from the RRZ in any year after specific approval by the Minister or his delegate.

2. Such transfer must be by regulated pumping from Retention Pond 2, and using a pipeline which discharges directly to the Magela Creek, in a manner and a place designed to achieve rapid mixing and dilution of the waters released with the natural flow in the Magela.

3. The pump and pipeline installation shall be constructed so that it can be easily and securely locked off so that unauthorised operation is prevented.

4. The intake of the discharge pump shall be sufficiently above the pond floor to avoid disturbing and transferring sediments on the floor of the pond, so far as is practicable.

5. Approval to commence releases in any year will only be given if the Northern Territory Minister, or his delegate, is satisfied that the requirements set out in Annex W (attached) have been met.

6. The discharge rates, total volume discharged and the timing of discharges must comply with the physical, chemical and biological criteria set out in Annex X (attached).

7. Appropriate measurements and tests, including chemical, physical and biological monitoring will be carried out, and reported, as set out in Annex Z (attached) to ensure compliance with the regulatory requirements.

ANNEX W: Requirements for the commencement of RRZ releases in any Wet season

1. Physical and chemical parameters of water quality, as required to ensure compliance with the regulations set out in Annex X, must be available to ensure an appropriate release rate can be set. Such data should be less than 1 week old at the time of initiating any release unless otherwise specified by the Supervising Authority.

2. Results of pre-release biological testing of the toxicity of the waters to be released, as required in Annex Y, and conducted according to the procedures described in Annex Y must be available for assessment.

3. The cumulative wet season rainfall, since the preceding 1 September, measured at the Jabiru Airport must exceed a trigger value specified in the formula:

$$Rc = 1220 + 8.5n$$

Where Rc = minimum cumulative Wet season rainfall to the nearest millimetre (from 1 September) which would allow releases to be approved, subject to compliance with other regulatory criteria on dilution, quality and flow rates.

n = number of days after 1 February in that Wet season.

4. The flow in Magela Creek, measured at site GS8210009 must be greater than 20 cumecs and the recent history of flow must be such that it is reasonable to assume essentially continuous flow in the stream between the discharge outlet and the northern end of the flood plain. Average flow exceeding 10 cumecs over the preceding 7 days will be accepted as sufficient demonstration of this continuous flow.

ANNEX X: Criteria for the regulation of RRZ releases

1. Approval for release in any one year having been given, the release may be continuous or intermittent providing that at all times during a release the following conditions are complied with.

Stream Flow Criteria

2. The flow in Magela Creek, measured at the release pipe outlet or at GS8210009 at a particular time on each day must be greater than 20 cumecs for release to continue at any time through the 24 hours following the determination of flow rate.

3. Conditions of recent flow in the Magela must be such that it is reasonable to assume essentially continuous flow in the Creek between the discharge point and the northern end of the floodplain. (See Annex W, para 4)

Chemical Quality Criteria for Receiving Water

4. In order to protect the quality of the receiving waters the volumetric flow rate of any discharge shall be restricted so that the calculated increase in any of the water quality parameters listed in Table XI for the water in Magela Creek, does not exceed the maximum allowable addition specified in Table XI.

That is, the formula

$$D < A \times F/C$$

must be satisfied, where

D is the discharge rate from the pipeline
A is the maximum addition specified in Table X1
F is the Magela Creek flow rate at GS8210009
C is the concentration of a constituent or value of the parameter in RP2 water

5. The total volume of water released from all sources at Ranger during the whole Wet

season (release period) shall also be restricted so that the total load of those constituents listed in Table X2 does not exceed the additional annual load limits specified in Table X2 in any twelve month period commencing in September.

Biological Quality Criteria for Receiving Water

6. The flow rate of any water releases shall be limited so that the proportion of released water, when diluted with the total flow rate of the Magela at GS8210009, does not exceed one tenth of the lowest of the No Observed Effect Concentration (NOEC) determined from the applicable toxicity tests carried out on the water proposed for release.

7. The Director, Northern Territory Mines Environment Directorate (NTMED), will take account of other information available on results of additional biological tests or observation of effects on the environment, and may specify a requirement for a higher dilution ratio than that required by Clause 6, if such other information warrants this.

Criteria for Continuance of Water Release

8. A period of continuous release must be terminated if the daily determination of electrical conductivity of the waters being released varies by more than 50 mS/cm, or the pH varies by more than 0.8 pH units, from the values of conductivity and pH of the water used in the most recent toxicity tests, considered to be in effect at that time.

If releases are terminated in accordance with this clause, they may only be recommenced after consideration and application of the results of more recent biological tests carried out as required in Annex Y, together with all other appropriate criteria specified in this authorisation.

Reporting

9. Results of all tests and analyses carried out to comply with these requirements for water release are to be forwarded weekly to the Director, NTMED. A brief report, indicating the parameter or parameters limiting or likely to limit the discharge rate of any water, together with information confirming that the release has been carried out in compliance with the prescribed limits and criteria for any actual releases made, should accompany each weekly report.

10. Within six weeks of the last release of the Wet season a full report is to be submitted to the Director, NTMED, detailing:

i) Release quantities and timing.
ii) Monitoring results.
iii) Analysis of trends.
vi) Demonstration of compliance with the receiving water standards for Magela Creek.

TABLE X1

Standards for release of water to Magela Creek

Constituent	Units	Maximum allowable addition
Turbidity	NTU	1.5
Calcium	mg/L	1.3
Magnesium	mg/L	1.0
Sulphate	mg/L	19
Nitrate/nitrite (as N)	mg/L	0.6
Phosphate (as PO4)	mg/L	0.01
Copper, total	mg/L	0.6
Lead, total	mg/L	0.7
Zinc, total	mg/L	5
Manganese total	mg/L	24
Uranium, total	mg/L	3.8
Ammonia (un-ionised NH3 at Magela Creek pH)*	mg/L	20

* The proportion of un-ionised ammonia to ammonium ion is temperature and pH dependent and may be calculated from a table based on Table 801; VI in Standard Methods for the examination of water and wastewater, sixteenth edition 1985 (Ed. Franson, Mary Ann H.) published jointly by American Public Health Association, American Water Works Association, Water Pollution Control Federation.

TABLE X2

Additional annual load limits for release of water to Magela Creek

Note: Radionuclide limits are subject to summation of fractions of individual limits with the sum to be less than unity.

Constituent	Units	Additional annual load limit
Uranium -(238+234)	GBq/yr	90
Thorium -230	GBq/yr	170
Radium -226	GBq/yr	13
Lead -210	GBq/yr	8
Polonium -210	GBq/yr	7
Cadmium	tonne/yr	1.3

ANNEX Y: Authorisation of water releases from Ranger RRZ

Application of Biological Toxicity Tests on Water to be Released.

1. The biological tests based on cladocera survival and reproduction, hydra survival and reproduction, and embryo fish survival and hatchability described in the attachments to this Annex (or approved alternate tests) will be used in conjunction with the physical and chemical criteria set out in Annex X, to determine the minimum dilution ratio of the released waters into the Magela Creek.

2. Before the initial approval of releases in any year, the results of pre-release toxicity tests on the water to be released, using three different classes of biota (e.g. fish, cladocera, hydra) as advised in the attachments must be available, so as to determine a suitable minimum dilution ratio to be applied to the release.

3. For releases to continue, after the initial approval in any year, the results of at least one of the approved pre-release toxicity tests on the water to be released must be available weekly so as to determine a suitable minimum dilution ratio. This test should be a repeat of that test which indicated the lowest NOEC in the pre-release tests. If however, an alternate test is approved as provided for in paras 5 and 6, the dilution ratio for ongoing releases should be adjusted to reflect the difference in sensitivity displayed in the pre-release tests.

4. For the result of any toxicity testing to be applicable to the permitting or the regulating of releases, such tests must comply with the criteria for validity stated in the procedures, and except as provided in the following clauses should have been completed not more than 7 days prior to their application.

5. Provided however that toxicity tests to meet the requirements of this Annex have been properly commenced and pursued, if for any reason suitable results of such tests are not available, the Director NTMED may after consultation with the Supervising Scientist, and with his agreement, determine whether other recent test data on the toxicity of the water to be released, might be accepted as an alternate applicable test.

6. In any circumstances, when the availability of information from either biological or chemical testing falls short of the desirable criteria set down in this Authorisation, the Director NTMED with the agreement of the Supervising Scientist, may set a minimum dilution ratio to apply to continuing releases on the basis of any available information on the quality of the water to be released. Lacking such agreement however the release must not continue until adequate test information is available to justify and regulate such release.

7. In applying biological toxicity tests, the dilution ratio for the release, defined as the ratio of the measured flow rate in Magela Creek at GS8210009 to the flow rate of the discharge, will be no less than ten times that required to achieve the lowest NOEC in the receiving waters for any toxicity test applicable at that time.

The Supervising Authority may require the use of a higher dilution ratio if it is believed that this is better for adequate environmental protection. Note also that compliance with other criteria, in particular Clauses X4 and X5 may regulate the minimum dilution ratio for the release.

ANNEX Z: Physical and chemical monitoring requirements

SITE	MEASUREMENT	FREQUENCY
1. Prior to release:		
Waters to be released (at point of discharge from pond)	W1, W2, W7, W8, plus NH4 & PO4	At least once within the week prior to release.
Magela Creek (upstream of pipeline outlet)	W1, Mg, Ca, Mn, U	Within the week prior to release.
GS8210009	W1, Mg, Ca, Mn, U	Within the week prior to release.
Water to be released	W9	Within 2 months prior to release or sample on commencement of release with result to be available before 1 month in order to set any volume limits dependent on total load criteria.
2. During release:		
Waters to be released (at point of discharge from pond)	W1, Mg, Ca, Mn, U	Daily during release.
	W2, W7, W8 plus NH4 and PO4	During first week of release and thereafter weekly.
Magela Creek (upstream of pipeline outlet).	W1, Mg, Ca, Mn, U	Daily during release.
Water being released. Composite sample of annual releases.	W9	Composite for all releases analysed once per year (if any).
GS8210009	W1, Mg, Ca, Mn, U	Daily during release.

3. After release

Magela Creek (upstream of pipeline outlet)	W1, Mg, Ca, Mn, U	At least once within 24 hours of the end of any release.
GS8210009	W1, Mg, Ca, Mn, U	At least once within 24 hours of the end of any release.

In addition to the monitoring programs specified in this Annex if any other parameter in the water being released is found to limit the water release rate in order that the formula given in Annex X is satisfied, then that parameter shall be monitored on a daily basis at the point of discharge of the pond, upstream of the pipeline outlet to Magela Creek, and at GS8210009.

Notes

1. The following abbreviations are used in this Annex:

Ca - calcium
Mg - magnesium
Mn - manganese
NH4 - ammonium ion
PO4 - phosphate
RRZ - restricted release zone
W1 - conductivity, pH, turbidity, and sulphate
W2 - sodium, potassium, calcium, magnesium, alkalinity, chloride, and nitrate
W7 - manganese, uranium, and radium-226
W8 - copper, lead, and zinc
W9 - thorium-230, lead-210, polonium-210, cadmium
U - natural uranium

2. Note that not all parameters listed in W2 and W9 are required to be measured by Tables X1 and X2 but that the specified analytical schedules are consistent with existing Northern Territory authorisations.

Water Hazards in Coal Deposits and Prevention and Control Techniques in China

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ABSTRACT

There are more serious water hazard in many coal mines in China due to complicated hydrogeological conditions. The water hazards can be divided into four types:

The type 1: The water hazard of surface water body or overlying water bearing loose layer
The type 2: The water hazard of thick limestone karst crevice aquifer
The type 3: The water hazard of thick limestone karst heavy aquifer
The type 4: The water hazard of other aquifer

Because of various different conditions, each of the above four types can also divided into several sub types. According to different water inflow during mining, it can also be divided into four inundation grades.

In view of above various water hazard conditions, China so far has developed a complete set of methods of prevention and control water.

Owing to the requirement of technique development of prevention and control water and inevitable outcome, China has correspondingly researched and perfected comprehensive survey techniques of water hazards in coal deposits. China use five types of comprehensive techniques (prevention, drainage, dewatering, interception and block up) in line with local conditions and has achieved good results, solved problems of forecast, rescue and harness of complicated and serious water inrush in many mines, has effectly prevented and controlled water hazards in coal mines.

The article summarizes various techniques for prevention and control water and flood survey currently used in China.

Cartography of the Cl, SO_4, Chemical Elements and the Ratio Cl/ SO_4 in the Area of Guelma - Bouchegouf and Annaba

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ABSTRACT

Water chemistry of Oued seybouse (area of Guelma, Bouchegouf and Annaba) has been investigated during the period of january throughout march, 1989. The interpretation of the chemical analysis of water leads to the following conclusions.

The chloride, sulphate concentrations and the ratio Cl/SO_4 are higher along the banks of Oued Seybouse.

The sulphate concentrations are higher in the area of Guelma (Cl/SO_4 = 2) and become less important towards Bouchegouf (Cl/SO_4 = 5.2 computer results show the same observations represented by different pics.

These higher concentrations are due either to geological formation (interaction between the aquifer, the river (Oued) and the limestone formations in the area of Guelma (higher HCO_3) or to water from industrial sites in the area of Annaba, in the area of Bouchegouf, however, we detect the influence of two sources of pollution: geochemical (salt exploitation site) industrial source (yeast factory).

Environmental Pollution from Coal Mining Activities in the Enugu Area, Anambra State, Nigeria

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ABSTRACT

Hydrogeological studies of the Enugu coal mine area were carried out. Hydrogeochemical analyses revealed high sulphate and iron content in the acid mine drainage waters as well as high total dissolved solids' (TDS) values and low pH (acidity). The waters were also moderately hard. These waters issue from the Ajali Sandstone formation and the underlying carbonaceous Mamu Formation that is mined for coal. Huge volumes of (polluted) water flooding the mines are channelled into some streams or rivers which in turn get chemically polluted. Remedial measures have been indicated which include the treatment of acid mine waters before their pumping into streams or rivers; the disposal of mine spoil wastes in carefully prepared and designed disposal sites; planned and detailed mapping of the fractures in the Mamu Formation for more effective dewatering scheme and increased exploitation of the overlying Ajali Sandstone aquifer to reduce or limit the amount of water flooding the mines in the underlying Mamu Formation.

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Impact of Zinc-Lead Ores Exploitation in the Trzebionka Mine on the Quality of Groundwater (Southern Poland)

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ABSTRACT

The intensive mining activity carried out by "Trzebionka" zinc-lead mine causes changes in the hydrodynamic regime of the triassic aquifer as well as essential changes in the chemical composition of the groundwater.

The mine waters, in comparision with groundwaters collected directly from fractures and karstic channels and with groundwaters pumped out from wells situated in Chrzanow region, are characterized by higher contents of almost all major disscolved constituents as well as many trace elements.

Hydrogeochemical background of triassic carbonate series aquifer has been elaborated. Largest anomalies in extent of almost all elements have occured in area of the "Trzebionka" mine.

In these waters general trend of increase of pH, total dissolved solids and SO_4^{2-} concentration with simultaneous trends of decrease of Zn^{2+} and Pb^{2+} concentrations have been noticed.

Waters pumped out from the mine in spite of their low quality, are utilized in about 80% as potable waters. It requires their complicated treatment.

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Geothermal Changes in Karstic Reservoirs as a Result of Mine Dewatering and their Hydrogeological Interpretation

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ABSTRACT

Sinking the water level on purpose to protect mines from water inrushes can create depressions of considerable size. As a result of this in the surrounding aquifers the directions of filtration can be transformed, which are sensitively indicated by the following changes in water temperature. At the bauxite deposits of Hungary the regular thermometry on water wells of the water level monitoring system set up for observing the formation of depressions, makes possible to investigate, in combination with other methods, the hydrogeological structure of the surrounding territories.

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Mine Drainage Treatment in Polish Lignite Mining

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ABSTRACT

The paper presents volumes and characteristics of water drained from some Polish lignite open pits and methods for its treatment as well.

Results of research work concerned with increase in mine drainage efficinecy by using mainly processes of radiation, flocculation and filtration through a set of bog plants, i.e. so-called grass filter, are handled.

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Radioactivity of Surface Waters Around the Uranium Mine at Žirovski Vrh

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ABSTRACT

The uranium ore body at Žirovski vrh, 60 km from Ljubljana, Slovenia, Yugoslavia, was discovered in 1960, and at the end of 1984 the uranium mine and processing plant were put into operation. In the preoperational period the main source of environmental pollution was the mine water. The purpose of the environmental programme at that time was to control the levels of natural uranium and ^{226}Ra in surface waters and in sediments upstream and downstream of the confluence with mine water to obtain information on background levels of radionuclides in the near vicinity of the mine, around the projected mill facility and tailings pile.

From 1984, besides measurements of natural uranium and ^{226}Ra, radioactivity surveillance of local waters (mainly the streams Brebovščica and Todraščica), covers also measurements of 210Pb and 210Po in surface waters and in sediments.

In this work some results on radioactive contamination of surface waters around the uranium mine are presented, and a comparison between preoperational and operational periods will be made and discussed.

Complex Utilization of Mine-Waters

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ABSTRACT

This paper describes the complex utilization system of mine-waters in Hungarian bauxite mining. The quantity of water pumped - because of mine dewatering and supplying drinking water - is ten times more than quantity of waste and usable mineral resources.

The water extraction had been increasing in Dunantul mountain since 1950's but after having recognise its adverse impact on the environment it was neccssary to reconsider the complex utilization of mine-waters. The paper deals with the application of mine-waters coming from two different places:

- Nyirad mine area
- Rakhegy mine area

The utilization is examined from two points of view:

- using kinetic energy of mine-water to produce electric power
- using the heat-content of mine-water

The paper studies the economical of:

- using the mine-water to produce electric power
- the problems of reservoir in case of peak period power station connecting to environmental prescription
- backfeeding of mine-water and creating small underground power station using the kinetic energy of mine-water backfeed

Saving is expected by rationalising of existing water pumping systems. The paper shows the possibilities of future in the chapter of application of heat-content.

In case of Kincsesbanya (water temperature 30°C) there are possibilities to use the heat-content both in direct way and using heat pumps. Using heat plumps ensures more efficiency solution.

In case of Bito-II. mine (water temperature 32° C) the water is extracted separately in drinking water quality to make the water-pumping more efficiency. It is expedient to utilize the heat-content of this water. It can be achieved by constructing a warm-water pipeline. The pipeline can be made of plastic with heat insulation. After construction of the pipeline the suggested solution for utilization of heat-content can be achieved.

The use the heat-content of colder waters (water temperature 10-15°C) promises also success. It is important to utilize the heat-content of mine-waters because of:

- Hungarian bauxite mining will need water extraction for a long time
- these water resources are very important for supplying drinking water

As a conclusion it is obvious that the mine-water will be available in long term perspective and the existing water demands will express on its complex utilization. This fact is supported by the steady increase of power costs and prices and at the same time power can be produced in environmental-friendly way.

Grouting of Old Flooded Workings at M. Mayerova Mine in Czechoslovakia

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ABSTRACT

About 20 years ago in Western Czechia near the city of Karlovy Vary at M. Mayerova Mine, built at the end of 19th century, there occured a problem of eliminating flooded mine workings encountered in Jozef Seam at a depth of 176 m and two vertical 4 m. dia. mine shafts No. 2 and No. 5 to prevent the ingress of water into a planned coal pit and ensure the possibility of mining the overlying Antonin Seam at a depth of 88 m. by opencasting technique.

This problem had been complicated by a hydraulic connection of flooded workings of the Jozef Seam, recharged from the intersected fault zone, with regional reserves of mineral thermal springs of the city of Karlovy Vary through fissured sandstones and quartzites underlying the coal layer.

For resolving the problem and in accordance with the project report and methodology of Integrated Grouting Technique of P/A Spetstamponazhgeologia (STG), Geoindustria Enterprise, Czechoslovakia has conducted injection of the designed volume of clay-cement grout into the flooded workings. The grout was pumped through surface drilled boreholes under specified regimes. As a result, the inflow to the Jozef Seam workings was reduced from 0.5 m3/min to 0.0002 m3/min, ground water temperature fell down from 31 C to 18 C.

The paper deals with the actual data of this original project.

The Hydrologic Regime of the Water Inrush into the Kotredež Coal Mine (Slovenia, Yugoslavia)

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ABSTRACT

On March 4, 1981 a severe water inrush into the Kotredež coal mine occurred. Z. Kesserü already presented an outline of its hydrologic regime and of the proposed control measures at the congress of the IMWA in Granada.. Here we report about our analysis, prepared during the first year of the inrush, and present a discussion of these initial estimations and later observations.

Two peculiarities of the inrush allowed a quite reliable forecast. The first is the unusual geologic structure of the aquifer, and the second a spontaneous temporary obstruction of the inrush.

The Triassic basement of the Tertiary coal bearing sediments is composed of two quite different formations, a black shale and a highly permeable dolomite. During Tertiary tectonics the coal bearing strata were deformed into several narrow synclines. The dolomitic basement was cut into large blocks of limited horizontal extent, some of which protrude now from the deep lying basement high into the impermeable Tertiary cover and represent in many places dangerous aquifers for the coal mines of this region.

The outcrop of the dolomitic block at the Kotredež mine is so small that the surface water recharge is negligible. On the other hand, the underground water recharge from distant aquifers is quite large. As there are, even now 10 years after the inrush, no reports of declining yields of surface springs, a very large recharge area with negligible water table fluctuations must be supposed. Therefore a linear increase of the underground recharge with the drawdown of the water table at the Kotredež aquifer must be expected.

The second peculiarity of the inrush was the spontaneous obstruction that lasted three months and during which the rise of the water table could be measured. From changes of the water level immediately before and after the violent reopening of the inrush in Oct. 1981 and from its yield the recharge rate at this moment could be calculated.

For several simple models of the inrush the drawdown as a function of time was calculated. Owing to many unpredictable events (erosion and temporary parial obstruction of the inrush channels, drilling of drainholes at uneven intervals) and to the irregular and insufficiently known form of the aquifer an agreement of the calculated and observed functions could be expected only for shorter intervals. The observed yield of the inrush and of the drawdown during later years are in good agreement with the predictions.

Mine Water Risks in Open Pit Slope Stability

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ABSTRACT

Mine water risks are always present in slope stability in surface mine operations first, as water pore pressure or water pressure, and second, as water flow. In this paper, we shall present a brief theoretical background on both problems and some typical examples in mine water risks in open pit slope stability (Braćan-bauxite open pit, Šikulje-coal open pit, Smreka-iron open pit).

4th International Mineral Water Association Congress, Ljubljana (Slovenia)-Pörtschach (Austria), September 1991

Karst Water Systems and Coal Deposit Water Charge in the Northern Part of China

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ABSTRACT

In this paper, the northern part of China is hydrogeologically divided into 91 karst water systems. Among them, 52 systems have distribution of mine areas, including 47 coal mines, 20 iron mines and 1 copper mine.

The research work done on every system with coal mines was described as follows,

- Studying the water-governing regularities of regional tectonics, the rules of aquifers' sedimentation and the changes of their water content.
- Calculating the natural water resources of these karst water systems.
- Analyzing such conditions as deep karst, conduits, protective layers and depth of mining level below groundwater stage, which have influences on karst water getting into mine pits.
- Examining and corroborating the measured and prognosticated data with the above results, such as mine water inrush frequency and quantities, mine discharge and so on.

In the light of the research results obtained, karst water disasters of coal mines in the northern part of China have been classified and strategic pointviews countering 12 types of seams which are threatened with karst water put forward for coal exploration and water disasters control.

This paper is a part of the report of research program, KARST WATER IN THE NORTHERN PART OF CHINA, which was completed by the authors and colleagues from Ministry of Geology and Mineral Resources, China State-owned Coal Mine Corporation, Ministry of Metallurgy and Nonferrous Metallurgy Corporation.

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Hydrogeomechanical Problems in Mining

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ABSTRACT

The hydrogeomechanical problems of mining are considered, which deal with rocks and ground water as a single mechanical system. Among these problems are the open-pits slopes stability, rocks consolidation and surface subsidence due to ground water levem lowering, water inrushes into mine workings, rock bursts prevention by using the water injection into the advance boreholes, etc. The paper contains the basic theoretical grounds, as well as in-situ and laboratory methods for the investigation of these processes.

The combined study of ground water regime and rock deformations has resulted in the theoretical substantiation of the hydrodynamic and geomechanical processes within the scope of unique scientific direction-hydrogeomechanics (1). The hydrogeomechanical models are widely used now for the analisis and forcasting the extremely important processes connected with the safe and efficient minig operations, as well as with the proection of geological medium. Among these processes are:

- deformations of the open-pit slopes and spoil dumps;
- consolidation of rocks due to the ground-water pressure drop;
- water-and-rock material inrushes into mine workings caused by deformations of the undermined rock mass;
- geodynamical processes due to the changes in ground water regime;
- artificial hydrofracturing in rocks;
- transformations of clay linings under the tailing ponds and other technical water basins.

Constructional and Exploitation Features of Dewatering Wells in the Kreka Coal Basin

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ABSTRACT

Coal Mining in the Kreka Coal Basin is directly dependant on the dewatering degree of water bearing seams, accompanying productive coal seams. Along with a long-lasting development of both underground and surface mining, the system for previous dewatering have been developed as well, the basic components of which are hundreds of deep wells.

Complexity of montane-geologic and hydro-geologic conditions of the basin, along with different technical-technological factors, requested an optimal selection and adaption of constructional features of wells in certain conditions, so, different types of wells have been developed according to the following basic features:

- construction technology (methods of direct or reverse flushing)
- number of captures (one-degree or multi-degree wells)
- well depth and diameter
- method of installed well construction (characteristics and profiles of protectional-exploitational casings, enforced construction, cementing, etc.)
- kind and method of capture "organ" of a well processing (characteristics of filtering construction, widening in the interval of a water-bearing seam, characteristics of filter stowing, mechanical, chemical and hydraulic processing of a capture portion etc.)

In the drilled wells, we have done numerous experimental pumping for the determination of filtering features of water-bearing seams and their spatial distribution, as well as for the determination of hydraulic features of wells and their experimental parameters.

We have analyzed basic hydraulic characteristics of the wells:

- specific capacities and lowerings (Q/S relationship)
- exploitation capacities of the wells in individual and group operation
- hydraulic resistance and well loses
- flow regimes in the pre-filtering zone (mechanical and chemical choking up, erosion, foundation failure etc.)

The paper is giving a picture and systematization of the constructed wells, based on different criteria, but in the first place, based on constructional and hydraulic exploitation parameters.

The Surface Collapses in Mineral Deposits Bearing Karst Water in China

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ABSTRACT

This paper gives a brief introduction about surface collapses in mineral deposits bearing karst water in China.

The surface collapses was caused mainly by pumping, water invasion, dewatering and drainage of mines in karst mining areas. It is a special phenomenon in mineral deposit bearing Karst cave water. It's also a outstanding problem of hydrogeology, engineering-geology and geo-environment in the limestone covered by the shallow Quaternary sediments.

There are more than two million square kilometres of carbonate rock in China, in which mineral deposits bearing Karst water are wide-spread. So far, there are ninety-four place where surface collapses have been discovered in mining areas. There are about twenty-three thousands nine hundreds and forty-one points of surface collapses in which were occurred in South China. Only a few surface collapses are found in North China.

Surface collapses not only increases the water yield, water invasion, mud invasion which endanger safety of mines, but also deteriorate environment of mining areas.

In general, the distribution of surface collapse shows some regulations which is controlled by the Karstic development regularity. So that, also can be prognosticated and prevented.

Hydrogeological Research of VČSA Opencast Field

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ABSTRACT

This article summarises the results of hydrogeological part of VČSA opencast field research, which was carried out in the years 1981-1988.

Hydraulic and hydrogeological properties of basin sediments and above all of Krušne hory Mts. Slopes and basin underlying crystalline complex were tested.

Results of this research were used for the prognosis of groundwater-level decline in the years 1990, 2000, 2012, 2020, and 2030 as stages of working face progress.

It is possible to use the results for an eventual drainage works project for the VČSA opencast field.

Precipitations to Mine Infow Relationship as a Design tool for Mine Dewatering in Karstic Aquifer

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ABSTRACT

Aquifer dewatering imposed by mining activity creates within karstic and fractured aquifers large cones of depression, provoking thus substantial redirection of previously existing local or regional groundwater flow. At a design stage of a mine's underground operations extending or deepening or even at the mine's closing down design stage, successful prognostics on the water inflow rate and on the rate of its change depend in a complex hydrogeological structure very much on a correct analysis of the past inflow records. From these records one can deduce what part of the inflow originated from water storage within the drained parts of the aquifer, what was the part of the inflow originating from infiltration of precipitations and what part of the inflow should be attributed to other sources. All this information has to be later integrated into the required mine inflow prognostics.

To define the relationship between precipitations and aquifer discharge for the Mežica mine case we elaborated a method (and the corresponding software) based on stochastic approach to this relationship as known from karst aquifer research. By this approach, one is trying to define the equations governing with an acceptable error margin the output data on aquifer discharge or reserves on the basis of the input precipitation data without considering the physical meaning of the involved equation coefficients. In the Mežica case we extended the simple correlation function $Q = f(p)$ by a time variable infiltration margin $Q = f(p - (+-pn))$. By this one can treat also any other kind of time variable effects, such as snow melt or some other temporary aquifer recharge. By considering the aquifer recharge from the infiltration as a periodical function of changing intensity, lagging the respective precipitation event by a given time lag, we have analyzed the extent of correlation between the total precipitation P of time periods of different length, and the mine inflow Q, lagging these precipitation periods for different time lags L. The results are graphically displayed as a correlation function $r = f(L,P)$. With this analysis we found that the rain influences the mine inflow with a lag of max 7 days (melting dependent snow lag excluded). If we consider periods up to one year, the mine inflow is mostly influenced by the rain of the last two months (with a 7 days lag). Longer periods show, that the mine inflow of a given period can be totally defined by the precipitations of the preceding two years. The maximum response time of the aquifer towards precipitations can therefore be defined as 2 years. With these results we were able to define the mine inflow from a karst aquifer with otherwise stabilized cone of depression on the basis of sole the precipitation data. Adding the data on aquifer storage derived from the past events of mine deepening and roadway development, we were able to make the necessary prognostics.

Though the equation coefficients given in the article are case related, the exposed method and equations are applicable to other similar hydrogeological conditions.

Impact of Mining on the Groundwater Chemistry in the Upper Silesian Coal Basin (Poland)

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ABSTRACT

The Upper Silesian Coal Basin (USCB), 7500 km^2 area (including 5500 km^2 in Poland), is situated in the Variscian Upper Silesian intermontane depression. Coal - bearing Upper Carboniferous rocks occur beneath the permeable Mesozoic and Quaternary sediments in the NE part of the USCB and the impermeable clay Tertiary series in the southern and north - western parts.

Studies on hydrogeochemical environment showed a normal vertical and horizontal hydrogeochemical zonality in the extent of the basin. This xenolith is characterized by changes in mineralization and chemical of waters along circulation routes. Strongly mineralized waters of isolated structures represent brines of the type Cl-Na and specially Cl-Na-Ca. There is noted a general trend to increase of mineralization along with depth of occurrence of waters independently of age of the strata. The general regularity is disturbed by the phenomena of hydrochemical inversion mainly due to the mining activity.

In the USCB coal deposits have began to be intensively exploited as early as the XVIII century. The coal seams are exploited by the underground mining, mainly by the longwall system, down to the average depth of 650 m and 1200 m at the most. The steadily growing depth of exploitation and the opening of new mining levels increase the extent of drainage by mines and amounts as well as salinity of pumped out water. The total quantity of water pumped out of mines equals 724 m^3/min. Area of decreased piezometric heads, because of the mine drainage, covers about 2000 km^2. The coal mines carry workings in different hydrochemical zones. Therefore pumped mine waters vary chemically significantly. Mineralization of natural mine water ranges from 0.2 to 372.0 g/dm^{-3}.

The artificial hydraulic interconnections created by mines activities and deep drainage cause changes in the natural hydrochemical regime of groundwaters. The desalination effect caused by mining activity depends mainly on the depth and size of mining, duration of exploitation, drainage activity and geological conditions of the USCB.

The present hydrochemical xenolith in the USCB determined by the mining impact is shown on the maps of groundwaters mineralization at the depth of 500 and 750 m, as well as on the map of the depth of the occurrence of saline waters (35 g/dm^{-3}).

There is found a close dependence of mineralization of waters in the Carboniferous within the coal fields on type of overlaying rocks as well as degree in which the rock massif is affected by mining works. The maximum salinity of waters was found in depressional structures under the cover of sealing Tertiary rocks, Horst structures not covered by the Tertiary and affected by mining works for over a hundred years are characterized by a marked desalination of waters to the depth about 500 m.

Karstwater Inrush in Kanižarica Coal Mine as an Example of Problems and Solutions Related to the Inrush Blocking Activities

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ABSTRACT

In the first half of January 1990 a karstwater inrush occurred in Kanižarica brown coal mine. The inrush originated through an uncased research & dewatering borehole drilled into a fault zone from a development roadway opening a new section of the mine. This borehole was directed obliquely through a tertiary bottom wall protection layer towards a cretacious basement. The bottom wall protection layer is constituted mostly of unerodable calcareous marls but also of some erodable layers formed of clay and clayey coal. Cretaceous basement is built by karstified limestones and represents a karst aquifer of very high yield. Calcareous marls of bottom wall protection layer are impervious when unfractured, but when fractured in fault zones they may become quite pervious, thus representing a low permeability aquifer. Clays and clayey coal are impervious and, as far as clays are considered, swelling, but erodable under high flow conditions. By the inrush process the upper part of the borehole, drilled in coal and clayey coal, was eroded and within some hours the inflow reached a discharge rate of over 5 m^3/min. The subsequent erosional process in the lower part of the borehole, built of calcareous marls, was slow. The discharge rate was therefore slowly growing towards a peak discharge of about 8 m^3/min just before the inrush was blocked by the end of march 1990.

Parallel and only 30 m away from the development roadway in which the inrush occurred an other roadway was previously successfully constructed through the same faulted zone with the help of dewatering boreholes that were locally draining the calcareous marls of the protection layer, thus increasing its stability. Together, these boreholes were yielding only about 0.4 m^3/min of water.

First try of blocking the water was made with wooden pillar built close to the inrush site in the permanized part of the roadway. In that part the roadway was constructed with concrete blocks in clays and clayey coal and due to high rock stresses ought to be additionally reinforced by TH steel supports. But a rise of water pressure of only 1 - 2 bars behind the wooden pillar, when the discharge pipes were accidentally blocked, started a seepage process behind the concrete blocks at the top of the roadway, provoking thus a strong erosion and caving of the clayey hanging wall strata of the roadway.

Kanižarica brown coal mine is a small mine with a yearly production of about 120.000 tons of 16 GJ coal and a total water inflow of about 1 m^3/min. Nearly 20 years ago the mine was flooded and since than it disposes of installed pumping capacities (with 100 % reserve capacity included) of 8 m^3/min. The inflow of the material from combined action of caving-in and erosional process was filling up the roadways and endangering the existing pumping station. The blocking of this inrush was temporary made by means of two concrete bulkheads built in both parallel development roadways on preliminary selected and equipped sites thus allowing a quick and effective action. Finally, the fault zone, yielding the water to the borehole, was grouted from the surface. In this article the authors report and comment the problems and solutions related to this inrush.

4th International Mineral Water Association Congress, Ljubljana (Slovenia)-Pörtschach (Austria), September 1991

Multipurpose Use of Mine Water as a Means of Reducing Dewatering Costs in a Coal Mine

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ABSTRACT

Underground mining of coal in the Kotredež brown coal mine requires a continuous pumping of water from a dolomite aquifer within the frame of an active water inrush protection policy. Water inflowing rate is 133 - 140 l/sek, with mean temperature of water being 24-26°C. With current mine production rate at approximately 260.000 tons/annum of 12 GJ/ton coal and the lifting height of pumped water close to 500 m, the water pumping costs are heavily burdening the overall production costs.

The actual mine dewatering system pumps to the surface a mixture of waters originating from the technological process, from the old man, from the subsided and broken overburden strata and from the dolomitic bottom wall aquifer. Though about 90 % of this water originates from the dolomitic aquifer as a clear water, it is due to the existing mixing of waters lifted to the surface as a polluted water, which can only be discharged into the local stream. A parallel dewatering system tapping the water in the dolomitic aquifer would enable the use of this water as a low enthalpy energy resource and its subsequent or alternative use for water supply purposes. Such a solution would reduce the existing dewatering costs of coal production by integrating them into the costs of the newly developed resource. However, it would require an additional investment into a parallel dewatering system.

From a technico-economical analysis it follows that a separate dewatering system, consisting of a dewatering shaft or incline, both sunk from the 6. horizon of the mine and equipped with submersible water pumps, were the most appropriate solutions in the Kotredež mine case. An analysis of the investment-return costs of the dewatering system and of the energy converting and distributing facilities shows that the return periods would lye between 10 and 14 years for the entire system, the actual return period depending on the extent and modality to which the water would be used also for the water supply purposes. Even in the case of a progressively diminished or stopped mining activity, the operation of that part of the dewatering system which would be directly draining the dolomitic aquifer could remain economically feasible.

This article exposes the basic ideas that support such a solution of multipurpose use of mine dewatering water from hydrogeological, hydrogeothermal, mine-design, water & energy consumption aspects and from an economic viewpoint.

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Deep Piezometers Equipped with Absolute Pressure Cells as a Means of Increased Safety and of Reduced Data Acquisition Costs in Velenje Mine

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ABSTRACT

Over 170 observation wells with depth s ranging from 5 - 600 meters were drilled into the various aquifers within the Velenje mine area during the last 30 years. Since ground waters in the pliocene multiaquifer system are corrosive due to the high dissolved CO2 content, most of the observation wells older than 10 years (and in some cases even younger ones) show erroneous piezometric head values due to the corrosion of their casing. Though some attempts were made to introduce corrosion resistant high grade PVC or stainless steel casing and screens also to the observation wells, its introduction never succeeded; this was due either to the import restrictions or to the price incompatibility imposed by high import taxes.

Most of these observation wells were single observation wells cased with 2" or 3" zinc coated steel pipes. Multiple observation well construction trials failed mostly due to the problems with sealing of individual piezometers. A secondary, but not an unimportant, factor was a relatively high cost of such observation wells as proposed by the local drilling contractor.

A specific problem, regarding the durability of the observation wells, represents surface subsidence and caving of the overburden strata resulting from underground thick coal seam mining with sublevel caving as mining method. Due to this, all observation wells have to be grouted prior to their entrance into the caved area. Poor grouting of old observation wells with corroded and damaged casing and therefore often limited access to the well's bottom is considered to be a possible water inrush cause. An even worse case, already encountered, is a complete lack of grouting due to a human omission. Therefore, if a solution were found which would enable us to overcome the problem of observation well terminal grouting, this could be very rewarding to the mine operation safety.

All these factors forced us to seek a solution which would in the same time reduce the overall costs of the observation wells and eliminate the problems related to the terminal grouting of these wells. As a result we developed a multiple piezometer, equipped with piezoelectric absolute pressure sensors. Up to 4 (of possibly 7) pressure sensors per piezometer were built-in to a maximum depth of 600 m. With technical and technological problems of such a construction solved, we managed to install a 4-sensor multiple piezometer for the cost of a classical single observation well, the costs of terminal grouting, which generally occur years later, being a net gain. The overall costs per a piezometric head data collection point of a multiaquifer system were thus substantially lowered and all safety problems related to the terminal grouting were eliminated.

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Karstaquifer Storage as a Means of Reducing Mine Dewatering Costs of Underground Mine Operations

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ABSTRACT

Mining activity in several Slovenian underground mines is conditioned by a substantial karst or fractured aquifer water level lowering. Extensive water pumping is necessary in order to achieve the required local depressions within these aquifers and very often, as a result, water table conditions locally occur. Pumping represents a heavy economic burden for these mines and different solutions are sought to reduce the costs of pumping. One of them is the use of the natural storage capacity of karst or fractured aquifers under water table conditions for temporary storage of the water flowing into the mine. The use of natural storage capacity of such aquifers may be economically feasible when a system of double pricing is used in a country in order to promote the use of electric energy out of the hours of its peak demand, as it is probably the case in most industrially developed countries.

Within this article the cases of Mežica and Kotredež mines are used as an example to demonstrate the principle, the necessary hydrogeological background and the effects of such an approach, known in aquifer system management also under the term of aquifer discharge regulation by means of temporary aquifer overpumping. To take advantage of the natural karst or fractured aquifer storage, the water level in this aquifer should be kept oscillating under the maximum water level permitted by safety or some other production criteria which is even more restrictive. Gains in energy costs are partially outdone by the additional water lifting costs and by the costs of additional investments in pumping capacity and dewatering shafts, inclines, wells or galleries. On the other side, these investments can be compensated by the fact that no water galleries, legally imposed to provide the extra storage capacity for mine operation safety in the case of electropower failures and shortcuts, are no longer needed. However, it is shown that under the hydrogeologic and economic conditions met in these two mines, the achieved reductions in dewatering costs may lye between 5 and 10 % of the overall pumping costs, a percentage certainly not to be discarded.

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Application of Environmental Isotope Technique to Analysis of Water-Filled Coal Mine Area, Pindingshan City, China

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ABSTRACT

Pingdingshan Coal Mine Area lies in the western part of Henan Province, and the No. 7 mine is located at the area of south-west corner. With the increase of the mining depth, the threat of karst water from aquifer floor becomes more and more alarming to the mining. Employing environmental isotopes in hydrogeological techniques, we undertake some researches on the hydrogeological conditions of the coal mine area.

Through the complete and systematic analysis upon the atmospheric precipitation, hydrochemistry of the surface-water and groundwater, oxyhydrogen isotopes, we have ascertained: a) the creating, distributing and migration laws of the groundwater in No. 7 mine; b) the recharge sources and the combination mechanism of the mine-water; and c) the proportion of the youthful water in mine water and its age by separating the component of the mine water.

The researches reveal that the major recharge source of the groundwater of No.7 mine is surface-water, and more specific speaking is the impulsively concentrated, water-release recharge from the draining channels of reservoirs, and the perennial river leakage recharge of which the leakage zone are Cambra limestone exposed in the channels and the river valleys. The youthful water recharged that year accounted more than 90 percent of the total amount of the discharging mine-water, while the ages of water in different aquifers ranged from 1-2.2a. This research provides scientific basis for making plan of the mine-water control.

In-Situ Rock Parameter Measurement and Computer's Finite Element Analog-Model Methods in Researching Water Inrushes in Protective Layers of Coal

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ABSTRACT

On the basis of founding geology models and mathematics models of mining faces, cooperating various data in situ rock parameter measurement of protective layers of coal in mining process with simulating results of computer's two dimension finite element method, the writers take completely situation of stresses distribution in protective layers of coal in course of mining and use computer to imitate and analyze the various factors that affect deforming and cracking of protective layers of coal, giving out quantitative evaluation. Then give out a new elaboration on mechanism of water inrushes in protective layers of coal, and establish new water inrush judgement norms. According to this principles, we have done first application in foretelling water inrushes at three mining faces and have taken obvious effect.