Health hazards of South African mine water

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SYNOPSIS

The water supply in South African mines is not as good as most mining engineers would like to believe, nor is sufficient care taken to ensure the safe dispensing, transportation, and consumption of water. As long as cases of dysentery and typhoid continue to occur in large numbers, it can be assumed only that the water supplies are not safe, or that the water-dispensing methods are poor. A dual water supply is a real health hazard. The ideal water supply is a single safe source for human consumption and industrial use.

SAMEVATTING

Watervoorsiening in Suid-Afrikaanse myne is nie so goed soos die meeste myningenieurs graag sou wou glo nie en daar word ook nie genoeg sorg aan die dag gelê om die veilige beskikking oor vervoer en verbruik van water te verseker nie. So lank daar steeds gevalle van disenterie en ingewandskoors in groot getalle voorkom, kan daar net aanvaar word dat die watervoorrade nie veilig is nie, of dat die metodes om oor die water te beskik, swak is. 'n Dubbele watervoorsieningstelsel is 'n wesenlike gesondheidsgevaar. Die ideale watervoorsiening is 'n enkele veilige bron vir menselike en nywerheidsgebruik.

Introduction

Mines obtain their water from fissures in the rock underground, or from surface when sufficient underground water is not available. Some mines have an excess of water and have to pump millions of litres to the surface, whilst others are short of water. Mines with excess water have a high dilution factor in their favour, whereas mines short of water have to re-circulate their industrial water, which often becomes heavily polluted. Occasionally, a good supply of fissure water is available in one area, where it can be conveniently led into a large dam underground and circulated throughout the mine for industrial use and occasionally for human consumption. This water must be checked and chlorinated. One mine in the Stilfontein district has this system, and all the water collecting at the bottom of the mine is pumped to the surface to a water-treatment plant. After treatment, it is used on surface and at times some is sent back into the mine if extra water is required. Thus, the mine has a single safe water supply both for industrial and human consumption.

However, most mines have to introduce potable water into the mines for human consumption. The distribution of this water is largely dependent upon the type of mining practised: concentrated long-wall mining frequently has the potable-water pipe close to the working area, whereas scattered short-wall mining does not always have safe water close at hand. In most cases, gold mines have dual water supplies, i.e., potable water for human consumption and fissure water for industrial use. The industrial water is available all over the mine, but the potable water is often some distance away from the work site.

The average water requirement is 3 litres per man per shift in South African gold mines, which have a hot working environment. The industrial water requirements vary from 1000 to 4000 kg for every 1000 kg of rock broken.

Hazards to Health

Public health authorities have always been very concerned about dual water supplies where one is inexpensive and inferior in quality but satisfactory for general garden and industrial use, and the other is of a high quality fit for human use. Even when the community served is careful and intelligent, the hazards are considerable because of the ever-present possibility of interconnection. In gold mines, there is the extra danger that potable water is not always available on site, and people are prepared to drink industrial water because they have found that it is not as bad as they have been told and, in any case, if water comes out of a pipe, they regard it as fit for drinking.

The industrial water at the mines at present is not very palatable, mainly because it is relatively warm, but cold industrial water is to be used in the near future to improve the environmental temperatures. The workers will then probably prefer to drink the cold water. The safest and most economical way of supplying safe water would then be to have water-purification plants on surface that are associated with water-cooling towers to provide cheap, safe industrial water.

The potable water supplied at South African gold mines is often accepted as such by mining engineers with very little thought that it can ever be dangerous. But pollution can take place; for example, by short circuiting with industrial water, by pollution during servicing, by poor control of the underground transportation of potable water in water tankers or carts. If the sources of potable water are a long distance from the working site, the water carrier is easily tempted to fill the tanker with water close at hand, which is usually industrial water. Sometimes a hose is attached to the potable water supply to make filling of the tanker easier. Unfortunately, the hose often lies in a drain or on the dirty floor and so easily pollutes the potable water being tapped. Sometimes the taps on the water carts become jammed, and this results in workers using a communal cup to scoop water out of the tank. It is easily appreciated that their hands are rinsed by the water in the tank, and in no time the water presents a real hazard. The habit of passing a can of drinking water through a stope at regular intervals with one or two cups is another insanitary practice that should be discouraged.

Some mines have problems with the dual water system

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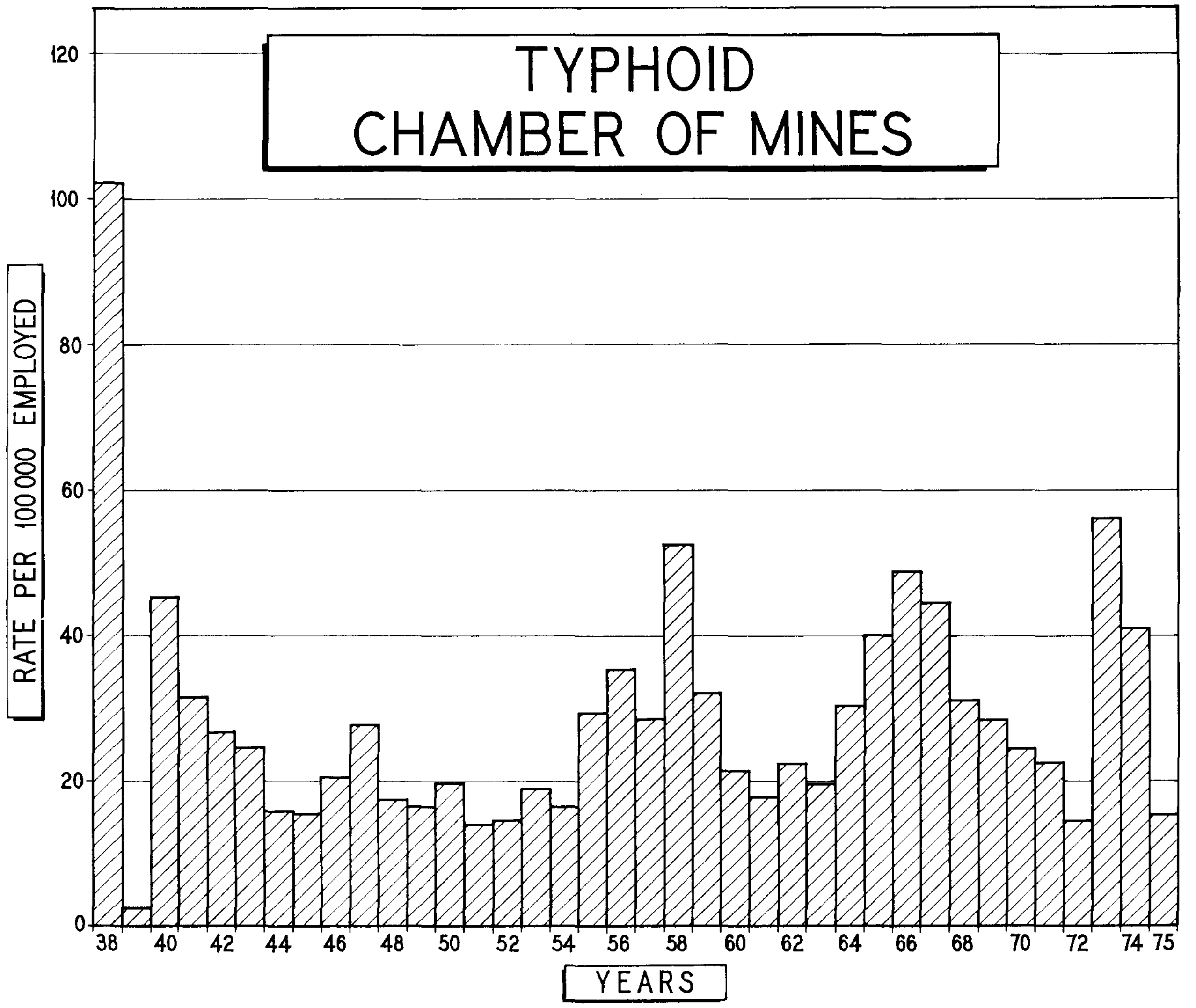

Fig. 1—The occurrence of typhoid in South African gold mines from 1938 to 1975

on surface, when the industrial water used on gardens is not always safe. Although the industrial water points for fire hydrants and gardens are clearly marked *Dangerous and not for human consumption*, it has often been noted that children and adults when hot and thirsty will drink this water.

The reduction works occasionally have problems with the industrial water used in their plants because of excessive amounts of oil and detergents polluting the water.

A list of common enteric, bacterial, parasitic, and viral diseases that can be transmitted via water to man are listed in Tables I and II. Three bacterial diseases important in the mines are dealt with here: typhoid, dysentery, and cholera. All are preventable diseases and are almost non-existent in developed countries.

TABLE I

PRINCIPAL ENTERIC, BACTERIAL, AND PARASITIC DISEASES TRANSMITTED BY WATER

Disease	*Causative organism*
Cholera	Vibrio cholerae including bio-type el-tor
Typhoid fever	Salmonella typhi
Paratyphoid fever	Salmonella paratyphi A. B. and C.
Bacillary dysentery	Shigellae
Amoebic dysentery	Entamoeba histolytica
Round worms	

TABLE II

PRINCIPAL VIRAL DISEASES TRANSMITTED BY WATER

Infectious hepatitis
Adenoviruses
Coxsackie A and B
E.C.H.O.
Poliomyelitis
Reo viruses

Although the gold-mining industry in South Africa has been in existence for over 80 years, typhoid is still an endemic disease on the mines. As recently as 1973, there was an epidemic of typhoid at a gold mine, where 106 cases were diagnosed between April and May of that year. As shown in Fig. 1, epidemics of typhoid occurred during 1938, 1940, 1958, 1966, 1967, 1973, and 1974. Although it is still a killer disease, the availability of effective antibiotics has made it less serious than previously.

The dysentery occurring in the mining population includes amoebic and bacillary dysentery, and, as shown in Fig. 2, occurs excessively. The rate of occurrences of dysentery in the gold mines is far too high, and, as long as dysentery occurs in these numbers, typhoid cases can be expected.

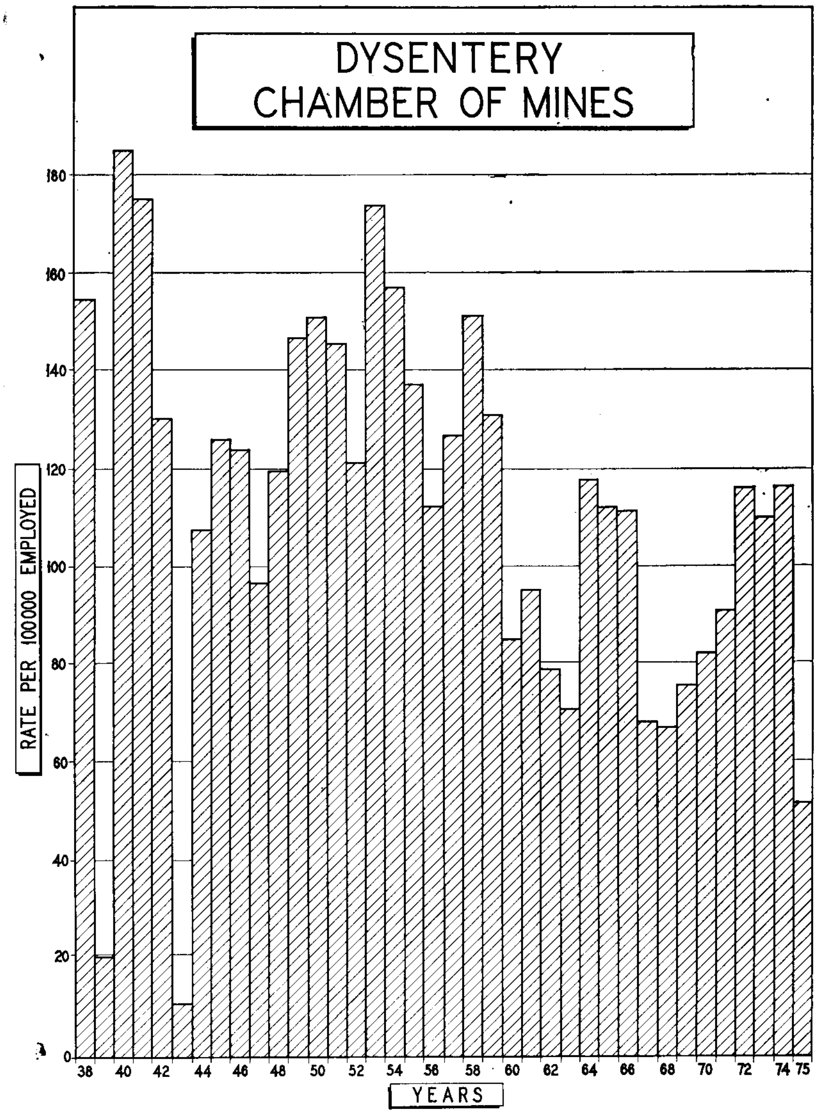

Fig. 2—The occurrence of dysentery in South African gold mines from 1938 to 1975

To prevent the occurrence of typhoid in an industrial population, one must realize that typhoid organisms leave the body via faeces and urine and infect man when he ingests them via food, including milk or water, that has been contaminated from these sources. Typhoid organisms are in the body and are excreted by acute cases of typhoid fever, by patients during convalescence after typhoid fever, and by carriers of typhoid. The faeces can be infectious from the beginning of the disease, when the patient may feel only out of sorts, so that the infection is easily spread via food, hands, and water during this period.

Occasionally, after a case has been treated, permanent carrier states can be established and relapses may occur with a further source of infection. Carriers are persons who excrete the typhoid organism but are asymptomatic and feel fit and well. There are three types of carriers: those who regularly excrete the organism, those who occasionally excrete the organism, and sub-clinical cases (people who feel well but have active typhoid).

In a study carried out by the author in 1960 to 1963, 1358 food handlers were investigated, and in 11 cases typhoid organisms were isolated from the urine and/or stool. The organisms were found persistently in 4 of these carriers, who can be regarded as chronic carriers. The other carriers, considered sub-clinical cases, were identified by the typhoid organism in their urine. This survey showed that, of the Blacks employed in South African gold mines, 2,94 per 1000 workers were chronic typhoid carriers. When all 11 excreters are included as possible disseminators of typhoid, the rate is increased to 8,1 per 1000 Black workers.

It is important to note that the urine of 8 foodhandlers was infected with typhoid organisms, which emphasizes the importance of the safe disposal of urine. Not one person in this survey developed clinical disease. However, cases of typhoid had occurred during this period, the typhoid rate per 1000 men employed being 0,215; 0,179; 0,221; and 0,197. At some stage before they reported ill or were diagnosed these men excreted typhoid organisms and so added to the potential pool of infection.

In March 1974, one of the mines experienced a cholera epidemic in which 31 symptomatic cases and 32 carriers were identified, isolated, and treated. This has been the only cholera epidemic in South Africa and caused great anxiety at the mine, the neighbouring mines, and the adjoining town. Once again, water was the vehicle of transmission. The acclimatization centre on surface, where safe potable water was in fact available, was identified as the main focus of infection. Owing to unfortunate dispensing practices, the water became polluted. It was found that the water for regular half-hourly drinking purposes was provided in galvanized buckets, from which the water was scooped in cups. The water remaining in the buckets after issue was found to be heavily contaminated with faecal *coli*. Another unfortunate habit was that the buckets were filled from hoses connected to safe water taps, but the hoses lay on the floor of the chamber in water that was found to be heavily infected with cholera organisms and other faecal *coli*. The floors became infected from the sweat dripping off the workers' bodies after some of it had washed the faecally contaminated perineum areas of the body. The supervisory staff also became infected carriers during this period and so kept the cycle of infection going.

It should now be appreciated that there is sufficient infective material available in the working and living environment on South African gold mines to cause an infection of unprotected persons and so establish an endemic disease. Unprotected persons are those who do not have safe systems for the disposal of faeces and urine, and clean, safe food and water. Standards for safe water set by the South African Bureau of Standards are reproduced in Tables III to V, and these are the standards that should be aimed at.

TABLE III

STANDARDS FOR POTABLE WATER

Property	Recommended limit mg/l	Maximum allowable limit mg/l
Anionic surfactants (as Manoxol OT)	0,5	0,5
Chloride (as Cl)	250	600
Copper (as Cu)	1,0	1,5
Iron (as Fe)	0,3	0,7
Magnesium (as Mg)	100	150
Manganese (as Mn)	0,1	0,4
Phenolic compounds (as phenol)	0,001	0,002
Sulphate (as SO_4)	250	400
Dissolved solids	500	2 000
Zinc (as Zn)	5	15
Min. total hardness (as $CaCO_3$)	20	Not specified
Max. total hardness (as $CaCO_3$)	200	1 000
Min. pH value	6,0	5,5
Max. pH value	9,0	9,0

TABLE IV

TOXIC SUBSTANCES IN WATER

Constituent	Recommended limit mg/l	Maximum allowable limit mg/l
Arsenic (as As)	0,05	0,05
Cadmium (as Cd)	0,05	0,05
Cyanide (as Cn)	0,01	0,2
Fluoride (as F)	1,0	1,5
Hexavalent chromium (as Cr)	0,05	0,05
Lead (as Pb)	0,05	0,1
Nitrates (as N)	10	Not specified

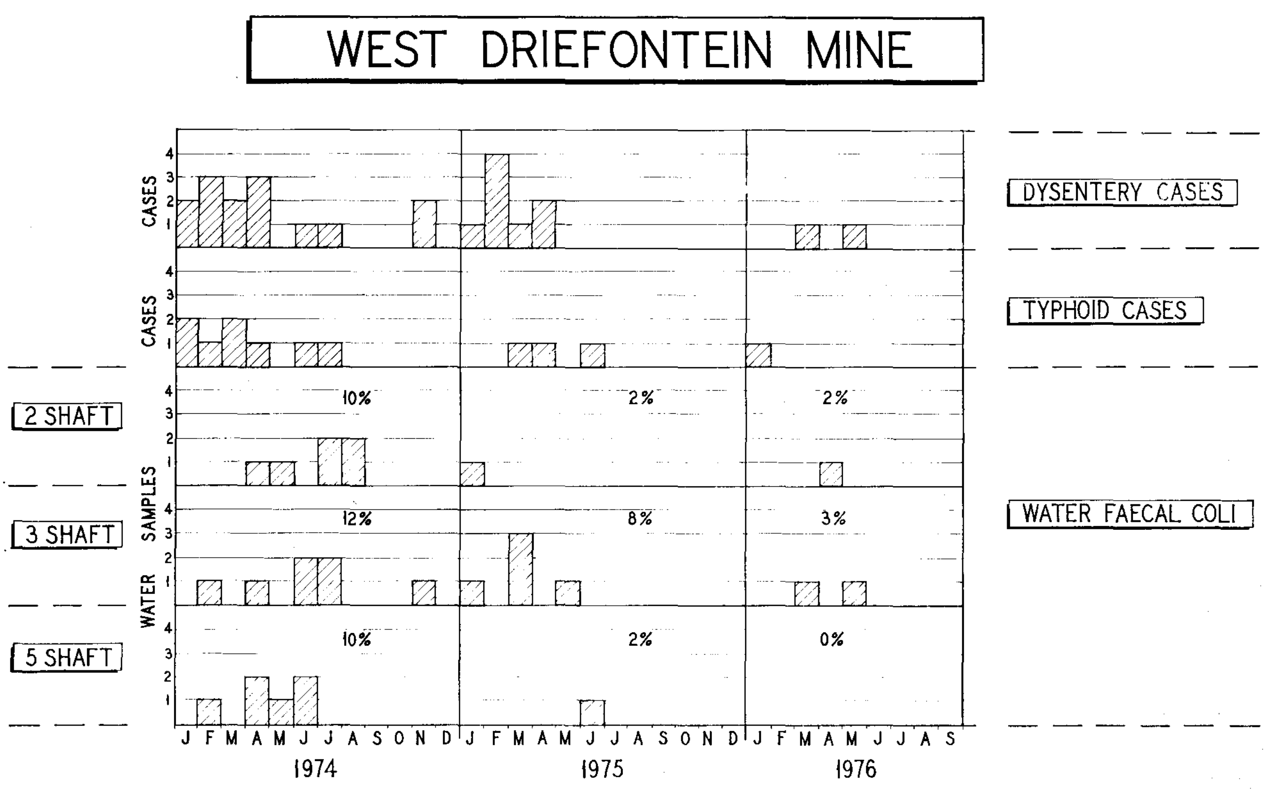

Fig. 3—Correlation of analyses of water samples with cases of dysentery and typhoid at West Driefontein Mine

TABLE V

BACTERIA IN WATER

Organism	Recommended limit	Maximum allowable limit
Coliform organisms, no. per 100 ml		10
E. Coli 1, no. per 100 ml	Nil	Nil
Total viable organisms, colonies per ml	100	Not specified

Causes of Water Pollution

On surface at the mines, there is water-borne sewage that provides for the safe disposal of human excreta, but underground there is still a mixture of sanitation systems, ranking from the pail to conservancy tanks, chemical latrine cars, and mobile gester latrines. The construction, supervision, and maintenance of underground latrines often fall far below safe health requirements; for example, the latrine is not always physically isolated and waste water and spillage enter mine water drains, supervision fails to prevent dumping of urine and faeces into drains (especially where buckets are used). Often the latrine area is not properly maintained, and there is a leakage of excreta and urine into drains. Frequently the latrines are too far from the working site or are unpleasant areas, with the result that the Blacks use old mine workings as latrines and this excreta is washed into the mine drain water. Regular checks of any mine drain water show human faecal contamination, but more so in the vicinity of the latrines. The water in the pump chambers is always polluted.

Another cause of faecal pollution of mine water is sweat. Sweat in the perineum area of the body washes off any faecal contamination of the surrounding skin, and, when one considers that at least $1\frac{1}{2}$ to 3 litres of sweat are produced per man at work, this is another real source of contamination of mine water.

Fortunately, not everyone drinking water polluted with typhoid or dysentery organisms will develop typhoid or dysentery, and the number of people infected is related to the available dose of the causative organisms. Therefore, explosive epidemics occur only when the dose of available organisms is high. Nevertheless, the mere fact that typhoid remains endemic in the gold-mining industry shows that the infecting agent remains in the population and environment, and ways of transmission are still available.

Mine drain water picks up organic material, dumped oil, and nitrous fumes that form nitrites, and ammonia. The nitrites and ammonia are strong reducing agents and come through the mine settlers unchanged. They are a nuisance when water is chlorinated because the chlorine is initially used to neutralize them before disinfecting the bacteria. In some mine water, up to 10 p.p.m. of chlorine are required before sufficient free chlorine is available for bacteriological action. This is why some mines find that chlorination is not effective. They are simply not providing sufficient chlorine for the water they are treating.

Since Gold Fields has been monitoring its water regularly with an ongoing and improving system of underground chlorination, the cases of typhoid and dysentery have dropped strikingly; but, because of the difficulties encountered with the varying qualities of mine water to be treated throughout the day and the week, cases continue to occur. This is illustrated in Fig. 3, in which analyses of water samples are correlated with typhoid and dysentery cases at West Driefontein Gold Mining Company.

Conclusion

It is the moral responsibility of modern industrialists, irrespective of the costs, to ensure that their personnel are protected from preventable diseases such as typhoid, dysentery, and cholera by providing safe water and safe facilities for the disposal of excreta. The medical profession can advise the engineers on what is required and, through health education of the population, attempt to ensure more responsible hygienic habits among the workers to prevent contamination of water. Pollution of water must be prevented and discouraged all the time, which will reduce the costs of purification for safe recycling purposes.

Water in underground works

On 18th to 22nd September, 1978, the National Association and the Superior Council of College of Mining Engineers of Spain will hold the International Symposium on Water in Mining and Underground Works (SIAMOS) in Granada. This Symposium has been made possible by the patronage of the University of Granada, the Hydrological Institute, the Superior Council of Scientific Research, the Spanish Geological and Mining Institute, and the National Water Well Association (U.S.A.). Steps are being taken to secure the sponsorship of other national and international associations and organizations.

Papers are to be grouped in the following sections:

— projects and works under the water table

— contribution of surface water to excavations and underground works

— role of water in the behaviour of excavations

— special techniques (freezing, injection, cementing, etc.)

— mathematical models applied to drainage systems

— other subjects.

The languages of the Symposium are Spanish, French, and English.

All enquiries should be directed to Prof. Dr. Eng. Rafael Fernández-Rubio, Director of the Work Group of Hydrogeology, Universidad de Granada, Apartado de Correos, 556, Granada, Spain.

NIM reports

The following reports are available free of charge from the National Institute for Metallurgy, Private Bag X3015, Randburg, 2125 South Africa.

Report no. 1776

The extraction of copper from copper–nickel catholyte by cation exchange. (26th Nov., 1975; re-issued Mar. 1977).

The work involved a laboratory study of the selectivity and capacity for copper of IMAC SYN 101 and Lewatit TP 207 resins. The sponsor had stated that the ion-exchange system could be incorporated into a closed process if the nickel content of the copper catholyte did not exceed 10 g/l and the additions of sulphuric acid and water did not exceed plant make-up rates.

The average results obtained to date are 43 g of copper and 3 g of nickel per litre of resin. These were obtained under the following conditions: a total number of bed volumes of 8 to 12, a temperature of at least 50 °C, and a flow-rate of 8 to 12 bed volumes per hour.

A mass balance based on a three-stage process is included for the whole copper-production circuit. The fixed-column separation entails three stages, i.e., loading, scrubbing (removal of entrained feed solution and loaded nickel), and regeneration (replacement of the loaded copper and a minor quantity of nickel with the use of recycled electrolyte from the electrowinning tankhouse).

Calculations showed that the circuit is very sensitive to the nickel carry-over into the copper circuit. The results for the resin loading covered a wide range (especially for nickel), and it seems likely that more laboratory work will be required if the project continues.

IMAC GT 73, a cation-exchange resin, which was tested for the removal of impurities from nickel catholyte, was found to reduce the copper concentration from 0,25 p.p.m. to less than 0,05 p.p.m. (which is the detection limit).

It was decided that a small resin column on-line with one of the cells should be installed at Bindura. Its effect in purifying the solution should be immediately apparent from the quality of the cathode.

Report no. 1830

The determination of iron in zircon beach sands and its leachability. (14th Jan., 1977).

The determination of iron in the range 0,05 to 0,20 per cent by spectophotometric, atomic-absorption-spectrophotometric, and X-ray-fluorescence procedures was examined. The methods finally developed give consistent results and have a precision varying from 2 to 5 per cent.

A preliminary examination was made in this application of emission spectrography with an induction-coupled plasma torch as the source. X-ray and emission spectrography were found to give the most rapid routine control, although the atomic-absorption procedure is currently the best referee method.

It was concluded that sample variability is insufficient to account for the wide differences normally observed in the analyses for iron by different laboratories.

The laboratory leaching test developed indicates that all the surface iron is removed after a digestion period of 1 hour in hydrochloric acid.

Report no. 1856

A study of model systems in anion exchange. (14th Jan., 1977).

Preliminary experiments are reported on the preparation and characterization of anionic sulphate and chloride complexes of UO_2^{2+} and iron(III), benzyltrimethylammonium cation being used as a model substance for the simulation of positive sites in an anion-exchange resin.

The structure of $(BTMA)_4$ $[UO_2Cl_3–O_2–Cl_3UO_2]$, a binuclear uranyl–peroxocomplex that has not been reported in the literature, was elucidated by single-crystal X-ray examination, and is described and discussed.

Report no. 1857

The determination of some trace elements in sulphide concentrates by spectrophotometry. (10th Feb., 1977).

The report describes the determination of trace amounts (as low as 1 to 10 p.p.m. depending on the element) of arsenic, germanium, molybdenum, nickel, phosphorus, selenium, tellurium, tin, and titanium in sulphide concentrates. The proposed methods, which are detailed in the appendices, are adaptations of established procedures that were modified to allow for the complex nature of the concentrates to be analysed.

Report no. 1865

A sensitive method for the measurement of osmium by atomic-absorption spectrophotometry. (15th Feb., 1977).

A sensitive method has been developed for the measurement of osmium by atomic-absorption spectrophotometry. With the use of simply constructed apparatus, volatile osmium generated in a small furnace is pulsed into a nitrous oxide–acetylene flame, permitting levels of osmium down to 0,2 μg to be measured. A large range of concentrations has been tested for many interferences. The best application for the method is as a sensitive means for the detection of osmium after osmium has been separated by distillation. For the determination of 5 μg of osmium, the method has a coefficient of variation of about 12 per cent.

Report no. 1869

The separation and determination of trace elements in iron ore. (26th Jan., 1977).

The separation, concentration, and determination of trace elements in iron ores are described. After the sample has been dissolved, the iron is separated by liquid-liquid extraction with a liquid cation-exchanger, di-(2-ethylhexyl) phosphoric acid. The trace elements aluminium, cadmium, calcium, chromium, cobalt, copper, lead, magnesium, manganese, mercury, potassium, sodium, vanadium, and zinc are determined in the aqueous phase by atomic-absorption spectrophotometry.

Report no. 1872

The determination of mercury by cold-vapour atomic-absorption spectrophotometry. (11th Feb., 1977).

This report describes an investigation into the determination of mercury, particularly in iron oxide and sulphide concentrates. The mercury is reduced by the addition of stannous chloride and is carried by a flow of air to the absorption tube, where its absorbance is measured and recorded on a chart recorder.

The optimum parameters affecting reduction and measurement (among them the concentrations of acid and stannous chloride, the time allowed for the reduction of mercury, the air flow-rate, and the sample volume) were established. In addition, a number of dissolution procedures in which use is made of various mixtures of acids (sometimes under pressure in sealed apparatus) were tested in an attempt to obtain satisfactory decomposition of samples and recovery of mercury. The possible interference from these acids and from thirteen probable interfering elements was also investigated. No severe interference was observed, and the method of additions was used to compensate for the minor levels of interference observed.

Methods are proposed for the dissolution of samples and the measurement of mercury in amounts between 10 p.p.m. and 0,1 p.p.m. The coefficient of variation at 3,4 p.p.m. was 5,3 per cent.

Report no. 1875

The determination of tungsten and iron in ferrotungsten alloys by X-ray-fluorescence spectrometry. (11th Feb., 1977).

An accurate and precise method for the determination of tungsten and iron in ferrotungsten alloys is described. Samples are prepared for analysis by fusion with sodium peroxide and sodium hydroxide in a zirconium crucible. The melt is leached in water and acidified with hydrochloric acid. The tungstic acid thus produced is brought into solution by formation of a complex with tartaric acid. Matrix correction and calibration are achieved by means of the single-standard calibration method, use being made of a reference solution for tungsten prepared from sodium tungstate and a reference solution for iron prepared from iron wire.

American Mining Congress

The 1978 AMC International Mining Show will be held on 9th to 12th October in Las Vegas, Nevada. It will offer opportunities to discuss mining problems and to inspect the newest equipment and technologies for more than 20 000 participants. They will represent metal mining, coal mining, industrial minerals operations, manufacturers of mining equipment, and government officials.

As part of the AMC's continuing educational effort, more than 75 technical papers will be presented. They will deal with open, underground, and undersea mining . . . energy . . . the environment . . . management . . . health and safety . . . mineral processing . . . and other topics of importance.

If you are interested in exhibiting products or attending the 1978 AMC International Mining Show, contact the American Mining Congress, 1100 Ring Building, Washington DC 20036, U.S.A.

GUIDE TO THE PREPARATION OF PAPERS FOR PUBLICATION IN THE JOURNAL OF THE SOUTH AFRICAN INSTITUTE OF MINING AND METALLURGY

The following notes have been compiled to assist authors in the preparation of papers for presentation to the Institute and for publication in the *Journal*. All papers must meet the standards set by the Council of the Institute, and for this purpose all papers are referred to at least two referees appointed by the Council.

Although the worldwide readership of the *Journal* results in a preference for papers in English, the Council treats papers in Afrikaans on an equal basis, but, to meet the needs of the majority of readers, an English summary of some 500 to 750 words should be provided.

STANDARDS FOR ACCEPTANCE

To merit consideration, papers should conform to the high standards that have been established for publication over many years. Papers on research should contain matter that is new, interpretations that are novel or of new significance, and conclusions that cast a fresh light on old ideas. Descriptive papers should not be a repetition of well-known practices or ideas but should incorporate developments that would be of real interest to technical men and of benefit to the mining and metallurgical industry.

In some cases, a well-prepared review paper can be of value and will be considered for publication. All papers, particularly research papers, no matter how technical the subject, should be written with the average reader of the *Journal* in mind, to ensure wide interest.

The amount of textbook material included in a contribution should be the minimum essential to the argument. The length of a paper is not the criterion of its worth, and it sh ould be as brief and concise as possibleconsistent with the lucid presentation ofthe subject. Only in very exceptional circumstances should a paper exceed 15 pages of the *Journal* (15 000 words if there are no tables or diagrams). Six to ten pages is more normal.

NOTE: Papers in the *Journal* are printed in 10 point type, which is larger than the 8 point type used on this page. For special publications, Council may decide on page sizes smaller than A4 used for this *Journal*.

The text should be typewritten, double-spaced, on one side only on A4 size paper, leaving a left-hand margin of 4 cm, and should be submitted in triplicate to facilitate the work of the referees and editors.

LAYOUT AND STYLE

Orthodox sequence

Title and author's name, with author's degrees, titles, position.

Synopsis, including a brief statement of conclusions.

An Afrikaans translation of the synopsis.

Introduction.

Development of the main substance.

Conclusions, in more detail.

Acknowledgements.

References.

Title: This shou d be as *brief* as possible, yet give a good idea of the subject and character of the paper .

Style: Writing should conform to certain prescribed standards. The Institute is guided in its requirements by:

Collins, F. H. *Authors & Printers' Dictionary*—Oxford University Press.

Hart, H. *Rules for Compositors and Readers*—Humphrey Milford (familiarly known as the *Oxford Rules*).

Fowler, H. W. & F. G. *The King's English*—Oxford University Press.

General: A few well-selected diagrams and illustrations are often more pertinent than an amorphous mass of text. Overstatement and dogmatism are jarring and have no place in technical writing. Avoid the use of the first person, be objective, and do not include irrelevant or extraneous matter. Avoid unnecessary use of capitals and hyphens; punctuation should be used sparingly and be governed by the needs of sense and diction. Sentences should be short, uninvolved, and unambiguous. Paragraphs should also be short and serve to separate basic ideas into compact groups. Quotation marks should be of the 'single' type for quotations and "double" for quoted matter within quotations.

Interpretations in the text should be marked off by parentheses ( ), whereas brackets [ ] are employed to enclose explanatory matter in the text.

Words to be printed in italics should be underlined *singly*. For small capitals they are to be underlined DOUBLY and for large capitals TREBLY.

If there is any problem in producing formulae accurately by typewriter, they should be handwritten in ink.

Abbreviations and symbols are laid down in *British Standard* 1991. Abbreviations are the same for the singular and plural, e.g., cm for centimetre and centimetres, kg for kilogram and kilograms. Percentages are written in the text as per cent; the symbol % is restricted to tables. A full stop after an abbreviation is used only if there is likely to be confusion of meaning.

Metric System: The Système International d'Unités (SI) is to be used for expressing quantities. This is a coherent system of metric units derived from six basic units (metre, kilogram, second, ampere, kelvin, and candela), from which are derived all other units, e.g., the unit of force is the newton (N) for kilogram metre per square second (kg m/s^2). Always use the standard metric abbreviations.

The comma must be used as a decimal indicator and must not be used for separating groups of digits. For ease of reading, digits should be grouped in threes counting from the decimal indicator towards the left and right. However, where there are only four digits to the left or right of the decimal indicator, there should be no grouping.

Illustrations: Drawings and diagrams are to be in black India ink and should be about 18 cm wide. When submitting graphical representations, avoid a fine grid if possible. Curves should be in heavy line to stand out. Lettering too should be bold, as a reduction in size is often involved in the printing process.

Numbering of tables should be in Roman numerals: I, II, etc., and figures in Arabic numerals: Fig. 1, Fig. 2, etc. (Always use the abbreviation for figure.) Photographs should be black and white glossy prints.

As a guide to the printer, the author should indicate by means of notes in the typescript where tables and figures, etc. are to appear in the text.

Paragraphs: A decimal system of numbering paragraphs may be used when the paper is long and complicated and there is a need for frequent reference to other parts of the paper.

Proof correction: Galley proofs are sent to authors for the correction of printers' errors and not for the purpose of making alterations and additions, which may be expensive. Should an author make alterations that are considered excessive, he may be required to pay for them. Standard symbols as laid down in *British Standard* 1219*C* should be used.

SYNOPSIS

It is most important that the synopsis should provide a clear outline of the contents of the paper, the results obtained, and the author's conclusions. It should be written concisely and in normal, rather than abbreviated,English, and should not exceed 250 words, except when an English summary of an Afrikaans paper is involved. While the emphasis is on brevity, this should not be laboured to the extent of leaving out important matter or impairing intelligibility. Summaries simplify the task of abstractors and therefore should present a balanced and complete picture. It is preferable to use standard rather than proprietary terms.

FOOTNOTES AND REFERENCES

Footnotes should be used only when they are indispensible. In the typescript they should appear immediately below the line to which they refer and not at the foot of the page.

References should be indicated by super-script, thus . . .[1] . . .[2]. Do not use the word *Bibliography*. When authors cite publications of other societies or technical and trade journals, titles should be abbreviated in accordance with the standards adopted by this *Journal*.

GENERAL

The Council will consider the publication of technical notes taking up to three pages (maximum 3000 words).

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