# 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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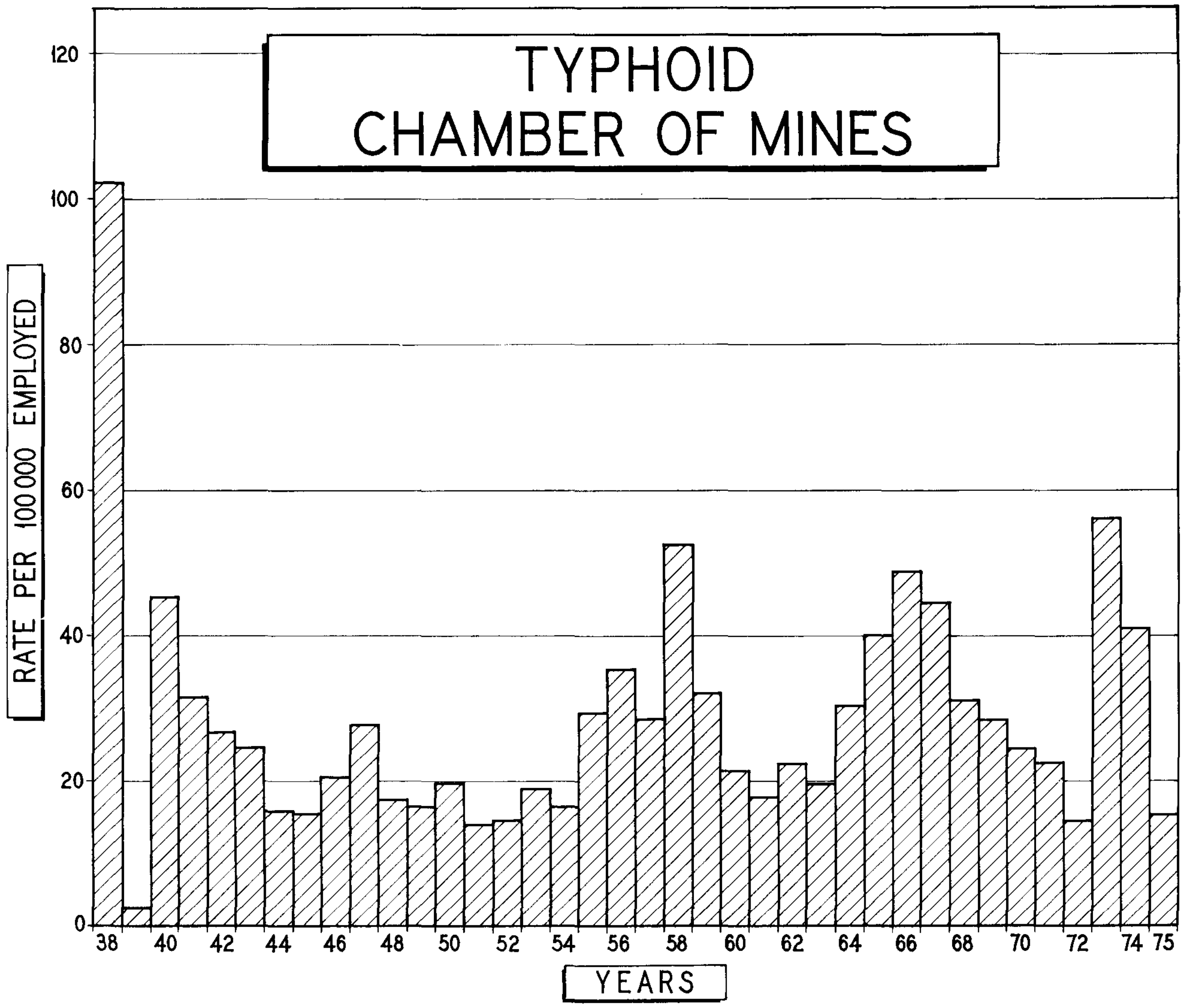


**Fig. 1—The occurrence of typhoid in South African gold mines from 1938 to 1975**

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.

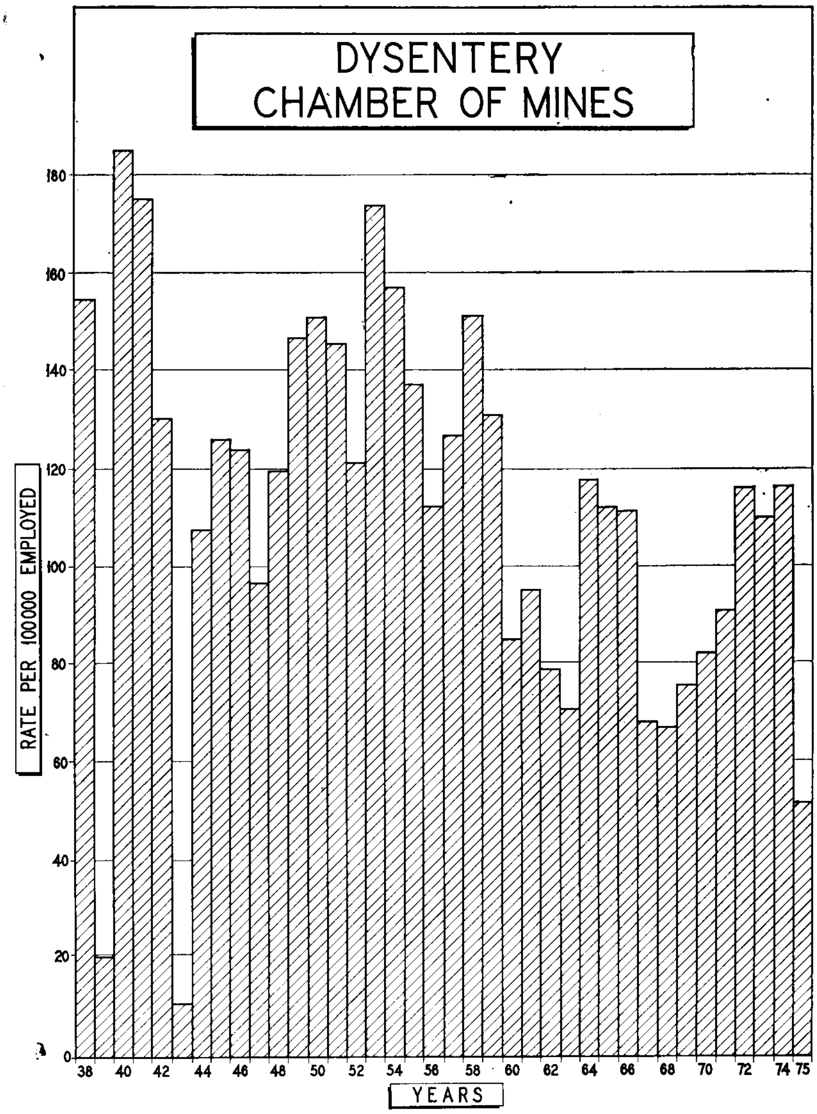


**Fig. 2—The occurrence of dysentery in South African gold mines from 1938 to 1975**

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 |

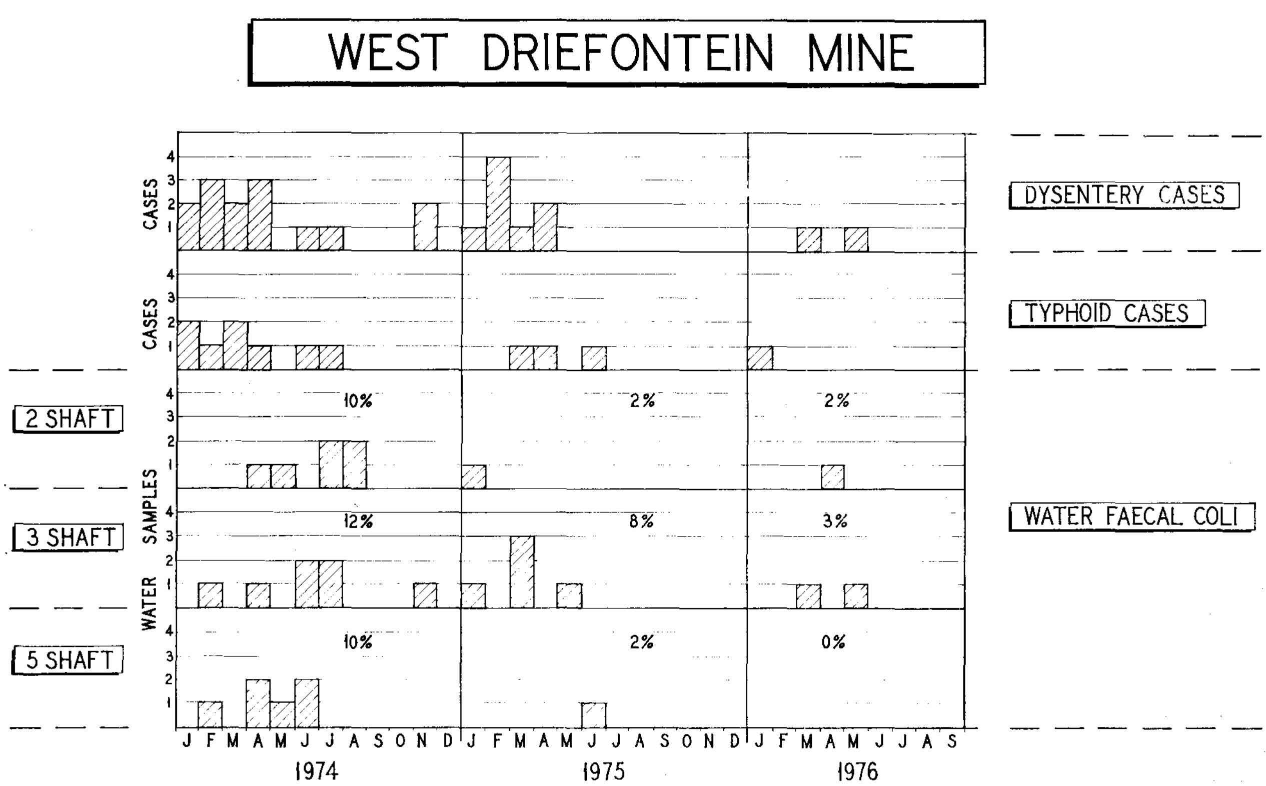


**Fig. 3—Correlation of analyses of water samples with cases of dysentery and typhoid at West Driefontein Mine**

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.

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