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Presidential Address: The mining engineer in a new Africa

by O.K.H. STEFFEN*

Introduction

Significant political and economic changes have taken place in our society in the past year that are going to impact on our minerals industry, and therefore also on our members. Surely, it is not coincidence that the economic and political changes have occurred simultaneously? South Africa, by virtue of its infrastructure and technology, is strategically placed to develop the potential of Africa's mineral wealth. In this address, I give my personal views on the ability of the mining industry to participate in the wider mineral resources of the African continent.

Firstly, consider the parameters that have changed.

- No matter what one's political viewpoint, there is no disputing that South Africa's relations with other African states have improved dramatically. This change has opened doors and created additional opportunities for business in these countries. Unless we seize these opportunities and develop a momentum of active participation, such trends can easily be reversed.
- Economically, like many other African countries, we have suffered the ills arising from a lack of confidence on the part of investors and, presumably, from many other things on which I am not qualified to comment.

The net result of all these factors is a declining rand and high inflation rates. Fig. 1 compares the inflation rates of the major mining countries in Africa.

The many complications of human ambitions and aspirations in a developing economy such as ours result inevitably in a high inflation rate. For our products to remain competitive on the world market, we have to make sacrifices in our standard of living unless we can increase the volumes of sales and improve productivity. Compared with the economies of the Western World, South Africa is favourably positioned to provide more affordable participation to other African countries. This position should be utilized to the full while it lasts.

Secondly, let us consider the opportunities. Fig. 2 illustrates the proportion of known mineral reserves in Africa and the production from Africa. Also shown is that part of the African reserves within the boundaries of South Africa, together with its production.

Participation in the African deposits of copper, cobalt, chromium, diamonds, and other precious stones is essential if South Africa is to exert any global influence on marketing strategies. More important still is the proportion of unknown mineral resources that are located in Africa.

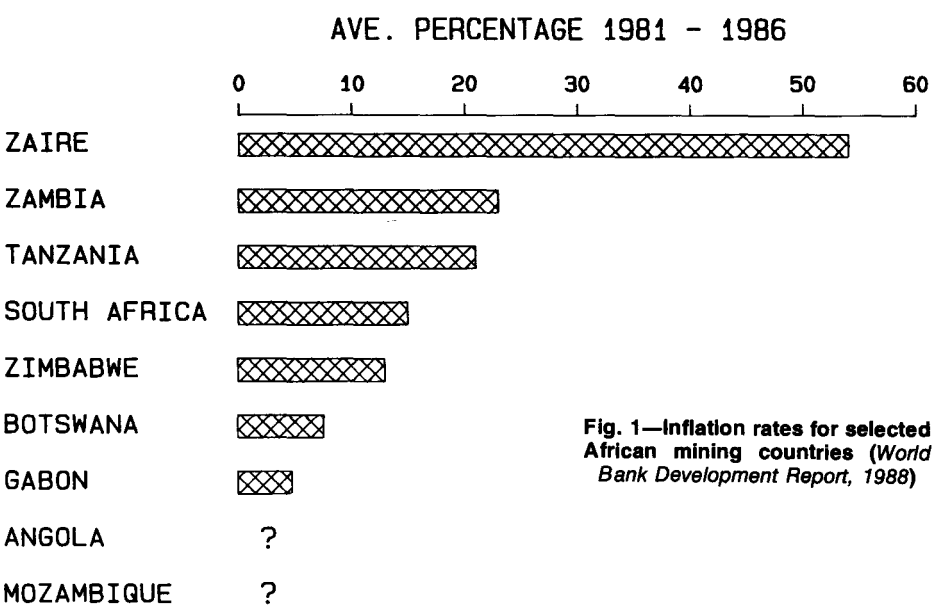

Fig. 1—Inflation rates for selected African mining countries (*World Bank Development Report, 1988*)

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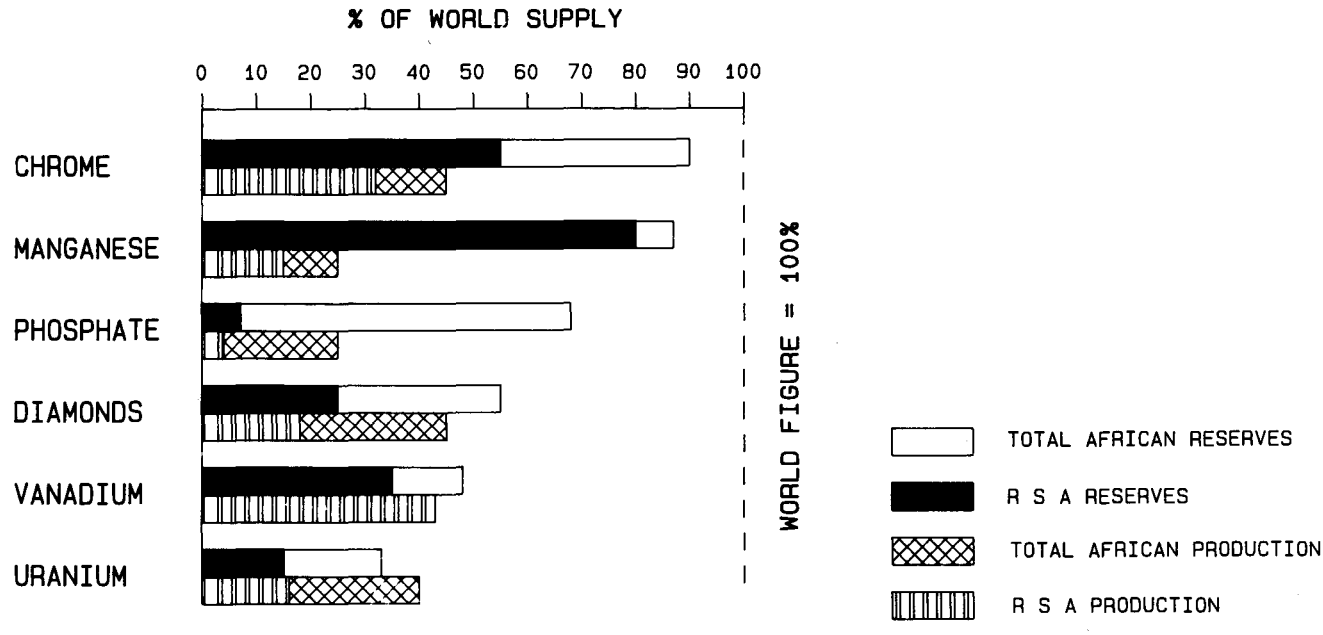

Fig. 2—Reserves and production of a few selected minerals in Africa as a percentage of the world supply

In view of the opportunities that have been created, effective participation in such endeavours depends upon the contributions South Africans are willing to make, and are capable of making, in the areas of marketing, finance, infrastructure, technology and, most importantly, entrepreneurial expertise. In examining our capabilities, I shall dwell only on our technical manpower resources and our technological expertise.

Technical Manpower Resources

Our technically trained staff in the mining discipline are sourced from university graduates and certificated managers. As a result of the continuing shortfall in the numbers of mining engineers graduating from South African universities, mining graduates have been recruited from overseas universities for many years. The industry has greatly benefited by the recruitment of trained staff from this wider technology-catchment area.

Of particular interest is a comparison of graduate numbers from different global zones in terms of the level of mining activity in each zone. On the assumption that this can be adequately described by the value of product mined per annum, Fig. 3 presents this comparison in terms of numbers per unit value of mined product, normalized.

When we consider our mining industry only in a con-

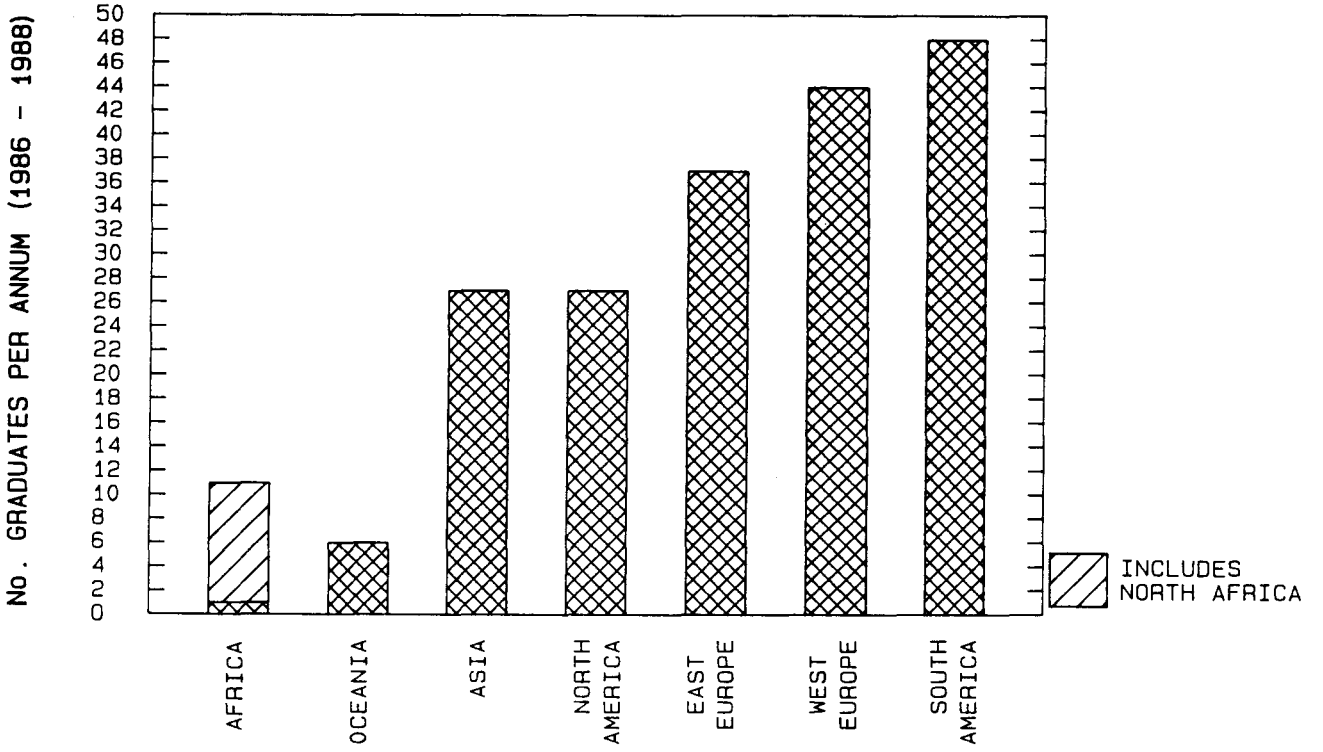

Fig. 3—Engineering graduates per value of mining production (normalized for the purposes of comparison)

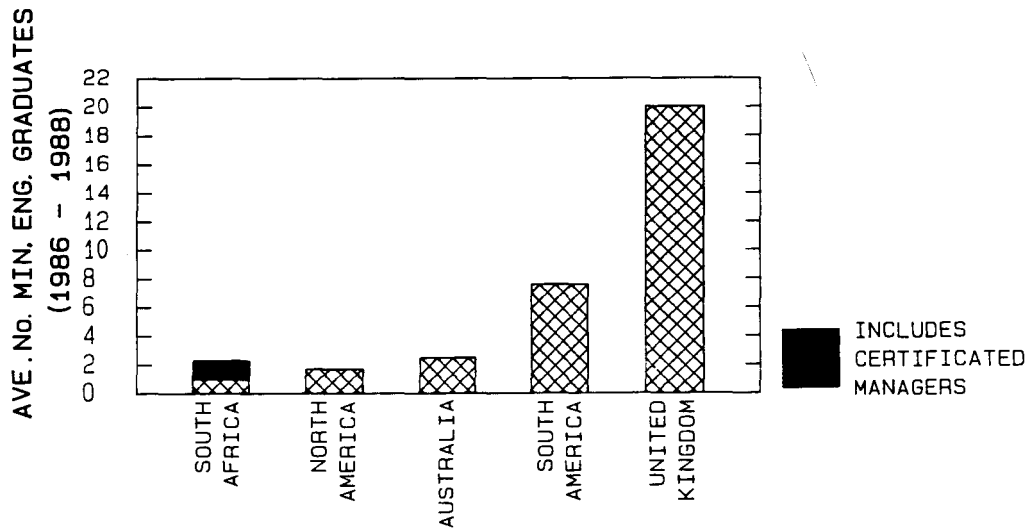

Fig. 4—Mining-engineering graduates per value of mining production (normalized for purposes of comparison)

sumer context, we see that the most attractive shopping malls for graduates are Europe and South America. While language and cultural comforts incline us towards Europe for recruitment, economic realities have already forced a trend away from the traditional sources into new fishing waters. This trend is likely to grow in the future. Fig. 4 illustrates the supply of graduate mining engineers on the same basis of comparison as in Fig. 3. This figure is significant in two ways:

(i) South Africa is not much poorer in the supply of mining engineers than are Australia and North America.
(ii) The major source of mining engineers is the UK and South America and, with our present economic status, we stand the risk of losing graduates to other countries with stronger currencies.

At the moment, however, we are faced with an inadequate supply of locally trained graduates for our own industry, as well as having to compete for the supply of mining engineers on the world market. While our mining industry is large by world standards, its role in the South African economy is enormous, and has been for over a hundred years. I think that, for as long as we have a demand for mining graduates from overseas universities, a supply will be provided and the urgency for a supply from local sources will be reduced accordingly. Ideally, the number of foreign recruits should balance the number of graduates leaving South Africa.

Such a thesis requires an extraordinary long-term view of future developments and, since it can be funded only by current profits, it is not a simple process. The problem of graduate numbers has received the attention of many illustrious personalities in the past. Innovative programmes have been drawn up with the aim of luring greater numbers of students to the engineering profession. The Phoenix Programme, administered by the Chamber of Mines and sponsored by industry, is one such initiative that has been very effective, and the Institute is proud to be so closely associated with this venture. We have an obligation to the architects of the concept to adapt and expand the programme to meet the changing needs. In the light of changed circumstances, a review of objectives and strategies is appropriate, and perhaps even a new vision is called for. With the enthusiastic efforts of Cliff MacMillan, the success of the PROTEC Programme has been so encouraging that an increase in the number of locally trained mining engineers must be possible if equally motivated.

The training of our human resources is the joint responsibility of the State and the private sector. The mining industry has a long and enviable record in the commitment it has made in this regard. It is estimated that the total amount of money spent by the industry on education alone will exceed 30 million rands in 1989. In spite of that, the results are not satisfactory. Every individual and corporate body in this industry should strive to improve the marketability of the industry. This Institute, under the auspices of its Education and Training Committee, will continue to play its part in influencing and contributing towards the professional requirements of the industry.

In the African context, South Africa is far better endowed with technically trained staff than any of its neighbours. Astute strategic planning in the past, and present, has provided adequate facilities for the training of our manpower to match our technical needs. The present emphasis on technikons is an example of the dynamic adaptation to industry needs that is being made in this country. When these needs are coupled with the economic constraints within Africa that I have already mentioned, the potential for exporting trained personnel becomes an exciting possibility with all the attendant long-term benefits, albeit indirect. Regarded in the light of our own shortages, this may seem preposterous at this stage, but horizons have to be set for a long-term goal. Training of graduates from other African countries at our colleges is an opportunity to be developed for a long-term benefit.

Technology

The far-sighted vision of doyens within the mining industry has placed us in a position in which our technology is respected world wide. The establishment of the research laboratories at the Chamber of Mines in 1952, and support of research programmes at the CSIR and the Bernard Price Institute, as well as at major universities, have contributed to technological advances in this country of which we can all be proud. Mostly, however, it is only with on-site development that a technology

becomes recognized. The following are typical examples of areas in which our industry has excelled:

- deep-level mining, encompassing rock mechanics, seismicity, and backfilling
- environmental engineering, with its refrigeration techniques and physiological demands
- raiseboring in hard rock
- shaft sinking
- longwall coaling operations
- throw blasting in strip mines
- trolley-assist truck haulage in open-pit mines.

And the list could be extended considerably.

Throughout the world, there has been an increasing awareness of the role of technology in determining the standard of living of nations. In our own country, cabinet posts have been created to give emphasis to the importance of technology. Research-and-development is the most creative part of the engineering discipline, and its success depends solely on motivation. For me, motivation derives primarily from accountability and reward. Frequently, either or both are absent from institutions that have been established with the purpose of advancing technology. These range from the smallest planning departments on a mine to large research organizations on a national level. Numerous competent and highly qualified persons are employed in these institutions who are not held accountable for the designs produced and are therefore also not remunerated in accordance with the value of their contribution. This leads to frustration and the ultimate departure of individuals from the industry. New initiatives are called for to maintain, and even accelerate, the rate of technological advancement in our industry.

By way of example, I can cite the development of mine-design software packages. In spite of all the expenditure on computers within the industry, only one commercially available design package has emanated from this country, and we are importing design packages from countries with smaller mining industries than our own!

Unfortunately, while the problem is easily defined, the solution is not so easy. Correctly, the norms in industry are to relate reward to productivity, and there is no scale by which productivity in innovation can be measured. However, there is no point in wasting energy on trying to solve the problem of how to measure productivity in these areas when the true need is to increase productivity by orders of magnitude. There is only one sure way of maximizing productivity, and that is by recognizing the need for competition. Our shortage of graduate engineers will then also be alleviated in direct proportion to the increased productivity achieved.

Bold and innovative steps are required to achieve the appropriate competitiveness to succeed. An essential ingredient is the threat of economic survival for non-performance, which serves as a counter to substantial rewards for high performance, rewards in this regard being determined by free-market forces. The support of a competitive service industry for the development of technology would require a different approach and attitude from the traditional hierarchical systems that have served the industry so well up to the present time. Such a technological service industry would range from individual experts to the 'science park' type of establishment, all operating competitively on a contract basis and being economically viable on the strength of their own products.

Strong arguments are often put forward for rationalization based on the limited technical resources available within the country. However, while rationalization may avoid a certain degree of duplication, it cannot be supported at the expense of productivity. Furthermore, we should meet competition from international sources by offering our technology on the international market.

Confidentiality and 'corporate' technology can be guaranteed by appropriate agreements or patent registrations, as is common in most countries. Protection from such measures in the mining discipline is, in any case, a doubtful requirement: such protection does not exist at present, but would be an important factor in process engineering. Far greater benefits would result from the constant pressure for innovative concepts that arises from a free-market enterprise than are realized from within a protected environment. This image of free enterprise for technologists is necessary to attract top scientists and engineers into an industry in which the future is heavily dependent on technical innovation as our mines grow deeper and the grades decrease. The technical challenges in mining are no less than in any other engineering discipline, and are perhaps greater, and we must recognize the need and the means of attracting technological entrepreneurs.

Consider the relevance of the above concepts to the new relationships that have developed between South Africa and other African states. Participation in ventures is derived primarily from perceived technology and available finance with good track records. The presentation of our technology on a broader free-market basis makes it more accessible, particularly to the owners of numerous small deposits that require a great deal of skill to render them viable. The advantages that arise from a total spectrum of services from the individual to large research establishments cannot be over-estimated. The addition of the business motivation of a free-market system to this potential would place South Africa in a strong position to become an even bigger player in developing the mineral resources of Africa.

Environmental Considerations

World-wide consciousness of environmental values has made everyone aware of the need for environmental management in regard to many matters extending from the ozone layer to wild life. Equally appreciated is the fact that some sacrifices are inevitable if living standards for human beings are to advance. Volumes have been written about the importance of environmental factors in defining man's living standards. Here, we have to concern ourselves primarily with what is happening in Africa, particularly in the minerals industry on this continent.

By comparison with overseas countries, including the developed Western World, the record of environmental control in our minerals industry is excellent. Here, a distinction must be made between legislation, where we do not appear to have reached the same standard as the most advanced Western nations, and practice, where in my opinion our standards compare very well.

That does not excuse us for systems that have been in-

adequately designed, and we do have some of those.

However, it is equally important that we should not be so prescriptive that industry and job creation suffer unduly. In South Africa, we have established a mining industry that has passed from an era of no environmental-control regulations to one of sophisticated integrated environmental management requirements. This action, which arose from a responsible attitude within our industry, can achieve far more than detailed legislative procedures, which can in any case never be fully implemented. It is this experience and attitude that should be encouraged in the development of Africa's mineral resources.

Legislation, when it is perceived as confrontational, frequently has the opposite effect to what was intended. Legislation can be sourced either from the regulatory authority or from the industry, or from both. Industry's comments are usually invited but not necessarily acted upon.

Following the trends in developed Western countries, it is apparent that more and more stringent environmental laws will be enacted in this country. It is a necessary evolutionary process that will become a dominant factor within our industry. We need to participate in this process pro-actively, and so avoid the confrontation that has resulted from environmental legislation in some countries.

South African interest in the environment is centred on the Council for the Environment. Each of the major mining groups has its own environmental department, and our Institute is represented on the Environmental Planning Professions Interdisciplinary Committee (EPPIC). Fig. 5 illustrates the relationship of the Institute to EPPIC and the Council for the Environment. Since EPPIC is an interdisciplinary body and the Council for the Environment an even wider-ranging interest group, the minerals industry or, more specifically, the mining industry does not have its 'own' forum for actively cultivating a policy or developing an industry culture to make a greater and more cost-effective contribution towards the protection of our environmental heritage.

The establishment of a standing Environmental Committee within the Institute has been considered necessary to develop awareness of the habitat within individual members. Such individual awareness and attitude is the core of any policy. Issues that require collective input can be categorized under the following headings:

- Legislation
- Standards
- Enforcement

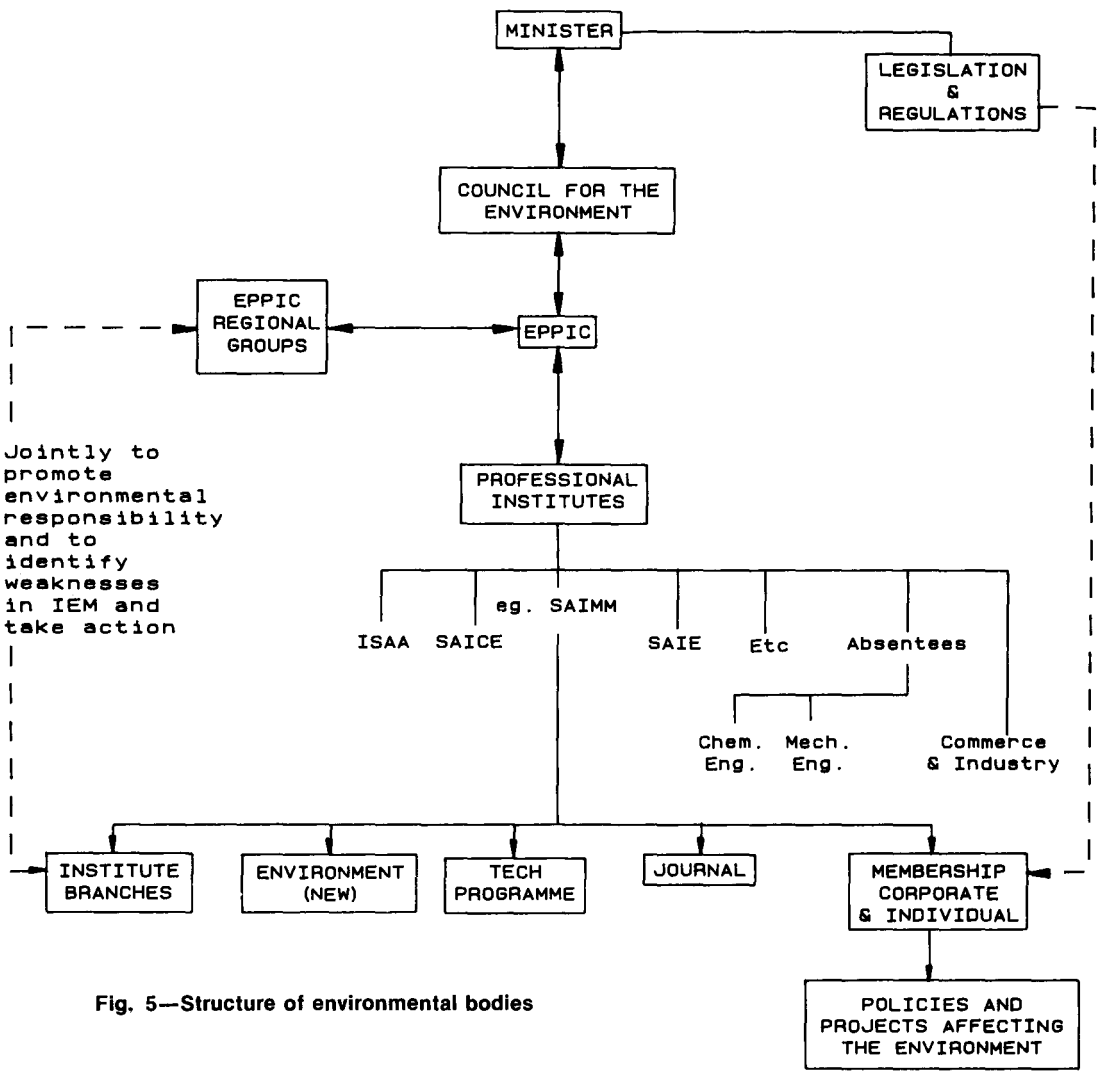

Fig. 5—Structure of environmental bodies

- Penalties
- Design guidelines
- Litigation.

While the Institute cannot act on behalf of the industry on environmental matters, it could be a suitable body to canvas general opinion and assist in formulating policy. This policy or opinion could then be represented at EPPIC before being considered at the Council for the Environment. Essential to this strategy is the representation on EPPIC, as well as on the Council for the Environment, of senior persons from within the minerals industry who are not necessarily environmental scientists. It is my belief that strengthening of existing structures with the appropriate people is the best way to initiate positive action to the benefit of our industry.

Acknowledging that there is constant change in population demands for environmental control, the particular circumstances applying to Africa are unique. These relate to climate, population attitudes, level of education and awareness, socio-economic conditions, and costs. Since financial resources are always constrained, the degree of development achieved is a direct function of the efficiency with which the funds are utilized.

Perception of environmental protection requirements is an attitude more than a calculable entity, and environmental engineering has to be region-related to be efficient.

Every engineered facility is associated with risk. Criteria for design are coupled with acceptable risks. The probability of an event can be related to the consequences, as shown in Fig. 6. The nuclear industry has advanced the analysis of risk more than any other, and a typical risk design criterion is represented in the probability–consequence diagram of Fig. 7. There is no reason why similar criteria should not be developed for specific environmental consequences applied to the mining industry. From such criteria, optimization in design moves from a subjective, and frequently emotive, basis to an objective and analytical basis—something engineers can identify with more readily.

Environmental hazards are recognized as circumstances that may lead to adverse consequences. Risk is the potential for loss of life, and for damage to health, property, or the environment, and is usually determined from the product of event probability and event consequence. Acceptable risks are therefore a function of the ability of the community that benefits from the project to pay for a failure. This can be related to the GDP of the beneficiaries. Figs. 8 and 9 are adapted from dam-safety evaluation proposals by Oosthuizen and Elges. A similar approach in environmental engineering would assist greatly in quantifying risks to the environment. A distinction has to be drawn between voluntary and involuntary risks. Environmental failures frequently fall into the category of involuntary risks.

Since the costs of all projects are ultimately recovered from the community for which they were undertaken, an over-engineered project may be just as damaging to the community as an under-engineered project. South African experience and engineering skills are attuned to the requirements of the African continent, and can produce balanced designs that strive towards the ideal within practical limits.

The present commitment of the mining industry to

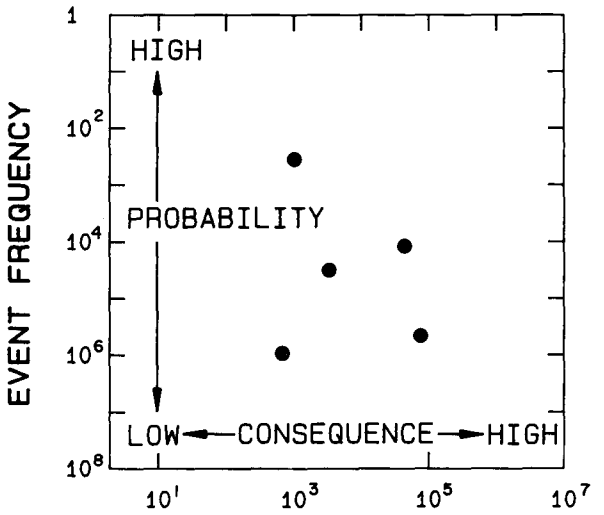

Fig. 6—Diagram of probability versus consequence

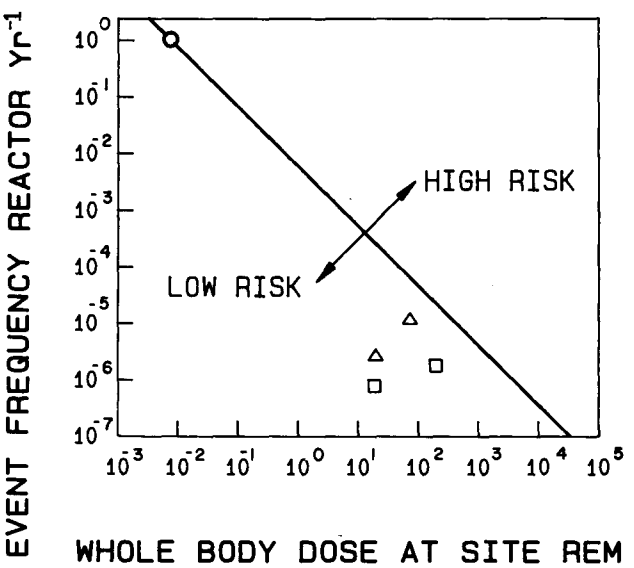

Fig. 7—Typical risk criterion for nuclear-reactor design

environmental protection offers a tremendous opportunity to the industry to present a positive image and attract engineers and scientists into a progressive industry.

Entrepreneurial Resources

South Africa's mining history is a fascinating story of colourful characters—people whom we would not hesitate to classify as 'entrepreneurs extraordinaire'. For some of the most famous, mining was entirely a new venture. The African continent today is somewhat more complicated than it was a hundred years ago, and gut feelings and *deja vu* attitudes are no longer a recipe for success in the development of mining projects. Or are they?

Have we become victims of data and information processing to the extent that it blurs our vision with too many risks that become 'too ghastly to contemplate'? The career paths of typical mining engineers have become so conditioned and systemized within the rigid framework of the discipline so essential to the efficient operation of labour-intensive production units that they are unlikely to generate entrepreneurial attitudes. The relative stability

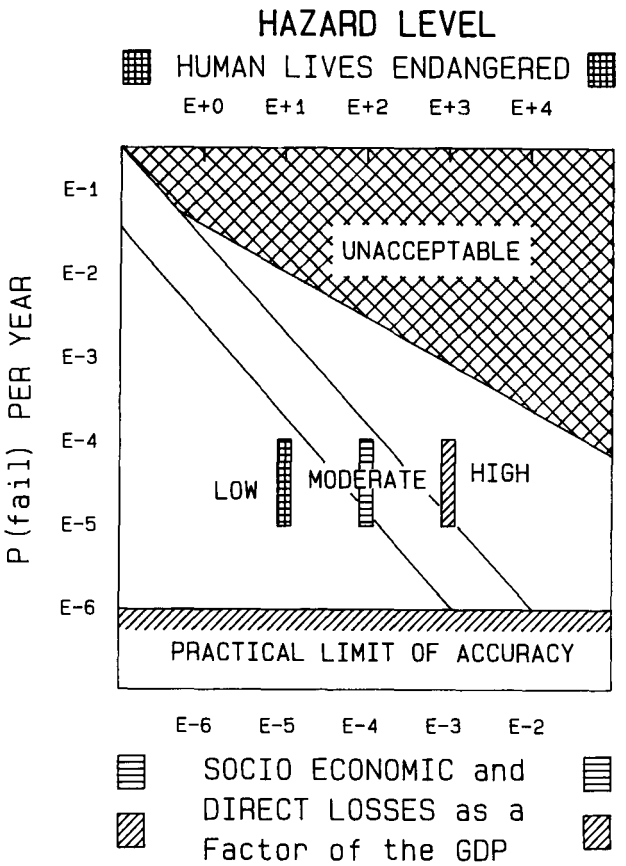

Fig. 8—Typical hazard level for dam design (adapted from Oosthuizen and Elges)

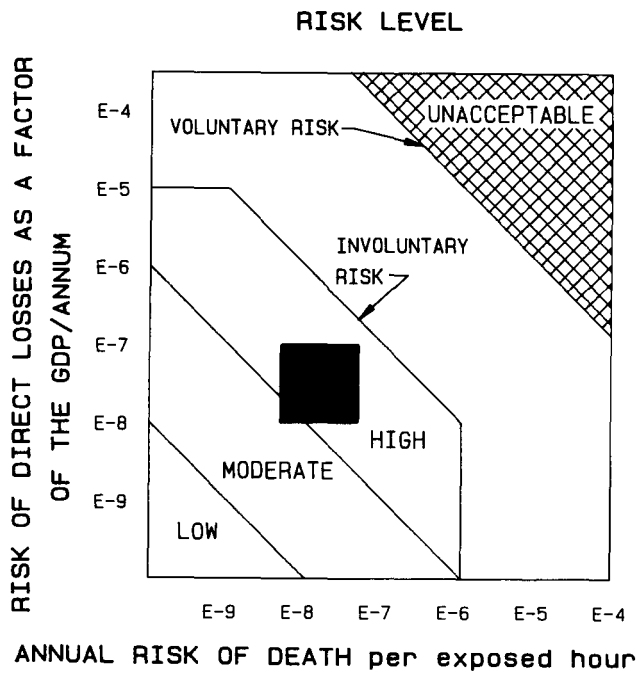

Fig. 9—Typical risk level for dam design (adapted from Oosthuizen and Elges)

of our mining industry has resulted in secure and complacent employment attitudes over many years, which, by definition, are counter-productive to entrepreneurial development.

The volatility of the price on the metals market in the past few years, as shown in Fig. 10, is changing these preconceptions of indefinite security, and therefore introducing a greater element of risk into the planning of mining ventures. While I do not condone or advocate such price fluctuations, they do have a side benefit in encouraging innovation, as has already been manifested in the establishment of many small-mining operations.

In the light of the African minerals potential, the foremost requirement is an adaptable marketing and financial approach, which will require much greater innovation and entrepreneurial spirit than ever before.

Conclusions

The new political climate that has now been created with other African states has suddenly changed the potential for our industry to participate in a much larger arena.

The unique problems of Africa place us in a strong position to provide the best deal to potential partners. However, the continent has become an international minerals arena with competition from many other countries, which have been attracted primarily by the tax concessions offered them when participating in developing countries. While this may appear to be a major disadvantage from our point of view, it is also likely to be the major reason for the likelihood of our success in the long term.

Success in the development of African mineral resources will come only to those who believe it to be possible. Here, again, we have the advantage over other countries, who have to adjust to local conditions, but our success will depend primarily on the attitude of the people within the minerals industry. This Institute is fortunate in having exceptionally talented and dedicated Council members and, with the assistance of our Secretariat, we shall do all we can during the coming year to stimulate our members into a greater awareness of the challenges that face them, and to make this industry an even more exciting one for future generations. Hopefully, that will attract more engineers into the industry.

To quote a learned friend, 'Opportunity doesn't knock; it only scratches'.

Acknowledgements

I acknowledge the assistance given to me by my overseas colleagues, who provided me with much of the statistical information on graduates, particularly Dr Neal Rigby and Mr Alan McCracken from our Cardiff Office, and Dr Andy Robertson, Beverley Muir, and Dan Charbonneau from our Vancouver Office; also, the very prompt and willing assistance from Mr Roy Swan, the Institute's corresponding member in Sydney, Australia, for his assistance in getting reliable data from that region, and Mr McSwain of the US Consulate in Johannesburg, who was most helpful in supplying information.

I am also grateful to the following people, who lent me some of their valuable slides: Dr R. Viljoen, Marc Demmer, Bryony Walmsley, and Professor I. Watt.

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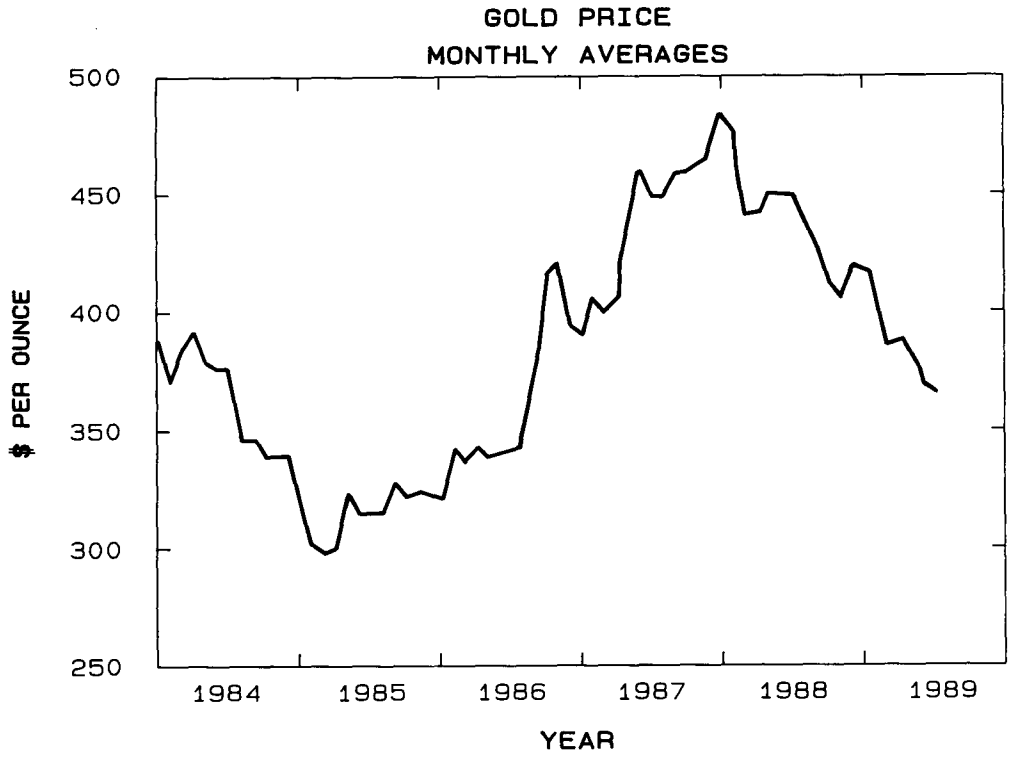

Fig. 10—Variations in the gold price

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Obituary: A.R.O. Williams, O.B.E.

Arthur Robert Owen Williams died on 18th May, 1989, at the age of 84. ARO, as he was known, was educated at Malvern in England, and graduated from the Royal School of Mines in 1926. He went to South Africa as a Learner Miner with Consolidated Gold Fields at Robinson Deep.

From 1930 to 1937, he worked at Kansanshi Mine in what was then Northern Rhodesia, and then returned to England as Assistant to the Chief Engineer at the London Office of Consolidated Gold Fields. In 1938 he was seconded to Gold Fields American Development Company Limited, and he took up residence in Toronto.

During the war, he served with distinction with the Royal Engineers, rising to the rank of Lieutenant Colonel in command of military tunnelling operations at Gibraltar. Later he served in France, Belgium, Holland, and Germany. He was mentioned in Despatches and was awarded the Order of the British Empire.

After the war, he returned to Consolidated Gold Fields as Resident Engineer in London and, during the next 20 years, became a director of many of the companies in the Group, including the parent company, from which he retired as Managing Director in 1970.

He was President of The Institution of Mining and Metallurgy in 1961–1962, and was awarded Honorary Membership of that Institute in 1973. He joined The South African Institute of Mining and Metallurgy in 1948, and was a Corresponding Member of Council of The South African Institute of Mining and Metallurgy from 1962 to 1970. He was made a Life Fellow of The South African Institute of Mining and Metallurgy in 1975.

ARO is survived by his wife and a daughter. He will be sadly missed by many friends throughout the mining world.