BUILDING GEOSCIENCE IN DEVELOPING COUNTRIES

by

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A Councillor of the Association of Geoscientists for International Development (AGID) candidly reviews both the advances and the continuing needs of geoscientists in developing countries. Pragmatic directions for future improvements, particularly at the grass-roots levels, are suggested.

The Past Experience

National and international organizations have provided much geoscientific technical assistance to developing countries over the last 20 years. Efforts in mineral exploration have probably been most important economically. Between 1960 and 1976, the UNDP alone spent or committed \$103 million toward mineral exploration programs in 66 Third World countries, and this was matched by \$65 million in local government contributions (Carman, 1979). These efforts led to the discovery of major deposits with a value estimated by Carman as exceeding \$26 billion, yet for a host of financial and political reasons (Bossou and Varon, 1976), few of these have been developed.

The UN record in groundwater programs is equally impressive: 100 projects in 57 developing countries by the end of 1977, involving UNDP contributions of \$63 million and resulting in wells supplying water to some two million people (Taylor, 1979). All too often, however, mechanical and human failures have led to the abandonment of wells, over-grazing around new installations, or contamination of the new water supply.

Abandoned heavy minerals separation plant, Dar es Salaam, Tanzania.

Results have been visible in the area of building and strengthening geoscience institutions and programs. In SE Asia, CCOP runs a successful series of programs involving research, information exchange, and training in the field of marine geology, and a similar series based in Fiji concentrates on South Pacific offshore areas. National and regional research centers have been established by the UN in Chile, SE Asia and East Africa, and more are now in the planning stages (Gabert, 1979). Regional training centres have been founded in Costa Rica, Saudi Arabia, Thailand, as well as in Europe and Japan, specifically for students from developing countries (Cooray, 1977); the number of new geological departments in Third World universities has grown (Ricaldi, in press).

The overall number of geoscience graduates has increased greatly in recent years. Some guess estimates suggest that there may be as many as 25 000 Third World geoscientists working in developing countries, excluding China. Their geographical distribution is, of course, uneven. Many are in Brazil (with an estimated 450 graduates per year at the first degree level), India (450 per year at the M. Sc. level) and Nigeria (80 B.Sc. graduates per year), while major mining nations like Zambia and Botswana probably still have less than 20 national geoscientists (Ricaldi, in press).

Current Situation

In spite of these advances, developing countries tend to remain outside the mainstream of global geoscience, and there is little evidence that their professional communities are functioning as effectively as they should, no matter how anxious individual geoscientists within them may be to contribute to a more rational and equitable national development. The "macroscopic" reasons for this are obvious: national crises involving droughts, food and petroleum shortages, clogged ports, limping or inoperative road and railway systems, sluggish postal and telecommunication services, monetary instability, and the like - all on a backdrop of rampant inflation and rapid political change.

At the "microscopic" level, it is difficult to obtain a balanced view. Third World geoscientists complain bitterly of low salaries and field allowances, shortages of supplies and equipment, little official recognition for good work done, few opportunities for promotion, and indecisiveness, inflexibility and nepotism at higher levels of authority. A complete sense of isolation from the international mainstream is commonplace: there are few opportunities to monitor the international scientific literature or to attend conferences and seminars. The most vocal criticisms are often directed at foreign "experts" regarded as professionally unacceptable in their own countries, overbearing, unsympathetic, or motivated solely by their high salaries and inflated (in local terms) lifestyles. The competition among aid agencies for highly visible projects which they can support with people and equipment from their own countries does little to dispel this image.

On the other hand, the traveller in developing countries sees many examples of inefficiency and poor management, disinterest in professional work, and a painfully slow pace of work and change. There are constant holidays and a two- or three-hour working day for professionals is not uncommon. Scientists have at times been accused of élitism, but in many Third World nations this problem reaches a fine art, exemplified by promotion of the mystique of science, a slavish adherence to theory and a forswearing of practice, lack of communication and cooperation with the scientific community, disdain for local expertise, and a distinct preference for Northern* rather than Southern specialists and scientific approaches.

In searching for future progress, it must be recognized that science (S) and the technology (T) based on it, carry societal values characteristic of the industrialized North and often in

* Industrialized nations of North America and Europe, the U.S.S.R., Japan, Australia, South Africa.

Figure 1. *Geoscientists and Science Policy: A View of North-South Relationships.*

conflict with the traditions, outlooks and values of developing societies, where, for example, an unquestioning respect for established values may be taught or where little pride or satisfaction may be taken in a job well done. Too often S and T have been seen as the leading edge for increased dependence upon the North - through S and T "outposts" in developing regions, or activities of the transnational corporations (Girvan, 1976, Sagasti, 1978). This dependence is reinforced by the traditional methods of technical assistance and technology transfer identified with foreign experts, training abroad, equipment and services from the North (Oteiza and Rahman, 1979).

One view regards scientists and technologists and the services they require and generate as "supply" inputs to a national system; they are "pulled along" at the end of a string by the production ("demand") side (Fig. 1). Funds for research (R) and development (D), education, and the priority areas for support are determined ultimately by the needs of industry which, in the South, has been dominated by that in the North. According to this structural model, altering the inputs (improving training, salary and work conditions) will not change the demand for S and T services; in fact, a string which is pushed develops "buckles and kinks" - an oversupply of frustration among S and T workers which can lead to increased "brain drain". If this interpretation is valid, efforts will be needed to reach and influence S and T policy makers and to emphasize national self-reliance in S and T.

How can science policy be influenced from below, from the scientific base? Geoscience societies can provide a link between government and individual geoscientists, assessing, for example, the effectiveness of national institutions or the state of geological research in the country. Publicizing the results of applied research programs and emphasizing through the media the benefits that can flow from a healthy mining industry are other ways of transforming the weak and flexible string into a rigid rod that can be pushed in the direction of the planners and policy makers. The main responsibility for this may lie with Southern geoscientists, who admittedly have major political barriers to overcome, but their Northern colleagues can assist by breaking down barriers in education and research and by bridging the gaps in communications and information exchange (Moravcsik, 1975).

Continuing Needs

Education and Training

Many universities in developing countries are still using curricula transplanted from Europe and North America and designed in part to produce graduates equipped for graduate training in the North. The result is that many newly employed graduates are at a complete loss when confronted by local, practical problems in geological surveying, mineral exploration, mine operations, engineering geology or groundwater development - fields in which the vast majority must work. It could be argued that the essential missing ingredient is often an "engineering" approach.

Curricula should concentrate more on locally relevant aspects of natural resource management, specifically: a) exploration through development and exploitation, to downstream activities in groundwater, minerals, fuels and soils, and b) coping with natural hazards, such as accelerated erosion, earthquakes, floods and mass wasting.

Advanced training at home or in other parts of the South where environments are similar would increase local self-reliance. Regional centers such as the Asian Institute of Technology in Bangkok (with its first-class post-graduate course in engineering geology), and the Institute of Earth Sciences in Jeddah provide excellent models (Cooray, 1977) and fit in well with the current endeavours toward greater technical cooperation between developing countries (TCDC).

Refresher and advanced short courses on specific subjects such as groundwater exploration or Gondwana stratigraphy, for example, are needed, as witnessed by the enthusiastic response to the USGS courses on remote sensing or those organized by AGID over the last four years. These include geochemical exploration (held in Zambia), tin geology (Malaysia), exploration techniques in tropical forests (Venezuela), engineering geology (Thailand), and groundwater management (Bolivia). The now defunct CENTO field course in mining geology has been well documented (Cooray, 1977) and should spark a new generation of similar field-based courses elsewhere. Again, a key to success in these courses is to have them located in developing countries and led by Third World geoscientists.

Emphasis on basic and applied research on local topics by Third World academics should be encouraged, especially to counter the "ivory tower" syndrome so marked in many developing countries. Progress is being made here, and the number of contributions to the international literature by academics from such countries as Malaysia, India and Brazil has increased. Applied research topics provide an excellent way of demonstrating to undergraduate students and the local public that geoscientists can contribute usefully to local development. Research projects now being carried out in Sri Lanka on gem-bearing gravels, in Tanzania and Kenya on the geology of heavy mineral sands and in Thailand on geothermal energy serve as examples.

Sorting and cobbing mica by hand, State Mining Corporation, Pallekelle, Sri Lanka.

On-going links and cooperative research programs between universities in the North and South are needed to provide continuing professional support (exchange of students, faculty, access to modern facilities at a Northern "twin") and the exchange of ideas that all scientists need. These links are not easy to develop in an equitable manner when the partners are at different stages of development; they can easily become vehicles for geoscientific "imperialism" if staff and graduate students from well-equipped Northern universities engaged in local research problems in the South carry out all the analytical work, discussing and publishing the results in Northern journals inaccessible to the developing country where the work was done.

Accelerated training of technicians and other sub-professionals is frequently stressed by Southern geoscientists, and the higher ratio of technical to professional staff (often 3 to 1) is but one measure of a different way of working. The need for geological field technicians, diamond drillers, and

Geological Survey of Ghana's Field Technician Training School, Saltpond, Ghana, 1979. Their motto reads "No Lasting Glory is Won Without Struggle".

laboratory personnel has led to the establishment of a number of specialized courses and technical schools, as, for example, in Peru and Ghana (for miners), in Ghana (for survey personnel), and in Kenya (for gemologists and field technicians).

More and better teaching aids, equipment, library material and reference collections are always needed, though much more can be done with what is already available. The biggest gap continues to be in the acquisition of journals and books, and especially basic textbooks which emphasize local environments. India has been a pioneer in producing its own textbooks (Cooray, 1977), while many geoscience texts originally written in (or translated into) Spanish are now in use in Latin America. In most countries, however, there are no alternatives to the American, British or French textbooks which tend to perpetuate dependency on the North.

Careful manpower planning preferably by geoscientists themselves is required to counter the continuing problem of the outward migration of scientists ("brain drain") or loss of professionals through unemployment at home. Estimates of the personnel needs and capabilities are generally not available, and few guidelines or documented case-histories of the growth and employment of geoscientists appear to exist (Berger and Mathavan, in press).

Information

Gaining access to international scientific literature remains a top priority. For many Southern geoscientists, the information explosion is a thing of the past, and there is little pretence of keeping up with journals and books; foreign exchange for subscriptions is simply not available. One possible solution would be for publishers to make available, at reduced prices, a small proportion of their books and journals to selected, key national and regional libraries in developing countries. This could perhaps be administered by AGID or IUGS, and should not have any appreciable effect on sales in the main market regions of the North.

"Recycling" of books and journals that are surplus to the needs of established libraries and individuals is another approach that could be effective if carried out on a large scale. The experience of AGID in operating such a service with the help of Carleton University in Canada has been positive.

Computer-based bibliographic and data systems are still a long way from extending their services to developing countries for obvious reasons of cost and distance. This is unfortunate, especially in the economically and socially important fields of minerals, energy, and water. The efforts of IAEA in the nuclear field and UNEP in environmental information, serve as examples of how this could be achieved. It is perhaps paradoxical that one of the basic requirements for technological de-linking (or increase of self-reliance) and the promotion of appropriate technologies and approaches, as for example, in groundwater development systems, small-scale mining, and mineral processing, may be information handled best by "black boxes" linked to satellites and Northern computerized data bases. The practical advantages to a state mining corporation of having cheap and rapid access to commodity prices or mineral technology data such as maintained by Northern agencies is obvious.

If Northern bibliographic systems are to spread Southward, they must increase their currently sparse coverage of the geoscience literature produced in developing countries, and perhaps even monitor the unpublished documentation that is so important in the South. A bibliography on groundwater in developing countries published by AGID (Stow et al, 1976) and compiled through an exhaustive search of citations then held in Northern data bases, captured only a small fraction of the important literature on groundwater known to the Third World water specialists. In the long run, the best approach will be to develop Southern-based information systems along the lines of the excellent and comprehensive Asian Inform-

ation System for Geological Engineering (AGE) operated by the Asian Institute of Technology, which itself has access to Northern geotechnical data bases and information systems. AGID, too, has been assisting a group of hydrogeologists in Bolivia in organizing national water information.

Improving Southern information management is probably, in the short run, more important than gaining access to Northern-produced information and documentation. Examples of disorganization are found in university, public, and government libraries in developing countries; there is often little attempt to identify, assemble, store, disseminate or use local documents and data. Up-to-date local bibliographies are needed, as are geoscience libraries and data banks accessible to the whole local geoscience community.

Programs to assist the publication and distribution of geoscience works on developing countries, in local languages where appropriate, are also needed. There are geoscience periodicals and journals published at irregular intervals by government departments, professional societies and university departments. A recent survey identified nearly 40 serial titles from Latin America and the Caribbean regions alone, though a number of these are published so infrequently that they may well have been discontinued by now. Yet major manuscripts on various aspects of Southern geoscience exist and, if published, would be invaluable contributions to local and regional education and research. AGID is currently experimenting with a revolving fund to provide modest financial assistance in such cases.

Geoscience literature specifically designed for developing countries is still needed. Useful publications too little known in developing countries include the works on small-scale mining (UN, 1972) and dimension stone (UN, 1976). AGID is now sponsoring the compilation and publication of an international guide to exploration and mineral development techniques of particular application in developing countries. Maintenance of microscopes and other laboratory equipment in tropical climates, and case-histories in rain forest exploration, are but some of the topics that could be of major importance.

The publication and distribution of newsletters constitute a rapid and cheap mode of communication in geoscience. Current examples of widely read publications include EPISODES, AGID News, Aguas Subterráneas - a recent newsletter published by AGID for Latin America, the CGLO Newsletter, and CCOP News; there is room for more.

Finally, one might note the importance of producing journals carrying key papers in translation from the international geoscience literature, particularly in French and Spanish for geoscientists in Latin America and the francophone regions.

Communications

Financial restrictions preclude access to international scientific meetings for the majority of Southern geoscientists. Improvements in this regard have been made through such international programs as the IGCP and AGID's conferences and workshops, but too often the travel funds available to developing countries are limited to high-level officials. International conference organizers sensitive to this problem should ensure at least some "grass-roots" representation from developing countries.

Scientific meetings held in developing countries are increasing and provide an invaluable boost to the development of Southern geoscience, as well as to the organizational and management skills of the people running them. Recent examples of productive regional meetings include the Third Regional Conference on the Geology of SE Asia (Thailand, 1978), the 5th Conference on African Geology (Egypt, 1979), and the 4th Latin American Geological Congress (Trinidad and Tobago, 1979). A number of countries (such as Brazil, India, Malaysia, Nigeria, Mexico, Venezuela, and the Philippines) now have an established series of national conferences and seminars. For others, this essential forum still remains unknown.

Geologists study exposures of Tertiary sediments on the SE shore of Tobago during the 4th Latin American Geological Congress held in Trinidad and Tobago in 1979.

National geoscience societies provide probably the best way of promoting cooperative efforts within a country and acting as advisory bodies to governments. The July 1979 issue of *Geotimes*, for example, lists some 325 geoscientific societies in developed countries; by comparison, the list of Southern societies (together with those known to AGID) totals 50 (7 in Africa, 25 in the Caribbean and Latin America, and 19 in Asia and the Middle East). While the establishment of geoscience societies is essentially a national responsibility, outsiders can act as "catalysts", particularly in strengthening existing organizations.

Perhaps the most effective mechanism is still the personal communication network that most Northern geoscientists have built for themselves. A conversation, a telephone call or letter to a colleague often brings the answer to a specific problem or presents an alternative way of looking at it. This is seldom possible in many developing countries and a pervasive sense of isolation results. The kind of volunteer referral service pioneered by VITA in the U.S.A., ITDG in England for a wide range of technical problems, and more recently by AGID as well, is useful and can be operated by anyone with a sizeable file on people willing to enter into correspondence on specific questions. At a larger scale is the UNESCO-sponsored Regional Network for Geoscience in SE Asia established in 1977 to link geoscience organizations (universities, government departments, and research institutions) for the purposes of training, cooperative research and exchange of information. This is a unique effort at improving communications in the geosciences and deserves close monitoring.

Finally, many of the activities outlined above may be regarded as the responsibility of librarians, administrators, or planners. In most developing countries, however, national priorities are directed toward eliminating illiteracy, increasing life expectancy, or rapid economic growth, and the scientist is not seen as a key contributor to such development. The only way to increase the pace of future change is for the scientist (who knows best what support he needs and what he can contribute), to take a hand in improving his own lot, possibly along the lines suggested above. Funding is, of course, always a problem, but as AGID's experience demonstrates, sound developmental programs conceived and run by scientists, especially in a non-governmental framework, are likely to gain the support of funding agencies.

New Directions for Technical Cooperation

Because of the contrast in economic, social, and environmental conditions between North and South, there are a number of areas for R and D where there is little point in relying on a transfer of experiences and approaches from the North. Here, attempts must be made to learn from the mistakes and the innovative approaches in other parts of the South.

Small-scale mining and mineral-based industries.

This topic was the subject of a major international conference organized jointly by the UN and Mexico in 1978 (Meyer, 1978) and, more recently, an AGID workshop held in Mombasa, Kenya. As is well known, small mines and quarries can be dangerous, wasteful, exploitive of labour, and difficult to regulate (Carman, 1979), but they continue to be the largest employers of mining personnel in many countries (25 000 to 30 000 people in Mexico for example). They offer potential for import substitutions (such as brick clays for imported cement) and a way of promoting rural industries - a significant priority for most developing countries. Current interest in small mining indicates that it is one area where TCDC is essential since it is primarily in the South that small mines still function. The obvious challenge lies in developing ways of promoting and controlling small operations while dealing with their undesirable characteristics. Appropriate technologies for mineral processing and new approaches to marketing are particularly important.

Quarrying quartzite for flagstone, Accra, Ghana.

Mineral exploration and development in tropical rain forests.

This represents one of the last major frontier regions located wholly within the South. The massive world literature on mineral exploration, metallogenesis, and other aspects of economic geology contains relatively little that is directly applicable to rain forest regions. Much fundamental research

relating to processes of laterization, migration of elements during tropical weathering, and methods for sensing bedrock characteristics under a thick soil blanket, remains to be done. Cooperation between developing countries with rain forest regions is needed. A proposal to establish an international research institute for this purpose was made at AGID's 1977 Caracas Conference on Exploration Techniques in Tropical Rain Forests and is now being circulated to the governments of rain forest countries and key funding agencies.

Groundwater development and management.

The need for adequate supplies of clean water is obvious in arid and semi-arid regions and the complexity of the social, economic, and cultural impacts of water developments on remote regions is well documented (Saunders and Warford, 1976). Methods of exploration are relatively advanced and probably of global application, but management strategies and techniques developed in the North are rarely transferable to the South. There are questions of choice, of well technologies, utilization of supplies, conjunctive use, data management, artificial recharge of aquifers, and capture of flood waters. The need here for exchange of ideas, information, and experiences between developing countries is obvious. As hydrogeologists in the South are quick to point out, there are very few properly documented case-histories of well drilling programs available. An excellent account of the construction of some 750 shallow wells in the Shinyanga Region of Tanzania (DHV, 1978) is an example of the kind of practical study that can be used both by technical personnel and those responsible for the planning of water programs.

Laulenyi mine, Kenya, where tsavorite (a gem quality grossular garnet) is recovered.

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