Geosciences in Development:

A Critical Comment

by P. Gerald Cooray

In this review the President of the Association of Geoscientists for International Development argues the case for a refocussing of efforts in the geosciences, especially in the Third World, towards industrial minerals, groundwater, urban problems, natural hazards, agriculture, environmental protection and public education. As illustrations, the author quotes examples from Sri Lanka and from the program of AGID itself. The author's views reflect many of those expressed in last year's Penrose Conference on geology for the 21st Century. They also provide a timely background for the forthcoming international conference "Geosciences in Development" to be held in this September, with AGID co-sponsorship. (Ed.)

The Meaning of Development

The word "development" is common in the language of politics and socio-economics, though used without much concern for definition. Of the many explanations found in dictionaries, those that suit our context best are "growth" (*Concise Oxford Dictionary*) and "to make available or usable resources" of a country (*Chambers Dictionary*), both natural and human. If it means anything at all, the word must surely imply a continuous raising of the standard of living for the majority of the people.

There are no per capita rates or alphabetical indices that can satisfactorily measure development. We can only judge whether or not it has taken place by the standard of housing reached, the availability of good domestic water supplies, the sufficiency of food supplies, and the absence of starvation and poverty, and condition of public health. Or we can gauge the supply of cheap energy, the safety of slopes, settlements, buildings and bridges, the minimization of risks from natural hazards like earthquakes and volcanoes, the conservation of the environment, and the local processing and use of mineral and other natural resources within the country of origin.

These are some of the more important factors that affect the quality of life and in which the geosciences are directly or indirectly involved. In spite of its small size, my own country, Sri Lanka, provides many relevant examples because of its variety of landforms, soils, geotechnical conditions and industrial minerals, and because of the growth of its geoscientific community in recent years.

Mineral Exploration and Exploitation

The historical evolution of geology is deeply rooted in the mining industry, which goes back many centuries. Naturally, therefore, one element in the philosophy governing all geoscientific education and activity has been that a major function of the geologist must be to search for minerals, especially as sources of metals and energy. These are the props of our present civilization, and they are likely to be so for decades to come. As a result, geoscientific activity in the developing countries is still mainly concerned with mineral exploration and the export of metals and of oil to feed the demands of the industrialized nations. It is said that the latter with only 25% of the world's population, use over 80% of the world's resources!

However, this dependence on export-oriented mining industries - at the expense of agriculture - has had disastrous results in recent years for some countries, as can be seen in Zambia and Nigeria. The much debated question as to whether the underlying philosophy is still valid is one, therefore, that must continue to be asked. Should the search for and extraction of economic minerals be the primary and main concern of the geoscientist? I believe it should not, even though the search for minerals must remain an important concern.

This is especially true as regards industrial rocks and minerals, the utilization of which is a greater index of the development of a country than most other measures. By this I mean that the local exploitation of industrial rocks and minerals does more to raise directly the living standard of the majority in a developing country than the export of large quantities of a single mineral. For example, the use of limestone for cement and clays for bricks and tiles results in better and more lasting housing. The use of quartz sands for glassware and kaolin for household crockery improves the

Figure 1: A tube well in the Dry Zone of Sri Lanka tapping previously unsuspected groundwater reserves in crystalline rocks. Photo by C. Pendley.

quality of everyday life, and the direct application of powdered marble, dolomite and apatite as fertilizers results in greater crop yields and hence, greater prosperity. All these effects have been seen in Sri Lanka during the past two or three decades.

If mineral exploration is to contribute to development in the real sense, emphasis, therefore, should be more on the search for and evaluation of industrial rocks and minerals and their use within the country. More effort should also be directed to assessing a country's metallic mineral resources and the conservation of such non-renewable wealth rather than unlimited and uncontrolled export, to the exploration of sea-bed resources, and to the intensive search for alternative sources of energy (e.g. solar and geothermal), by those who have no coal or oil resources.

It is the geoscientists themselves, through their institutions and societies, who should convince governments of the very real need to make these changes. The geosciences should also be increasingly engaged in a much wider spectrum of activities, all of which are essential for raising the living standards. These include the search for groundwater, the maintenance of public health, the improvement of soils, the safeguarding of urban growth, the minimization of natural hazard risks, the applications of engineering geology, the protection and monitoring of the environment, and the enlightenment of the general public as to the role of minerals in the economic and social life of the country.

Groundwater

In many parts of the world, particularly in the arid and semi-arid regions, exploration for groundwater is a priority activity of governments. In the deserts of northern Africa and the Middle East, for example, exploration takes the form of the search for fossil groundwater, generally hundreds of metres below the surface (e.g. 50 to 1,200 m in Saudi Arabia). Although the provision of fossil groundwater has resulted in tremendous socio-economic development of the desert regions (e.g. 500 productive wells and the cultivation of 50,000 hectares in the Sarir region of Libya), the supplies are non-renewable and over-extraction may have serious consequences (Margat and Saad, 1985). Moreover, the situation may be exacerbated by careless management, such as when overgrazing is caused by the clustering of nomadic cattle around wells in dry regions.

In the crystalline-rock region of northern and southeastern Sri Lanka groundwater was previously thought to exist haphazardly only in pockets in the weathered overburden. However, from 1978 to 1986 nearly 5000 tube wells were successfully located by searching for joints and fractures in the underlying crystalline bedrock (Fig. 1). The provision of such water supplies has had important benefits, not only in Sri Lanka, but elsewhere in the world. These include the reduction of time spent (five hours or more) by rural women in fetching water from great distances, increase of water consumption leading to greater personal and domestic cleanliness, and reduction of incidence of water-borne diseases.

These developments have been made possible by the use of modern techniques such as geophysical methods (e.g. electrical resistivity, Very Low Frequency electromagnetics, and even refraction seismics), and photogeology and satellite imagery in the search for and interpretation of lineaments.

Environmental Geochemistry and Medical Geology

Pollution of the environment by industrial waste used to be considered a problem facing only industrialized nations, but this is now appearing more frequently in the developing countries, partly because of rapid industrialization with little regard for environmental protection. Bowel diseases are rampant in rural areas, due to such factors as contamination of groundwater by animal and human faecal matter

and high nitrate contents in groundwater because of intensive fertilizer use. In Sri Lanka, for example, 40% of the population suffers from one or another of typhoid, dysentery, hepatitis, gastroenteritis, colitis, and worm infections caused by contaminated water supplies, and some lagoons and lakes have become the repositories of effluents from urban drainage systems (Dissanayake, 1983). Rivers, streams, canals and lakes are also becoming sewers for the disposal of industrial, animal and human waste, and of toxic substances such as pesticides and chemical fertilizers.

Figure 2: Distribution of fluoride ions in groundwater of Sri Lanka (Dissanayake and Weerasooriya, 1987).

Geoscientists and others in Sri Lanka have found that, as elsewhere in the world, dental diseases are directly related to concentrations of fluoride in soils and water (Fig. 2). The hardness of water may affect the incidence of heart diseases, and nitrates in groundwater the incidence of oesophageal cancer (see Dissanayake, 1983). Lung diseases such as pneumoconiosis are prevalent in cement factories and graphite mines in Sri Lanka. Geochemistry has a vital role to play in these areas of environmental pollution in tracing cause-and-effect relationships and in monitoring them over the years.

In Sri Lanka, the publication of the *Hydrogeochemical Atlas* (Dissanayake and Weerasooriya, 1987), the preparation of a soil chemistry atlas, and studies of environmental pollution

and health are important first steps in this area of geosciences and development. They have a direct bearing on improvements in living standards and exemplify the new directions that the geosciences could begin to follow.

Agrogeology

This is a comparatively new area of geoscientific activity but one that assumes real importance when it is realized that the intensive use of chemical fertilizers may, in the long run, do more harm than good. Indeed, efforts are increasing to find alternatives, such as local rock materials, that can be applied directly to soils to improve them in various ways. These include the addition of nutrients not found in chemical fertilizers, the correction of acidity or alkalinity, the improvement of soil structure and fertility, the enhancement of resistance to soil erosion, and the reduction of water losses. Among the materials being used are limestone, dolomite, rock phosphates, volcanic scoria and zeolite-bearing rocks, all of which have considerable potential in one or more of these respects.

Figure 3: Planar rockslide in quartzo-feldspathic schists, old Teldeniya road in the Central Highlands of Sri Lanka.

Studies are now being undertaken in several countries on aspects of agrogeology, particularly in Africa where Canadian expertise is involved. Indeed, in June 1986, the first African Conference on Agrogeology was held in Malawi (Chesworth and van Straaten, 1986). Relatively simple techniques such as the addition of peat are now being developed in India, Canada and the U.S.A. for making phosphatic rocks more reactive without energy-intensive industrial processing (e.g., Toomey, 1987; Anon., 1987a).

In Sri Lanka, where crushed calcitic and dolomitic marbles have for long been used as fertilizers, a large apatite deposit, with proven reserves of 25 to 40 million metric tonnes, is now being worked. The powdered apatite is being applied directly to tea, rubber and coconut lands, but its effects, i.e. addition of phosphate, will be long term owing to the relative insolubility of this apatite. Studies on converting the apatite into a water-soluble super-phosphate have been carried out, and a pilot plant is now needed to test the process that has been evolved. Continued efforts are also required to resolve the problem of using this valuable resource with a minimum of chemical treatment.

Urban Geology

It has been said that urbanization is by far the most important social transformation of our times and that by the end of the century the urban population will be four times greater than in 1950. Moreover, most of the growth will be

in Third World countries. This rapid rate of urbanization, generally haphazard and uncontrolled in developing countries, brings with it serious problems of development and planning.

Many of the problems associated with urbanization are related to geological factors. For example, over-extraction of groundwater by the urban population of Bangkok has led to the subsidence of that city with alarming consequences, such as regular flooding that paralyzes transport, and contamination of the shallower aquifers with salt water (United Nations, 1985; Rau, 1986), and population pressure in Hong Kong has led to intensive construction on unsuitable slopes, leading to earthslips and related phenomena (Burnett et al., in Whiteside, 1987).

Realizing that these are important problems for developing countries, the Association of Geoscientists for International Development (AGID) initiated the concept of LANDPLAN conferences in 1982. The first of these, held in Bangkok, 1982, concentrated on the impact of soil, geology and land-forms on land-use planning in developing countries (Nutalaya et al., 1982); LANDPLAN II was a workshop (Kuala Lumpur, 1984) on the role of geology in the planning and development of urban centres in Southeast Asia (Tan and Rau, 1986), and LANDPLAN III (Hong Kong, 1986) was a continuation of this theme in a setting where this relationship is strikingly demonstrated (Whiteside, 1987).

It is not enough to seek solutions after the problem has arisen, very often too late for any permanent answers to be found. It is necessary, rather, to monitor the growth and development especially of smaller towns and cities before they become unmanageable. This can be done by the preparation of earth science maps for development and planning, for land-use management, for prevention or minimization of natural hazard damage, and other aspects of urbanization (e.g. Robinson and Spieker, 1978). The absence of such maps can lead to urban damage and losses through landslides, floods, and land subsidence; loss of mineral, water and agricultural resources by building over; increase of man-made and man-aided geological hazards such as collapse of slopes due to excavation for construction; and contamination of ground and surface waters through improper waste disposal and landfill.

For many towns and cities, the basic information is only available from a number of scattered sources. The need is to put this data together, collect data where the gaps exist, plot the data and prepare maps of landforms, geology and resources, land use, hydrology, slopes, waste disposal, groundwater and environmental pollution, and city expansion. The expense involved need not be very great, as the preparation of these maps could form suitable research projects for geoscience post-graduate students working in collaboration with local authorities. For example, a UN geologist while studying the urban geology of Colombo's satellite town, Sri Jayawardenapura, found that over 200 boreholes had been drilled in the city of Colombo, the data from which provided a good idea of subsurface conditions.

Risks from Natural Hazards

In many parts of the world, loss of life and damage to property through earthquakes, volcanic eruptions, earthslips, and soil and coastal erosion are very considerable. Some of these hazards are the result of natural causes beyond human control, but others are largely due to human practices. All of them require the attention of the geoscientist.

On the one hand are earthquakes and volcanoes, about which we can do little except to try and understand their causes, learn to recognize signs of their imminence, and devise methods of prediction in order to minimize damage and loss of life. Recent research results were presented, for example, at the 1986 International Symposium on Neotectonics and Volcanic Risks sponsored by AGID in Bogota in December 1986. Seismological and earthquake engineering studies

are being vigorously pursued in many countries of the world susceptible to these natural hazards, including Mexico, Japan, the Philippines, the U.S.A. and New Zealand (e.g. Souther et al., 1984).

On the other hand, desertification, soil and coastal erosion, and earthslips are very much accelerated and assisted by human activities such as deforestation and removal of vegetation, overgrazing of marginal lands, intensive cultivation of unsuitable slopes, poor drainage of unconsolidated scree slopes, and removal of material from coastal strips. Earthslips and rockslides (Fig. 3), for example, are a common hazard in tropical lands, affecting roads and communications, settlements, terraced fields, and cultivated and built-on slopes. Geoscientists are now increasingly involved in remedial and preventive measures, and also in monitoring unstable slopes in order to understand the nature of the movements and their causes and effects. In Sri Lanka, the National Building Research Organisation has recently begun such studies, especially where major roads are being affected.

Coastal erosion is also a serious problem in many tropical countries, where the problem is often aggravated by beach- and river-sand mining and the removal of coral from reefs for lime burning. In 1984, for example, more than 18,000 tons of coral were collected from the southwestern coastal area of Sri Lanka, and several thousands of cubic metres of sand were mined from the western and southern coasts. It has been estimated that about 175,000 to 285,000 m³ of coastal sand are lost by erosion each year along the 685 km-long western and southern coasts of the island (Fig. 4), 145,000 m³ of which is lost from the 137-km segment running north from Colombo (Anon., 1987b).

Engineering Geology

Not long ago geologists in developing countries were rarely ever consulted when dams were to be built or tunnels constructed. Twenty years ago, engineering geology was not even a subject taught in developing country universities. If geologists were consulted, it was only when problems arose from, for example, the presence of inconvenient structures such as faults or joints, or from excessive seepage.

An example was the case during the locating of the Kotmale Dam and during the drilling of the Polgolla tunnel in Sri Lanka (Vitanage, 1982). Initially, siting of the dam proved difficult even after 10 years of investigations (1968-78) because of adverse geological conditions. It was only after a detailed geological map of the project site on the scale of 1:10,000 was prepared that a suitable site, downstream of the original one, was chosen. Insufficient attention had

Figure 4: Erosion of laterite cliffs at Bernwela on the southwest coast of Sri Lanka.

been paid to the prediction, based on geological mapping, of the presence of deep shear zones along the tunnel lines. As a result, nearly 1,600 m³ of sand, silt and rock "erupted" into the tunnel during a period of 15 days, and the tunnel was flooded to a depth of 0.3 m.

In Sri Lanka, engineering geologists (geotechnical engineers) of the Central Engineering Consultancy Board are now attached to all major dam construction projects from the very beginning. The Mahaweli Development Scheme in Sri Lanka is one such project, involving the building of a succession of dams along the river for hydroelectric purposes, and the diversion of water for irrigation (Fig. 5). Board engineers carry out detailed geological mapping of the site, and monitor it during and even after construction has been completed. In a recent visit to Randenigala-Rantembe, the last of the series of dams and reservoirs in the Mahaweli scheme (Fig. 6), I was very impressed by the meticulous and detailed mapping of the dam sites, the grouting tunnel and the environs carried out by young Sri Lankan geotechnical engineers. They are a new breed in my country - well trained, enthusiastic, devoted, and confident but willing to learn.

Figure 5: The Mahaweli Ganga Development Scheme showing the locations of major dams and reservoirs: 1- Kotmale, 2- Victoria, 3- Randenigala, 4- Rantembe, 5- Ulhitiya Oya.

Environmental Monitoring

Development projects in various parts of the world are generally regional in scope, sometimes confined to natural regions such as river valleys and basins or coastal belts. As a result of the Mahaweli diversion, for example, changes such as reservoir silting, micro-seismic activity, slope instability, salination of irrigated land, and displacement of population are taking place. These effects are influencing the social and physical pattern of the land, but we know little or nothing of how and to what extent.

Monitoring such effects is a very necessary adjunct of all development programs, and useful examples are provided by the U.S. Geological Survey (Robinson and Spieker, 1978) and the Texas Bureau of Economic Geology (Wermund, 1982)

with their environmental maps. Such atlases, needing multi-disciplinary efforts, present a record of the different environments that exist within a region and the processes going on in them. Each atlas could, for example, contain maps of the geology, mines and minerals, landforms and substrate conditions, land-use patterns, erosion, sedimentation, rainfall, stream discharge, water systems, slopes and slope stability, and geochemistry of soils and waters of a region or series of regions. Atlases would also provide means of communication between and sources of information for the many people involved in one way or another in the life of the region.

Figure 6: The Victoria Dam and Reservoir.

However, the embarking on such a venture requires, besides considerable financial expenditure, the appreciation of the benefits to be derived. In general this comes only when immediate and concrete benefits are expected. And so, we in developing countries may have to wait a very long time before the long-term benefits of such environmental monitoring are recognized and appropriate action taken to establish the kind of system described above. We can, however, take steps to remedy this situation by bringing the benefits to the notice of the general public and the authorities by all the means at our disposal. Much more can be done to project and propagate our knowledge for the public good through the newspapers, the radio and television, and our geological societies and science associations.

Earth Science Education

We have so far been dealing with areas of activity in which the geosciences have to be and are directly involved, but there is another side to this activity where the involvement is indirect. This is the field of earth science education at all levels. We geoscientists have been too reluctant to talk to the non-specialist about our science, too backward in pointing out how geology affects the community at so many points, perhaps even too unaware of the importance of geoscientific factors that influence the environment (Cooray, 1988). Yet one of the most important needs is to make the people around us realize the vital necessities of careful use of resources, and the preservation and conservation of the environment.

Although earth science is taught in many schools in North America and Europe, this is not true for the Third World. A start has, however, been made in Thailand and Sri Lanka to introduce integrated earth-science curricula into secondary schools. In Thailand, for example, AGID is now sponsoring a pilot scheme in a school where an earth-science curriculum is being tried out as part of the regular program. In Sri Lanka, some aspects of earth science are now being taught during school years 6 to 11 in the two compulsory subjects

'Science' and 'Social Studies', but there are serious gaps in the curricula of the two. AGID and the Curriculum Development Committee of the Sri Lanka Department of Education are holding a series of meetings in which the gaps have been identified and suggestions made as to how they should be filled. From them we hope that a more meaningful content of earth science will be introduced into the secondary school program of Sri Lanka.

Constant revision and reassessment of teaching and research programs is also needed at the tertiary level. A good foundation in "pure" geology is, of course, a basic necessity, for it has been said that "all exploration, from pick and shovel to country-wide aerial surveying, is based on someone's geological concept." The important thing is that this truism applies to all aspects of applied geology: hydrogeology, engineering geology, agogeology, medical geology and environmental geology. But basic geological training is only a prerequisite for the increased production of applied earth scientists, a direction which education at both undergraduate and post-graduate levels must take in the future. The relative neglect of such subjects as modern structural geology, Quaternary geology, marine geology, and geoscientific writing (Fig. 8) must be remedied if we are to keep pace with evolving concepts in the geosciences.

Last, but certainly not least, is the need to educate and inform the general public about the geosciences in terms they can understand. Only thus can we show how geology is relevant to everyday living, how it can raise the standard of living and improve the quality of life, demonstrate to non-geologists the inter-relationships among resources of the land, and impress upon them the necessity of using those resources wisely for their benefit and that of generations to come. As a first step towards this objective, the Geological Society of Sri Lanka is planning to embark on a series of evening classes on "Minerals, Rocks and Gemstones" of Sri Lanka. Geological societies in other developing countries might well embark on similar projects to bring geoscience to the people.

Figure 7: AGID handbook on geoscientific writing and editing (Cooray, 1987).

The Role of AGID in Development

AGID has, in many ways, helped geoscientists to play a greater part in development, especially in the Third World. A look at the Association's activities in its early years (1970s) will show that even though much of the emphasis was on minerals, there were projects in other areas that were more directly related to "development," as defined here. Indeed, of the 41 projects sponsored by AGID in the 1974-1984 period, more than half were on such applied areas as engineering geology (7), geoscience education (5), groundwater (4), agrogeology (3), urban geology (2), energy (1), environmental geology (1) and data management (1). This trend has continued in the period 1984-1988, and environmental geology and some traditional aspects of "pure" geology have begun to occupy an important place in the Association's programs. Another important trend in the activities of AGID has been the encouragement of projects involving training of young Third World geoscientists, at the expense of the usual seminars and symposia.

AGID has also pursued a vigorous publication policy ever since its inception in 1974. Its publications include the official newsletter, *AGID News*, now running into its fourteenth year of publication, regional newsletters for Latin America, Africa, and South and West Asia, and its "special publications," most of which are the proceedings of AGID-sponsored seminars, symposia and training courses.

AGID holds a unique position in the field of international scientific endeavour, as no other scientific discipline has a comparable international global community held together by similar aims and achievements. AGID "provides services to the international geoscientific community that are not substantially duplicated elsewhere," in the words of an independent evaluation of the Association. Further recognition by the international scientific community has come through AGID's affiliation to the International Union of Geological Sciences (IUGS), and steps are now being taken for AGID to become the first international association to be affiliated to the Geological Society of America in this its Centenary year. If approved, this action would follow AGID's formal recognition earlier this year by the creation

of a joint organization with the oldest geological society in the world, the Geological Society of London. AGID is also on the roster of the United Nations Economic and Social Council, with the option of designating official representatives to the United Nations.

It has been an honour and a privilege for me to have been the President of this unique organization for the past four years, and it has been particularly gratifying to watch AGID moving into new directions. I am convinced that if we, as geoscientists, are to make a significant contribution to national and international development, we must be more and more involved in scientific activities that lead directly to the improvement of living conditions for the majority of the people on this planet. I trust that this same philosophy will continue to influence the Association and those charged with the direction of its affairs.

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References

- Anon., 1987a. Agrogeology in Tanzania. *Geology Today*, v. 3, no. 1, p. 8.
- Anon., 1987b. Sri Lanka Coastal Management Plan. Coast Conservation Department, Colombo, 124p.
- Chesworth, W. and van Straaten, P., 1986. First African Conference on Agrogeology. *Episodes*, v. 9, no. 4, p. 255.
- Cooray, P.G., 1987. Geoscientific Writing and Editing, Association of Geoscientists for International Development, Bangkok, Thailand, 30p.
- Cooray, P.G., 1988. The geosciences, international development and AGID. *AGID News*, no. 54, p. 20-25.
- Dissanayake, C.B., 1983. Research in Environment. *Daily News*, Colombo, July 27.
- Dissanayake, C.B. and Weerasooriya, S.V.R., 1987. Hydrogeochemical Atlas of Sri Lanka. Natural Resources, Energy and Science Authority of Sri Lanka, Colombo, 106p.
- Dissanayake, C.B., 1988. Nitrates in the groundwater in Sri Lanka - implications for community health (Abs.). Symposium/Workshop on 'Groundwater in Sri Lanka', Kandy, 1988. Abstracts volume, p. 7.
- Krinsley, D.B. and Workman, D.R., 1987. LANDPLAN III: geology in urban development. *Episodes*, v. 10, no. 2, p. 122-123.
- Margat, J. and Saad, K.R., 1985. Deep-Lying aquifers: water mines under the desert? *Water Resources Journal*, v. c146, p. 14-20.
- Nutalaya, P., Karasudhi, P., Thanasuthipitak, T., Kheoruenromme, I. and Sudhiprakarn, A., 1982. Soil, Geology and Landforms: Impact on Land Use Planning in Developing Countries. Association of Geoscientists for International Development, Bangkok, 1226p.
- Rau, Jon, 1986. Geotechnical problems in the development of Bangkok. *AGID News*, no. 49, p. 30-34.
- Robinson, G.D. and Spieker, A.M. (eds.), 1978. Nature to be Commanded; Earth-science maps applied to land and water management. U.S. Geological Survey Professional Paper 950, Washington, 95p.
- Souther, J.G., Tilling, R.J. and Punongbayan, R.S., 1984. Forecasting eruptions in the Circum-Pacific. *Episodes*, v. 7, no. 4, p. 10-18.
- Tan, B.K. and Rau, J.L., 1986. LANDPLAN II, Role of Geology in Planning and Development of Urban Centres in Southeast Asia. *AGID Report* 12, 92p.
- Toomey, Jerry, 1987. Rocks in the Service of Soil. *AGID News*, no. 50, p. 9-11.
- United Nations, 1985. Geology for urban planning, Selected Papers on the Asian and Pacific Region. Economic and Social Commission for Asia and the Pacific. Bangkok, 41p.
- Vitanage, P.W., 1982. Importance of Detailed Morphotectonic and Geological Studies as a Means of Predicting Hazards and Problems in Tunneling and Site Investigations. Proceedings of the Fourth International Congress of the International Association of Engineering Geologists, India, v. IV, p. 203-220.
- Wermund, E.G., 1982. Communicating with planners: mapping in Texas. *Episodes*, v. 1982, no. 3, p. 24-30.
- Whiteside, P.G.D. (Ed.), 1987. The Role of Geology in Development. Geological Society of Hong Kong Bulletin No. 3, 600p.