Uranium Exploration in Developing Countries – Facts and Trends

by Paulo M.C. Barretto

EXPLORATION IN DEVELOPING COUNTRIES

The interest of the developing countries in uranium exploration has increased notably since 1973, and this is evidenced by the growing number of requests submitted to the IAEA by Member States for assistance in this field. Although there are many reasons that account for this growing interest, the most important are the desire on the part of these countries for self-sufficiency in energy, the rising price of petroleum and the dramatic increase in the market value of uranium. The IAEA, in response to such requests, has had to expand support for exploration-related activities through its programme of technical assistance. Figures 1 and 2 illustrate increasing activity in the field of uranium exploration from 1971 to 1978. During 1978 twenty-eight Member States profited from such assistance in the form of (i) consultancy services provided to Governments on exploration, mining, legislation, programme planning and related matters; (ii) expert services and equipment; and (iii) on-the-job and fellowship training of national personnel.

At the present time, large scale projects assisted by the United Nations Development Programme (UNDP) are being carried out in Chile, Colombia, Peru, Chad and Madagascar while smaller exploration programmes are being supported in Bangladesh, India and Lesotho. In addition, at least six large UNDP projects are now either being considered by Governments, or are at the negotiation stage; it is expected that a project will soon be initiated in Yugoslavia.

Uranium exploration projects are also being supported under the Agency's Regular Programme of technical assistance in Bangladesh, Bolivia, Brazil, Chile, Ecuador, Indonesia, Libya, Madagascar, Malaysia, Mali, Morocco, Pakistan, Peru, Portugal, the Republic of Korea, Sri Lanka, Thailand, Tunisia, Uruguay and Zambia.

Increased efforts on the part of the IAEA in support of exploration for uranium in the developing countries are evident from Figure 3, which shows annual expenditures for exploration-related assistance provided by UNDP and the IAEA under the Regular Programme.

These figures are significant. They clearly show a continuous rising trend through the last five years. From this trend plus the existence of powerful exploration incentives such as

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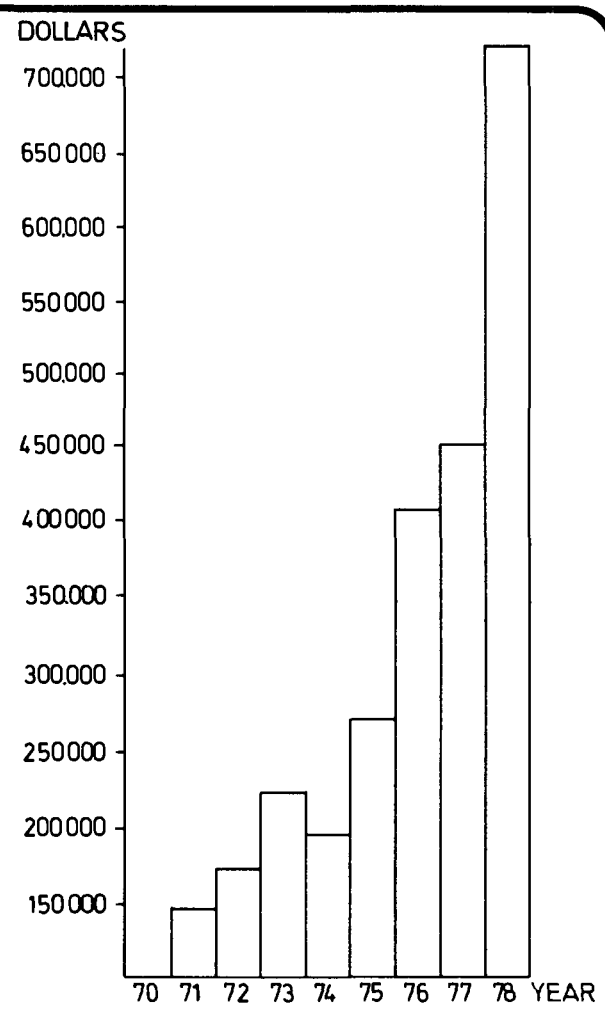
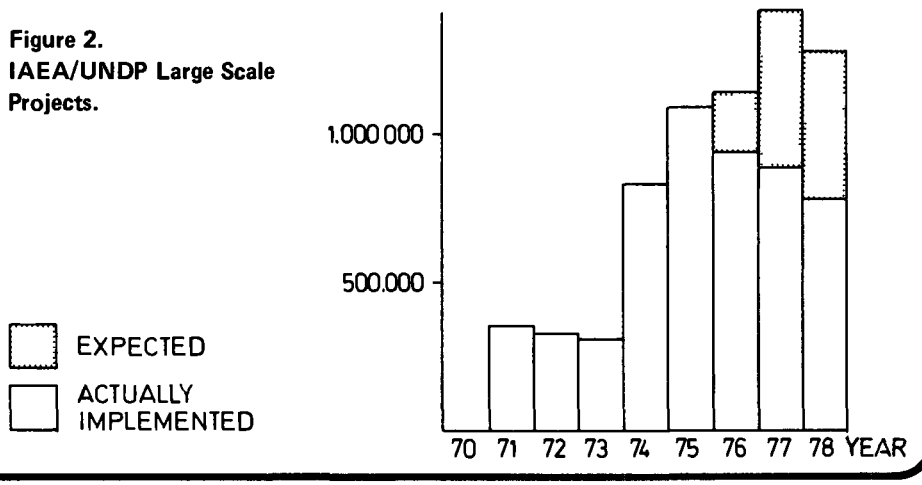


Figure 1.
Implementation of Projects in the Field of Nuclear Raw Materials (IAEA Regular Programme).

Figure 2.
IAEA/UNDP Large Scale Projects.



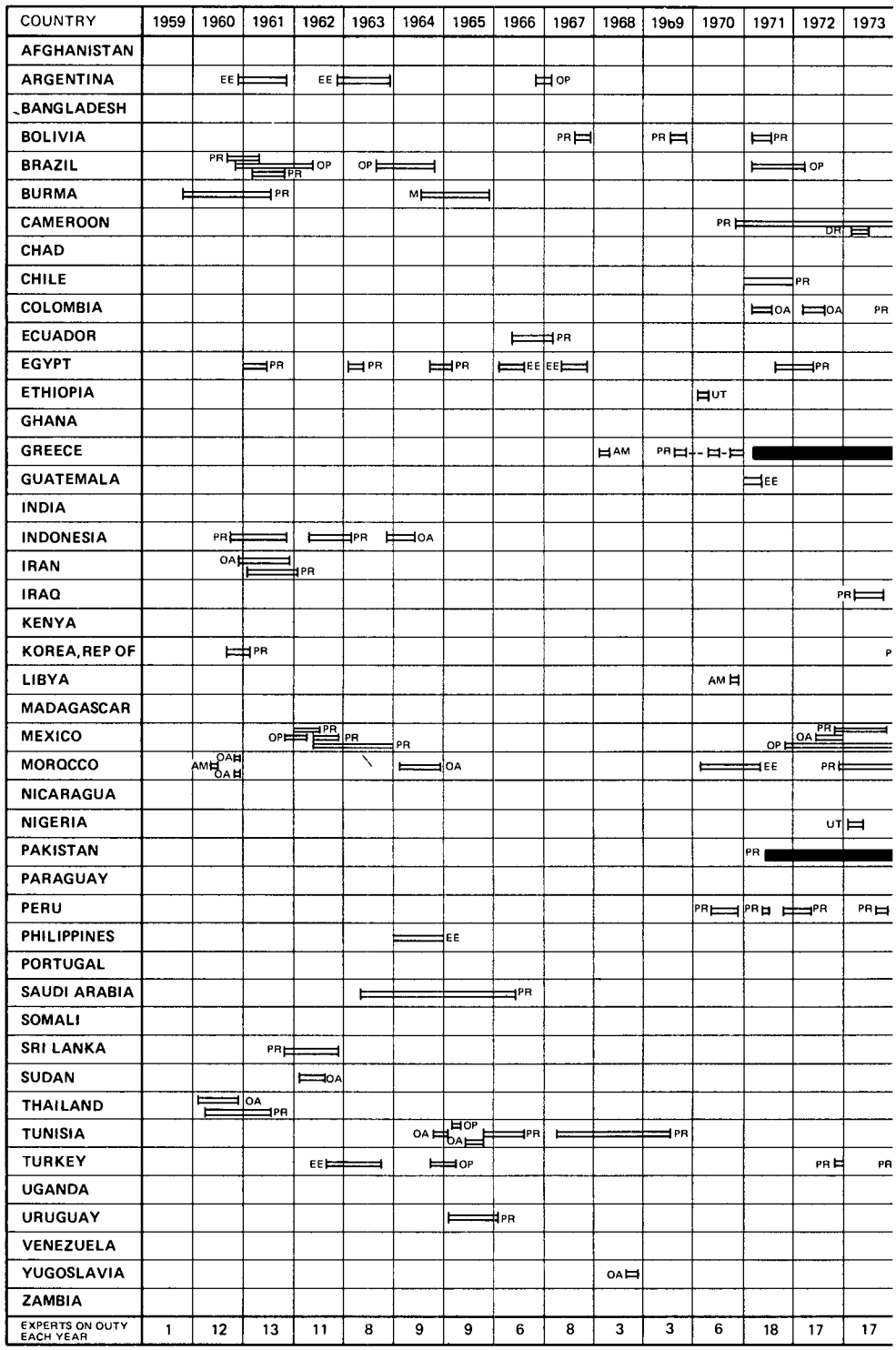
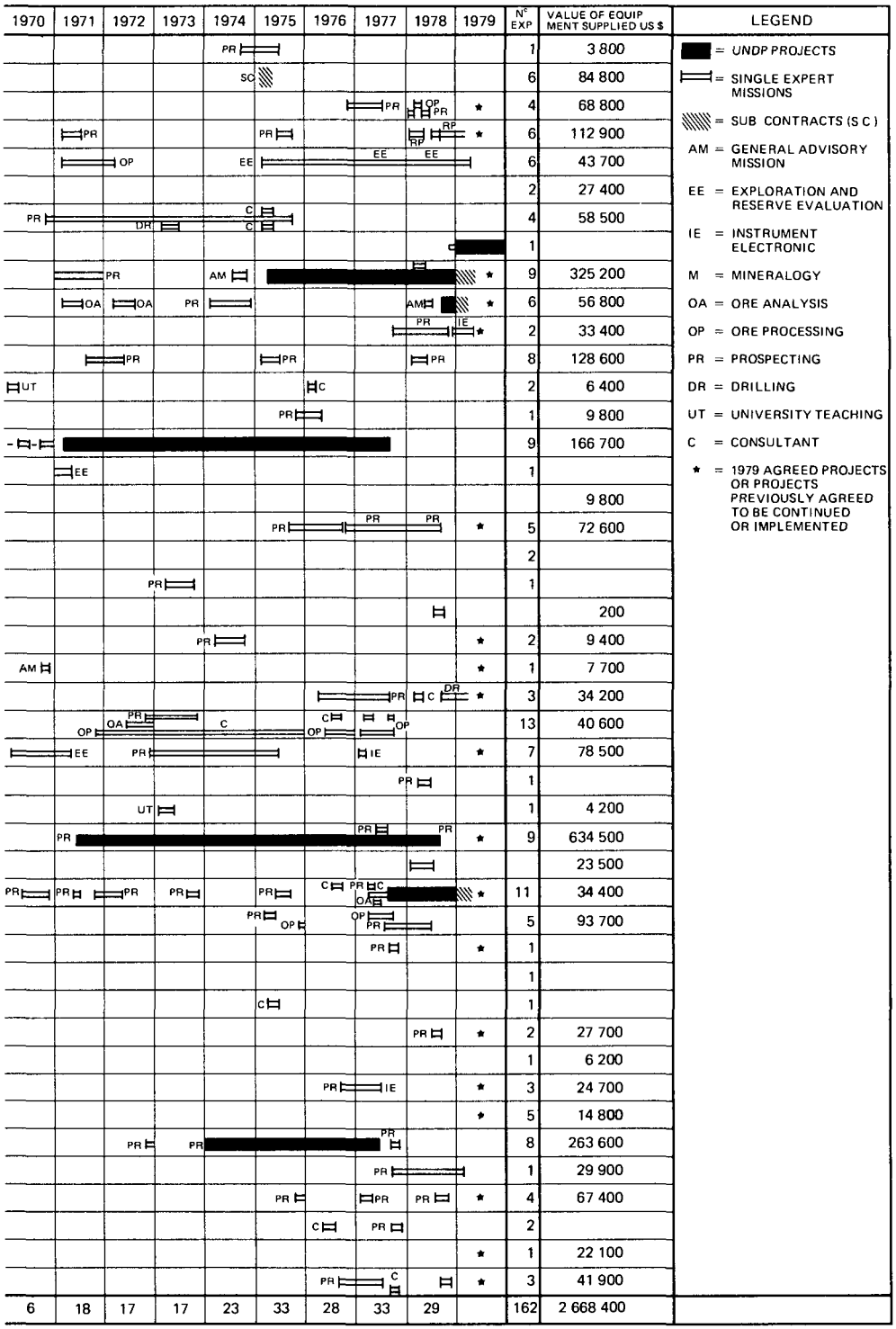


Figure 3. Types of Assistance Provided: 1958–1979 (UNDP and IAEA's Regular Programme).


1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
N° EXP
VALUE OF EQUIPMENT SUPPLIED US $
LEGEND
3 800
84 800
68 800
112 900
43 700
27 400
58 500
325 200
56 800
33 400
128 600
6 400
9 800
166 700
9 800
72 600
200
9 400
7 700
34 200
40 600
78 500
4 200
634 500
23 500
34 400
93 700
27 700
6 200
24 700
14 800
263 600
29 900
67 400
22 100
41 900
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18
17
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33
28
33
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162
2 668 400
= UNDP PROJECTS
= SINGLE EXPERT MISSIONS
= SUB CONTRACTS (S C)
AM = GENERAL ADVISORY MISSION
EE = EXPLORATION AND RESERVE EVALUATION
IE = INSTRUMENT ELECTRONIC
M = MINERALOGY
OA = ORE ANALYSIS
OP = ORE PROCESSING
PR = PROSPECTING
DR = DRILLING
UT = UNIVERSITY TEACHING
C = CONSULTANT
* = 1979 AGREED PROJECTS OR PROJECTS PREVIOUSLY AGREED TO BE CONTINUED OR IMPLEMENTED

skyrocketing uranium prices and the need by most of the industrialized countries to have assured supplies it is expected that the number of requests for technical assistance in uranium exploration and production will continue to increase in the near future.

URANIUM RESOURCES IN DEVELOPING COUNTRIES

Whereas the uranium resources known at present in the developing countries represent only a small percentage of the world's reserves, it is certain that a considerable fraction of the as yet undiscovered reserves are located in the developing world. Since 1975 this percentage has been increasing in relation to the known total. It should be mentioned in this regard that exploration for uranium is a long-term endeavour, with considerable time elapsing between the commencement of exploration and the discoveries. Most developing countries were not engaged in uranium exploration a decade ago, and the deposits now being found in these regions are the result of systematic, albeit small-scale, exploration programmes carried out in some countries over a considerable period of time.

Excluding countries with very small surfaces areas such as Hong Kong, Lebanon and oceanic islands, roughly 60% of the developing countries are at present committed to some form of uranium exploration. The degree of this commitment varies of course in terms of human and financial resources from country to country, and so does the motive for exploration. Assessing the exploration commitment in such countries is problematic, however, owing to the many factors involved and the year-to-year fluctuations in resources allocated to this endeavour. Table 1 below is an attempt to classify the efforts made by developing countries to December 1978. To facilitate analysis only five levels of relative commitment have been used. The basic parameters taken into account are (i) financial investment in exploration made by the Government and/or private sector (including private and foreign investors); (ii) the number of professional personnel engaged in exploration (including Government research centres and universities); and (iii) the intensity/continuity of exploration over the last five years.

Among the countries listed in Table 1 are several with known uranium reserves in the range of 1000–5000 tonnes uranium. Six of them, however, reported reserves (reasonably assured resources) equal to or greater than 20 000 tonnes uranium in the cost category of 80 US dollars/kg. These countries are listed in Table 2 below, and the deposits and most important uranium occurrences in the developing countries are shown in Figures 4 and 5.

RESEARCH AND DEVELOPMENT

Most of the developing countries are located in the tropical zone, while the exploration techniques for uranium which are in wide use today have been developed in the industrialized countries of the northern hemisphere. As weathering and ground surface processes are considerably different in tropical regions, it is not always possible, nor desirable, to apply the same techniques and/or procedures developed for more temperate zones. There is thus a need for research and development in respect of techniques and equipment suitable for desert and tropical rain forest conditions. Investigations are now in progress, for example, to determine optimal procedures for radiometric surveys in areas with thick soil cover and dense vegetation, to develop appropriate geochemical procedures for such terrain, and to test methods of extracting uranium from refractory minerals which

Table 1. Commitment of developing countries to uranium exploration and production (excluding countries with centrally planned economies) as at December 1978

I. MAJOR EFFORT	II. SUBSTANTIAL EFFORT
Algeria	Bolivia
Argentina	Central African Empire
Brazil	Chile
Gabon	Colombia
India	Pakistan
Iran	Yugoslavia
Niger	Zambia
III. MODERATE EFFORT	**IV. SMALL EFFORT**
Egypt	Afghanistan
Indonesia	Bangladesh
Korea, Republic of	Chad
Libya	Cameroon
Mali	Ecuador
Mexico	Ethiopia
Morocco	Ghana
Nigeria	Greece
Paraguay	Ivory Coast
Peru	Kenya
Philippines	Malaysia
Portugal	Sri Lanka
Saudi Arabia	Sudan
Turkey	Tanzania
Uruguay	Thailand
Venezuela	Tunisia
	Uganda
V. MINOR EFFORT	
Burma	Jamaica
Congo	Jordan
Costa Rica	Lebanon
Democratic Kampuchea	Nicaragua
Dominican Republic	Panama
El Salvador	Senegal
Guatemala	Sierra Leone
Haiti	Syria
Iraq	United Arab Emirates

Table 2. Uranium reserves in selected developing countries*

Country	Reasonably assured resources (in tonnes uranium)	Estimated additional resources (in tonnes uranium)
Algeria	28 000	50 000
Argentina	23 000	4 000
Brazil[1]	62 000	58 000
Gabon	20 000	5 000
India	30 000	24 000
Niger	160 000	53 000

* Uranium Resources, Production and Demand, NEA/IAEA, December 1977.
[1] Updated to December 1978.

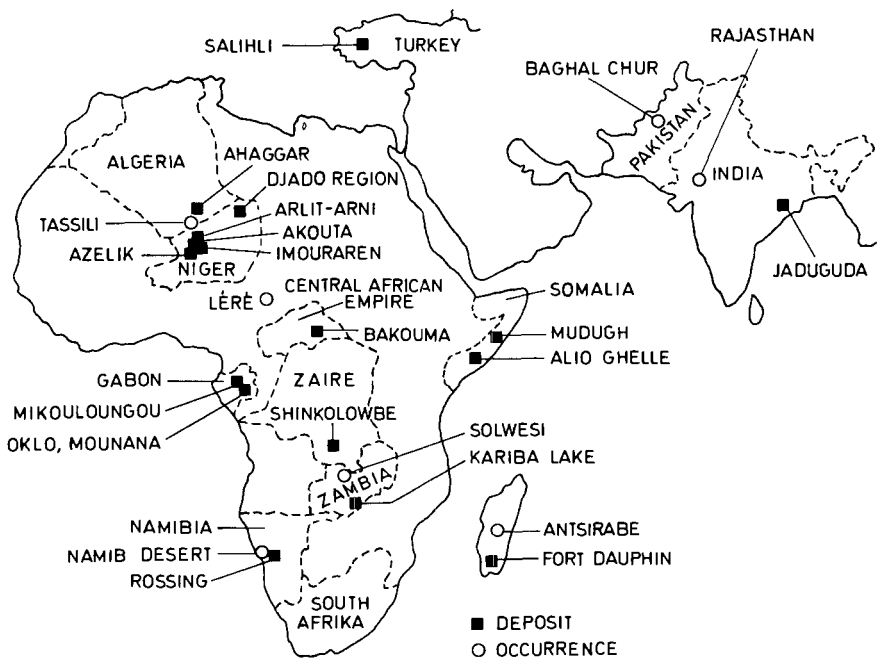

Figure 4. Uranium Deposits and Major Occurrences in Africa and the Middle East (excluding mineralization associated with phosphates).

Figure 5. Uranium Deposits and Major Occurrences in Latin America.

are abundant in many developing countries. Calibration facilities for surface, sub-surface and aerial radiometric equipment, for which there is a general demand, are now being established.

MANPOWER DEVELOPMENT

One of the best ways of gauging the interest of Member States in the field of uranium resource development is to examine their requests for training Here again the figures indicate that interest is growing (see Figure 6). It should be noted that, in addition to the fellowship programme, the Agency regularly sponsors training courses; the interest shown has been so great that approximately 50% of the officially nominated participants have had to be turned away.

It is envisaged that such training courses will continue to be organized in the future as many countries have offered to host them. The next regional course on uranium exploration techniques is scheduled for May-June 1980 in Bolivia.

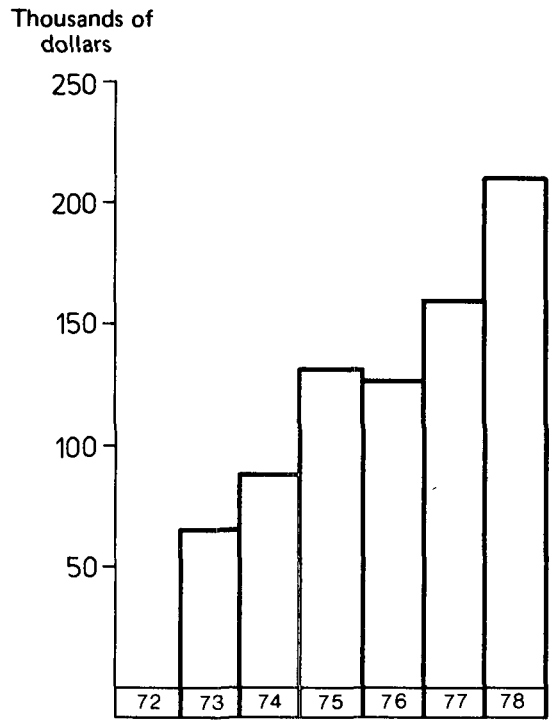

Figure 6. Training Provided by the Agency in Uranium Exploration-Production (1973–1978).

NATIONAL POLICIES

Many developing countries have not yet taken any official decision, at the national level, on uranium exploration, mining and production, even though exploration programmes are already in progress. Without suitable policies and legislation defining the responsibilities of national agencies and governing the participation of the private (national or foreign) industry, little progress can be made.

The IAEA recently carried out a survey of 50 developing countries on their policies on the uranium mineral industry and incentives given to exploration or production, if any. This survey indicated that one quarter of those countries had no involvement in uranium exploration and have not, therefore, considered formulating policies and enacting laws concerning uranium exploration and production. One third have expressed their interest in uranium through legislation and exploration has been carried out thus far by the Government alone. The remaining countries have legislation in force allowing agreements and joint ventures with the private sector, national or foreign.

Regarding government incentives towards exploration and production, it was found that one half of the countries surveyed did not at present encourage exploration – they are not funding much state activity, nor are they allowing participation of the private sector. One

third allow, or might allow, foreign investment but are not actively encouraging such activity (some of these countries have rather substantial exploration programmes being carried out by Government organizations). The remaining countries have legal mechanisms and promote the participation of the private groups.

As indicated by this survey there is a large number of developing countries that may have to consider formulating national policies regarding the uranium industry. It is envisaged that the IAEA will be requested to provide consultation as it has done in the past.

CONSTRAINTS ON EXPLORATION

When examining the options available for the evaluation and development of national uranium resources, some developing countries fail to give sufficient consideration to difficulties or constraints in the country – such as difficult access, a shortage of manpower and legislative impediments – which will render even the most ambitious effort ineffective. The most common problems in this respect are as follows:

Geography: This is an important consideration in many countries. Although desert conditions clearly impose constraints on exploration and development, such difficulties can be overcome; examples of successes in such areas are the Arlit, Akouta and Azelit deposits in Niger. Exploration is similarly difficult in jungle and rain forest conditions; it is not impossible, however, and the Bakouma deposit in the Central African Empire is a case in point. It must be borne in mind that the costs of exploration in difficult areas exceed by several times those in which access is adequate and where established methods are easily applied. Lead times are also significantly longer.

Manpower: The shortage of adequately trained staff in sufficient numbers is a serious impediment to successful exploration, as many years are required for the development of competent exploration organizations. Similarly, support staff such as chemists, electronics engineers and mathematicians, as well as lawyers specializing in mining legislation, cannot be acquired overnight.

Land use: Disputes over the jurisdiction and use of land in areas where discoveries are made can also delay well-planned exploration/production programmes.

Legislation: The absence of laws, or the existence of legislation which is not sufficiently specific or clear regarding investment in nuclear raw materials development is probably the single most serious constraint on the future exploitation of uranium resources in developing countries.

THE STRATEGY OF SUCCESSFUL EXPLORATION

The search for uranium, while similar in many respects to exploration for other scarce metals in the earth's crust, is distinguished by the fact that this element is naturally radioactive. Exploiting this characteristic, geologists have developed methods for measuring the emitted gamma radiation and/or the decay products of uranium as a guide to ore deposits. Thus, in exploration for this element, extensive aerial and ground radiometric surveys are carried out with sensitive instruments so that areas with higher than normal radioactivity can be delineated. As the mechanism of uranium mobilization and deposition

is, for the most part, understood, it is possible for the exploration geologist to identify the types of geological environment in which concentrations of this element are likely to be found Geochemical and geophysical exploration methods are also commonly employed to determine varying amounts of uranium, and daughter products – which are present in the parts per million range – in rock, soils, soil gas, stream sediments and water. These exploration methods and their geological interpretation serve as guides to locating concentrations of the element and, in conjunction with drilling, are indispensable for successful, cost-efficient exploration.

A comprehensive strategy has been developed and proved effective in which the individual exploration techniques described above are co-ordinated and applied in a logical, systematic manner. Experience has shown that, in addition to sufficient financial and human resources, such an approach is required to ensure that the invested resources produce reliable, if not economic results. "Phased exploration" is a name given to this sequence of prospecting activities and is practised by successful exploration groups the world over. The objective of this strategy is the evaluation of the uranium potential of extensive areas by the investigation and rejection of regions in which the criteria for uranium accumulation – indicated by the various exploration techniques – are not met. In other words the focus of the exploration effort gradually narrows on an area in which there is greatest likelihood for uranium deposition The phases of exploration are as follows: (i) planning; (ii) definition of area; (iii) reconnaissance; (iv) follow-up; and (v) detailed exploration/ development.

In exploration for uranium, co-ordination of the many essential activities is of paramount importance. Data must be obtained in a systematic and sequential way, avoiding omissions of individual exploration stages in the pursuit of immediate results. Such "short cuts" lead to little more than squandering of valuable resources and the needless prolongation of a questionable exploration programme. Only in the final stage, after all the steps have been completed satisfactorily, when areas of no interest have been rejected and all data judiciously interpreted, does the effort "pay off" – with final evaluation of the area and the possible identification of an ore deposit. Since this approach entails considerable capital investment, a high level of technical expertise, wide experience and time, developing countries are seldom able to embark on effective uranium exploration programmes without guidance.