ATOMIC SURVEY IN AFRICA AND GREECE

A preliminary assistance mission* of the International Atomic Energy Agency visited Greece, the Ivory Coast, the Federation of Mali, Morocco, Tunisia, and the Sudan during April-May this year. Its main purpose was to collect technical information on the nuclear activities and plans of these countries, advise them on the development of their peaceful atomic energy programs, and help them in formulating requests for Agency assistance.

This was the fifth mission of its kind, the earlier four having visited a number of other countries in Asia, Africa, Latin America and Central Europe. As in previous cases, the mission was despatched at the request of the countries concerned.

Some of the more important information collected and suggestions made by the mission are summarized in the following sections.

Organization of Activities

The Greek Atomic Energy Commission was established in 1954 and re-organized in 1955. While its structure is adequate for the present stage of atomic development in Greece, the mission felt that in view of its anticipated expansion in the near future, it should also include representatives of power and industrial interests.

There is no national body for atomic energy in the Ivory Coast. It was, however, suggested that a modest start might be made in those aspects of atomic energy more immediately beneficial to the country's economy, e.g. medicine and agriculture.

As for the Federation of Mali, the Mission felt that it might be appropriate to set up a scientific committee with atomic energy as one of its concerns.

There is no central authority within the Moroccan Government responsible for atomic energy programs, but considerable interest was expressed by the scientific departments concerned. The Mission thought that both in the Federation of Mali and in Morocco phased programs for the introduction of atomic energy needed to be drawn up by experts and the Agency could be called upon to provide assistance in this respect.

In Tunisia, an Atomic Energy Commission is expected to be formally established later this year. At present, all matters concerning the peaceful uses of atomic energy are co-ordinated through the Commissioner for Scientific Research and Atomic Energy, whose office falls within the Ministry of Industry and Transport.

At present, there is no national organization for atomic energy in the Sudan. Since plans are being considered for the utilization of atomic energy, the mission recommended, as a first step, the establishment of a council or co-ordinating committee to advise the Government on scientific activities and suggested that for the time being all atomic energy matters should be initially referred to this body.

Education and Training

There are seven institutions of higher learning in Greece, including two universities and one Technical University. The standard of training and facilities is of a high order. Introductory courses in nuclear physics are given to students of physics, and medical students attend lectures on the clinical applications of radioisotopes. Courses in the application of radioisotopes are also held at the Greek Atomic Energy Commission establishments at the Democritus Center. However, more staff will be required to carry out the comprehensive plans for atomic research and development, and the mission thought it necessary that the existing universities and institutes should develop nuclear science teaching to meet these requirements.

At Abidjan in the Ivory Coast, training facilities at the intermediate, technical and higher education levels are still in an early state of development. A Faculty of Science, affiliated to the University of Paris, is being organized, but there is no immediate provision for nuclear science training. Before a program for the peaceful applications of atomic energy can be introduced, staff will have to be trained, and this in turn can only be done when the Faculty of Science and technical education are fully developed. In the meantime, it might be possible for the Agency to render limited assistance through its fellowship program.

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* *The six-man mission was headed by Mr. John Webb, acting Director of IAEA's Division of Technical Supplies, and included Mr. Hugh Belcher, a specialist in the medical uses of radioisotopes and Head of the Radioisotope Laboratory of the Post-Graduate School at the Hammersmith Hospital, London, and Mr. Pierre Pèlegrin, an expert on isotope applications in agriculture and Chief of the Applied Agronomy Group in the Biological Service at Saclay France. The three other members were Mr. Oliver Llyod, Mr. George Petretic and Mr. Vjacheslav Ustinov - all from the IAEA Secretariat. Mr. Pèlegrin and Mr. Petretic were not on the mission during its visit to Greece and Mr. Nathaniel Coleman and Mr. Milan Osredkar, both members of the Agency Secretariat, joined the team in their place.*

Advanced studies in the Federation of Mali are centered for the present in the University of Dakar where excellent facilities exist for scientific and technical training. The Science Faculty of the University, which is rapidly developing, can form a valuable nucleus for an extension of the necessary training facilities. At present, however, the available scientific and technical staff as well as the average yearly number of science graduates are insufficient to meet the growing requirements, and as much effort as possible should be made to increase the facilities for training as well as the number of students trained. For the introduction of any limited program for the application of radioisotopes in agriculture, medicine and industry, it may be necessary to utilize training facilities available in other countries and use could be made of Agency fellowships.

In the Faculty of Science of Rabat University and other educational establishments in Morocco, no specialized courses in atomic energy are given at present, but the Faculty programs in physics and chemistry include some sections dealing with atomic energy. The Faculty is supplemented by an Engineering School, a Medical School in Casablanca and an Agricultural School in Meknes. These facilities, if developed, can provide a potential basis for the training of specialists when atomic energy projects are instituted. Future requirements of trained staff could be supplemented by the use of training facilities in universities abroad, in which case the Agency's fellowship program could be utilized.

The Faculty of Science of the newly created University of Tunis is at a transitional stage. The proposed establishment of an institute of nuclear physics within the university will provide an opportunity for carrying out atomic research, but this will immediately require a number of trained staff. It is desirable that account be taken of this fact in any decision to expand the program of atomic energy for peaceful purposes. The Agency could assist by the award of fellowships for the training of students in countries overseas.

The major educational problem in the Sudan at present is the re-organization of primary education and the organization of secondary education, and the mission felt that the opportunity thus provided of increasing the facilities for technical studies should not be lost. Higher education is centered exclusively in the University of Khartoum, where the Faculty of Science is well organized and has equipment adequate for present needs. However, the Department of Physics requires additional laboratory facilities and teaching staff. There is at present no specialized teaching in nuclear sciences in the Sudan. The Agency's assistance, the mission thought, should take the form of long-term training for undergraduates because of the scarcity of graduate specialists; a limited number of post-graduate fellowships might also be provided in selected fields.

Isotopes in Medicine

The mission visited the Alexandra Hospital in Greece where radioisotope work of a wide range and high standard is undertaken. The laboratory facilities available, the great variety of techniques in use and the quality of the work done are such that the hospital could be developed as a valuable training center for the medical applications of radioisotopes. Some teaching of radioisotope techniques has already been undertaken, but the potentialities should be more fully explored. The mission also visited the Anti-Cancer Hospital and the Evangelismos Hospital. At the Anti-Cancer Hospital a small radioisotope unit has been formed and a new radioisotope center is to be built in the near future. A cobalt-60 teletherapy unit is also being installed. At the Evangelismos Hospital a small but well-designed radioisotope center has already been constructed and equipped. Medical radioisotope work could be extended to other centers as well, provided that they already have adequate basic laboratory services and other facilities. At the Democritus Center, the mission discussed plans for setting up an Institute of Biology and Experimental Medicine including a Department of Experimental Medicine. It found that the designs for the proposed new laboratories to be housed in the institute were in principle sound, but urged that detailed consideration should be given to the problem of staffing.

Members of the IAEA mission on a visit to the medical radioisotope section of the Alexandra Hospital in Athens

While visiting medical institutes and hospitals in the Ivory Coast, the mission noted the interest shown by the scientific personnel in the medical applications of radioisotopes, both in therapy and diagnosis. Before the establishment of a Faculty of Medicine and the completion of a new medical center in the country, it would be premature to initiate work with unsealed sources of radioisotopes, although provision should be made for such work at the proposed new center. The existence of a well-established Department of Radiology at the Abidjan Central Hospital does make it possible to introduce cobalt-60 teletherapy. Should the Government consider such a possibility, the

mission would recommend assistance by the Agency in the training of staff and in the installation of the necessary equipment.

At the various departments of the Faculty of Medicine in the University of Dakar, the Hôpital Le Dantec and other hospitals and medical research institutes in the Federation of Mali, the mission was impressed by the high quality of the work done in spite of the inadequacy of staff. However, because of the present shortage of skilled staff in all branches of medical work and the urgent need for basic medical services, the initiation of a large-scale program of medical isotope work should not be undertaken at the present time. If the fundamental problem of lack of trained staff can be overcome, the Hôpital Le Dantec in Dakar could suitably house a center for clinical diagnostic and therapeutic work with isotopes. There is a plan for the setting up of an anti-cancer center which would include facilities for radium therapy, deep X-ray therapy and cobalt-60 teletherapy. Such a center could well be a nucleus for the future development of diagnostic and therapeutic work with unsealed radioisotopes. The Institut Marchoux at Bamako would like to carry out radioactive tracer studies of the distribution and metabolism of drugs used in the treatment of leprosy. If the appropriate labelled compounds could be obtained, it would be useful to pursue these investigations.

In Morocco, any large-scale development of the medical applications of atomic energy would be premature at this stage in view of the lack of skilled staff available for specialized training in these techniques. However, it is not too early for the Government to consider plans for the introduction of such techniques as diagnostic tests with unsealed radioisotopes, radiotherapy by internal administration of unsealed radioisotopes and teletherapy with sealed radioisotopes. Two projects might be considered independently or in conjunction: (a) the setting-up of a clinical radioisotope unit to undertake first diagnostic work and later both diagnostic and therapeutic work with unsealed radioisotopes; and (b) the establishment of a cobalt-60 or cesium-137 teletherapy unit. This will need careful planning in regard to staff, buildings and equipment; in particular a trained physicist will be necessary to undertake radioactive assay or radiation dosimetry and to be responsible for radiation protection. There is also a plan for the establishment of an anti-cancer center, which will include a cobalt-60 teletherapy unit. The staff for such a center should include a trained medical physicist to undertake radiation dosimetry and to be responsible for radiation protection. In the beginning, the center should also receive the advice and assistance of an expert radiologist.

The Sudan Government intends to establish in Khartoum, with the support of the World Health Organization (WHO), a radiation and isotope center designed primarily for the diagnosis of cancer and its treatment by radioisotopes and X-ray teletherapy. In future, this might serve as a center for work with unsealed sources of radioisotopes in other branches of clinical medicine and research. However, in view of the limited number of skilled staff, such developments should not be initiated until radioisotope teletherapy has been established. It is understood that the services of a radiotherapist and of a medical physicist will be supplied by WHO to initiate radiotherapeutic work at the institute and that a radiotherapist is undergoing training overseas. The training of a counterpart medical physicist is essential for the success of the institute, and Agency assistance in this respect would be desirable.

Agricultural Applications

At the Democritus Center in Greece, the mission discussed several special problems concerning the uses of isotopes in agriculture. Among the topics of immediate interest were:

(a) a program of research aimed at the eradication of the olive parasite by male sterilization;

(b) the use of radioisotopes to investigate crop adaptation to the various soil regions, especially from the point of view of fertilizer requirements;

(c) a program relating to the production of mutation in crop plants through the use of radiation;

(d) a proposal to subject the larvae of certain animal parasites to radiation as the basis for vaccine; and

(e) the measurement of strontium-90 in milk and vegetables.

Agricultural research in the Ivory Coast is well organized, and five specialized institutes and one basic organization, the Office de recherche scientifique et technique d'outre-mer (ORSTOM) amply cover all present requirements. Up to the present no work has been undertaken with radioisotopes or radiation, apart from a current study on insect tagging. Discussions revealed some problems which could profitably be tackled with nuclear techniques, and the mission suggested that as a first step elementary nuclear training should be given to some of the scientists. Later, the services of an expert could be made available to assist in the planning and setting up of the radioisotope laboratory which is to be established at the ORSTOM and in initiating research programs.

In the Federation of Mali, the major problem is to develop traditional agriculture with special emphasis on rice, groundnuts and cotton. Much progress has already been made with conventional methods. A problem which could be tackled with radioisotopes is phosphorus uptake by plants and phosphate fertilization. This is particularly important in view of the considerable deposits of phosphates in the Federation. Information on soil water would also be useful in developing rice cultivation in regions where irrigation waters are saline; measurements of soil water using nuclear methods should, however, be deferred until some scientists and technicians have been trained.

Agriculture in Morocco consists of two main enterprises: crop production - with emphasis on cereals - and animal breeding. For the first, water is the main problem. Research centers are few and the first step to be taken in applying atomic energy to agricultural research is to increase the number of trained staff. An expert should be assigned for six months, with the necessary equipment, to study soil water. This work would benefit not only the agriculturalists who specialize in cereal production, but also foresters in their efforts to regenerate the forests of cedars and cork trees. Cattle breeding suffers severely from tick-borne disease which damages the skins of cattle. The mission suggested a study of the economic merits of eradication through male sterilization, and further investigations depending upon the results of the study.

Tunisia, though possessing a few highly qualified engineers, has an inadequate number of engineers and technicians. As soon as possible, engineers should be given short-term courses of specialized training in nuclear agricultural techniques, and training courses of at least one year's duration should be given to technicians. The main agricultural problem in Tunisia is measurement of soil humidity. An Agency expert on this subject was due to arrive there shortly. The expert could also assist the laboratory of the Botanical and Agricultural Institute of Tunisia in its studies of the phosphorus problem, which is an important one in Tunisia.

The most important economic aspect of agriculture in the Sudan is that of cotton production. Long-fibre cotton is grown under irrigation over an area of 800 000 hectares. The annual production of 500 000 tons of cotton fibre is good, but might be increased by the application of advanced agricultural research techniques. At present the main problem is considered to be effective irrigation in the cotton-growing region which has a high clay content, and the mission was of the opinion that nuclear techniques could be used for measuring soil water and porosity. The Sudan Government proposes to send a physicist to the Harwell Research Establishment, United Kingdom, to supplement his training in the use of radioisotopes and radiation in agricultural research. The mission thought that a research contract in this subject would be useful. After this preliminary work, it would also be desirable to assist the research station at Wad Medani in studies of phosphorus migration in soils and of phosphorus uptake by cotton.

Raw Materials

The mission suggested that the Agency might assist Greece in developing programs of prospecting for nuclear raw materials and that a request for such assistance should include the necessary equipment for car-borne surveying. It would be useful to undertake such a survey in order to determine the Greek resources of nuclear raw materials in preparation for the time when these may be required for the country's own use. Since, however, there is no immediate or early requirement, there is no special urgency for this work. A survey of uranium and other nuclear materials could also be included in a general survey of minerals in Greece. Discussions were held on the possible application of radioactive methods in hydrological work in Greece, particularly in tracing the flow of underground water. It is understood that the use of tritium is proposed for this work in a project which is now being carried out by the Greek Government in association with the United Nations Special Fund and the Food and Agriculture Organization (FAO).

Two members of the mission (extreme left and right) seeing part of the reclamation scheme of L'Office du Niger in Soudan in the Federation of Mali

In the Ivory Coast, development work including gridding has been carried out in one area, but these searches have not revealed any economic uranium deposits. If, however, work on uranium deposits is to be carried out, laboratory facilities will have to be provided for the Geological Survey. The mission thought that, in view of the present and future market position of uranium and until the emergence of the Ivory Coast's own needs for the mineral, it would be better to include prospecting for uranium in general prospecting for all minerals. There are encouraging occurrences of certain other nuclear minerals in the Ivory Coast.

No uranium deposits of commercial significance have yet been discovered in the Federation of Mali. Uranium in low concentration has been found in phosphate rock. As for other nuclear raw materials, deposits of zircon exist and are being mined for export and ores of lithium of commercial importance have been located. Prospecting for nuclear raw materials is being actively carried out by the Commissariat à l'Energie Atomique of France, and general mineral prospecting by the Bureau des Recherches Géologiques et des Mines. Prospecting and development plans for uranium should be related to the establishment of reserves of ore for the Federation's ultimate needs and to opportunities for disposal of uranium production on overseas markets. Under present conditions,

prospecting for uranium, instead of being given any special emphasis, could be included as part of a general program of mineral prospecting. The prospects of locating deposits of other nuclear materials are good.

The geological and chemical laboratories of the Direction des Mines of Morocco have excellent facilities for operations connected with mineral production but are lacking in facilities for the special testing of nuclear materials. The mission noted that the authorities proposed to request the Agency for the services of an expert in analytical procedures to advise on the necessary equipment and staff for the testing of nuclear raw materials. Production of uranium from phosphates was briefly discussed, but since this had been the subject of a special mission from the Agency, no recommendations were made. Geological operations in Morocco are well established, and the possibility of locating uranium deposits and other minerals of nuclear significance may be regarded with optimism.

In Tunisia, the Service des Mines and the Geological Division are both competently managed and reasonably equipped to carry out the appropriate work. While noting the wish of the authorities to prospect for uranium and other nuclear raw materials, the mission considered it doubtful whether any higher priority should be given to uranium prospecting than to prospecting for other minerals. While the future needs of uranium and other nuclear materials should be kept in mind, uranium could best be included in a general survey for other minerals.

The Geological Survey in the Sudan is well established and effectively organized. The search for minerals has revealed a large deposit of copper, with a content of both secondary and primary uranium. To assist in assessing the production potential of this deposit, the mission recommended the appointment of an expert in uranium analysis to set up the facilities and give instruction in uranium analysis. Some additional equipment would also be required. Meanwhile, the Geological Survey might send selected ore samples for testing in the Agency's laboratory.

Power and Reactors

It was noted at the Democritus Center in Greece that the laboratory for electronics had installed the electronic system of the reactor there in order to study its properties and function. It is intended to build a separate reactor simulator and connect it with the reactor control system for educational purposes. In the electronics laboratory a number of prototypes of nuclear instruments have been developed with the aim of complementing the special training of electronicians and preparing for the possible domestic production of electronic instruments. Discussions were held with the Public Power Corporation on the present electric power situation in Greece and the plans to meet anticipated industrial development up to 1970. A large part of future requirements will be met from hydrological projects already approved. Further expansion of thermal power facilities is contemplated, and it is in this connection that it might be possible to consider nuclear power as an alternative.

The demand for electricity in the Ivory Coast is relatively small. Even in the Abidjan area, where the demand is increasing rapidly, a peak of a little more than 20 MW is anticipated in 1965. Present requirements of nearly 10 MW are more than adequately supplied by the existing system, and the planned addition of stations should meet the projected demand. An additional hydro-electric plant is under study and is expected to be in operation by 1965. This plant, a 12 MW oil fired unit and a 30 MW hydroelectric plant, will meet the power demand amply beyond 1965. Thus there does not appear to be any economic incentive to consider nuclear power in the Ivory Coast before 1965. Since, however, the cost of imported fossil fuels and the construction of hydroelectric power stations is high, the Government might well consider a study of the economic merits of nuclear power as an alternate means of providing its power needs in 1965 and afterwards.

In the Federation of Mali, the only significant power requirement is in the electrically interconnected Dakar-St. Louis-Kaolack area, the installed capacity of which is more than adequate for present needs, and the realization of present planned construction will adequately meet the expected demand until 1965. For nuclear power to be considered as a competitive source in the Dakar area, nuclear fuel costs will have to be in the order of one CFA franc per kWh, and a future power expansion of about 20 000 kW will have to be contemplated. The mission recognized that the Federation has no known resources of natural fuels and if the present exploration for oil should prove unsuccessful, the utilization of nuclear power on a long-term basis would merit consideration. To meet such an eventuality it would be prudent to make provision for the basic training of the required staff.

In Morocco, the area north of the Atlas Mountains has a well integrated electric power system. Because of the adequate available generating capacity and the large hydroelectric storage, no further expansion of generating capacity is proposed until after 1962. Interest was expressed in the possible use of nuclear power to meet a 50 MW requirement in an area having a generating cost of 5 to 10 Moroccan francs per kWh, and 5 to 15 MW power requirements south of the Atlas Mountains where present generating costs are about 20 Moroccan francs per kWh. The 50 MW requirement, which was considered in relation to the proposed industrialization in the area of Ouijda, could be met by the use of domestic coal or hydroelectric power, potentially by the use of imported fuel or natural gas, or by nuclear power. The evaluation of the economic merits of nuclear power in meeting the requirement is complicated because of the many alternate possibilities for power generation, and will be influenced by the overall plan of industrialization of the area. As for the small power needs south of the Atlas Mountains, the mission noted that at present the specific power demands were less than 5 MW.

In Tunisia, there is at present little interest amongst those concerned with electrical power generation in the possible utilization of nuclear reactors to meet forecast electricity demands. This is largely due to the ready availability of imported fuel oil from Italy and the possible import of oil, gas or electricity from Algeria. However, interest in the future potential of process heat reactors was noted, but the mission recommended that this be examined in the light of an overall long-term plan of industrial development and power requirement in the area in question and the potential means for meeting this requirement. It is intended to construct a sub-critical assembly and to purchase a Triga Mark II research reactor. Expert advice would be needed for the installation of the assembly and organization of an experimental course.

The only significant electric power supply in the Sudan is in the Khartoum area which is more than adequately provided by the 30 MW Burri power station. The addition of 10 MW from a station now under construction will permit the retirement of less economical diesel power and provide additional capacity. In addition, the 15 MW Sennar hydroelectric station will be connected with the Burri plant and permit transfer of electricity between these stations. On a long-term basis, the Sudan is favorably endowed with hydroelectric power potential - the estimate is in the order of two million kW. A forecast of power generation, consumption and distribution for 1962 for the Khartoum area has been drawn up, but it is recommended that a more general development plan be prepared for the whole country. The mission further understood that the possibility of an increase in capacity at the Burri plant was under consideration. If the Government decides that this expansion is necessary, and if it so requests, the Agency, in the view of the mission, might assist in conducting a study to determine the potential of nuclear power as a long-term means of meeting this demand.

RADIATION DOSE MEASUREMENTS

About 200 scientists from 28 countries and 5 international organizations met at a symposium on radiation dosimetry held by the International Atomic Energy Agency in Vienna from 7 - 11 June 1960.

The standard techniques and instruments for radiation measurements are well known, and instruments such as the Geiger Mueller counter for the registration of the number of ionizing events produced by radiation are now in extensive use all over the world. Recent developments in atomic energy applications have, however, made it necessary to devise new methods of measurement to meet certain complex and exacting requirements.

One of the most important requirements is, of course, the highest possible versatility which is essential not only for protection against radiation damage, but also for the effective use of radiation in various fields. Among the more specialized and relatively new requirements is the measurement of extremely large radiation doses, such as are employed in industrial processes. Another complicated task is to determine the distribution of different types of radiation when they are mixed. For example, reactors produce a mixture of neutron and gamma radiation and for purposes of radiation protection it is essential not only to measure the total dose but also the amounts of its components.

In his inaugural speech at the symposium, the IAEA Director General, Mr. Sterling Cole, explained that

Opening session of the symposium on radiation dosimetry

radiation dosimetry already covered such a large field that it was not possible to deal with more than a few selected topics at one scientific meeting. The aim of the symposium was not so much the description of a large number of measuring instruments as a discussion of the methods used, with special emphasis on those problems which had become important in the context of recent developments, such as the measurement of mixed or very large doses.