

20 - 40 tons per hour, they recommended cobalt-60 sources, with which it is possible to achieve a radiation efficiency of 50 - 70 per cent.

Discussing possible locations of pilot plants the panel thought that they should, if possible, be incorporated into existing or projected elevators for use by commerce or government. They should be situated

in countries where there is a need for the treatment of a high proportion of grain passing through the elevators and where there are at least minimum facilities for entomologists and engineers who will be concerned with the evaluation of the pilot plants in operation. Tropical and sub-tropical areas, it was noted, seem especially suitable for such pilot plants.

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## A SURVEY OF ATOMIC PROSPECTS IN TEN COUNTRIES

During April, May and June this year, an IAEA mission visited nine countries in Africa and one in the Middle East to study their prospects, plans and activities for atomic energy applications and to assess their needs for assistance from the Agency. \* This preliminary assistance mission, which was the ninth of its kind to be sent out by the Agency, went to three countries in East Africa, namely Kenya, Tanganyika and Uganda; to three countries in West Africa, namely Cameroun, Gabon and Togo; to three other African countries, namely the Congo (Léopoldville), Ethiopia and Madagascar; and to the Lebanon.

In all these countries, the Agency team held extensive discussions with the national authorities, collected information on their plans or activities in the atomic energy field as well as on subjects that may have a bearing on the prospects of atomic energy applications, gave them such advice on the spot as was needed, and assisted them in formulating requests for Agency assistance for implementing their atomic energy programmes. The mission's reports on its visits will not only help the Agency in dealing with such requests, but serve generally as reference sources regarding the conditions and prospects in these countries for the development of atomic energy for peaceful purposes.

Some of the information contained in these reports, which is likely to be of wide interest, is summarized in this article.

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\* The mission was composed of five members of the Agency's staff (Mr. John C. Webb, of the Division of Technical Supplies, who led the mission; Dr. H.T. Daw, of the Division of Health, Safety and Waste Disposal; Mr. M.M. de Orival, of the Division of Reactors; Mr. O.E.S. Lloyd, of the Division of Economic and Technical Assistance; and Dr. A. Trofimenko, of the Division of Exchange and Training) and two outside experts (Dr. J.F. Goetz, of Tauernkraftwerke A.G., Salzburg, Austria; and Dr. B.D. Mayberry, Head, Department of Horticulture, Tuskegee Institute, Alabama, USA).

### THREE EAST AFRICAN COUNTRIES

#### Raw Materials

Prospecting for uranium and other nuclear raw materials in Kenya has been carried on intermittently since 1948. The work has included some aerial surveying and an extensive car-borne scintillometer survey, but no deposits of economic significance have been located, except for a deposit of pyrochlore, north of Mombasa, which might be regarded as a potential source of niobium.

Tanganyika has a well-staffed and well-equipped mining and geological service, the main activities of which are at present devoted to the continuation of geological mapping and exploration of any mineral indications found in field work. No significant uranium discoveries have yet been reported but the Agency mission felt that this should not be taken as implying that radioactive minerals and other nuclear materials do not exist in Tanganyika. The geology of the country suggests favourable conditions which would warrant detailed study at the appropriate time. The mission noted the existence of a large deposit of pyrochlore in Tanganyika and the research being done to develop a process to extract niobium from this source.

Uganda occupies an important place in nuclear raw materials production by virtue of its expanding production of beryl ore and the projected production of niobium from pyrochlore. Beryl production is expected to exceed 1000 tons this year. The exploitation of large deposits of leached carbonatite soils near Tororo is about to begin, with the primary objective of producing fertilizer from apatite. The pyrochlore tailings from apatite flotation will be treated for the recovery of niobium oxide, the expected annual production of which will be 80 tons of marketable concentrates. No uranium deposits have

been located, but some thorium bearing formations are known.

## Power

Concerning power supplies, the search for coal, oil and natural gas in Kenya has not so far been successful in finding any exploitable deposits. However, there are rivers near Nairobi which have a considerable hydro power potential. Most important is the potential of the River Tana, which is about 300 000 kW in the upper reaches. Hydro power plants are already in operation, meeting approximately one third of Kenya's public demand, which at present is about 400 million kWh. The East African Power and Lighting Company has worked out a hydro power project on the River Tana - the so-called Seven Forks Scheme. The power plants under this scheme will have a capacity of 230 000 kW and an annual production of about 900 million kWh, so that Kenya will be self-sufficient in electric power supply if the scheme can be carried out fast enough. For the time being, therefore, there does not appear to be any case for the introduction of nuclear power, but if the power demand in the coastal area exceeds an installed capacity of about 40 000 kW (which might happen within the next 10 years), it would be worth reconsidering whether the increased demand should be met from the Nairobi area by means of a high tension line or by the installation of a power reactor near the coast.

The main industrial centres of Tanganyika, i.e. Tanga and Dar-es-Salaam, will be supplied within two years with very cheap hydropower from the Hale plant. Certain other industrial regions, however, are at present at a considerable disadvantage from the point of view of the price of electricity, because of the need to transport coal over long distances. If in these regions a survey of hydropower possibilities does not show any prospect for cheap energy, there would be some considerations in favour of nuclear power. However, nuclear plants that could at present be operated economically in such locations would be too large for the anticipated requirements. With further industrial development of these centres and with progress made in the economics and technology of small sized nuclear power plants, the situation could be reconsidered in five to ten years' time.

Uganda has no known deposits of coal, oil or natural gas, but a vast hydro power potential, which is almost the sole source for the production of electricity. The hydro power potential is estimated at 3 million kW, mainly on the Victoria Nile. At present, the need is much smaller than this, and therefore only one sector of the Victoria Nile, close to the outlet of Lake Victoria, is exploited in the Owen Falls Power Scheme, which has a capacity of 120 000 kW. A considerable part of the production is delivered to Kenya. Two further generator sets can be installed, increasing the capacity to 150 000 kW. By storing water in Lake Victoria in the wet seasons and using it in the dry periods, it should be possible to meet the power demand of Uganda for the next four to five

years. To meet the increased demand thereafter, a project has been prepared for a power plant downstream from Owen Falls, with a capacity of 180 000 kW, and the possibilities on the Victoria Nile and on other rivers are being studied. Considering the favourable circumstances for the erection of hydro power plants in Uganda, the mission thought that it would be uneconomic at present to install a nuclear power reactor in preference to hydroelectric power.

## Medicine

In Kenya, the mission visited the King George Hospital and discussed the various possibilities of using atomic energy in medicine. It was informed that X-ray facilities are used only for diagnostic purposes and no deep therapy is available. Cancer cases are treated mainly along chemotherapeutic lines. There are some plans, still under discussion, for the formation of a laboratory to introduce radioisotopic techniques on a limited scale in diagnosis and therapy. The possibility of installing a cobalt-60 unit of 3000 curies in the Aga Khan hospital was discussed. It was generally felt that the unit would be of value mainly for training and teaching in connection with the East African University. The mission also discussed the possible application of radioisotopes in medical research, and noted considerable interest in the possibility of using isotopes in the study of various anaemias and deficiency and parasitic diseases.

There is no medical school in Tanganyika; the Makerere College in Uganda, which has a big teaching hospital, serves the present needs of Tanganyika. Isotopes have been used to a very limited extent for tagging anopheles mosquitoes and tagging bilharzial snails by cobalt-60. There is no deep X-ray therapy in the hospitals, nor are there any plans for introducing it in the immediate future. The mission visited the Radiology Department of the Princess Margaret Hospital and discussed the problems of occupational radiation protection. At present, there is no film badge service, and the mission recommended the early establishment of one. Some interest was expressed by the Analytical Chemistry Department in the assessment of the present level of radioactive contamination of milk, vegetables, meat, bone, etc., with a view to establishing a base line for the level of background radioactive contamination.

In Uganda, radioisotopes are being used on a limited scale in medicine: iodine-131 in the treatment of thyroid cancer, chromium-51 and iron-59 for the investigation of anaemias, and carbon-14 for studies on steroids. A small nuclear laboratory attached to the Makerere College medical school will be used to extend the use of isotopes to phosphorus-32 and gold-198. There is provision at Mulago hospital for a small isotope laboratory for limited research and clinical work, but no provision for therapeutic X-rays or teletherapy units. Interest in using radioisotopes in the study of the movement of the stomoxys fly, labelling the prophylactic drugs of trypanosomiasis, and generally in pesticides, was expressed at

the Animal Research Centre in Entebbe and at the East African Trypanosomiasis Research Organization in Jinja.

## Agriculture

Because of the importance of agriculture to Kenya, several well-organized and well-equipped organizations are engaged full time in research related to the major agriculture enterprises. Research conducted by the Ministry of Works on soil density and soil moisture has progressed to the point where isotopes could make a useful contribution. Research work on soil moisture done in the Department of Agriculture has also reached a stage where isotopes could be advantageously employed. Other areas in which radioisotope techniques could be used in the future include entomology, plant nutrition, and animal pathology as related to animal physiology.

Tanganyika presents many challenging problems for applied as well as fundamental research in agriculture. Among the more common problems which need attention are soil and fertilizer studies as related to crop production, irrigation studies, particularly those relating to cost and return, improvement of livestock and new varieties of crops, and livestock pest control. In some of these fields there is scope for the use of radioisotope methods but their introduction is hardly practicable in the existing absence of conventional research.

In Uganda, the mission visited well-equipped laboratories for conventional research at the Makerere University College, the Research Division of the Uganda Department of Agriculture, the East African Trypanosomiasis Research Organization, and the Empire Cotton Growing Corporation. Despite insufficient staff, progress in conventional research has been encouraging. Work relating to the availability of phosphorus to coffee during the flowering season, the use of elephant grass in returning nutrients from the sub-soil to the top-soil during rotation, chemical forms of phosphate available to sisal, coffee and cotton, and pesticide persistence studies have progressed to the point where isotopes could be effectively used.

## Education and Training

In Kenya, there are five technical and trade schools, and the Kenya Polytechnic, which was opened in May 1961, offers various technical courses for 600 students. At the Royal College, Nairobi, the physics course in the Faculty of Science includes some atomic physics and electronics. The mission noted an acute shortage of teaching personnel for degree courses, which limits the future development of the Faculty. Technical education in Tanganyika is centred mainly at the Technical Institute in Dar-es-Salaam. Until recently there was a tendency in East Africa to concentrate on the study of basic and technical sciences

in Nairobi (Kenya), medical and agricultural sciences in Kampala (Uganda), and law in Dar-es-Salaam. The mission recommended that more attention be paid to the teaching of basic and technical sciences in Tanganyika.

In Uganda, the course in physics in the Faculty of Science of the Makerere University College includes elements of atomic physics. The mission noted the present and proposed application of radioisotopes at the Makerere Medical College, and a proposal for the establishment of a radioisotope laboratory in the School of Physics at Makerere. This laboratory would form a centre for the training of technicians in the handling and application of radioisotopes and for electronic maintenance and repair of instruments used in radioisotope work.

An important development which should affect favourably the higher education situation in East Africa is the establishment of the University of East Africa incorporating colleges in Kampala, Nairobi and Dar-es-Salaam.

## THREE WEST AFRICAN COUNTRIES

### Raw Materials

In Cameroun, it is proposed to carry out a systematic aerial survey to produce detailed maps and obtain geological information on which future geological activities can be based. The Government is not at present interested in nuclear materials, until the survey is completed.

Gabon has already established itself as an important producer of uranium in Africa, and the known

Uranium processing plant at Mounana, Gabon



reserves at Mounana are sufficient to maintain the current production of 400 tons of uranium per year for at least 12 years. In addition, there seem to be reasonably good prospects of locating further deposits. Possibilities also exist for establishing reserves of other nuclear minerals, notably colombite-tantalite, and there are indications of thorium minerals. The country, however, has few nationals trained in geology and prospection, and it would be desirable for the Government to give some attention to this problem.

Extensive geophysical surveys, including scintillation surveys, are to be carried out in Togo under a UN Special Fund project. If as a result of these surveys uranium indications are found, the Government of Togo may wish to seek assistance from IAEA in the more detailed surveying of these indications and the development of those which have commercial possibilities.

## Power

Cameroun has no known deposits of coal, oil and natural gas, but there is a huge hydro power potential which at present is estimated at 4 million kW. One stage of the Sanaga River has already been exploited at Edea near Douala with a hydro power plant of a capacity of 160 000 kW. The possibilities of building a dam on the Sanaga River and its tributaries above Edea are being studied. The intention is to store water in the rainy season and to use it in the dry period in Edea to utilize the naturally fluctuating water flow there, and to get in this way an almost constant power output. For the next ten years the hydro power plant of Edea will be able to meet the increasing demand in Edea and Douala. For the coastal area northeast of Douala and the country beyond, up to Foumban, it is intended to build a hydro power plant with a capacity of 15 000 kW. A general survey of conventional energy, with emphasis on hydraulic resources, is being undertaken as part of the country's first "Quinquennial Plan". The results of this survey will be sent to the Agency, and comments and recommendations on future possibilities in nuclear power could at that time be made to the Government of Cameroun. From first impressions, it appears that the northern part of Cameroun might eventually present favourable features for the establishment of a nuclear plant.

In Gabon, natural gas feeds the steam power plant of Port Gentil; only 20 per cent of this gas, however, is at present used for power production. Crude oil is produced mainly in the area of Port Gentil, but almost all of it is exported because there is no refinery. Exploitable deposits of coal have not yet been found. The hydro power potential of Gabon is not exactly known, but is estimated at about 2 million kW. No hydro power plant is now in operation or under construction. The Government authorities are, however, studying the possibilities of exploiting the hydro power potential as the basis of planned industries. From the point of view of industrialization,

five existing or possible centres of importance can be considered, each of which has its own conventional resources. Gabon does not offer at present any features that would favour the establishment of a nuclear power plant. Hydro power development should be able to meet all the energy requirements at least for the next ten years.

Togo has no known deposits of coal, oil or natural gas, which could be exploited for power generation. The hydro power potential is considerable, but sites where hydro power plants of suitable size can be erected are far away from the likely places of consumption. On first consideration, it seems that the use of nuclear energy in producing electric power has some prospects, although taking into account the size of the expected increase in demand over the next four to five years, the operation of power reactors is not likely to be economical. The mission recommended that the growth in power demand in Togo should be reviewed after four to five years in the light of developments in the technology and economics of small sized power reactors.

## Medicine

In Cameroun, the mission visited the general hospital at Yaounde, which has a radiology section with a conventional X-ray machine for diagnostic purposes. No deep X-ray therapy is carried out at present, but the mission was informed that a conventional 250 kV machine had arrived and that facilities for its installation would soon be available. Radioisotopes have not been used in medicine, nor are there adequate laboratories or trained personnel for such techniques at present. On the health protection side, a film badge service has just been started; the films will be processed and the doses estimated at Saclay, France. Radioisotopes can be used in the study and diagnosis of various diseases. In view of many other pressing medical problems in the country, however, the mission felt that at present there was no immediate need for the introduction of radioisotope techniques, but the situation should be reviewed in a few years' time.

Diagnostic X-ray machines are provided in all administrative regions of Gabon as well as at sub-regional district centres. The mission visited the Libreville General Hospital and noted that the only ionizing radiations used were diagnostic X-rays. Plans have been made for the installation of a conventional deep therapy machine but there are no plans for teletherapy units or for the introduction of radioisotope techniques. Fluoroscopy is commonly used. There is no film badge service, nor at present any regulations governing radiation protection. The mission visited the uranium and manganese mining installations. Workers at the uranium mine and processing plant have a film badge service, the films being processed at Saclay in France. The mission is of the view that there is a need in Gabon for the application of ionizing radiation, particularly deep-ray therapy for the treatment of malignant tumours,

and that radioisotopic methods could be used in diagnosis. There is, however, no immediate need for the introduction of radioisotope techniques.

Medical applications of radioisotopes have not yet been introduced in Togo. The Lome Hospital has a diagnostic X-ray machine. The mission recommended that the Agency's assistance be sought for the early establishment of radiation protection regulations, particularly in regard to X-ray machines. It did not think that there was any need for the immediate introduction of radioisotope techniques in medicine.

## Agriculture

Cameroun has a well-equipped laboratory at Yaounde for fundamental research on soils (Institut Recherche Cameroun), and an Agronomic Research Centre comprising four applied research laboratories (dealing with plant physiology, genetics, entomology and pathology) operated by the Government. A member of the staff of each of these research institutions is to go abroad for training in the use of radioisotopes in agricultural research. The mission thought that prior to their return to introduce these techniques in Cameroun, the Government should introduce legislation and establish policies governing health physics and radiation protection concerning the procurement, handling and distribution of radioisotopes.

The economy of Gabon is based principally on forest products and minerals. Development plans for agricultural education and research are still in the planning stage. The mission, therefore, felt that four to five years' time should be allowed for these plans to be realized before the use of radioisotope methods is considered.

Although agriculture is the principal basis of Togo's economy, its soils are not particularly fertile, and a programme of research on soils and plant nutrition, with special reference to crop production, would be extremely useful. No such fundamental research is now in progress. Radioisotopes could play a very important role in studies on soils and plant nutrition.

## Education and Training

Technical and higher education in Cameroun is still in the formative stage. At some time in the future, the Government plans to introduce courses in radioisotope techniques in higher educational establishments. The mission was of the view that the Government should pay more attention to the basic sciences, and introduce courses in mathematics, physics, chemistry and biology in schools and other educational institutes.

In Gabon, the Government intends to set up a Polytechnic Institute in Port Gentil or in Libreville in 1963. There are also plans for the creation, in due course, of a laboratory for nuclear physics. The proposed structure of this institute foresees the par-

ticipation of students from neighbouring countries, and some hopes have been expressed of the possibility of creating a regional scientific centre on the basis of this institute. The mission noted the great efforts being made to improve education in the country, but felt that still more attention should be paid to the basic and technical sciences.

## CONGO, ETHIOPIA AND MADAGASCAR

### Raw Materials

Apart from any remaining reserves of uranium in Katanga, there are no known uranium deposits in the Congo. Formerly, the Congo was a large producer of beryl but its continued exploitation is handicapped by the distance of the deposits from the coast and consequently by transport costs. The Congo has some reserves of coal and extensive deposits of oil bearing rocks, while conditions favourable to oil occurrences are found in the coastal regions.

In Ethiopia, the lack of a geological survey and the absence of any well-organized mining industry precludes the possibility of initiating any systematic search for nuclear minerals. There is, at present, no foreseeable need for these minerals in Ethiopia's economic or energy development. One occurrence of radioactive ores has been recorded south of Alge, Borana, and some occurrences of beryl have also been noted.

Madagascar is in a commanding position in respect of nuclear raw materials. Most of these, such as uranium, thorium, beryllium and niobium, are already in substantial production and form a valuable export commodity. Under a convention with the

Uranium mine at Ambatomika, Madagascar



French Atomic Energy Commission, Madagascar has the benefit of technical assistance in the prospection, mining, development and treatment of its uranium resources. Similar arrangements with other French organizations ensure the development of its resources of beryl and monazite. Madagascar is thus unlikely to seek technical assistance from the Agency in this field.

## Power and Reactors

The Congo has an enormous hydro power potential, the extent of which has not yet been fully estimated. For example, the River Congo downstream from Léopoldville has an exploitable hydro power potential of 28 million kW. At present, hydro power is the main basis for the production of electricity in the Republic. The annual production in 1961 was about 4000 million kWh, the installed capacity, including that in Katanga, being about 850 000 kW. Industry and mines are the main consumers of electricity, especially in Katanga. In 1961 the capital, Léopoldville, required 136 million kWh with a peak load of 30 000 kW. The nuclear centre "Trico" was inaugurated in June 1959 at Lovanium University. It is built round a Triga Mark I reactor and is mainly used for the production and application of short-lived radioisotopes and nuclear physics training. Some 600 radioisotopes have been prepared for various research programmes and for studies at the University and elsewhere. The mission welcomed proposals to convert the existing reactor to the Mark II type and to extend the reactor building so that it could accommodate additional laboratories, particularly for radiochemistry.

Coal, oil and natural gas have not yet been located in Ethiopia and there are no indications that these fuels could be found in quantities sufficient to meet the demand for proposed new power plants with 10 000 kW of installed capacity. The country, however, is extremely rich in hydro power resources. The Blue Nile from its origin at Lake Tana to the Sudanese border has an exploitable hydro power potential of about 5.2 million kW. This is approximately 50 per cent of the total hydro power potential of Ethiopia, excluding Eritrea. It appears that the power demand until 1965 will be adequately met by the existing plants. To meet the increased demand after 1965, a hydro power plant is being planned, at a site about 25 km downstream from the existing plant at Koka. The new plant will have an installed capacity of 36 000 kW. Two further sites exist further downstream. Thus, there are abundant hydro power resources relatively close to Addis Ababa, which can be exploited easily. It is also estimated that the hydro power units will produce power at a much lower cost than that of power produced by nuclear reactors of the same installed capacity.

There are no known deposits of oil and natural gas in Madagascar. Deposits of oil bearing sands which are now being investigated, might, if they could

be economically exploited, be an important source of oil fuel in the future. Coal is found in the south of the island but its use in steam power plants supplying one of the consumption centres of Madagascar would not apparently be economical. The extent of the hydro power potential in the island has not yet been estimated but is undoubtedly large. Hydro power plants are already in operation and, in 1960, supplied approximately 60 per cent of the electric power demand. To meet increased demand in the next four to five years, the existing power plants could be easily equipped with further generating units. The expected increase in demand in the next few years is not likely to be such as could make the operation of a nuclear power plant an economic proposition.

## Medicine

At Lovanium University in the Congo, isotopes have been used in animal investigations at the Medical School as well as in some limited clinical work. Conventional X-ray machines are used for diagnostic purposes. There is no regular film badge service at present. The nuclear equipment is of a rather advanced type and is used for a variety of research work in medicine and biology. There is not much training equipment for the students, but the mission was informed that such equipment would be available in the near future.

Radioisotopes have not yet been used in Ethiopia. The mission recommended that the Ethiopian authorities consider the introduction of elementary isotope techniques in the biological sciences as a subject of study in biology courses at the University College. The mission visited the Haile Selassie Hospital, which has therapeutic X-ray equipment of the conventional type. Radium needles are used mainly in gynaecological work. There is at present no film badge service, nor any legislation for radiation protection. The mission visited the Pasteur Institute, which is investigating cases of goitre, in which radioactive iodine could be used. In connection with the Institute's research on yellow fever, the mission discussed the possibility of undertaking studies of the Aedes mosquito by radioactive tagging methods.

At the Commissariat à l'énergie atomique at Tananarive, Madagascar, beryllium analysis is done by exposure of the ore to a strong gamma source. The source is well shielded and the staff have a film badge service, processed in Saclay, France, as well as self-reading pocket dosimeters. At the Institut Pasteur, various vaccines are prepared and some rat trypanosomic work is being done as part of a Pan African trypanosomiasis research, and at the I.R.S.M. enterological section research is being conducted on the malaria mosquito and its ecology. Great interest was expressed in the possibility of tagging anopheles larvae with phosphorus-32 with the aim of studying both the flight distance and the longevity of the mosquito. The mission also visited the animal husbandry laboratories, where very important work is being

carried out on animal nutrition and metabolism of various minerals. Interest was expressed in the utilization of labelled amino acids for metabolic studies, and in the use of radioisotopes for the analysis of trace elements.

Radioisotopes have not yet been applied in medicine in Madagascar, but the question is under study. Radiological applications consist of conventional X-ray therapy and the use of radium needles. Plans are now being prepared to install a radioisotope laboratory in the Faculty of Science for various purposes, such as medicine and agricultural research. The mission recommended that the Malagasy Government should formulate legislation for the safe handling of radioisotopes (which are now used to a limited extent in agriculture) as well as the use of ionizing radiation in general.

## Agriculture

The mission visited the agricultural facilities at Lovanium University, which has well-equipped laboratories with highly trained and experienced scientists engaged in fundamental as well as applied research. The mission visited the University Research Farm, where applied research is being carried out on problems of coffee production, soil improvement, tobacco production, and fish breeding and conservation. In an animal husbandry unit, research is being done on poultry and cattle pest control. Protein deficiency has been noted in the Congo, and research involving a study of the amounts of molybdenum required for microbiological activity in certain soils is proceeding. It is hoped to increase proteins by cultural or plant nutritional improvements. In addition, fundamental studies relating to carbon data on fossil samples of wood are being carried out in the Department of Agriculture.

About 97 per cent of the income of Ethiopia is derived from agriculture. Except for a small number of plantations operated by concessionaires, agriculture is conducted on small holdings, and there is a great need for research and extension work in the agricultural programme. The Imperial College of Agriculture is engaged in both fundamental and applied research, much of which has progressed to the point where isotopes could be usefully employed. The mission, however, felt that the use of isotopes should be deferred until the urgent applied research needs have been more fully satisfied.

Agriculture constitutes the major economic activity of Madagascar. Problems of mineral nutrition of plants, especially of rice, are widespread, and closely allied are problems of soil chemistry, soil physics, and soil classification. Five research and training organizations are engaged in studying the agricultural problems of Madagascar by several different conventional techniques. Isotopes are in use, on a very limited scale, in soil moisture and soil phosphorus studies. The research programmes in general are limited by a shortage of scientific per-

sonnel. The mission recommended that the research organizations form a central isotope laboratory, probably at the University, to service all research programmes and for training. The establishment of such a laboratory is at present under study.

## Education and Training

Higher education in the Congo is centred mainly at Lovanium University, where the course in physics at the Faculty of Science provides general knowledge of atomic and nuclear physics. The research reactor at the University is also used for training.

In Ethiopia, the physics course in the University College of Addis Ababa includes some elements of atomic and nuclear physics. A laboratory course in physics, which has been recently introduced, includes some experiments and measurements in optics, electricity and atomic physics. The mission recommended the establishment of facilities in radioactive tracer techniques at the University's Faculty of Science. It also recommended close co-ordination between the University and the country's Engineering Colleges in activities using the available nuclear equipment and experience.

The mission noted the recent rapid growth of secondary, technical and university education in Madagascar, but also the scarcity of Malagasy scientists. It recommended that attention be paid to the training of the country's nationals in different scientific fields.

## LEBANON

### Raw Materials and Hydrology

The Lebanon does not have a national geological organization. At present, the major geological activity is in the field of hydrology and water supplies and it is unlikely that this organization could render any service in prospection for nuclear minerals. These minerals are not likely to be required in the country for some time to come, but if they are needed in the future, the necessity will arise for an established geological organization.

Hydrological studies, to be carried out in connection with a UN Special Fund project, involve the tracing of underground water-flow in conditions in which conventional methods are not applicable. Radioactive methods using tritium tracers could be successfully employed in this work.

### Power

Despite the fact that Lebanon has no deposits of coal, oil and natural gas, substantial quantities of oil - transported through Lebanese territories from Iraq and from Saudi Arabia to the ports of Tripoli and

Saida - is available. Seventy per cent of the production of electric power in the main consumption area in and around Beirut is based on oil, the remaining 30 per cent being supplied by hydro power plants. Increase in power demand, which is estimated at 15 per cent annually, can be met partly by the existing steam power plants, by the expected output under the Litani Hydro Power Scheme, and by new steam power plants, of which one will be put into operation near Tripoli in 1962. The new plants can meet the increased demand until the end of 1968, when the peak load in the Beirut area is expected to reach 240 000 kW, which would correspond to an installed capacity of about 330 000 kW.

For the time being, there does not appear to be any case for the use of nuclear energy for the generation of power, but the mission also considered the prospects for the future. The supply of energy in the Lebanon can be carried out by a central grid system, and the problem to be studied is that of introducing nuclear power into such a system. A major thermal power scheme has been planned, the first stage of which will start in about four years' time, and the last in about ten years. The mission recommended that before undertaking the final stage, the nature of the thermal plant to be introduced should be reconsidered, and that the Government, in four or five years' time, should request IAEA to send a special mission to study the problem of introducing nuclear power within a central grid system.

## Medicine

The mission visited the isotope laboratories at the American University in Beirut, which are fairly well equipped with conventional equipment. Training courses have been held in the application of radioisotopes in medicine. Laboratory work has been done on various haemoglobinopathies by using radioactive isotopes of iron and chromium. Isotopes have also been used in the investigation and treatment of thyroid diseases, and research work is being carried out on intermediary metabolism. The University has a cobalt unit, and its radiology department is equipped with diagnostic and therapeutic X-rays and other conventional facilities.

The mission visited the Institut de Radiologie et Laboratoire St. Joseph, which has a cobalt unit. A radioisotope laboratory at the institute has been more or less completed, but the laboratory equipment has not yet been fully installed. The laboratory is intended to do two types of work, one related to patients and the other related to public health aspects.

The mission thought that the Lebanese Government could profitably seek the assistance of the Agency's laboratories in Vienna for the analysis of food, soil and vegetable samples for radioactive contamination.



Members of the mission discussing results of radioisotope applications in wheat cultivation at Telle Amara research station, Lebanon

## Agriculture

The Lebanon is essentially an agricultural country, and its physical and climatic character provides for a variety of agricultural enterprises. The mission was informed that, except for the irradiation of two lots of seeds by overseas agencies for the Ministry of Agriculture, isotopes had not been used in agricultural research. At the Ministry of Agriculture research laboratories at Telle Amara, there is an excellent installation of physical facilities for conventional research on soils, plant nutrition, plant breeding, plant protection and animal nutrition.

Applied research is also being done in poultry breeding, wheat and barley breeding, and dairy feeding. The agricultural faculty of the American University of Beirut also has a variety of well-equipped research laboratories. The mission noted that the research work in mineral nutrition of sheep, fertilizer studies in fruit and vegetable crops, and comparative irrigation studies has advanced to the point where radioisotopes could make a useful contribution.

The mission was of the view that the Government of the Lebanon should provide the necessary machinery for closer co-ordination between the research activities of the Ministry of Agriculture and those of the American University of Beirut.

## Education and Training

The course in physics at the Lebanese University includes studies of atomic and nuclear physics, and new equipment for practical studies in nuclear physics

phenomena will be installed in the University physics laboratory next year. In the Physics Department of the American University of Beirut, the main emphasis is on solid state physics and low temperature physics. The University laboratories are adequately equipped for education and research purposes. St. Joseph's University has no special faculty of science, but physics courses are introduced for students of the Medical School and the Higher Engineering School. The Centre de Physique et Mathématique de l'Ecole

Supérieure has a four-year programme of studies in physics and mathematics. The physics laboratory of the Centre has equipment for practical work in a general course of physics.

The mission recommended that more attention should be paid to the study of basic and technical sciences in the Lebanese colleges. Closer co-operation between the different universities in their scientific activities and in the use of available equipment would be most desirable for further development.