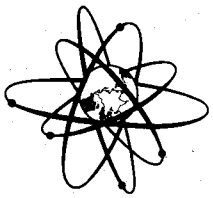
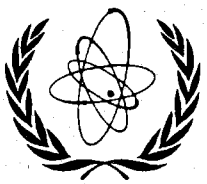
IUREP

INTERNATIONAL
URANIUM RESOURCES
EVALUATION PROJECT

OECD
NUCLEAR ENERGY AGENCY
PARIS, FRANCE





INTERNATIONAL
ATOMIC ENERGY AGENCY
VIENNA, AUSTRIA

IUREP ORIENTATION PHASE MISSION

Summary Report

BURUNDI

A summary report prepared on behalf of the
Executive Group for the IUREP Orientation Phase

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THE OECD NUCLEAR ENERGY AGENCY

38, Boulevard Suchet, F-75016 Paris (France)

The OECD Nuclear Energy Agency (NEA) was established on 20th April 1972, replacing the OECD's European Nuclear Agency (ENEA).

NEA now groups all the European Member countries of OECD with Australia, Canada, Japan and the United States. The Commission of the European Communities and the International Atomic Energy Agency take part in the Agency's work.

The main aims of the NEA are to promote cooperation between Member governments in the safety and regulatory aspects of nuclear power and in the development of nuclear energy as a contributor to economic progress.

This is achieved by:

- *encouraging the harmonisation of governments' regulatory policies and practices;*
- *reviewing technical and economic aspects of the nuclear fuel cycle;*
- *assessing demand and supply, and forecasting the potential contribution of nuclear power to energy demand;*
- *exchanging scientific and technical information; and*
- *coordinating and supporting research and development programmes, notably through the setting up of joint projects.*

INTERNATIONAL ATOMIC ENERGY AGENCY

Wagramerstrasse 5, A-1400 Vienna (Austria)

The International Atomic Energy Agency (IAEA) came into being in Vienna, Austria, on 29 July 1957. Its main objectives are to "seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world" and to "ensure, so far as it is able, that assistance provided by it or at its request or under its supervision or control is not used in such a way as to further any military purpose".

The IAEA is an intergovernmental organization like the United Nations, the World Health Organization and other specialized agencies of the United Nations. It is directed by a Board of Governors, which is composed of representatives from 34 Member States, and a General Conference of the entire membership of 112 States. The IAEA has its own programme, approved by the Board of Governors and the General Conference, and its own budget, currently at 107 million dollars (1985), financed by contributions from its Member States.

Although autonomous, the IAEA is a member of the United Nations system and sends reports on its work to the General Assembly and to other United Nations organs.

CONTENTS

SUMMARY

A report has recently been published which describes the findings of the International Uranium Resources Evaluation Project (IUREP) Mission to Burundi.

The IUREP Orientation Phase Mission to Burundi estimates that the Speculative Resources of that country fall within the range of 300 to more than 4 100 tonnes of uranium. The potential is rather evenly distributed throughout the Proterozoic of Burundi in various geological environments (unconformity, hydrothermal, fault controlled, etc.)

The mission recommends that over a period of five years U.S. $ 3 to 4.5 million be spent on exploration in Burundi, with even spending on the various exploration techniques as e.g. prospecting, drilling trenching, geophysical surveys, analyses, etc.

INTRODUCTION

During the bibliographic study, which formed the first phase of the International Uranium Resources Evaluation Project (IUREP), Burundi was identified as one of the countries with good potential for uranium resources in addition to those reported on in "Uranium Resources, Production and Demand, December 1977" (OECD (NEA)/IAEA). Following a meeting at which the IUREP Orientation Phase was discussed in some detail with a number of selected countries, the Burundian authorities requested an Orientation Phase Mission. This Mission was undertaken by two consultants, W. Gehrisch and M. Chaigne in May/June 1983.

The full report on this mission (100 pages, 25 figures, 16 tables, 5 appendices) has been released and is available for study at the locations listed in the Annex of this summary report.

The Executive Group for the IUREP Orientation Phase wishes to acknowledge the excellent cooperation given to the mission by the Burundian authorities and the Burundian Staff assigned to assist the mission. Particular thanks are expressed to Mr. I. Nyaboya, Minister of Public Works, Energy and Mines, to Mr. E. Ndahibeshe, General Director of the "Direction Générale de la Géologie et des Mines" and to Mr. G.H. Brouxhon, UNDP Chief Technical Advisor as well as to Mr. S. Smejkal, Chief Geologist of the UNDP/DTCD Mineral Project for their assistance in organizing the mission.

GENERAL GEOGRAPHY

The Republic of Burundi, with an area of only 27 834 km^2, is located in central Africa, 300 km south of the equator, 1 200 km from the Indian Ocean and 2 200 km from the Atlantic Ocean and has common border with Rwanda, Tanzania and Zaire. Most of its western border goes through Lake Tanganyika.

Burundi is located on the eastern side of the western branch of the East African Rift System. Its relief rises to 2 600 m, dominated by a precipitous cliff and the tectonic trench now occupied by Lake Tanganyika and

the plain of the Ruzizi valley. The relief falls off to the east and gradually joins the central plateaus. The east is characterized by low plateaus.

The climate is equatorial with two rainy seasons: hot and humid in the Ruzizi valley (23°C average temperature; 800 mm of precipitation) and temperate in mountaineous regions (16°C average temperature; up to 1 200 mm of precipitation).

The population of Burundi was 4.2 million in 1981, and with a population density of 150/km^2, Burundi has one of the densest populations of Africa. Bujumbura, the capital, located at the northern shore of Lake Tanganyika has about 150 000 inhabitants.

Official languages are Kirundi and French.

Topographic maps of the country are available at the scales of 1:50 000 and 1:100 000. Geological maps at the scales of 1:500 000 (the entire country),and 1:100 000 (only 4 maps out of 13 are published) may be obtained from the mapping unit of the Geological Survey. Photogeological maps at a scale of 1:250 000 and photomosaïcs are also available. Air photographs at the scale of 1:50 000 (except for the Zaïre - Nile ridge) can be obtained from the French "Institut Géographique National". Photographs covering the remaining area are available from Geosurvey Nairobi.

ADMINISTRATIVE BODIES CONCERNED WITH URANIUM

In Burundi, there is no Atomic Energy Authority or Commission and all activities associated with geology and mines are centered around a main official body, the "Ministère des Travaux Publics, de l'Energie et des Mines".

The United Nations Development Programme (UNDP) initiated a mineral exploration project in 1969, executed by the Department of Technical Cooperation and Development (DTCD) of the UNDP and managed by a National Director and Coordinator. This mineral exploration project also included prospecting and exploration for uranium.

LEGISLATION CONCERNING URANIUM EXPLORATION DEVELOPMENT AND PRODUCTION

In Burundi the mineral industry is ruled by the Mining Act (1976) and the Investment Code (1979). The only reference to radioactive minerals is found in title one of the Mining Act (Code Minier et Petrolier):"the entire country is a Reserve as far as precious and semi-precious metals, all substances related to Atomic Energy and salts are concerned" (Act 22).

The Investment Code Act No. 1/8 was established in 1979 by the President in order to promote local and foreign investment in Burundi. No minimum Burundian participation is required for foreign investment.

GEOLOGY OF BURUNDI

Most of Burundi is underlain by Proterozoic metamorphic, non-metamorphic and intrusive rocks, and, to a much lesser extent, by Archean basement. Cenozoic volcanics are only found in the extreme northwestern corner of Burundi, whilst the Ruzizi Valley and the bottom of Lake Tanganyika contain Cenozoic sediments (See Figure 1).

The oldest rocks in Burundi, some in granulite facies, are of Archean age (2.6 G.a.) and occur in three small complexes at the periphery of the country.

Lower Proterozoic rocks, locally known as Ruzizian crop out in northwestern Burundi as the continuation of the Congo-Nile watershed of Rwanda, and east of the Ruzizi Valley and Lake Tanganyika. The Ruzizian is part of the NNW-SSE trending Ubendide-Ruzizide Belt of the region. It consists mainly of geosynclinal metasediments, graphitic metapelites, quartzites, meta-conglomerates, marbles, some basic metavolcanics and volcano-sedimentary complexes. They were deposited between 2.4 and 2.1 G.a. and contain possibly younger series. The Ubandian-Ruzizian orogeny (2.1 - 1.85 G.a.) resulted in tight, partly isoclinal folds, dipping southwest and west. The belt was intruded by Ruzizian and Burundian (1.3 G.a.) plutons, ranging from granites to ultramafites. Metamorphic grade ranges from greenschist to amphibolite facies. The belt extends into Rwanda and Zaïre to the north and west and into Tanzania to the south-east. It forms the basement of the Middle Proterozoic Kibaride-Burundide Belt.

The Middle Proterozoïc of Burundi, underlying most of the country is represented by rocks of the Kibaride-Burundide Belt, which extends from southern Katanga (Zaïre) to Uganda and consists of metasediments evolving from platform to geosynclinal deposits: conglomerates, quartzites and metapelites with local dolerite flows. They were deposited between 2.1 and 1.3 G.a. and folded and metamorphosed during the Kibaran-Burundian orogeny at 1.3 G.a. This resulted in various styles of folding, varying from large parallel to tight and overturned folding with thrust plaines to the east, further complicated by calc-alkaline granitic intrusions. Metamorphic grade is mainly of lower greenschist facies.

In the north of the country, post-tectonic events of the Burundian orogeny, around 950 m.a., led to the emplacement of muscovite tin granites and associated tin-tungsten-tantalum-niobium bearing pegmatites and gold bearing quartz veins. Monzonites and nepheline syenites, associated with carbonatites and basic dikes and sills are post-orogenic.

The Upper Proterozoic in Burundi is known as the Malagarasian, which is part of the Bukoban (Tanzania) - Katangan (Zambia and Zaïre) system. These deposits start with molasse type sediments derived from the Kibaride-Burandide mountain chains. Beds overlying these early sediments are mostly unconformable and range from psephitic to pelitic with numerous recurrences.

The Malagarasian, though developed as a time equivalent to the Bukoban of Tanzania, developed in isolation from the Bokoban and hence has its own specific sequence, characterized by a dominance of argillitic and limy to dolomitic sediments.

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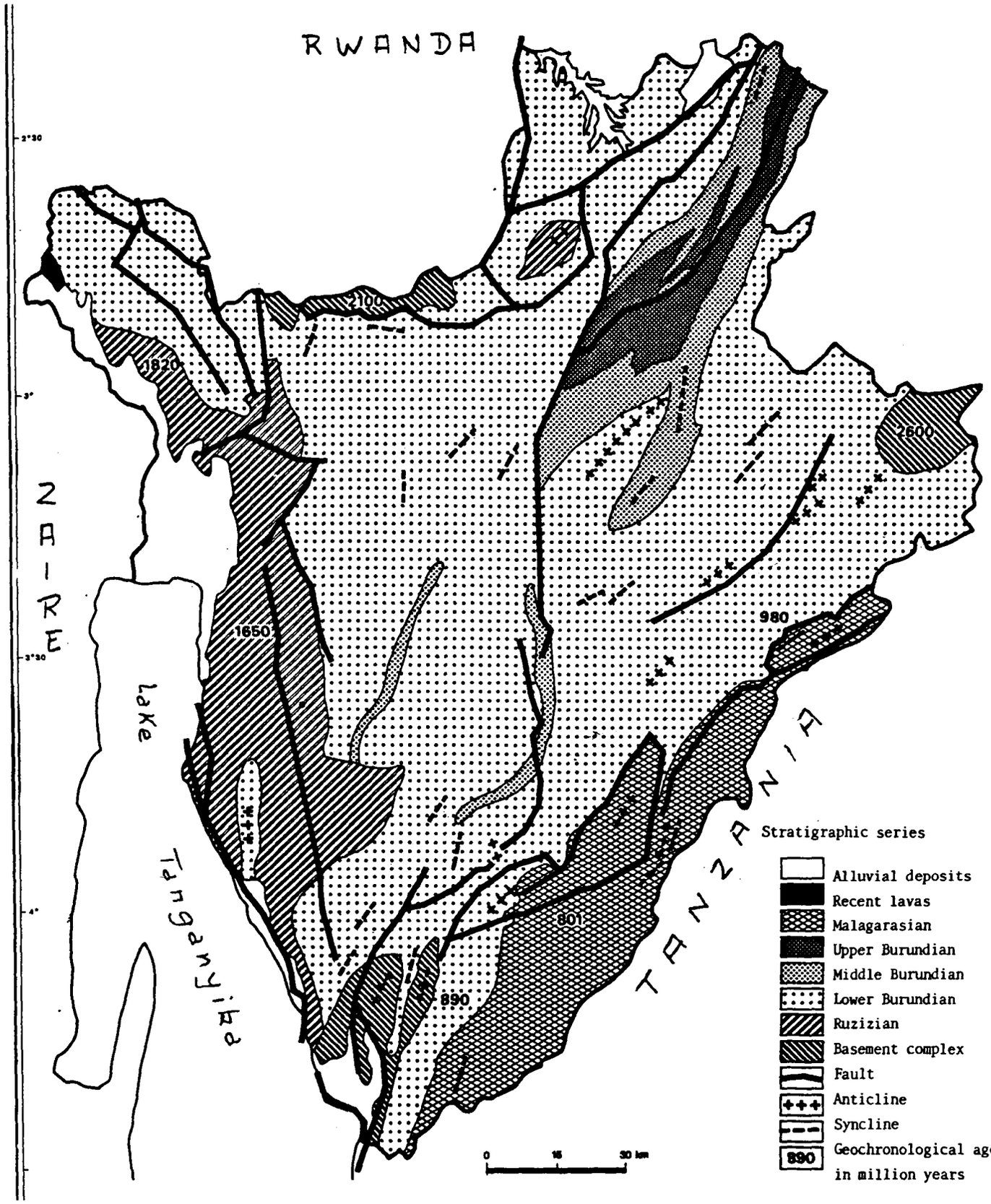
* G.a. : 10^9 years

Figure 1

GEOLOGY OF BURUNDI



The next event in Burundi was the abortive rifting of the East African Graben system 65 m.a. ago, with Cenozoic volcanism and sedimentation and tilting of the Precambrian block towards the east.

Mineral Resources

Cassiterite, wolframite and other tungsten minerals, columbo-tantalite, bastnaesite and gold were mostly mined from secondary deposits. There are no mines in operation at the present time (Government Decree of 1978).

Important resources of apatite, rare earths, nickel, copper, cobalt, lead, zinc, vanadium, titanium and possibly platinum in primary deposits have been located.

PAST EXPLORATION

Uranium exploration started in Burundi in 1969 when the United Nations Development Programme initiated, at the request of the Government, a programme of mineral exploration with funds provided by the United Nations and facilities created by the Geological Survey of Burundi. The programme was divided into four phases:

1st phase (1969-1972): General reconnaissance studies and interpretation of geological structures with a broad use of photogeology. Airborne spectrometer survey by Hunting Surveys Ltd.

2nd phase (1972-1977): Completion of a combined magnetometer and radiometric airborne geophysical survey covering part of the country. (Hunting Surveys Ltd.). Detailed exploration of specific occurrences.

3rd phase (1977-1981): Carborne radiometric surveys as infill of areas not covered by airborne surveys and ground checking of anomalies. Airborne (E.M. - Mag - Spec survey) by German Geological Survey (BGR). Detailed exploration of E.M. - Magnetometer-Gamma Spectrometer specific occurrences.

4th phase (1982-end of 1984): Priority was given to the delineation of Ni, Cu, Co. and Ti, Fe, V orebodies as well as to feasibility studies. Uranium and even Rare Earths prospects were not regarded as very promising. It is understood that no further prospecting is to be carried out during the next year on such targets.

From 1981 on, the French BRGM did extensive field work in north-eastern Burundi.

The German BGR is assessing the potential of the bastnaesite deposit of Gakara/Karonge.

OCCURRENCES OF URANIUM

No major uranium occurrences are known in Burundi. However, a number of smaller occurrences have been found (see Figure 2).

The Kiganda occurrence (32 km east of Bujumbura)

Assay results of up to 500 ppm U associated with high Zn and Cu values were obtained from trenches dug on radiometric anomalies in an area underlain by Burundian metamorphics at the western periphery of the granite-gneiss complex of Kiganda. Radiometrically anomalous rock types encountered in the trenches include: limonitic breccias, limonitic and hematitic schists partly with graphite and quartz zones, as well as an 8 m wide fault zone.

The Musigati occurrence (68 km NE of Bujumbura)

Assay results of up to 578 ppm U were obtained from trenches dug over radiometric anomalies in an area underlain by Burundian and Ruzizian metamorphics (schists and gneisses) and pegmatites. The U-mineralization occurs as pockets of autunite, irregularly distributed within or at the contact of the partly brecciated and limonite stained pegmatites. Some radioactivity is also found to be associated with pyritic, siliceous and hematitic mica schists. No primary mineralization except allanite was found. Drilling did not give encouraging results.

The Mparamirundi and Kigambi occurrences (107 km NE of Bujumbura, near the Border with Rwanda)

Assay results of up to 2 000 ppm U were obtained from trenches dug over radiometric anomalies in an area underlain by Ruzizian metamorphics (schist, quartzites and gneisses) and pegmatites. No visible U-mineralization was reported. The high assays were obtained from limonitic rocks and quartz breccias (fault zone) within mica schists, gneisses, pegmatites and limonitic quartzite breccia, underlain by graphitic schists.

The Matongo occurrence (10 km ESE of Musigati occurence)

At Matongo, a uraniferous carbonatite mainly considered for its phosphate potential and probably related to the syenite complex of the Kayanza granite-gneiss complex, yielded assay results of up to 3 300 ppm U in its weathered capping. Uranium recovery as a by-product of phosphate mining was considered at time, but the rich uraniferous pockets were found to be too small and too sparse.

FAVOURABLE AREAS FOR SPECULATIVE RESOURCES

In Burundi, no specific U-exploration project was ever envisaged, considering the moderate uranium potential of the country. None of the known and visited U-occurrences indicate an economic potential in itself. However, theoretical consideration on geological grounds lead to some interesting results:

No potential is attributed to the Archean blocks of Burundi on the grounds of paucity of Archean U-deposits worldwide.

The Ruzizian and Burundian periods of the Proterozoic era are discussed together. Elliot Lake type placer deposits are excluded on grounds of their specific environment not found in the Ruzizian.

A rather modern point of view regards the Ruzizian as being higher metamorphic Lower Burundian - at least as far as Burundi and Rwanda are concerned. In this case, sedimentation of Burundian sequences would be bracketed between 2.4 and 1.3 G.a., encompassing the time interval between 1.9 and 1.7 G.a., when syngenetic pre-enrichment of uranium occurred in partly graphitic pelites in Australia and Canada. If sediments of this time interval are present in the area hitherto assigned to the Ruzizian, then metamorphism and granitic intrusions could have remobilized the potential preconcentration, and form uranium deposits either as vein deposits or dissemination in granitic to alaskitic bodies.

The report reiterates the fact that uranium accumulations are not found throughout the earth's history. They are rather confined to certain periods in the earth's evolution with particular affinity to carbonaceous matter, and other reducing agents. Remobilization and reconcentration of these primary uranium accumulations, themselves not of economic value at today's market price, lead to the formation of the economic U-deposits exploited in Canada and Australia. In contrast to the vein and alaskite-hosted uranium deposits the Canadian and Australian U-deposits occur at or close to unconformities of Upper Proterozoic sediments with Lower Proterozoic metasediments.

Such a situation seems possible in Burundi, where Upper Proterozoic Malagarasian sediments overly Burundian metasediments. A close examination reveals however, that the part of the Burundian, overlain by the Malagarasian is of very low grade metamorphism and does not belong to the Lower Proterozoic but to the Middle Proterozoic, much less favourable for primary uranium accumulations. Nevertheless, appropriate facies changes within the Burundian sequences could have led to the required preconcentrations of uranium, and deep burial under Malagarasian sediments in conjunction with some local heating due to the Katangian orogeny (at 620 m.a.) could have remobilized this uranium to the unconformity at form economic U-deposits.

To test this concept, it is suggested to map the graphitic units of the Burundian in the vicinity of the Burundian-Malagarasian unconformity using the data of the recent aerial EM survey, and to select radiometrically anomalous units. Subsequently, they should be traced beneath the Malagarasian cover and detailed investigations of the unconformity be carried out.

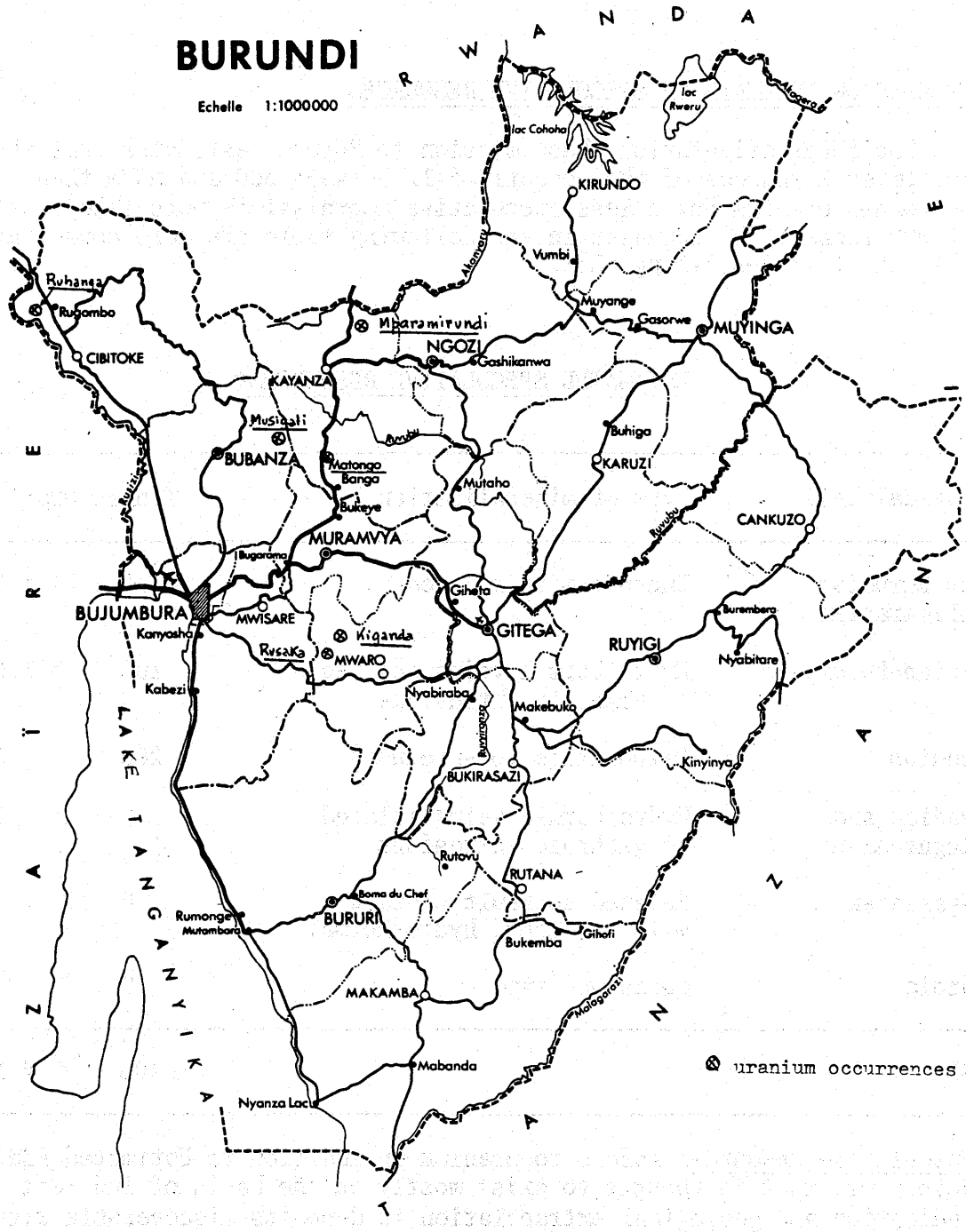
Other targets are supergene uranium enrichments in graphitic metasediments already pre-enriched by metamorphic processes or by processes related to granitic intrusions in the vicinity or beneath the metasediments (example Mparamirundi).

The possibility of discovering interesting uranium mineralization in conjunction with basic dikes cutting through the Malagarasian sediments is evoked as examples of this type are known in Eastern and Western Canada. Also, the faulted contact with the Burundian basement may be favourable.

At Matongo (Carbonatite), uranium may potentially be recovered as by-product from phosphate production.

Figure 2

LOCATION OF URANIUM OCCURRENCES



The potential of the Malagarasian for syngenetic U-mineralization as found in the Roan sediments of Katanga and Zambia is discussed and rated rather low, since the reducing conditions as prevailing temporarily in the Roan sediments do not occur in the Malagarasian sediments. Therefore, and because of the lack of indications of the Katangan orogeny in this area, also remobilization of uranium from protores is not likely.

Very limited potential is attributed to the Cenozoic sediments of the Ruzizi valley. However the possibility of roll front type U-deposits is not ruled out.

IUREP MISSION ESTIMATE OF SPECULATIVE RESOURCES

The IUREP orientation phase mission to Burundi estimates that the Speculatives Resources of that country fall between 300 and more than 4 100 tonnes uranium but a less speculative appraisal is more likely between 0 and 1 000 tonnes. The tonnages in the following table are more conservative than in the text describing them.

ESTIMATED SPECULATIVE RESOURCES*

Geological Unit	Type of Mineralisation	Tonnes Uranium
Lower Burudian Malagarasian	Unconformity related	0 - > 1 000
Ruzizian-Burundian	Hydrothermal veins related to granitic intrusions	100 - > 1 000
Burundian	Carbonatite (by-product)	200 - 500 (?)
Burundian and Malagarasian	Hydrothermal veins related to gabbroic intrusions	0 - > 100
Malagarasian	Related to fault contact with basement, hydrothermal	0 - > 1 000
Cenozoic	Sandstone type	0 - > 500
TOTAL		300 - > 4 100

* Speculative Resources refers to uranium in addition to Estimated Additional Resources, that is thought to exist mostly on the basis of indirect indication and geological extrapolation in deposits discoverable with existing exploration techniques. The location of deposits envisaged in this category could generally be specified only as being somewhere within a given region or geological trend. As the term implies, the existence and the size of such resources are highly speculative.

RECOMMENDATIONS

In the absence of any known uranium occurrence with economic potential, the IUREP mission proposes a redefinition of targets according to geological setting on the basis of rock geochemistry and regional stream sediment geochemistry in conjunction with airborne EM and spectrometric anomalies.

According to the different geological models proposed, the following exploration strategies are suggested:

For uranium associated with "gabbroic" intrusives in Malagarasian sandstones, checking for alteration zones in and around the intrusives in conjunction with anomalous radioactivity is proposed, once these bodies have been located by making use of the existing airborne magnetrometer survey. Expected tonnage is low (around 500 tonnes uranium).

For uranium in hydrothermal veins related to granitic intrusives and their metasedimentary envelopes, and starting with the occurrences of Kiganda, Mparamirundi and Musigati, rock geochemistry and thin section studies are proposed to locate fertile granites with high U-levels and Low Th/U ratios. Select those with high ratio of leachable/non leachable uranium in conjunction with reducing (graphitic) metasediments. Once a target is located, the usual detailed exploration methods are proposed. Possible tonnage is estimated to be in the 1 000 and 3 000 tonnes uranium range.

For hydrothermal U-deposits related to faulted contacts of Malagarasian with Burundian, a combined airborne spectrometry. and geochemical (stream sediment) approach is suggested to select fertile structures, and ground geophysics to test the quality of structures. Possible tonnage is estimated up to 5 000 tonnes uranium, but probability of success is rated very low.

For unconformity related uranium deposits, a geophysical approach is suggested: from the existing BGR airborne EM-survey, those conductors spatially related to areas of high geochemical uranium background should be selected for Helium surveys combined with overburden drilling in order to locate prospective conductors after which ground geophysics and drilling should be carried out. The potential tonnage of such deposits could exceed 10 000 tonnes uranium. In the light of geological findings for the area under consideration, the probability of success is rated rather low and not in proportion with high costs involved in exploring for relatively deep seated and often blind deposits.

The low probability of locating the above speculative resources is reflected in the somewhat lower figures of table page 12.

IUREP MISSION PROPOSED PROGRAMME, SUMMARY AND COSTS

Item	Million U.S. $/5 Yrs
Prospecting (ground check of airborne anomalies radiometric gridding, geochemistry)	0.5
Rock geochemistry and petrographic mineralogical investigations	0.3
Analytical costs (including helium)	0.7
Trenching and tunneling	0.5
Geophysical ground surveys	0.3
Overburden drilling	0.5
Exploration drilling if results of above investigations justify (including down hole logging) 1 000 to 10 000 m.	0.17 to 1.7
TOTAL	2.97 to 4.5

FUTURE EXPLORATION SUMMARY

No plans for future uranium exploration do exist for Burundi, as far as the IUREP mission is aware.

ANNEX

Those wishing to consult the full report on which this summary is based should write to one of the following:

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The Library
Bundesanstalt für Geowissen-Schaften und Rohstoffe
Stilleweg 2
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Power Reactor and Nuclear Fuel Development Corporation
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