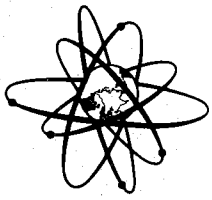
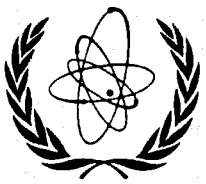
IUREP

INTERNATIONAL
URANIUM RESOURCES
EVALUATION PROJECT

OECD
NUCLEAR ENERGY AGENCY
PARIS, FRANCE





INTERNATIONAL
ATOMIC ENERGY AGENCY
VIENNA, AUSTRIA

# IUREP ORIENTATION PHASE MISSION

Summary Report

# RWANDA

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 Interantional Uranium Resources Evaluation Project (IUREP) Mission to Rwanda.

The IUREP Orientation Phase Mission to Rwanda estimates that the Speculative Resources of that country fall within the range of 500 to 5 000 tonnes of uranium. The majority of this potential is expected to be located in the Precambrian Ruzizian, especially in conjunction with tectonized pegmatoidal remobilizations of metamorphic sediments of western Rwanda. Other favourable geological environnements include lamprophyric dikes and post tectonic granites of central Rwanda.

The Mission recommends that over a period of five years approximately US$4.2 million be spent on exploration in Rwanda. The majority of this would be spent on airborne and ground geophysical surveys ($1.5 million) and exploration drilling ($1 million). Prospecting, trenching and tunneling and analytical work would require the remainder of the $4.2 million ($1.7 million).

INTRODUCTION

During the bibliographic study, which formed the first phase of the International Uranium Resources Evaluation Project (IUREP), Rwanda 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 representatives of selected countries, the Rwandan authorities requested an Orientation Phase Mission. This Mission was undertaken by two consultants, W. Gehrisch and M. Chaigne in April/May 1983.

The full report on this mission (88 pages, 20 figures, 12 tables, 9 appendices) has been released and is available for study at the location 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 Rwandan authorities and all the Rwandan staff assigned to assist the mission. Special thanks are expressed to W.J. Zigirababili, Director of the Rwandan geological survey, to Mr. J.B. Bicamumpaka, National Director and Co-ordinator of the UNDP/D.T.C.D. Mineral Project in Rwanda, and to Mr. Bertram Starke, UNDP Chief Technical Advisor for their assistance in organizing the mission.

GENERAL GEOGRAPHY

The Republic of Rwanda with an area of only 26,338 $km^2$ is located in central Africa, 120 km south of the Equator at about 1 200 km from the Indian Ocean and 2 200 km from the Atlantic Ocean and has common border with Uganda, Tanzania, Burundi and Zaïre. Rwanda's relief is hilly and mountainous and altitude increases from east to west with elevations of up to 4 507 m

(Mt Karisimbi) dominating the western Rift Valley in which Lake Kivu lies. To the east, high plateaus form the center of the country while further east, towards Tanzania swampy valleys and lakes separate low mountain chains.

The climate is equatorial with two rainy seasons. Influenced by altitude, it is rather temperate, with average temperatures between 19° and 23°C. Rainfall may exceed 1 600 mm/year.

The population of Rwanda was 5,3 million in 1981 and with a population density of 230/km$^2$, Rwanda is one of the most densely populated places of Africa. Kigali, the capital of Rwanda has not much more than 100 000 inhabitants.

Official languages are Kinyarwanda and French.

Topographic maps of the country are available from the "Service de cartographie". In 1982 only 8 (southeastern Rwanda) out of 43 maps covering the country at a scale of 1:100 000 had been published. Other maps covering part of the country are available at various scales from 1:50 000 to 1:20 000. A map at the scale 1:1 million covers the entire country. Aerial photographs at 1:200 000 scale are available from the French Geographic Institute (I.G.N.) in St. Mandé near Paris (France). Geological maps at various scales may be obtained from the local geological survey.

## ADMINISTRATIVE BODIES CONCERNED WITH URANIUM

In Rwanda, there is no Atomic Energy Authority and the only official body involved in geological and mining activities is the National Geological Survey, related to the "Ministère des Ressources Naturelles". A specific budget is provided for the national geological mapping programme by the Belgian Cooperation Fund.

At the request of the Rwandan Government, the United Nations Development Project (UNDP) initiated a mineral exploration programme in 1968, executed by the Technical Cooperation and Development Department (DTCD) of the UNDP and managed by a National Director and Coordinator. This mineral exploration programme also included prospecting and exploration for uranium.

## LEGISLATION CONCERNING URANIUM EXPLORATION, DEVELOPMENT AND PRODUCTION

Specific regulation regarding all substances related to Atomic Energy are listed in Chapter VII of the Mining Act as Acts 98, 99 and 100. These include:

Mining licences can only be granted through presidential decision;

The State may expropriate and compensate the owner of a mining licence granted for a specific mineral if substances relating to Atomic Energy are found after such a licence has been granted.

The Investment Code Act No. 30/77 was established in 1977 by the President in order to promote local and foreign investment in Rwanda. No minimum Rwandan participation is required for any foreign investment.

## GEOLOGY OF RWANDA

Most of Rwanda is underlain by Proterozoic metamorphic and intrusive rocks. Tertiary and younger, mostly volcanic, rocks are found only in the rift environment of the extreme western and northwestern parts of the country, now partly occupied by Lake Kivu (see Figure 1).

Two major orogenic belts, the Lower Proterozoic Ubendide-Ruzizide belt in the western regions, and the Middle Proterozoic Kibaride-Burundide belt in the central and eastern regions, join each other in Rwanda.

The NNW-SSE trending Ubendide-Ruzizide belt, though mainly consisting of metasediments of Lower Proterozoic age, may contain remnants of Archean basement. Ruzizian deformation resulted in tight, in part isoclinal, folds plonging south-west. The belt was intruded by Ruzizian and Kibaran (Burundian) granitic plutons. Metamorphic grade is generally of amphibolite facies, resulting often in pegmatoidal injections. Rock sequences consist largely of metapelites, quartzites metaconglomerates and crystalline limestones, deposited in a geosynclinal environment. North and westwards the Ubendide-Ruzizide belt extends into Zaïre and southeastwards into Burundi and Tanzania. It forms the basement of the Middle Proterozoic Kibaride-Burundide belt.

The Kibaride-Burundide belt extending from southern Katanga (Zaïre)in the south, to Uganda in the north, consists of Middle Proterozoic sediments, and was folded and metamorphosed during the Kibaran-Burundian orogeny at 1.3 G.a*. Folding may vary between a relatively simple style of large parallel anticlinorial and synclinorial zones partly overturned in the south (Katanga, Zaïre), and strong folding with sharp overturning towards the west and thrust planes dipping towards the east in the north (Burundi, Rwanda, Uganda). This zone is further complicated by the granitic intrusions (or doming) of the Burundian orogeny. Metamorphic grade is mainly of (lower) greenschist facies, increasing towards the Ruzizian basement. In Rwanda, Burundi and Uganda, first platform and shallow marine and then progressively geosynclinal rock sequences consist of conglomerates, quartzites and (mainly) metapelites, whereas in Katanga crystalline limestones and rhyolites are also locally present in an entirely geosynclinal sequence.

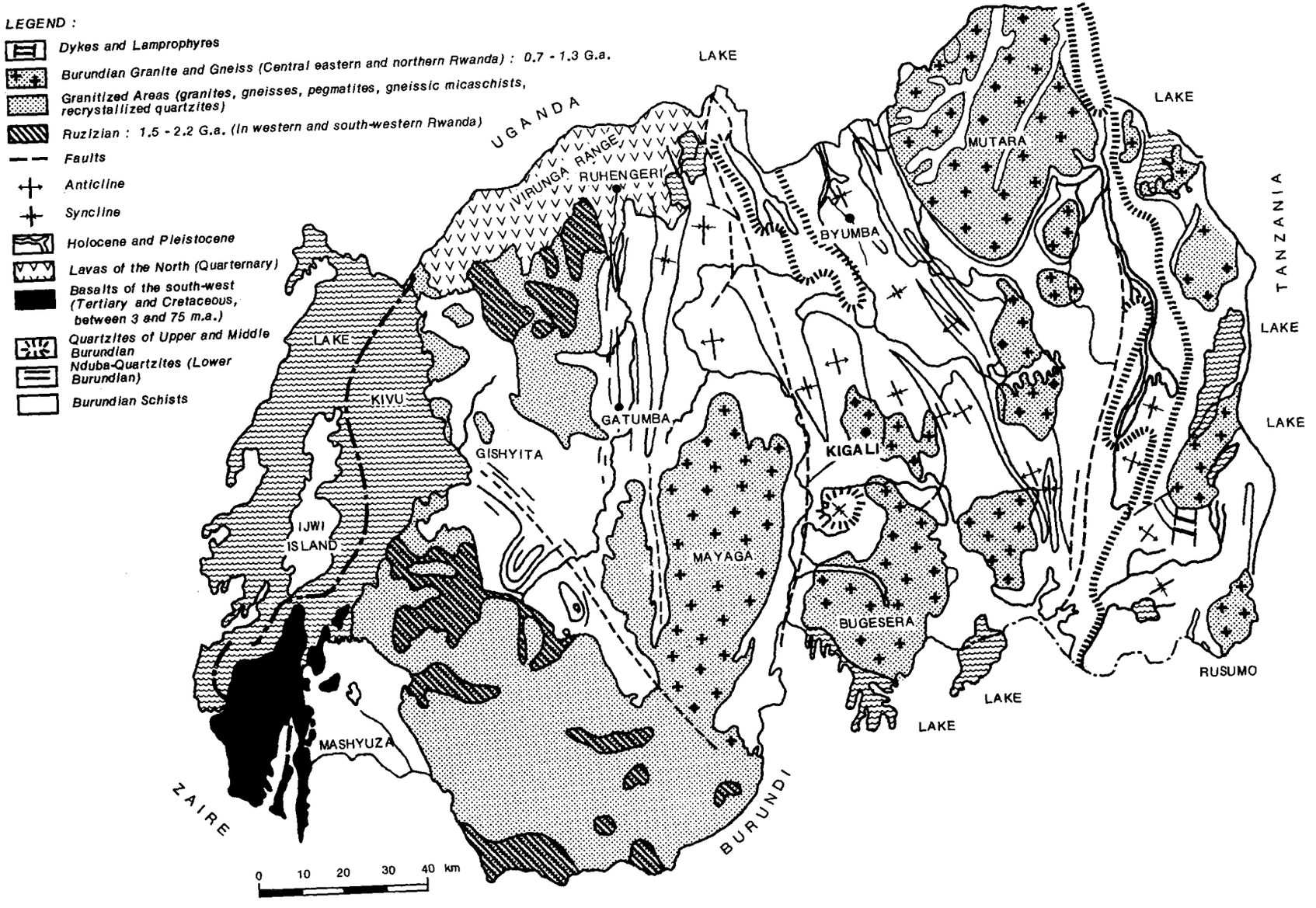
Post-tectonic events of the Burundian Orogeny at around 950 m.a. led to the emplacement of equigranular muscovite tin-bearing granites, associated tin-tungsten-tantalum-niobium bearing pegmatites and gold bearing quartz veins. Sodic phases of the pegmatites are as young as 850 m.a. The Katangan Orogeny is held responsible for pegmatite injections in the 600 m.a. range.

No sediments of Katangan age (Upper Proterozoic) are developed in Rwanda.

The next event in Rwanda was the abortive rifting of the East African graben system 65 m.a. ago, accompanied by Tertiary and younger volcanism and tilting of the Precambrian block towards the east.

* G.a. = $10^9$ years

*Figure 1* **SIMPLIFIED GEOLOGICAL MAP OF RWANDA**



## Mineral Resources

The Rwandan mineral industry is mainly based on small scale mining of cassiterite, wolframite and other tungsten minerals, columbotantalite and gold, mined from primary and secondary deposits.

## PAST EXPLORATION

Before independence in 1962, exploration by small private Belgian companies led to the discovery in 1954 of the Karago uranium occurrences in the north of the country in Gisenyi prefecture. Two hundred kg of uranium ore at 20 to 60% $U_3O_8$ is estimated to have been mined from pitchblende bearing quartz-veins at the contact between schists and pegmatites. Production apparently stopped in the late fifties, but detailed prospecting continued in 1968 :

1st phase (1968-1973) comprised airborne geophysics and detailed prospecting in localized areas. Total airborne survey coverage was 3 300 $km^2$, flown by Hunting Surveys Limited. Detailed prospecting, trenching and drilling was carried out at Karago.

2nd phase (1974-1977) comprised regional stream sediment sampling at 500 m spacing and follow up of airborne radiometric anomalies. The Nshili area (south-western Rwanda) was radiometrically and geochemically investigated. Uranium, thorium and R.E.E. mineralization were discovered at Nshili.

3rd phase (1978-1980) included general prospecting (scintillometry, geochemistry) and detailed systematic exploration of most promising anomalies (trenching, pitting, drilling). A 12 km long stream sediment anomaly with U-contents of up to 400 ppm was found in the Mwesa River Valley, SE of Kigali.

4th phase (1981-1983) included airborne (helicopter) spectrometry and magnetometry over the whole country; this survey was carried out by Sander Geophysics Ltd. of Canada. The final interpretation of the airborne survey was still pending at the time of the IUREP Mission. In this final phase, uranium mineralization probably associated with lamprophyres was identified in south central Rwanda (Rusatira).

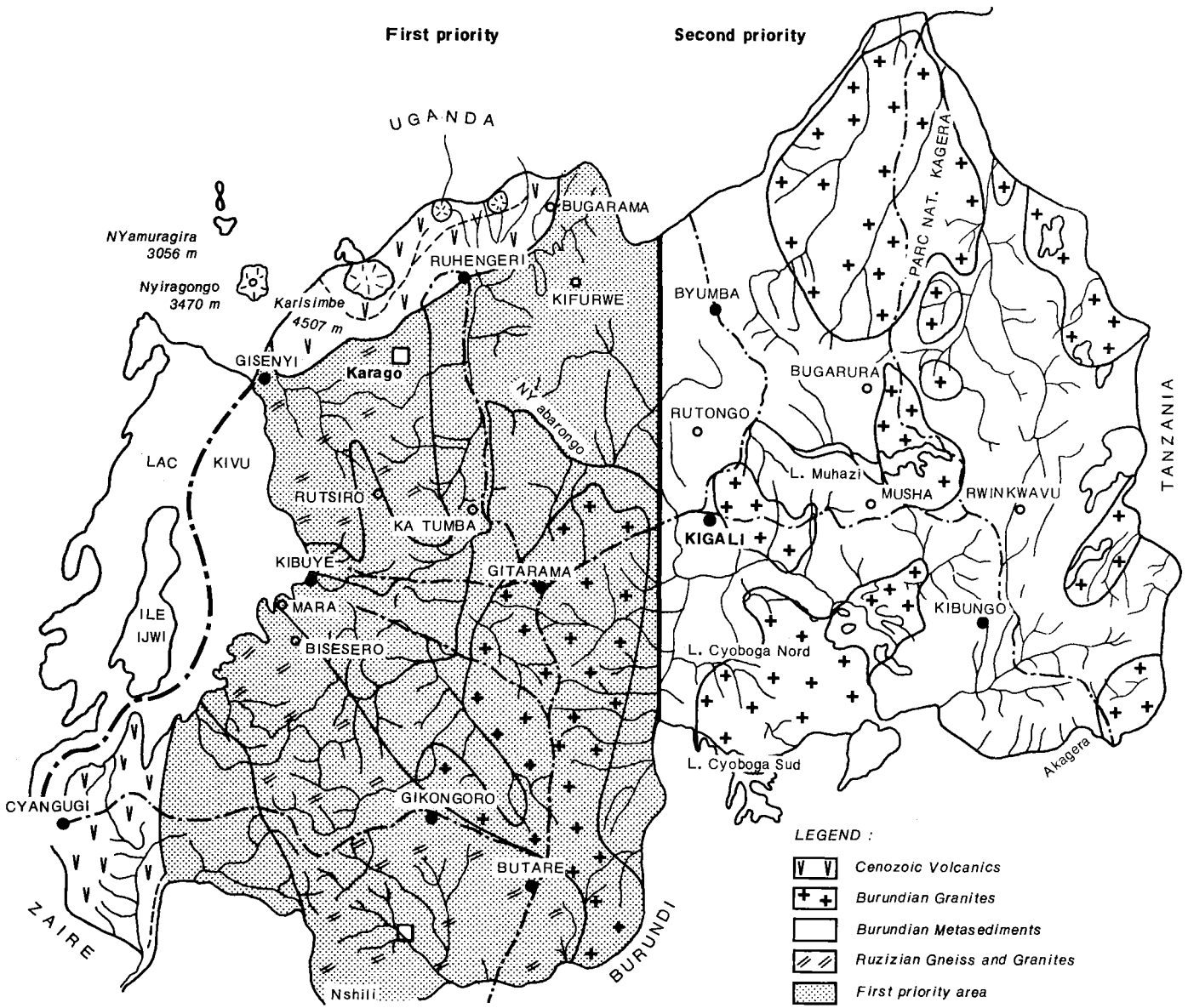
## OCCURRENCES OF URANIUM

Private prospecting and UNDP surveys have located two major uranium occurrences at Nshili and Karago (Figure 2). However, a substantial number of uranium geochemical and radiometric anomalies has been found during the various phases of the UNDP - DTCD mineral survey programme.

U-mineralization was recognized to be associated with the following geological environments:

1. Tectonized and deeply weathered pegmatites and pegmatoidal injections, in one case associated with remnants of graphitic schist.

*Figure 2* **AREAS RECOMMENDED FOR FURTHER EXPLORATION**



2. Post-tectonic Burundian granites.

3. Lamprophyres.

4. Exotic cenozoic volcanism.

5. Alluvial sediments.

During three days of field work only the first category was found to have sufficient potential for immediate consideration, with the second and third category only having a speculative potential. Therefore only the Nshili and Karago occurrences will be described here.

The Nshili occurrence

The radioactive mineralization at Nshili is of the mixed U-Th type, with probably residual Th enrichment at the surface. The area is underlain by Lower Proterozoic Ruzizian rocks thrusted to the west against Burundian rocks.

The Ruzizian comprises metapelites and metasandstones, micaschists with biotite or muscovite, often with pegmatitic lenses, and amphibole schists grading into gneisses, biotite augen gneisses with large pegmatitic bodies. Granitic intrusions are abundant in the area of the uranium anomaly. Mafic dikes have been reported in its vicinity.

Trenching revealed highly radioactive WNW trending, argillitic zones with Th/U ratios of up to 50 or more (up to 19 500 ppm Th and 2 000 ppm U), dipping 70° east, followed along a strike length of 200 m, with a thickness of 1 to 3 meters. The mineralization is located at the fault contact between a partly pegmatitic gneiss and a thick pegmatite body. Hematitization is apparent. A hand specimen taken from the mineralized zone yielded very high radioactivity with a Th/U ratio clearly in favour of uranium (1/8) and contained well visible soft black (sooty pitchblende?) mineralization. Drilling revealed continuation of the mineralization down to a depth of 120 m. Unfortunately, the uranium assays on drill cores of this zone are not very reliable.

Other less well mineralized zones exist in the area. This type of mineralization clearly offers a very good potential for economic uranium deposits.

The Karago occurrence

Uranium mineralization at Karago is again related to pegmatitic bodies. Whilst a 1 cm wide pitchblende vein apparently related to a quartz vein in pegmatite was worked out in the early fifties, and not far from there a high grade pitchblende bearing boulder was found in the late fifties, the most interesting mineralization of this area was found in a subvertical graphitic zone with visible torbernite, within a remnant of biotite micaschist in a pegmatitic to granitic gneiss environment. Siliceous veins with smoky quartz are found close to the contact between granite and micaschists

but faults or shear zones are not evident, although possible. Earthy hematite, probably related to a hydrothermal event is obvious in the micaschist. Unfortunately the zone is only 0.5 m wide, 90 m long, and maximum radioactivity was 15 000 c/s URTEC U.G. 135.

Provided thicker and more consistent graphite bearing septas of micaschist could be found in granitic bodies or embayments or close to the granites, this type of occurrence also holds a good potential for economic U-mineralization.

## FAVOURABLE AREAS FOR SPECULATIVE RESOURCES

Considering the moderate overall potential of Rwanda for economic uranium deposits, uranium exploration in this country has always been conducted as a sideline to exploration for tin, tungsten, columbotantalite etc. Nevertheless the metamorphic terrain of the Lower Proterozoic Ruzizian with its granitic intrusives and pegmatitic to pegmatoidal injections has been found to hold substantial potential for U-mineralization, though no economic deposit has been found to date.

The speculative uranium potential of Rwanda is discussed in the order of decreasing favourability according to the various litho-stratigraphic units.

### 1. The two Ruzizian basement blocks (Figure 2)

The most valuable target for uranium exploration in Rwanda seems to be the metamorphic Lower Proterozoic, Ruzizian, outcropping in a northern and a southern block in the west of the country. In the course of the UNDP programme numerous interesting geochemical U-anomalies have been obtained in these areas. Furthermore, the two most interesting U-occurrences of Rwanda, Karago and Nshili are located here.

The mission report emphasizes, that Ruzizian rocks, though generally older than 2.1 G.a., most probably contain Lower Burundian lithologies with possible ages between 1.7. and 1.9 G.a., a time span when synsedimentary uranium-enriched pelitic protores were deposited in Canada and Australia. Thus enrichment of uranium within such protores by metamorphic or magmatic metasomatic or hydrothermal events could well have led to economic uranium mineralization within the Ruzizian blocks as indicated by one of the U-occurrences at Karago. It is felt, that the potential of the Ruzizian blocks should be further assessed by delineating possible graphite zones through an airborne electromagnetic survey. These zones could then be the targets for further detailed exploration.

The Nshili U-occurrence is probably a different example of mobilization of uranium from a high background protore, but without separation of uranium and thorium, hence more related to magmatic differentiation of remelted sediments with further enrichment in fault zones. The consultants stress the possibility that the "fault" zone in Nshili may be a highly weathered acid thoro-uraniferous metatuff. Tuffs of this nature have been found elsewhere in the Ruzizian blocks. The potential for finding more of the Nshili type mineralization or of finding a depth extension of the already known mineralization is rated rather good.

2. The area of Burundian sediments, metasediments and intrusives

The Lower Burundian sediments with thick sequences of bituminous shales and graphitic phyllites could be an ideal environment for fixation of uranium. Unfortunately, as these lithologies occur in very thick and monotonous sequences their uranium level is too low for their consideration as U-protore. There may however exist some transition zones between the pelitic facies of the west and the more psammitic facies to the east, where U-accummulation may have been possible. Such a facies in association with granitic intrusions could have produced a Midnite-type or peribatholitic vein type uranium deposit.

An additional target would be the post-tectonic Burundian granites themselves: In the Rusatira area uraniferous lamprophyric (?) dikes are found in the granitic complex of Gitarama. Their potential for U-mineralization is well known. Though from the economic point of view their potential is limited, they may be regarded as a viable exploration target in low labour cost countries.

3. The Cenozoic Age

The uranium potential of the young volcanics of the rift valley is rated very low. The possibility of finding R.E.E. carbonatites bearing uraniferous pyrochlore is evoked.

The uraniferous sediments of the Mwesa River Valley are too thin and too low in uranium to have any potential for economic considerations. It is however proposed to examine the underlying Bugesera granite more closely, since it is considered to be the source of uranium in the sediments.

## IUREP MISSION ESTIMATE OF SPECULATIVE RESOURCES

The IUREP Orientation Phase mission estimates that the Speculative Resources of Rwanda fall between 500 and 5 000 tonnes uranium (see Table 1), the majority of which is located in the Ruzizian.

## RECOMMENDATIONS

The IUREP Experts propose a thorough assessment of all UNDP uranium exploration data gathered so far. Specifically the down hole gamma log and chemical assay results from the Nshili prospect should carefully be checked. A repetition of two to three drillholes in this area is proposed before any further exploration is considered. Should the results be positive, then the following approach is proposed:

1. Nshili

Geophysical resistivity survey in order to delineate structural trends, magnetometry to delineate lithologies, core drilling to test the down dip extension of mineralized structures, systematic drilling along strike. If

Table 1

ESTIMATED SPECULATIVE RESOURCES

| Geological Unit | Occurrence or project | Tonnes uranium | | |
|---|---|---|---|---|
| Ruzizian | Nshili | 250 | to | 2 250 |
| | Karago | 50 | to | 1 000 |
| | Other | 150 | to | 1 000 |
| Burundian | Rusatira area | 50 | to | 750 |
| Other | --- | -- | | -- |
| TOTAL | | 500 | to | 5 000 |

* Speculative Resources refers to uranium in addition to Estimated Additional Resources, that is thought to exist mostly on the basis of indirect indications 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 is highly speculative

results are positive, examine other anomalies in detail. Petrographic-mineralogical studies of core samples to assist interpretation of host rock to mineralization.

2. Karago

Geophysical survey: (airborne?) E.M. input, resistivity etc. to delineate graphitic septas within or at the margin of granites. Overburden drilling. Core drilling of best geophysical , geochemical, and radiometric anomalies. Petrographic-mineralogical studies of drill core.

3. Rusatira

Mapping of basic dikes using existing airborne magnetometer data and LANDSAT imagery, false colour photos, etc. Study of photo lineaments. Rock geochemistry to outline areas of fertile granite. Detailed prospecting in farourable areas and geophysical ground surveys where needed. Drilling of best targets.

4. Regional investigations

Revision of geochemical data. Look for pathfinder elements. Rock geochemistry and petrology should be used in granitic areas. Hidden granites may be outlined by airborne magnetic data, which will be available by now. Also the airborne spectrometry data will be of great help to outline prospective targets.

Models for U-mineralization should include uranium in structural traps in granites, in reducing, graphitic or sulphide bearing metasedimentary septas in granites, uranium in peribatholitic environments above and around granite intrusions, hydrothermal enrichment of pre-existing disseminated stratabound uranium. An airborne EM-input survey in selected areas may be of great help in outlining graphitic and/or sulphide bearing strata.

IUREP MISSION PROPOSED PROGRAMME, SUMMARY AND COSTS

| Items | Million U.S. $/5 years |
|---|---|
| Exploration drilling (6 000 m) including down hole logging | 1.00 |
| Geophysical surveys airborne and ground | 1.50 |
| Prospecting radiometric and geochemical | 0.50 |
| Trenching and tunneling | 0.50 |
| Rock geochemistry and petrographic mineralogical investigation | 0.20 |
| Analytical costs | 0.50 |
| TOTAL | 4.20 |

FUTURE EXPLORATION SUMMARY

No plans for future uranium exploration exist for Rwanda, 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:

Commissariat à l'Energie Atomique - DgMN
31-33, rue de la Fédération
75752 Paris Cedex 15 (France)

The Library
Bundesanstalt für Geowissen-Schaften und Rohstoffe
Stilleweg 2
D-3000 Hannover 51
(Federal Republic of Germany)

M. Zaccaria
AGIP Esum
S. Donato Milanese
Milano (Italy)

Power Reactor and Nuclear Fuel Development Corporation
Sankaido Building
9-13, 1-chome, Akasaka
Minato-ku
Tokyo 107 (Japan)

The Library
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Utrechtsweg 310
P.O. Box 9035
6800 Et Arnhem
(The Netherlands)

U.S. Department of Energy
Grand Junction Office
Grand Junction, Co. 81502
P.O. Box 2567
(USA)

U.S. Geological Survey
345 Middlefield Road
Menlo Park
California 94025
(USA)

U.S. Geological Survey
Denver Federal Center
P.O. Box 25046
Denver, Co. 80225
(USA)

U.S. Geological Survey
National Center
Reston
Virginia 22092
(USA)

D.M Taylor
Commission of the European Communities
200, rue de la Loi
B-1049 Brussels
(Belgium)

International Atomic Energy Agency
Wagramerstrasse 5
P.O. Box 100
A-1400 Vienna
(Austria)

OECD Nuclear Energy Agency
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75016 Paris
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