REPORT ON THE MINERAL EXPLORATION IN THE HOMA BAY AREA REPUBLIC OF KENYA

PHASE II

MARCH 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

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PREFACE

In response to the request of the Government of the Republic of Kenya, the Japanese Government decided to conduct a Mineral Exploration in the Homa Bay Area and entrusted the survey to Japan International Cooperation Agency(JICA) and Metal Mining Agency of Japan (MMAJ).

The JICA and MMAJ sent to the Republic of Kenya a survey team headed by Mr. Haruo Watanabe from 18 July to 4 November, 1988.

The team exchanged views with the officials concerned of the Government of the Republic of Kenya and conducted a field survey in the Homa Bay Area. After the team returned to Japan, further studies were made and the present report has been prepared.

We hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

We wish to express our deep appreciation to the officials concerned of the Government of the Republic of Kenya for their close cooperation extended to the team.

February, 1989

Kensuke Yanagiya
President
Japan International Cooperation Agency

Junichiro Sato
President
Metal Mining Agency of Japan

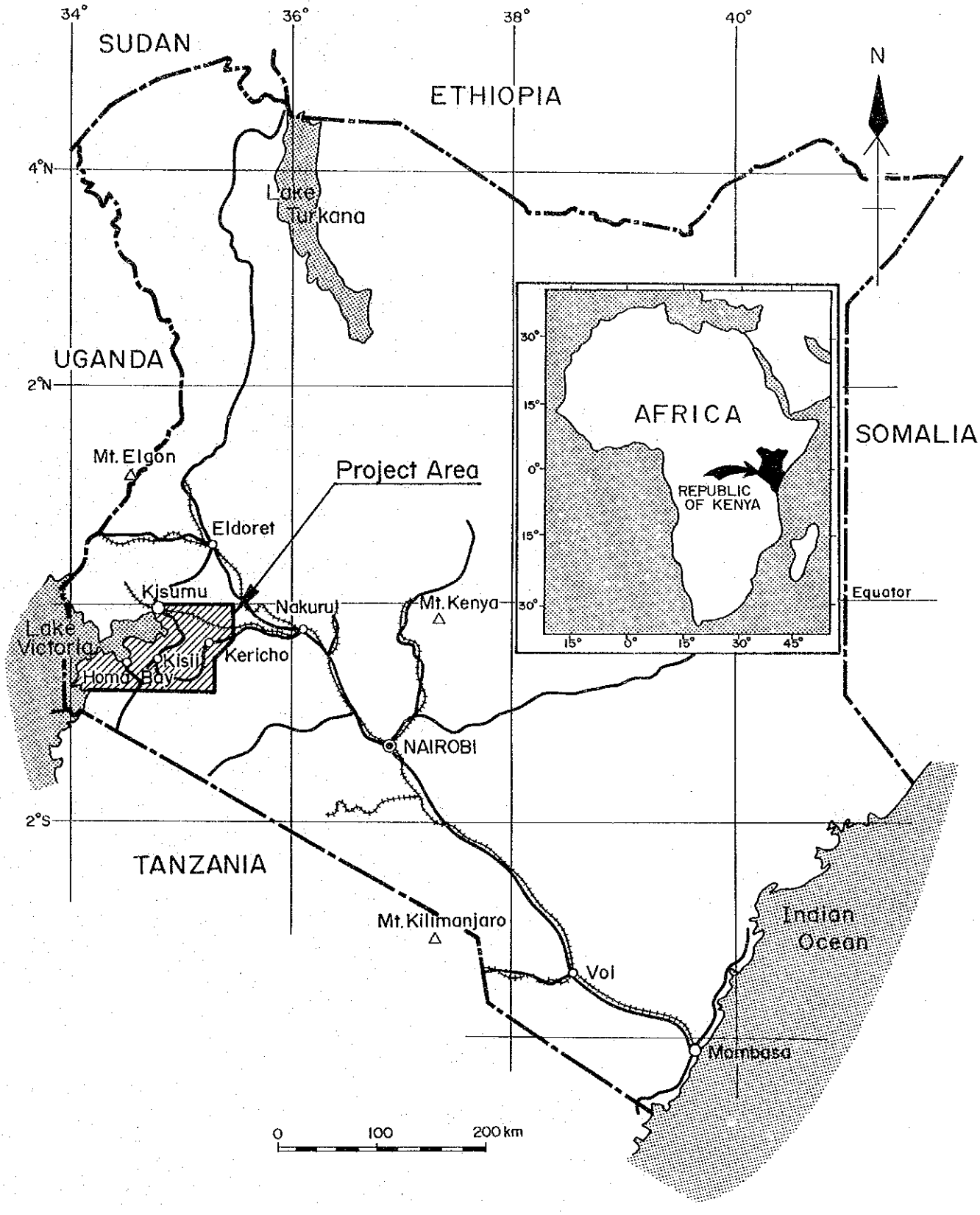

Fig. 1 Location Map of The Project Area

ABSTRACT

The Mineral Exploration Project in the Homa Bay Area is a three year project commenced in the 1987 fiscal year. The purpose is to explore and assess the mineral potential of carbonatite in the area.

The programme of this year (Phase II) comprises detailed survey in three areas ; Buru Hill Area (an area of 0.96 km^2), North & South Ruri Hill Area (an area of 1.68 km^2) and Kuge-Lwala Area (an area of 1.10 km^2), which were selected from the semi-detailed survey areas in Phase I programme according to the survey results.

In the Buru Hill Area, size of the mineralized zone and horizontal and vertical variations of REE, Y and Nb were clarified through detailed geological survey and diamond drilling (17 holes, total length 1,000 m).

In the North & South Ruri Hill and the Kuge-Lwala Areas, the size, mode of occurrence and the mineral potential of carbonatitic rocks in geochemical anomalous zones were investigated. The results for each area are summarized as follows ;

(1) Buru Hill Area

Carbonatites in the Buru Hill Area are of a concealed intrusive body which is overlain by mineralized, brecciated basement rocks.

Mineralization of REE, Y and Nb is found almost everywhere in the whole hillock (in an area of 0.2 km^2) and this has been confirmed to continue for more than 200 m in depth from the surface by diamond drillings. The mineralized zone can be vertically divided into an upper oxidized layer of supergene enrichement and lower fresh layer at the present underground water level.

Average contents of 50 m from the surface in the mineralized zone are estimated as follows ; La + Ce + Nd : 1.93%, Sm + Eu + Tb : 0.036%, Yb + Lu : 0.0037%, Nb : 0.095% and Y : 0.065%.

Because of the big scale of the mineralized zone and the high contents of the elements, it is desireble to carry out further explorations to assess the economic potentiality of the area.

(2) North & South Ruri Hill Area

Three sectors in this area were comprehensively studied through detailed geological and geochemical explorations, and it has turned out that REE and Y concentrate in ferrocarbonatitic rocks which usually occur in the marginal parts of the Ruri Hill carbonatite cone-sheets.

Geochemical anomalies were found in each sector, but they are not potential target areas for the project Phase III because of the small scale and low contents of REE and Y of the ferrocarbonatitic rocks.

(3) Kuge-Lwala Area

Two sectors : Kuge and Lwala were investigated in this area.

Kuge Sector ; A ferrocarbonatite body which is located in the eastern part of Kuge Hill comprises a group of dykes and is 60 m wide in maximum and more than 600 m long. Covering the body, there are anomalous zones of Th, Y, La + Ce + Nd (maximum value : 2.7%), Eu and Tb. The big scale of the body and the high contents of REE and Y warrant further follow-up explorations.

Lwala Sector : Anomalous zones of Y, La + Ce + Nd and Eu are delineated in a zone underlain by ferruginous breccias which are considered to be effusive facies of carbonatites. The thicknesses of the ferruginous breccias are very low and the contents of REE and Y are very low in comparison with that of other sectors, resulting in the low potential of the sector for mineralization of REE and Y.

It is concluded that Buru Hill and Kuge Hill are worth for further exploration as a results of synthesizing the geological and geochemical findings.

In order to explore and assess the two target areas, it is recommended to carry out diamond drillings and mineralogical test.

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PART I GENERAL

PART I GENERAL

CHAPTER 1 Introduction

1–1 Circumstances of the Survey

The main objective of the Survey is to explore and to assess the mineral potential of the Srvey Area, as mentioned in the Scope of Work for the Mineral Exploration in the Homa Bay Area. The Scope of Work was agreed in July 1987 between the Government of Kenya through Ministry of Environment and Natural Resources(MENR), and the Japan International Cooperation Agency(JICA) and the Metal Mining Agency of Japan(MMAJ).

The present Survey is a three-year project commenced in the fiscal year of 1987, and this year is the second year (Phase II) of the project.

The programme of the first year included a reconnaissance geological survey (Regional Survey) for an area of about 2,700 km^2, and geological and geochemical surveys (Semi-detailed Survey) for 10 known occurrences of carbonatite (190 km^2 in total). The major targets for both surveys are rare earths (REE) and so-called rare metals.

In the Regional Survey Area, four small outcrops of carbonatitic rocks and a very small occurrence of green copper specks were newly located, and a few small gold operations (lodes and placer) were examined. However, all these are too small to warrant further follow-up exploration.

In the semi-detailed survey areas, it was concluded that North & South Ruri Hill (Y and REE), Kuge (Y and REE), and Buru Hill (Y, REE and Nb) were worth further exploration, as a result of synthesizing the geological and geochemical findings, and other factors. Among these, Buru Hill seemed to be the most prospective, since it shows a high concentration of REE (average 1.31% and max. 3.98% as combined La, Ce, and Nd) at the surface, and it also has a possibility that Y and Nb might be concentrated at depths, being judged from its occurrence and geochemical features.

Therefore, the above mentioned three areas were selected as target areas for the survey of this year, then detailed geological survey followed by drilling exploration (17 holes, 1,000 m in total length) was introduced in the Buru Hill Area (an area of 0.96 km^2), and detailed geological survey and geochemical explorations were conducted in both North & South Ruri Hill Area (an area of 1.68 km^2) and Kuge-Lwala Area (an area of 1.10 km^2).

1–2 Conclusion and Recommendation for the 2nd Phase

1–2–1 Conclusion

(1) Regional Survey Area

The result of the geological mapping is consistent with the previous geological maps and papers.

For mineralization in the area, four small outcrops of carbonatitic rocks and a very small occurrence of green copper specks were newly located, and a few small gold operations were examined.

It is concluded that the newly discovered carbonatitic and copper occurrences are too small to warrant further follow-up.

As for gold, it may be worth paying attention to it, as the project area is adjacent to the long known Migori Gold Field, and includes rocks that are considered to be equivalent to those in the Greenstone Belt, which is noted throughout the world as a favourable host for gold mineralization. Nevertheless, it is also necessary to be careful not to infringe vested rights, as there are already several works in operation.

(2) Semi-detailed survey areas

The exploration potential of each area has been assessed by integrating the results of the geochemical explorations and interpretation of geological structure of the area.

i) It is considered that the commodities which are worth further exploration in the present project area are rare earth (REE) minerals, yttrium (Y), and niobium (Nb) which are closely related with carbonatite, especially with ferrocarbonatite in general.

It may also be necessary to pay attention to gold in some way. However, it is concluded that other elements, such as phosphorous etc. are not worth further exploration, as most of their absolute values are low, whereas relatively higher ones are distributed sparsely and locally.

ii) It is recessary to carry out some follow-up works in Buru Hill (REE, Y, and Nb), Kuge-Lwala (REE, Y), South Ruri (REE, Y), and North Ruri (REE, Y) (priority is in the order above).

iii) The mineralization at Buru Hill is found to be related with a carbonatitic intrusion although no carbonate minerals were recognized on the surface during the present study. This is because, sovite was intersected in DDHs by NCGF (Cluver; 1958) and the chondrite normalized REE patterns suggest the carbonatitic affinity of the mineralization. Here, superimposition of the mineralizations of different stages is inferred, as relatively deeper facies (sovite, magnetite and Nb) and shallower one (LREE and brecciated structures) occur in the same place.

iv) Because the mineralization in the ferruginous breccia at Lwala is somewhat similar to that of Buru Hill, and the interpretation of geology at Kuge indicates a high level emplacement of the carbonatite complex, it is necessary to explore the depths at Kuge-Lwala Area.

v) As for gold, the assay result of one of 7 handspecimens taken from a ridge of Homa Mountain is 33 g/t Au, though others are trace to 2 g/t. It is then necessary to conduct follow-up work in the area.

1–2–2 Recommendation for the 2nd phase

It is recommended to carry on some of the following works.

(1) Buru Hill Area

To carry on a programme concentrated mainly in drilling, the aims of which are to explore the size, shape and character of the secondary enrichment zones of REE, niobium and yttrium that may be expected under the leached capping and to explore a potential blind carbonatitic plug that might occur some 500 m south of the main hillock.

It is also recommended to execute pitting, cleaning of the old inclined shaft, mineralogical and metallurgical tests of ores.

(2) Kuge-Lwala Area

To carry on an exploration programme concentrated mainly in drilling and geochemical grid-sampling including trenching. The aims of the drilling are to explore at the depths the ferrocarbonatite dyke located at Kuge, and to explore Y and REE at depths in the ferruginous breccia body, which is located at Lwala and resembles ores at Buru Hill.

(3) North & South Ruri Hill Area

To carry on an exploration programme including mainly geochemical grid-sampling and geological mapping in detail for an anomaly of REE and Y.

1–3 Outline of the 2nd Year Programme

1–3–1 Location

(1) Location

The project area (Homa Bay Area) is located in the western part of the Republic of Kenya; eastern coast area of the Lake Victoria, and is spread over two provinces, mainly in Nyanza Province, and partly in Rift Valley Province (Fig. 1, Fig. 2).

The following are the three survey areas of this year (Phase II); Buru Hill located in the northwestern part of the Kericho District in the Rift Valley Province, Kuge-Lwala and North & Ruri Hill Areas located in the central part of the South Nyanza District of the Nyanza Province.

The central towns of the Kericho and South Nyanza districts are Kericho and Homa Bay respectively.

(2) Communication

Kericho and Homa Bay towns are accessable by car from Nairobi following the roads which are asphalted. The road distances from Nairobi to Kericho and to Homa Bay are about 270 km and 400 km respectively and it takes about 4 and 7 hours respectively.

Nairobi - - - - - Makutano - - - - - Kericho - - - - - Sotik - - - - - Kisii - - - - - Rongo - - - - - Homa Bay

A–104 B–1 C–23 B–3 A–1 C–20

The railway between Nairobi and Kisumu passes by Muhoroni which is close to Buru Hill (5 km in distance).

The Buru Hill area is situated 24 km northwest of the town of Kericho and is accessable from Kericho via B–1 (30 km road distance).

The North & South Ruri Hill and the Kuge-Lwala Areas are situated 10 km to the west of the town of Homa Bay, and it takes 40 and 50 minutes by car respectively.

1–3–2 Purpose of the survey

The purpose of the survey is to comprehend the modes of mineral occurrences in carbonatite deposits in Homa Bay area through clarifying the geological conditions of the area.

The programme of this year comprises detailed survey in three areas, Buru Hill, Kuge-Lwala and North & South Ruri Hill Areas.

Aims of the survey in each area are as follows:

(1) Buru Hill Area: The vertical and horizontal variations of REE, Y and Nb and the size of the deposit are to be determined. The economical potentiality of the deposit is to be investigated through drilling exploration in connection with geological, trenching and pit surveys.

(2) Kuge-Lwala Area: Size and character of the Kuge anomaly which covers the ferrocarbonatite body in the Kuge Hill and shows high geochemical anomalies for Y, Sm, Eu etc., and

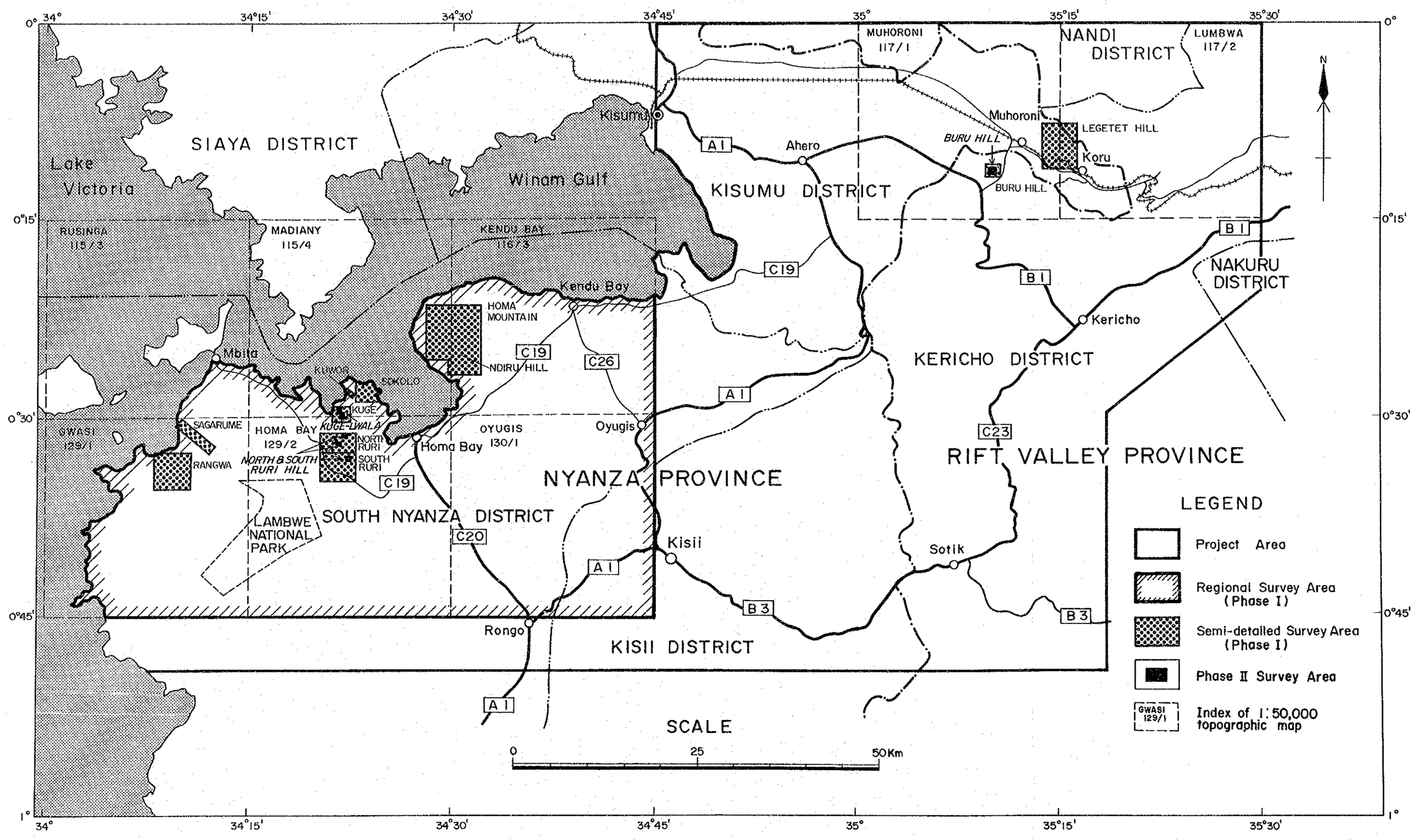


Fig. 2 Location Map of Phase II Survey Area

Lwala anomaly zone which covers ferruginous breccia at Lwala and shows high geochemical anomalies for Y, Yb etc., are to be investigated through geological, geochemical and trenching survey.

(3) North and South Ruri Hill Area: Size and Character of two areas in the North Ruri Hill and one area in South Ruri Hill show high geochemical anomalies for Y, La, Ce etc., through geological and geochemical explorations.

1–3–3 Methods of the work

Detailed geological mapping and drilling (DDH) in the Buru Hill Area and detailed geological and geochemical explorations in the Kuge-Lwala and North & South Ruri Hill Areas were carried out for the survey of this year.

All the work carried out is listed in Table I–1–1.

(1) Geological survey

In the Buru Hill Area, a 1/2,000 topographic map was drawn from existing air photos for geological mapping in the area. Field data were plotted on the map. Sketches for trenches and pits at scale of 1/100 were drawn.

Geology as a result of the survey, together with the results of drilling exploration, is to be compiled in the same scale map.

In the North & South Ruri Hill and Kuge-Lwala Areas, 1/5,000 topographic maps for the areas were prepared by enlarging existing 1/50,000 topographic maps.

Geological mapping in the area was carried out on the basis of the above 1/5,000 topographic maps.

Sketches at scale of 1/100 for trenches in Kuge-Lwala Area were drawn.

Geology and geochemistry of the areas, as a result of the survey are to be compiled in the 1/5,000 topographic maps.

(2) The survey traverses were set on lines at 100 m intervals in the North & South Ruri Hill Area, and at 50 m in the Kuge-Lwala Area respectively, and geochemical samples were collected at 50 m intervals along the traverses.

Measurements of total intensity of γ-radiation at geochemical sampling points were taken to know the correlation between the intensity of γ-radiation and geochemical anomaly.

(3) Drilling Exploration

Drilling exploration was conducted in the mineralized zone of the Buru Hill Area.

Number of drilled holes are 17 (200 m in one hole, 50 m in other 16 holes in length), totaling 1,000 m in length.

Two sets of drilling machines, suitable for the planned drilling length, were utilized and a wireline system was applied in the drilling operation.

(4) Interpretation of the Results and Preparation of Report

All the results of the field work and the laboratory tests were comprehensively interpreted together with available existing data and reports.

Analytical works and laboratory tests are listed in Table I–1–2.

Table I–1–1 Content and Quantity of Field Work

Area	Content of Survey	Quantity of Survey	
BURU HILL	Geological Survey (Detailed Survey)	Area	0.96 km
		Survey length	19.0 km
	Drilling Exploration	17 Holes	1,005.7 m
	Trenching Survey	10 localities	200 m
	Pit Survey		5 localities
KUGE-LWALA	Geological and Geochemical Explorations (Detailed Survey)	Area	1.10 km
		Geochemical Samples	266
	Trenching Survey	4 localities	320 m
NORTH & SOUTH RURI HILL	Geological and Geochemical Explorations (Detailed Survey)	Area	1.68 km
		Geochemical Samples	324
TOTAL	Geological and Geochemical Explorations (Detailed Survey)	Area	3.74 km
		Geochemical Samples	590
	Drilling Exploration	17 Holes	1,005.7 m
	Trenching Survey	14 localities	570 m
	Pit Survey		5 localities

Table I–1–2 Outline of Laboratory Tests

	Mode of analysis	Amounts
1	Thin section of rocks	20
2	Polished section of rocks	12
4	Chemical analysis : Rocks	
	SiO_2, Al_2O_3, TiO_2, T. Fe_2O_3, MnO,	40
	MgO, CaO, K_2O, Na_2O, P_2O_5, L. O. I.	480 elements
	F (12 elements)	
	U, Th, La, Ce, Nd, Sm, Eu, Tb, Yb,	210
	Lu (10 elements)	3,150 elements
	Nb, Sr, Y, Ba, Au (5 elements)	
5	Chemical analysis : Geochemical Samples	
	U, Th, La, Ce, Nd, Sm, Eu, Tb, Yb,	590
	Lu (10 elements)	8,850 elements
	Nb, Sr, Y, Ba, P (5 elements)	
6	EPMA	10

1–3–4 Members of the teams

The members of the preliminary mission are listed in Table I–1–3 together with that from the Kenyan side. The member list of the field team is shown in Table I–1–4.

Table I–1–3 Preliminary Mission and Kenyan Personnel in the Meeting

JAPANESE SIDE		KENYAN SIDE	
Mr. Toshihiko Hayashi	MMAJ *1	Mr. J.K. Wachira	MGD *2
		Mr. F.K. Muruga	MGD
		Mr. Isaac Onuonga	MGD

Table I–1–4 Member List of Field Team

JAPANESE SIDE		KENYAN SIDE	
Mr. Haruo Watanabe (Geologist)	MMAJ	Mr. Isaac Onuonga (Geologist)	MGD
Leader of the Field Team		Co-leader of the Field Team	
Mr. Takumi Onuma (Geologist)	MMAJ	Mr. William Okech (Geologist)	MGD
Mr. Katsuei Narita (Driller)	MMAJ	Mr. Haron Onsomu Maragia (Geologist)	MGD
Mr. Takehiro Manabe (Driller)	MMAJ	Mr. Adipo Komo (Geologist)	MGD
Mr. Masaaki Fujita (Driller)	MMAJ	Mr. E. Likhaya (Driller)	MGD
		Mr. Peter Obiero (Driller)	MGD
		Mr. Joseph Ango (Driller)	MGD
		Mr. Chambege Sembe (Driller)	MGD

*1 MMAJ : Metal Mining Agency of Japan

*2 MGD : Mines and Geological Department of Kenya

1–3–5 Periods of work

Periods of the work for the field team are summarized as follows;–

Planning and Preparation : June 16, '88 – July 15, '88

Travelling and Preparation in Kenya

Geologists : July 16, '88 – July 21, '88

Drillers : July 30, '88 – August 2, '88

Field Work	Geologists	: July 22, '88 – October 27, '88
	Drillers	: August 3, '88 – October 27, '88
Reporting to MGD		: October 28, '88 – November 1, '88
Travelling		: November 2, '88– November 4, '88
Laboratory Work and Preparation of Report		: November 5, '88 – February 10, '89

CHAPTER 2 GEOGRAPHY

2–1 Physiography

2–1–1 Topography

The survey areas of this year are all situated in the Kavirondo Rift Valley which is thought to be a branch of the Great East African Rift Valley. The Kavirondo Rift is 20 to 30 km in width and 200 km in length generally trending east–northeastward from the shore of the Victoria Lake (1,136 m above the sea level).

The western part of the Rift comprises flat lands covered by alluvium deposits and a group of hills which are 600–1,000 m higher than the surrounding flats and composed of Carbonatite-alkaline rock complexes. The North & South Ruri Hill Area belongs to one of these hills, on the other hand, the Kuge-Lwala Area is situated in a gentle slope between the flat lands and the hills.

The western part of the Kavirondo Rift comprises eastern gentle slopes continuing to eastward highland covered with volcanic rocks of the Tertiary and western flat alluvium area. The Buru Hill Area is located in this gentle slope close to the flat lands and it is a discrete hill with a relief of about 70 m above the surrounding flat.

2–1–2 Drainage system

The Buru Hill Area is located on the southern bank of the middle stream of the Nyando River which originates from the Mau Forest, the background of the Kericho highland, and passes through the Kusumu Plains emptying itself into Lake Victoria. The Raragewit River which is a major tributary of the Nyando river is to the east of the Buru Hill and has smaller tributaries with their confluences south of the Hill. The Raragewit River System has a permanent water flow.

There are no big rivers in the North & South Ruri Hill Areas. Water flow is just seen in gulleys only during the rainy season. The big Lambwe Valley of 10 km maximum width and 30 km in length situated to the west of the North & South Ruri Hill and Kuge-Lwala Areas is dry except during the rainy seasons.

2–2 Climate and Vegetation

2–2–1 Climate

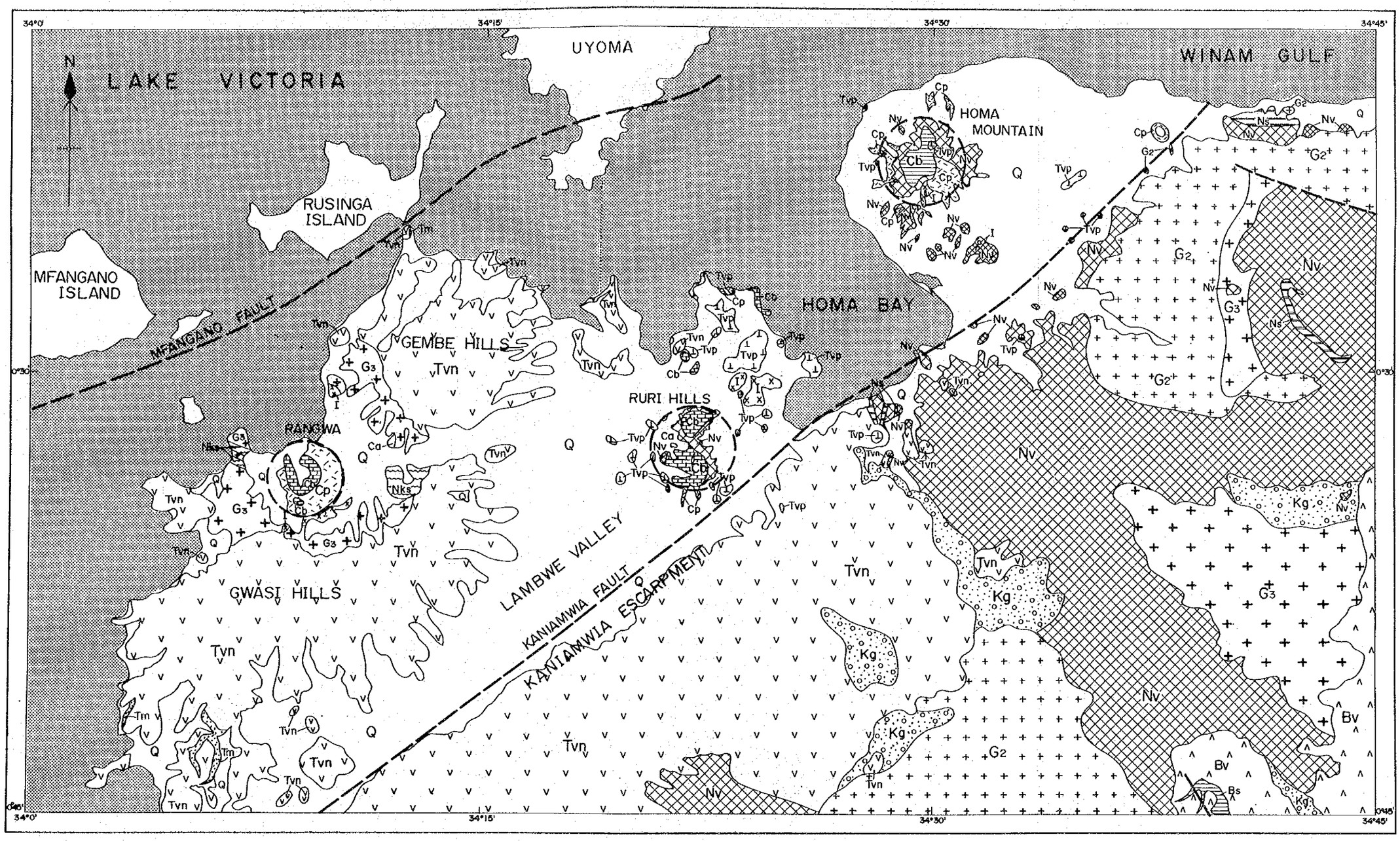
The climate in the project area is semi-arid with annual precipitation of about 1000 to 1200 mm and humidity of about 60 %. There are two rainy seasons; the long rains from March to May or June, and the short rains in November and December. The temperature changes little throughout the year, averaging 24 C, but sometimes rising up to 40 C.

2–2–2 Vegetation

In general the natural vegetation of the project area is rather poor, as its climate is semi-arid, belonging to savanna, and as the area is heavily inhabited.

The plains including the North & South Ruri Hill and Kuge-Lwala Areas are more or less covered with fields of maize, millet, cassava, and cotton. These are often fringed by sisal (Agave sisalana). However, the lands do not seem fertile. On the other hand, the flat lands in the proximity of Buru Hill are fully utilized for a large scale sugar cane plantation.

Most of the hilly carbonatite-alkaline centers are in an open grass land, with scattered acacia trees (Acacia drepanolobium and other species), Cactus Euphorbia (Euphorbia ingens), thorn bush, etc.



LEGEND

Quaternary
- Q — Alluvium

Tertiary
- Tvp — Phonolites
- Tvn — Nephelinitic. Volcanic. rocks
- Tm — Sedimentary rocks

BUKOBAN SYSTEM

Pre-Cambrian
- Bv — Volcanic rocks
- Bs — Sedimentary rocks

KAVIRONDIAN SYSTEM
- Kg — Conglomerate, sandstone

NYANZIAN SYSTEM

Pre-Cambrian
- Nks — Kaksingiri schists
- Ns — Metasediments
- Nv — Metavolcanic rocks

INTRUSIVE ROCKS

Tertiary
- Cb — Carbonatite complex
- Cp — Calcareous Pyroclastic rocks
- I — Alkaline intrusives

Pre-Cambrian
- G3 — Granitic rocks (Post-KAVIRONDIAN)
- G2 — Granitic rocks (Post-NYANZIAN)

Major faults

Carbonatite center

Fig. 3 Geological Map of the Homa Bay Area

CHAPTER 3 GENERAL GEOLOGY

The geological map of the Homa Bay Area; Regional Survey Area of Phase I which includes the North & South Ruri Hill and Kuge-Lwala Areas, is shown in Fig. 3.

The area is bisected by a major fault (Kaniamwia) trending in a NE-SW direction. This fault forms the southeastern escarpment of the Kavirondo Rift which branche off westerly from the centre of the Kenya Rift. There occurs plutonic and volcanic rocks of carbonatite-nephelinite series of Tertiary and Quarternary ages, basement granitoid inliers within volcanics and Quarternary alluvials to the northwest of the fault, while the rocks to the southeast of the fault comprise Archean greenstones and sediments (the Nyanzian and the Kavirondian Systems), intrusions and nephelinitic volcanics overlying the Precambrian.

North Ruri Hill and South Ruri Hill (called Ruri Hills collectively) are formed of one of the three largest carbonatite-alkaline rock complex units in the Homa Area and are a pair of hills which project out prominently above the surrounding alluvial plain and composed of two typical cone sheets.

Ijolite and carbonatite bodies are known to be distributed at several localities in the Wasaki peninsula to the west of the town of Homa Bay.

The Kuge-Lwala Area includes a small carbonatite body located in the southwestern end of the carbonatite area mentioned above.

The geology of the two areas comprise the basement Nyanzian Metabasalt, Tertiary volcanics, carbonatites, carbonatitic breccias and Quarternary surfical deposits.

The geology of the surrounding areas of the Buru Hill comprises undifferentiated granitoid gneisses (the Mozambique Metamorphic Rocks of today), calcareous sedimentary rocks of the Tertiary, the Tindret Volcanic Rocks in the northeast and phonolitic rocks in the south. The Buru Hill is thought to be formed by carbonatite intrusion to the granitoid gneisses.

The Kaniamuiwa Fault which is the limit of the southern margin of the Kavirondo Rift continues to the Kendu Fault, whereas in the eastern side it becomes indistinct near the Buru Hill.

CHAPTER 4 GENERAL DISCUSSION FOR THE SURVEY RESULTS

4–1 Summary of the Survey Results

(1) Buru Hill Area

The Buru Hills, a discrete hillock formed by intrusion of carbonatite, comprises a massive body of carbonatite with roof of mineralized basement rocks. The area of the zone of mineralization is about 0.2 km^2 covering almost all the hillock. Drilling exploration revealed that the mineralization of REE, Y and Nb continues more than 200 m below the surface.

The mineralized zone is divided into two parts by present underground water level (1,295 m from the sea level); oxidized and reduction zones, with secondary enrichment in the former.

Average values of major components up to 50 m below the surface are as follows;– La+Ce+Nd; 1,93 %, Sm+Eu+Tb; 0,036 %, Yb+Lu; 0,0037 %, Nb; 0,095 %, Y; 0,065 %.

(2) North & South Ruri Hill Area

Detailed geological and geochemical exploration in two sectors in the North Ruri Hill and another in the South Ruri Hill shows that REE and Y are concentrated mainly in the ferrocarbonatites which usually occur at the marginal parts of the carbonatite corn-sheets.

Geochemically anomaly zones were found in each sectors, but all of them are too small in size and density to warrant further follow-up work.

(3) Kuge–Lwala Area

The ferrocarbonatite dyke occurring in the east of Kuge Hill has the size of 60 m in maximum width and more than 600 m in length, and the area covering the dyke corresponds to the anomaly zones of Th, Y, La+Ce+Nd (maximum value : 2,7 %) and the first principal component in principal components analysis which represent the concentration of REE. The size and high contents of REE of the dyke encourage further exploration drilling in Phase III.

In Lwala sector, anomally zones of Y, La+Ce+Nd and Eu were loated in the area underlain by ferruginous breccia. But the breccias are judged to be effusive facies of carbonatite, and the thickness is very small and contents of REE are relatively lower than in the other sectors, resulting to a lower priority area for further follow-up work.

4–2 Geological structures, and Characters and Control of Mineralization

(1) Geological structures

All carbonatite complexes in the Western part of Kenya are situated in the Kavirondo Rift and the existance of the Rift is the major structure which controls the occurrences of carbonatites.

Both North and South Ruri Hills have domal structures formed by intrusion of carbonatite complexes which show cone sheet structure. In the upper part and marginal part of the complexes, carbonatites occur as sheets or dykes, on the other hand, in the central part as massive bodies. Ferrocarbonatites occur as sheets or dykes in the marginal part of the complexes and dip toward the center.

In the Kuge Hill, a much smaller carbonatite cone sheet compared with Ruri's one, carbonatites occur in a semicircular form which represents the uppermost part of the intrusive body. Ferrocarbonatites occur as dyke swarms extending in a N-S direction and dipping steeply westward surrounding alvikite cone sheet. There are some possibilities that southern and northern extentions of it occur in the depths of the alluvial plain surrounding the alvikite cone sheet.

The Buru Hill is composed of concealed small body and the its roof composed of basement rocks. The carbonatite occur as cone sheet in the upper part and massive body in the lower part.

(2) Characteristics of Mineralization

Chemical character of the carbonatites in the three areas is that they are poor in Nb and P. In the Turu Hill it has turned out that the carbonatites are rich in Ba and F, all of which indicate the shallower facies of carbonatite intrusion.

There are no secondary enrichment in the North & South Ruri Hill and the Kuge-Lwala areas, showing the shallower erosion level of carbonatites in two areas because of the young age of intrusion.

In the Buru Hill area, on the other hand, the erosion level is much shallower than that of the other two areas, resulting in the existance of a mineralized roof which has undergone secondary enrichment, but the enrichment has not reached the massive carbonatite body below the roof.

(3) Control of Mineralization

Rock facies which have originally high contents of REE and Y are relatively more favourable for mineralization, for these elements, as the carbonatite itself has not undergone secondary enrichment.

Then occurrences of ferrocarbonatites are the major factor which control the mineralization

for target elements in North & South Ruri Hill and Kuge-Lwala Areas.

In the Buru Hill area, on the other hand, ferrocarbonatites are very scarce compared with other areas. Therefore, basement rocks overlying the carbonatite body are strongly veined with various ores related to the carbonatite instrusion and have undergone secondary enrichment, with concentrations of REE, Y and Nb.

4–3 Potentiality of REE Mineralization

From the comprehensive interpretation of the results of geological, geochemical and drilling explorations, it is judged that the Buru Hill has the highest potentiality for REE mineralization and the Kuge Hill in the Kuge-Lwala area is the second favourable.

The three sectors in the North & South Ruri Hill area are judged to have not high potentiality for REE mineralization.

4–4 Relation Between Geochemically Anomalous Zones and Mineralization

In the North & South Ruri Hill and the Kuge-Lwala Areas, geochemically anomalous zones for 9 components; Nb, P, Y, Th, La+Ce+Nd, Eu, Yb, γ-ray intensity and scores of Z1 component in principal components analysis, were investigated.

Anomalies which correspond to the characteristics of each area were found especially in Th, La+Ce+Nd, Eu and Yb components.

These anomalies are usually located in the same areas in each sector but the dimensions of the anomalies are different. On the other hand anomaly zones for scores of Z1 component in the principal components analysis are very effective to abstract the various anomaly zones of these elements related to REE mineralization.

The anomalies of the component cover the areas of ferrocarbonatites or ferruginous breccias (Lwala sector) closely coinciding in area, resulting to be a good indicator of REE mineralization.

In the Buru Hill, the results of analysis of core samples do not neceessary coincide with the anomaly zones of Phase I survey. The strong facies change in the zone drilled is thought to be the reason of lower coincidences of the two factors.

CHAPTER 5 CONCLUSION AND RECOMMENDATION

5–1 Conclusion

5–1–1 North & South Ruri Hill Area

Geological and geochemical explorations were conducted in three sectors of the area. The three sectors are situated in the marginal parts of the carbonatite cone-sheets of the Ruri Hills and their geology comprises basement Nyanzian Metabasalt and carbonatitic rocks which have intruded the former.

From the geochemical exploration, it is found that rare earth elements (REE) and Y concentrate in ferrocarbonatites or ferrocarbonatite breccias in these three sectors.

Conclusion on geology and geochemistry of the three sectros is summarized as follows:

(1) North Ruri Hill North Sector

Ferrocarbonatite breccias occur in the central part of the sector in an area of 0.03 km^2 trending eastwards. The rocks have undergone strong weathering and have their facies change.

Geochemical anomalies of REE and Y are in the zone of ferrocarbonatite breccias and their immediate peripheries.

The ferrocarbonatite breccias in the zone is rich in middle to heavey rare earth elements and poor in right rare earth elements in comparison with other sectors.

However the possibility of a potential mineralization occuring in the sector is thought to be very low from results of both geology and geochemistry.

(2) North Ruri Hill South Sector

A group of small ferrocarbonatite dykes (dyke swarm) is found in the southern part of the sector. The dykes are usually a few to several tens of centimeters wide and a few to several tens of meters long.

Main geochemical anomalies of Y, Th and La + Ce + Nd cover the dyke swarms in an area of 0.06 km^2.

The ferrocarbonatite in the zone are richer in La and Ce in comparison with the other sectors.

From results of both geology and geochemistry the possibility of potential mineralization here is very little.

(3) South Ruri Hill Sector

The main ferrocarbonatite zone is in the central to northwestern part of the sector in an area of 0.05 km^2. The zone comprises a group of small ferrocarbonatite dykes and the basement Nyanzian Metabasalt.

A major geochemical anomaly of La+Ce+Nd covers the zone, but no other important anomaly was observed in the sector.

The ferrocarbonatites of the zone are somewhat richer in La and Ce in comparison with other sectors.

From the nature of ferrocarbonatite dykes, the zone is considered to be worthless for further follow up explorations.

5–1–2 Kuge-Lwala Area

(1) Kuge Sector

There is a group of ferrocarbonatite dykes which froms a body of 600 m long and 60 m wide maximum in the eastern part of the Kuge Hill.

Strong geochemical anomalies of Y, Th, La+Ce+Nd, Eu and Yb are found in a zone covering the body, and the rocks are rich in Nd in comparison with the other sectors.

The large scale of the body and the strong geochemical anomalies suggest an existance of a potential mineralized zone of REE and Y.

(2) Lwala Sector

The geology of the sector comprises basement Nyanzian Metabasalt, carbonatitic rocks and phonolitic rocks.

Ferruginous breccias which widely occur in the northern part of the area and were expected to be a potetial target for REE and Y by the Phase I survey, are considered to be thin effusive facies of carbonatites. The rocks comprise breccias of ferrocarbonatite, alvikite and metabasalt, and ferruginous matrix.

Main geochemical anomalies of Y, La+Ce+Nd and Eu are found in the zone of the ferruginous breccias in the northern part of the sector. But the scale are very small.

Chondrite-normalized patterns of the ferruginous breccias show poor contents of REE, particularly in light rare earth elements.

It is considered that the sector is not a target area for Phase III becasue the contents of REE and the thickness of ferruginous breccias are very low.

5–1–3 Buru Hill Area

(1) Geology

Buru Hill Area is located in the Kavirondo Rift Valley which is a branch of Kenya Rift Valley, and the geology comprises a concealed carbonatite body which is overlain by brecciated basement rocks of the Mozambiquean System.

The carbonatites are composed mainly of alvikite and partly sövite, ferrocarbonatie and vein rocks. The carbonatites in the area are considered to be shallow facies of an intrusive carbonatite body.

There is a possibility that a blind carbonatitic plug may occur below a brecciated zone of silicified basement rocks in a place which is about 500 m to the south of the Buru Hill.

(2) Mineralization

Primary mineralizations are devided into five types, i.e., carbonatite, ferrocarbonatite, calcareous iron ore veins, manganiferous iron ore veins and siliceous iron ore veins. Brecciated gneisses overlying the carbonatite body have acquired strong mineralization from these primary materials and supergene enrichment.

The main REE mineral of the primary mineralized materials is bastnäsite which is a carbonate mineral with fluorides. The main Nb-bearing mineral is pyrochlore. The whole mieral assemblege in the supergene zone remains uncertain.

(3) Size of the zone and mode of occurrence of the minerals.

The mineralized zone covers almost all of the Buru Hill area in an area of 0.2 km^2 and continues at least for more than 200 m in depth from the surface of the hill.

With the water table of the area as a boundary, the mieralized zone can be divided into an upper oxidized layer of supergene enrichment and a lower layer of primary mineralization.

Average chemical contents of 50 m depth from the surface in the mineralized zone are estimated as follows ; La+Ce+Nd : 1.93%, Sm+Eu+Tb : 0.036%, Yb+Lu : 0.0037%, Nb : 0.095% and Y : 0.065%.

The large scale and the high chemical contents of the mineralized zone suggest that the area is a potential target area for REE, Y and Nb.

5–2 RECOMMENDATION

It is recommended to carry out following works as the 3rd Phase Programme to the Buru Hill and the Kuge-Lwala Areas.

(1) Buru Hill Area

A programme concentrated mainly in diamond drilling and mineralogical tests is recommended .

The aims of drilling are to know the exact boundary of the mineralized zone and the shape and character of the supergene enrichment and the lower zones, and also to explore a potential blind carbonatite body that might occur at the depth to the south of Buru Hill.

The aims of mineralogical tests are to reserch the whole mineral assemblege in both the supergene enrichment and the lower primary mineralization layers.

(2) Kuge-Lwala Area

A programme concentrated mainly in diamond drilling and mineralogical test is recommended .

The aims of drilling is to explore the depths of the group of ferrocarbonatite dykes located in the eastern marginal part of the Kuge Hill.

The aims of mineralogical tests are to know the mineral assemblege of rare earth elements of the dykes.

Part II DETAILED REPORT

Part II DETAILED REPORT

CHAPTER 1 NORTH & SOUTH RURI HILL AREA

1–1 Methods of Survey

1–1–1 General features

Both detailed-geological mapping and geochemical survey were carried out in two sectors in the North Ruri Hill and another in the South Ruri Hill Areas totalling in an area of 1.68 km^2.

The survey routes were set on lines at 100m intervals, and geochemical samples were collected at 50 m intervals along the traverses.

Measurement of total intensity of γ–radiation at geochemical sampling points were done to know the correlation between the intensity of γ–radiation and geochemical anomaly.

Geology and geochemistry of the areas, as results of the survey were compiled in the 1/5,000 topographic maps.

1–1–2 Geological survey

Field survey was carried out using 1/5,000 topographic maps as base maps, which had been photographically enlarged from 1/50,000 topographic maps published by the Kenya Survey and redrafted. Traverse routes were decided to cover each sector, and survey lines set for geochemical exploration were used for the purpose.

Preparation of fact maps on a scale 1:5,000, collection of representative rocks, and detailed geological sketch and photographing for important outcrops were done, and all results were compiled in the 1:5,000 geological maps and sections.

1–1–3 Geochemical explorations

(1) Sampling

The geochemical sampling was carried out at the same time with geological mapping. Sampling points were located at a 100x50 m grid using 50 to 100 m vinyl chains and compasses.

Rock samples from outcrops were usually taken for geochemical use, but float samples which were estinated to be in situ were also taken where no outcrop existed.

Sampling was not done in those places where no floats in situ was found or soil cover was thick.

(2) Measurement of total gamma-ray intensity

Measurement of intensity of total gamma-ray was carried out at the same points of geochemical samples. Every necessary corrections for the data were applied. The measurement was done using a Differential Spectometer GRS-500 made by EDA, Canada.

(3) Chemical analysis and results

The elements analyzed and their methods of analysis, and detection and upper limits are shown in Table II-1-1. There were some samples which are below the detection limits in Nd, Lu, U, Th and Nb or exceeded the upper limits in La and Ce.

For the purpose of statistical analysis, to those samples which have contents below dtection limits, 1/2 of detection limit were given.

In case of La and Ce, for those samples which exceed the upper limits, estimated values were given to Ce from La and to La from Nd by extrapolating after calculation of theircorrelation coefficients. Correlation coefficients between Ce and La, and La and Nd are both more than 0.9.

Table II-1-1 Analytical Method of Geochemical Samples

Element	Unit	Method	Detection Limit	Upper Limit
Ce	ppm	NAA	2	10000
Eu	ppm	NAA	0.5	100.0
La	ppm	NAA	1	1000
Lu	ppm	NAA	0.1	500
Nd	ppm	NAA	5	1000
Sm	ppm	NAA	0.1	500
Tb	ppm	NAA	0.1	1000
Th	ppm	NAA	1	1000
U	ppm	NAA	1	10000
Yb	ppm	NAA	0.1	1000
P	%	COLORIMETRIC/ICP	0.010	100.0
Sr	ppm	AAS	1	10000
Ba	ppm	AAS	10	10000
Y	ppm	XRF	5	10000
Nb	ppm	XRF	5	10000

NAA : Newtron activiation analysis

AAS : Atomic absorption spectometric analysis

XRF : X-ray fluorescent analysis

ICP : Induced coupled plasma analysis

(4) Data Processing

Univariate statistical analysis, correlation analysis and principal component analysis were applied for data processing and interpretation methods, and also chondrite-normalized REE patterns were drawn.

2 sectors of the Kuge–Lwala Area were combined with the 3 sectors of the area and all sectors were statistically analysed as well (chapter 3).

Univariate statistical analysis

It was decided to process the data on a logarithmic scale, after the patterns of histograms and cummulative frequency curves were examined both on log and antilog scales.

Threshold values in each sectors were decided applying the method of Otsu et. al. (1983).

Correlation analysis

Correlation coefficients were calculated by sector for all the combinations of the 16 components including total gamma–ray intensity.

Principal component analysis

Principal component analysis was applied to all sectors and the results up to 4th principal component of each sector are shown and interpreated.

Chondrite-normalized REE patterns

Condrite-normalized REE patterns were drown by each sector. For normalization values by Masuda et. al. (1973) were applied.

Presentation of the results

Cumulative frequency distributions and Histograms, and geochemical density and anomaly maps for 9 components; P, Nb, Y, Th, La+Ce+Nd, Eu, Yb, gamma–ray intensity and first component in principal component analysis were presented to each sector considering the results of pruncipal component analysis of this year and the results of Phase I.

In chondrite – normalized REE patters, data of 6 samples in each sector which have high scores for the first component were ploted on the patterns because the first component had turned out to show concentration of REE.

1–2 General Geology

North Ruri Hill and South Ruri Hill (called Ruri Hills collectively) are formed of one of the three largest carbonatite-alkaline rock complex units and are a pair of hills which stand out above the surrounding alluvial plain and are composed of two typical cone-sheets.

North Ruri Hill is formed of a cone–sheet of carbonatites that lacks the SE part at the surface. Basement rocks occur in the central part of the Hill. The carbonatites comprises mainly