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REPORT
ON
THE MINERAL EXPLORATION
IN
THE MOMBASA AREA
REPUBLIC OF KENYA

PHASE III

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MARCH 1993

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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PREFACE

In response to the request of the Government of Republic of Kenya, the Japanese Government has agreed to implement the Cooperative Mineral Exploration Work, such as geological research, geochemistry, diamond drill and etc., in the Mombasa Area, which is located in coastal province of Kenya, under an entrust to the Japan International Cooperation Agency. The Agency has further assigned the Work to the Metal Mining Agency of Japan, who properly conducts mineral resources investigation and evaluation works.

The current works in the fiscal year 1992 are of the third-year programme in the Mombasa Area Project, which was initiated as the first-year programme in 1990 to be consecutively followed by the second-year programme in 1991. The Metal Mining Agency of Japan has sent a geoscientific survey team, embodied by six engineers, to the project field of the Mombasa Area from 22nd September 1992 to 11th February 1993.

The field works of the current programme were successfully completed by the full supports and cooperations by the Mines and Geological Department of the Ministry of Environment and Natural Resources and related governmental organizations in Kenya.

This report is to produce the geoscientific investigation results of the third-year programme and is to form a part of the final report of the entire Mombasa Area Project.

Finally, we wish to express our deepest appreciations and sincere thanks to the officials concerned to the Government of Kenya, the Ministry of Foreign Affairs, Japan, the Ministry of International Trade and Industry, Japan, and the Japanese Embassy in the Republic of Kenya, for their strenuous cooperations and supports extended to the survey team.

March 1993



Kensuke Yanagiya

President,

Japan International Cooperation
Agency



Takashi Ishikawa

President,

Metal Mining Agency of
Japan

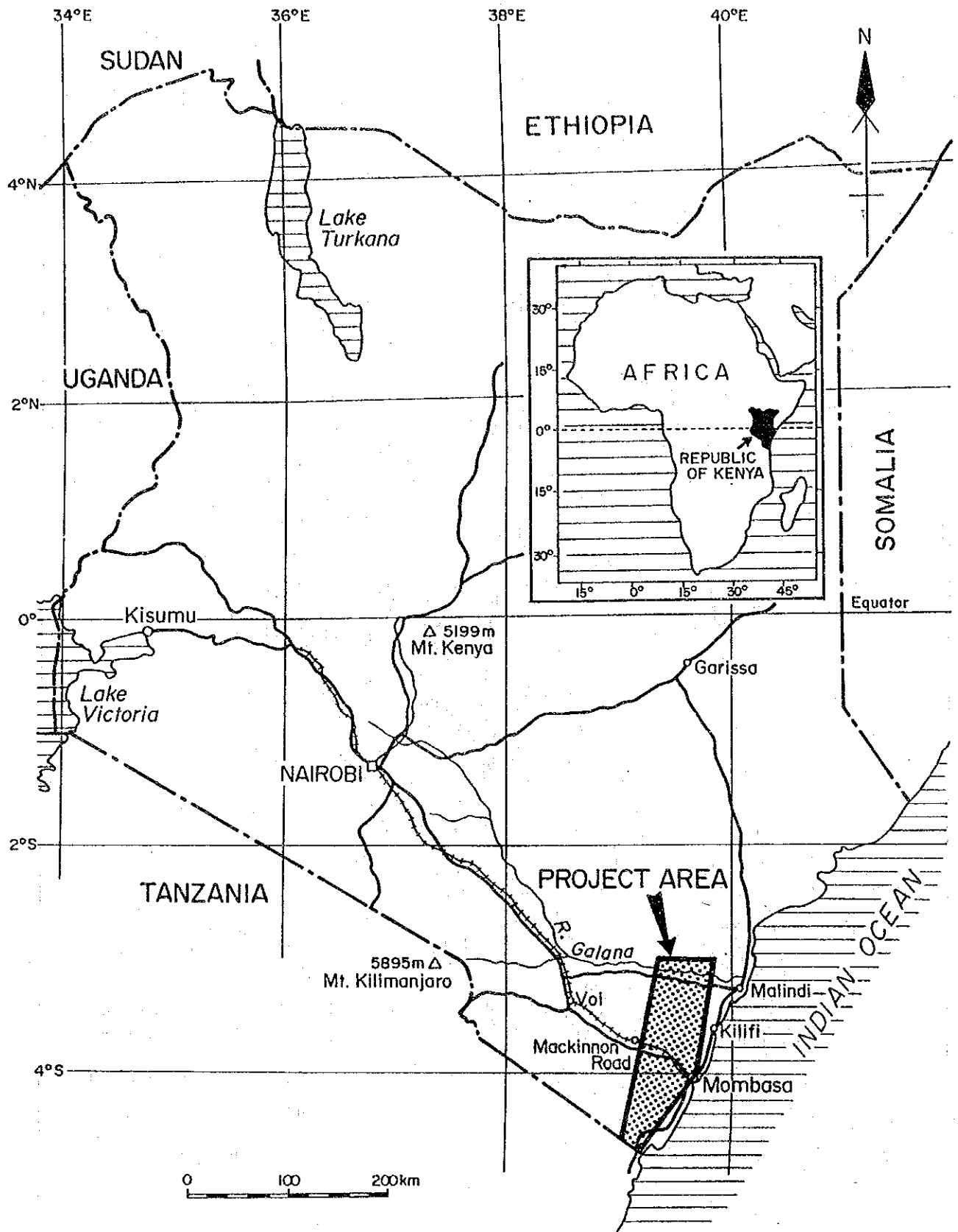


Figure 1 Index Map of Kenya Showing Location of the Mombasa Area

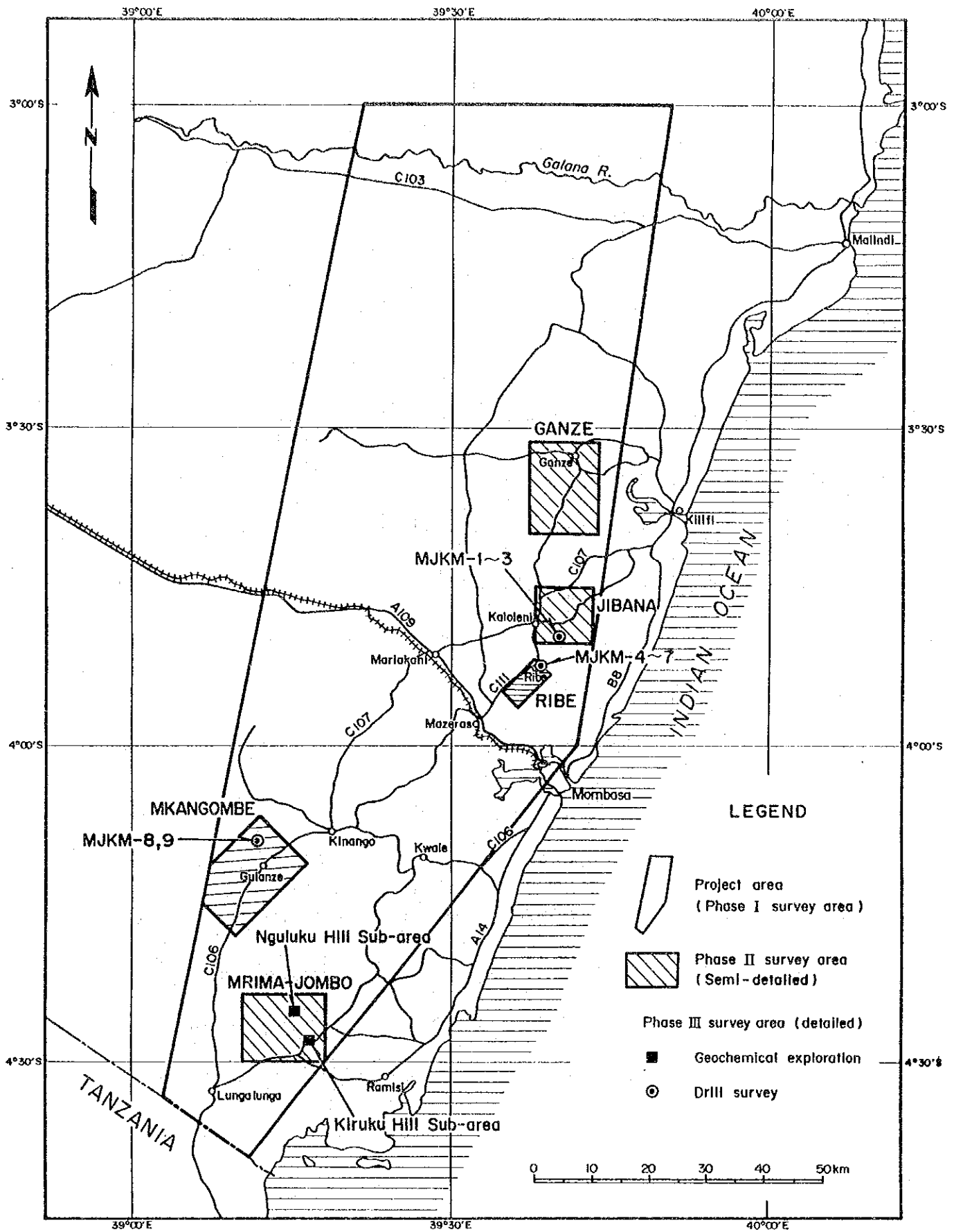


Figure 2 Location Map of Phase III Survey Area

SUMMARY

The major objectives of the Cooperative Mineral Exploration Work in Mombasa Area, Republic of Kenya, are to specify the mineral occurrences in the Area by studies of existing geoscientific informations, geological and geochemical research works, diamond drill works and etc. and are to facilitate a technical transfer to the counterpart organizations in compliance with the achievements of Work.

The third-year programme works as the final phase of the entire project, operated during the term from September 1992 to February 1993, include implementations of diamond drill exploration work in such three Areas as Jibana, Ribe and Mkangombe and of detailed geochemical exploration works in Mrima-Jombo Area, which were selected in accordance with the work results of the previous second-year works, 1991.

Base metallic elements ore mineralizations have majorly been targeted in Jibana, Ribe and Mkangombe Areas, meanwhile, niobium and rare earths elements mineralizations in Mrima-Jombo Area.

The summary conclusions by the third-year programme works are stated below:

(1) Jibana Area

Mineral occurrence showings of ore veins of significance have not yet been specified in the area and nearby, which was covered by the current diamond drill works.

(2) Ribe Area

Chiume Hill Mineralized Zone is evaluated to be with relatively limited scale, meanwhile, downward extension underground of the Zone is unlikely encouraging.

By the results of diamond drill works in Ribe Mineralized Zone, the occurrences of barite fine vein in silicified rock were solely observed by unaided eye, however, the showings of the potential occurrence of lead-zinc ore veining mineralization have not yet been specified.

(3) Mkangombe Area

By the results of diamond drill works in Mkangombe North Ore Showing of quartz-base metal ore veining mineralization, it has shown a geological possibility that quality and scale of ore mineralization in deep underground could be eventually higher than that on ground surface to lead to an assumptive possibility of an occurrence of ore mineralization of economical significance in the vicinity. An occurrence of massive sphalerite ore vein, 24 cm wide,

intersected by Hole MJKM-8, should support a geological consideration of a possibility of the above eventuality.

Outcrops and floats of quartz veinings, associated with copper minerals, have been newly discovered nearby Mkangombe South Mineral Showing by the current geological reconnaissance works. Those are evaluated to pose a geological possibility of an occurrence of ore mineralization of significance in quartz veining mineralized zones.

(4) Mrima-Jombo Area

Geochemical anomalies of niobium and rare earths elements and etc. have been specified in Kiruku Hill area. The mineralization of niobium, rare earths elements, precious and base metallic elements is estimated to have been formed in accordance with formings of silicified rocks by hydrothermal activities along with faults, NW-SE to WNW-ESE directional. The estimation is also supported by the chemical assay results of rocks.

The mineralization extent and quality of niobium and rare earths elements in Kiruku Hill is smaller and lower than those in Mrima Hill. Those are possibly inferred to be shown by a difference of mineralization genesis between Kiruku Hill occurrence, associated with silicified rock, and Mrima Hill occurrence, associated with carbonatite plugs.

Geochemical anomalies, which could be respondent to an occurrence of niobium and rare earths elements, have not yet been specified in Nguluku Hill area.

Based on the conclusions, stated above, implementations of the following works, to be deserved to warrant in future exploration programming, are recommended as stated below:

(1) Jibana and Ribe Areas

Implementations of consecutive exploration works are currently evaluated to unlikely be deserved to warrant.

General developments of faulting and hydrothermal alteration in Jibana and Ribe Areas are overall evaluated to could still pose a considerable geological potential of mineral occurrences. Implementations of further steady consecutive studies to specify new ore showing in the Areas are considered to be required in future.

(2) Mkangombe Area

Implementations of diamond drill explorations works for deeper extensions underground of Mkangombe North Ore Showing to cover an entire extension of the

showing are considered to be recommended. Implementations of detailed geological reconnaissance works in quartz veining mineralized zones to thoroughly cover never-examined spots are also recommended.

The current exploration works in Mkangombe Area are to be recognized to have initially provided a springboard of the exploration activity of base metal ore minerals in the inland area in the district of Mombasa, otherwise, such past activities have been prone to be emphasizedly implemented targeted on lead-barite ore mineralizations in coastal areas. Consecutive exploration results by such activity are expected to could be highly promising in inland areas.

(3) Mrima-Jombo Area

Implementations of consecutive exploration works in Kiruku Hill area are evaluated to unlikely be deserved to warrant. Research works related to modes of occurrence and secondary enrichment of niobium and rare earths elements in silicified rocks in Kiruku Hill are considered to should be required with academic interests. Regional research works of the extensions and relations to geology and geological structure of hydrothermal activity in the Area, that could have caused silicification to rocks, are considered to be one of research themes, which could likely lead to a possibility to specify hydrothermal ore mineralization occurrences of varied types.

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PART I GENERALS

CHAPTER 1. INTRODUCTION

1-1 Circumstances of Survey Works

The current geoscientific research works in 1992 in the Mombasa Area, Republic of Kenya, following to those since 1990, were implemented as the third-year programme of the entire works of the Cooperative Mineral Exploration Project, which is under the agreement of Scope of Work on March 13, 1990, between the Ministry of Environment and Natural Resources: MENR and the Mines and Geological Department: MGD of Kenya, and the Japan International Cooperation Agency: JICA and the Metal Mining Agency of Japan: MMAJ, Japan.

The first-year programme in 1990 was targeted on to elucidate the geological features of ore showing spots in the entire Mombasa Area, as shown in Figure 1, by studies of existing geological informations to establish a geological concept for further works and to evaluate mineral potentials in the area and by implementation of geological/geochemical research works in the ore showing spots to specify the geological/mineralogical features in the area.

The second-year programme in 1991 consisted of geological mapping and geochemical exploration works in five areas, Ganze, Jibana, Ribe, Mkangombe and Mrima-Jombo, as shown in Figure 2, in accordance with the results by the first-year work, and was targeted on to elucidate geological structures and geochemical features and to specify the mineral occurrences and mineralized zones in the areas.

The current third-year programme is targeted on to further implement geochemical and diamond drill exploration works in mineral and ore showing spots and geochemical anomalous zones in Jibana, Ribe, Mkangombe and Mrima-Hill Areas, which were areally specified by the second-year work, and to scout up mineral occurrences on ground surface and in deep underground.

1-2 Conclusions and Recommendations by the Second-Year Programme Works

1-2-1 Conclusions by the second-year works

The conclusions established by the second-year programme works in 1991 are stated below:

(1) Ganze Area

Mineral showings of significance, to be deserved to warrant fostering further exploration work programmes, have not yet been specified in the Area by the geological reconnaissance and geochemical works.

(2) Jibana Area

Jibana Mineralized Zone with some discontinuity, some 100 m wide and some 2 km long, composed of gossanous materials in weakly altered sandstone beds, has

been specified. Remarkable concentrations of economical significance of precious and base metal elements have also not yet been represented by chemical assay of four gossan samples.

Geochemical anomalies of lead, 84 ppm to 142 ppm, which are inferred to be genetically related to the occurrence of Jibana Mineralized Zone, have been represented in a part the Zone coverage. Lead and zinc anomalies, estimated to be genetically related to the forming of ferruginous concretions in limestone beds coverage of Kambe Formation, copper anomalies in possible relations to shale beds coverage of considerably high copper contents in Mtomkuu Formation and barium-sulphur-overlapped anomalies, north-southerly extended, in sandstone beds of the Middle member of Mazares Formation have been specified by the works, while, the former two are estimated to be genetically irrelative to the mineralization and the latter is to be obscurely related to that.

(3) Ribe Area

The Kinagoni lead mine in mining operations and Chiume Hill Mineralized Zone are situated in the vicinity of the Area, while, Changombe North and South Mineral Showings are located in the Area. Ribe Area is evaluated to be favourably mineral-potential of vein ore type under an unique geological structure with well-developments of vast faulting. Ribe Area is evaluated to be highly mineral-potential from the standpoints of the distributions of ever-known mineral ore bodies and mineral showings and further of geological structural features. Ribe Mineralized Zone has newly been specified by the second-year works to support the above expectation.

Considerably high concentrations of economic metal contents have not yet been shown by the chemical assay results of altered rock specimens in Ribe Mineralized Zone, however, a possibility of thorough leaching of economic materials on ground surface by weathering to cause a showing of the current geological situation is still be interested.

Such geochemical anomalies as 0.2 ppm to 3.3 ppm of silver, 88 ppm to 718 ppm of lead and 766 ppm of zinc have been represented with possible genetic relations to the occurrences of mineral showings in Changombe North and Changombe South.

(4) Mkangombe Area

Mkangombe North Ore Showing has been specified by the works to be composed of copper-lead-zinc-quartz veins ore mineralizations, under structural controls by faulting, with strike/dip values of N25° to 30° E/55° to 70° SE, more than 300 m long and more than 20 cm to 1.5 m wide. Concentrations of precious metal elements in the Showing have not yet been specified by the works.

Abundant quantities of quartz vein ore floats and quartz veining outcrops are distinctively observed in a zone, linearly extended from Mkangombe North Ore Showing toward Mkangombe South Ore Showing, more than 10 km long and N45° E directional, to form a quartz veining mineralized zone.

Geochemical anomalies shown in the Area are scatteredly represented with possibly less genetic connection with the occurrence of mineralized zones. Those are possibly inferred to be caused by a local spread of wall rock alterations by mineralizations and an establishment of considerably long-spacing sampling intervals.

(5) Mrima-Jombo Area

Mineral potentials of precious and base metallic ore mineralizations of economic significance in the Area are evaluated to unlikely be promising, since ground surface showing of precious and base metallic mineralizations have not yet been specified and geochemical anomalies, of silver, lead and zinc, represented in the Area, are estimated to be genetically shown in relations to the occurrences of carbonatite and agglomerate bodies.

Geochemical anomalous zones of niobium and rare earths elements have been specified in Mrima Hill and also in Kiruku Hill to show a possible occurrence of mineralization of those in Kiruku Hill. These type of mineralizations are inferred to be potential in agglomerate bodies in Nguluku. Fertilized bodies in northern Mrima Hill is possibly estimated to be underlain by subsurface carbonatite bodies.

1-2-2 Recommendations by the second-year works for the third-year works programming

The recommendations by the second-year works for the consecutive third-year work programming in 1992 are stated below:

(1) The zone, which extends from Jibana Mineralized Zone, through the Kinagoni mine, toward Changombe Mineral Showings, in northern three Areas, such as Ganze, Jibana and Ribe, is evaluated to be most-highly mineral-potential. Implementations of diamond drill operations to scout up mineralization occurrences in deep underground are recommended in Ribe and Chiume Hill Mineralized Zone, where diamond drill has never been carried out by the past exploration programme even though occurrences of significant wall rock alteration have ever been known. Detailed geological survey works preceding the drill operations should be required to select drill sites allocation in both of the mineralized zones.

In one view, a possible new discovery of ore body occurrence in the zone is expected to provide remarkable contributions further for a local economical

development to be sustained for a long period of time and also for a considerable extension possibility of the Kinagoni mine life, existing mine facility utilizations, man power employment and etc.. Therefore, the future mineral exploration works in the Project Area should be implemented with the most emphases laid on this zone.

(2) Implementations of diamond drill operations for deeper portions underground of Mkangombe North Mineral Showing, in which a most distinct quartz veining ore mineralization occurrence has been specified by ground surface mapping, were recommended to be deserved to warrant in Mkangombe Area.

(3) Further implementations of detailed geological and geochemical research works (including trench prospect) were recommended to be deserved to warrant in Kiruku Hill, Mrima-Jombo Area, to produce a thorough evaluation of geochemical anomalies of niobium and rare earths elements in lateral and vertical extensions. Agglomerate body in Nguluku, which is estimated to be under a similar geological situation to that in Kiruku Hill, was also evaluated to warrant a further fostering geoscientific works to elucidate modes of mineralizations in the site.

1-3 Outlines of the Third-Year Programme Works

1-3-1 Area covered

The entire Mombasa Area, located in Coast Province in south-eastern coastal district of the Republic of Kenya, occupies an area of about 9,000 square kilometres as shown in Figure 1. Figure 2 shows the respective areas, in where the respective yearly works have been carried out.

The current third-year works cover such four Areas, as Jibana, Ribe, Mkangombe and Mrima-Jombo. Jibana and Ribe are situated in Kilifi district in northern part of the Mombasa Area, while, Mkangombe and Mrima-Jombo are in Kwale district in the south.

Road net works in the respective project sites are well-developed to be readily accessible by motor vehicles from Mombasa within less than 1.5 hours of time on sealed and/or unsealed roads.

1-3-2 Objective of survey work

The major objectives of the current works are to scout up a springboard to a new discovery of ore mineralizations in the site areas in progressive accordance with elucidations of geological settings and modes of mineral occurrences of economical significance and to facilitate a technical transfer to the counterpart organizations in compliance with the achievements of works.

Geochemical and diamond drill exploration works of the third-year programme have been implemented in the project sites, which had been screened out by the results of the preceding first- and second-year works.

Soil geochemical works in Mrima-Jombo Area by the current programme have been emphasizedly targeted on an establishment of geological elucidations of the occurrences of niobium and rare earths elements, associated with agglomerate bodies-vent agglomerate- in Kiruku Hill and Nguluku Hill areas.

The diamond drill works have properly been targeted on scouting up of the occurrences of copper, lead, zinc ore mineralization of economical significance and etc. in deep underground of ever-known mineral showings and mineralized zones in Jibana, Ribe and Mkangombe Areas.

1-3-3 Measures of survey work

Soil-geochemical exploration works of the current programme have been implemented in Kiruku and Nguluku sites in Mrima-Jombo Area, meanwhile, diamond drill works have been in Jibana, Ribe and Mkangombe Areas.

Tables 1, 2 and 3 show the detailed measures and quantities of the work.

Geochemical works are of soil chemistry to collect soil specimens on 100 metres by 100 metres grid modes. Soil specimens, properly collected on the B-horizon, were initially air-dried in the field camp to produce chemical assay samples of minus 80-mesh fraction after sieving. Geological reconnaissance works were concurrently carried out with the progress of soil geochemistry, by using enlarged topographical maps of 1 to 5,000 scale, to produce the detailed geological maps and cross-sections of 1 to 5,000 scale.

Wire-line operations of diamond drill works, NQ and/or BQ sizes, were carried out. Log sheets of drill cores, 1 to 200 scale, were provided after rock identifications.

1-3-4 Organization of survey team

The members of programming/negotiation/coordination and field survey teams are tabulated in Tables 4 and 5.

1-3-5 Periods of survey work

The periods of time of the current field works are outlined below:

Mobilization of Japanese team	: 22 Sept. - 25 Sept. 1992
Courtesy visits to related Kenyan government officials and discussions	: 25 - 28 Sept. 1992
Transportation of drill rigs, equipments and materials,	: 27 Sept. 1992 - 8 Oct. 1992

provisional works	
Soil geochemistry	: 1 Oct. 1992 - 13 Oct. 1992
Diamond drill operations	: 9 Oct. 1992 - 24 Jan. 1993
Movement, makeup works, transportations of rigs	: 25 Jan. 1993 - 1 Feb. 1993
Submit interim report and courtesy visits to related Kenyan government officials	: 2 Feb. 1993 - 7 Feb. 1993
Demobilization of Japanese team	: 8 Feb. 1993 - 11 Feb. 1993

Table 1. Amount of Geochemical Works

Area	Area surveyed in sq.km	Number of soil samples collected
Kiruku	4	400
Nguluku	2	200
Mrima	-	6 (for comparison purpose)
Total	6	606

Table 2. Amount of Drilling Works

Area	Hole number	Hole direction	Hole inclination	Hole depth in metres
Jibana	MJKM-1	N 70° W	-50 °	150.00
	MJKM-2	N 68° W	-50 °	150.00
	MJKM-3	N 53° W	-50 °	150.00
Ribe	MJKM-4	N 82° W	-50 °	150.00
	MJKM-5	N 75° W	-50 °	150.00
	MJKM-6	N 75° W	-50 °	150.00
	MJKM-7	N 75° W	-50 °	150.00
Mkangombe	MJKM-8	N 63° W	-65 °	100.00
	MJKM-9	N 63° W	-65 °	100.00
Total	9 holes			1250.00

Table 5. Member List of Field Survey Team

Japanese team	Kenyan team
Akira TAKIGAWA, SC, Leader	S.S. HUSSEIN, Co-Leader, MGD
Kenjiro KAWADA, SC	M.N. MWANGI, MGD
Masashi HAYAKAWA, SC	T.N. NDOLA, MGD
Takashi UENO, SC	M. MASIBO, MGD
Yukio FUKUSHIMA, SC	E. IRURA, MGD
Masaru MARUYAMA, SC	J.A. LICHINA, MGD
	P.O OKELO, MGD
	J.O. KITINYA, MGD
	B. OWADE, MGD
	M.C. NYANG'ARA, MGD
	J.K. NZINGA, MGD
	M.M. MUHEA, MGD
	J.E. SIMWA, MGD
	L. ANYIKA, MGD
	A.K. AURA, MGD

MGD : Mines and Geological Department of Kenya

SC : Sumiko Consultants Co., Ltd.

CHAPTER 2. GENERAL GEOGRAPHY

2-1 General Topography and Water System

General topographical features in four project areas are respectively shown below:

Jibana Area : General topography in south-eastern part of the Area, where Mtomkuu Formation overlies, is topographically characterized by showing a hilly representation, with an average altitude of 50 to 150 metres high above sea level. The other parts in the Area show a slightly more undulated land lay, hilly mountainous, 150 to 300 metres high above sea level, while, 309.6 metres is the highest.

Most of the water system, which is typically represented by flowing down southerly or south-easterly, is majorly integrated to the Mtomkuu River system. Diamond drill sites of the current works in Jibana Area have been allocated in a transitional part, where a flat land along Mwanai River basin turns to a hilly region in the west, 110 to 140 metres high above sea level.

Ribe Area : General topography in Ribe Area is characterized by showing a hilly mountainous representation with an average altitude of 50 to 200 metres high above sea level. The water system in northern half of the Area is integrated to the Tsalu River system, meanwhile, to the Rombeni River system in southern half of the Area. The main stream of Kombeni River meanders down southerly around the western margin of the Area, where a distinct valley topography is formed.

Diamond drill sites of the current works in Ribe Area have been allocated nearby the slope terminals, relatively steep, where hilly mountainous topography turns to hills along sea shore.

Mkangombe Area : General topography in Mkangombe Area is characterized by showing a less-undulated hilly representation with an average altitude of 150 to 250 metres high above sea level. The water system in northern part of the Area is integrated to the Duma River system, meanwhile, to the Mbadzi River system in south-eastern part of the Area and to the Ramisi River system in south-western part. River water in the Area is almost dried in dry season.

Diamond drill sites of the current works in Mkangombe Area have been allocated in considerably flat parts, jumbledly dissected by dry creeks, some 2 metres high or so.

Mrima-Jombo Area : General topography in Mrima-Jombo Area is characterized by showing a hilly representation with an average altitude of 50 to 150 metres high above sea level, however, is remarked by being associated with isolated

conspicuous hills, which are Mrima Hill, Kiruku Hill and etc.. Jombo Hill shows the highest altitude in the Area, 462.3 m high above sea level. Water system in the Area is barely dissected enough to merely form Ramisi River, which flows easterly down in northern margin of the Area. Nguluku Hill is of small-scale, however, shows a distinct land lay with the isolated hill.

2-2 Climate and Vegetation

The monthly average maximum and minimum air temperature and rainfall in Coast Province of the Republic of Kenya is shown in Table 6.

Table 6. Monthly average maximum air temperature, minimum air temperature and rainfall in Coast Province, Kenya

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Average maximum air temperature (°C)	32	32	33	31	29	29	28	28	29	30	31	32
Average minimum air temperature (°C)	23	24	24	24	23	21	21	21	21	22	23	24
Average rainfall (mm)	17	10	30	108	149	54	34	47	46	62	66	32

Jibana, Ribe and Mrima-Jombo Areas, which are considered to have ever been covered by forest in old time, are under a humid and high air temperature climate condition. Agricultural development in the Areas are well-organized to exuberantly produce coconuts, cashewnuts, corns, mangos and rice plants. Thick tropical forests are currently reserved in the vicinity of Mrima Hill and Jombo Hill.

Mkangombe Area is under the semi-arid climate condition to be covered by acacia trees, cactuses and thorn bush. Corns are currently produced in cultivated fields in the Area.

CHAPTER 3. GENERAL GEOLOGY

Summarized geological map and representative geological profile sections of the current project areas are shown in Figures 3 and 4, respectively.

General geology in the entire Mombasa Area consists of the formations of Precambrian to Quaternary ages and is composed of sediments, igneous rocks, metamorphic rocks and unconsolidated sediments. The major geological units in the area are specified to be of Mozambique System in north-western part of Mombasa Area, of Palaeozoic-Mesozoic Groups in major part of the Area and of Tertiary System, associated with later sediments in coastal province in the Area.

Mozambique System is mainly comprized of metamorphic rocks, i.e., gneiss and schist. Permian System is observed in western part of the Area. Permian and overlying Triassic Systems in the Area are composed of a series of the alternations of grit, sandstone and shale beds. Jurassic System in the Area (Kambe and Mtomkuu Formations) consists of marine limestone and shale beds. Permian-Triassic Systems in the Area (Druma Group, i.e. Taru, Maji-ya-Chumvi and Mariakani Formations and lower part of Mazeras Formation) are correlated to Karroo System in South Africa, however characteristically show finer facies than that in other area. Karroo System is typically characterized by being associated with coarse-grained sediments, caused by the repeated sedimentations of materials in connection with geotectonism nearby sedimentary basin structure, however, Karroo System in Mombasa Area, the above, is of a lack of coarse-grained facies. Facies change of Karroo System from southwest toward northeast in Mombasa Area is more remarkable than that from west toward east. Non-volcanic Tertiary System and Pleistocene sediments are observed along the coastal province in the area. Uplifted coral reefs along the coast are of Pleistocene age.

Limited occurrences of dykes are observed in Palaeozoic and Mesozoic sediments in Mombasa Area. Alkaline rock intrusives are observed in Jombo Hill and nearby, while, carbonatite intrusives are in Mrima Hill.

Faults, extending NNE-SSW to NE-SW directionally and nearly parallel to the direction of sea shore line in Mombasa Area, are well-developed. The major faults among those, which are observed long extendedly along the coast in the area, make the demarcation of Mazeras sandstone and Kambe limestone beds. Another type of faults, which traverse major faults in the Area, the above, and are considered to be formed later than those, are also observed in association with well-developed fissures.

Lead-zinc-barite mineralizations, represented by the Kinangoni ore bodies, are considered to be structure-controlled by the major faults, NNE-SSW to NE-SW

directional. Geochemical anomalies of the elements, related to lead-zinc-barite mineralization, are also detected nearby the major faults, nearly parallel to the direction of sea shore line in Mombasa Area. The ore showing in Mkangombe North is considered to be a representation of fault-controlled copper-lead-zinc-quartz ore mineralization, extending NNE-SSW directionally. Ore mineralizations of niobium and rare earths elements are observed in carbonatite plugs in Mrima Hill and in silicified rocks in Kiruku Hill.

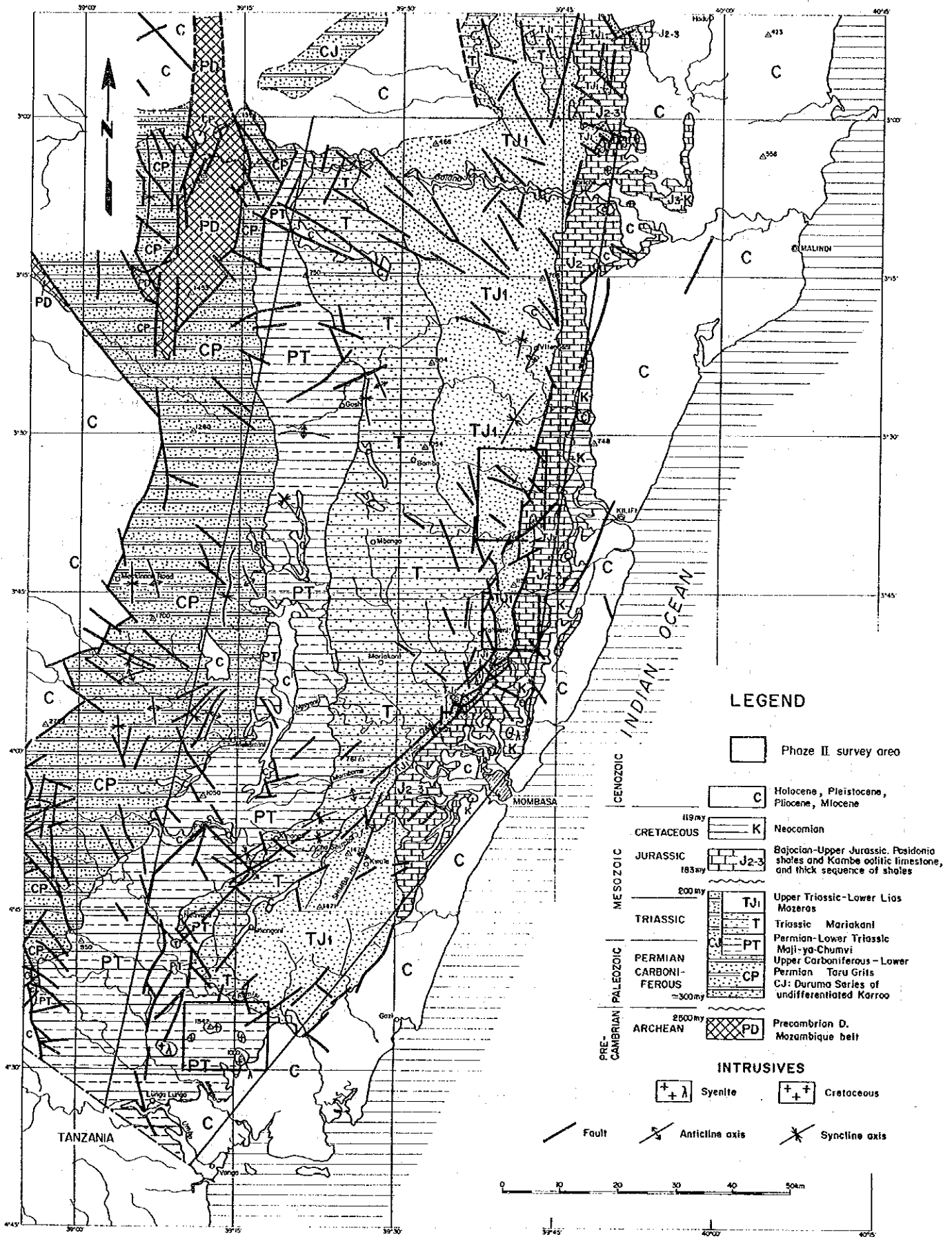


Figure 3 Generalized Geological Map of the Mombasa Area

ERA	PERIOD/SUB-PERIOD		AGE (Ma)	LITHOLOGY		STRATIGRAPHY	TECTONIC EVENTS	MINERAL OCCURRENCES	
Ceno-zoic	Quater-nary	Holocene	0.01		alluvium colluvium dune sands sands reef				
		Pleisto-cene							
	Tertiary	Neogene	Pliocene	23.5		sands	Magarini Fm.	Faulting	
		Miocene	ss. (sh/marl)			Marafa Fm.			
			ss. (ls/sh)			Baratum Fm.			
Meso-zoic	Creta-ceous	Paleo-gene	65					Mkang'ombe, Mkundi: Pb-Zn-Cu +++++++ Mrima Hill: Niobium/ Rare earths	
		Senonian	89				Alkaline igneous intrusion		
		Gallic	119				Mtoakuu Fm.		Faulting
		Neocomian	132			sh. (ls) sh. (ss) sh/ss/ls			
			146						
	Jurassic	Malm	157			Kambe Fm.		Limestone: (Pb-Zn) +++++++ Kinangoni, Vitengeni: Pb-Zn-Ag	
		Dogger	178		ls, (sh)				
		Lias	183						
	Triassic			20					Major faulting Up-coming
			Tr3	208		ss.(cs.gd)	Mazeras Fm.		
Tr2			ss, sh			Mariakani Fm.			
Scythian			245	sh, silt st		Maji-ya- Chumvi Fm.	Subsidence		
Paleo-zoic	Permian	Zechstein	290					Major faulting Up-coming	
		Rotliegen. Pennsylv.					Druma Group (Karoo)		
	Carbon-iferous		300		grits	Taru Fm.		Initial faulting	
		Devonian	362.5						
		Silurian	408.5						
Ordovician		439.0							
	Cambrian	510							
Precam-brian	Protero-zoic		570					Initial faulting	
		Archean	2,500		gneisses schists etc.	Mozambique Belt	Mozam- biquian orogeny		

Figure 4 Geological sequence of the Mombasa area

CHAPTER 4. GENERAL EXAMINATIONS OF SURVEY WORK RESULTS

4-1 Geological Structure, Features of Ore Mineralization and Mineralization Control

Mineral exploration targets, specified for the current third-year work programme in the Project Area, are stated below:

- (1) Base metallic elements ore veining mineralizations, associated with gold and silver, in Jibana, Ribe and Mkangombe Areas.
- (2) Niobium and rare earths elements mineralizations in Kiruku Hill and Nguluku Hill areas in Mrima-Jombo Area.

Base metal ore veins mineralizations are divided in such two types, as lead-zinc-barite ore veining mineralization, represented by the Kinagoni Ore Bodies, and copper-lead-zinc-quartz ore veining mineralization, observed in Mkangombe North Ore Shwoing. Those veining ore mineralizations are distinctly structure-controlled by the activities of faulting, NNE-SSW to NE-SW directional, which are parallel to the coast line in the Project Area. The occurrence of hydrothermal wall rock alterations, associated with ore mineralization, is distinct in the occasion of the former Kinagoni-type, meanwhile, is weak or obscure in the occasion of the latter Mkangombe-North-type. Igneous activities, estimated to have provided a contribution to the ore forming, are still obscure in the former, meanwhile, lamprophyric dyke activities are possibly inferred in the latter.

Niobium and rare earths elements mineralizations in Mrima Hill Area are estimated to generally be of a type of residual deposit formed by weathering of carbonatite bodies. Those are considered to have been enrichedly formed by secondary accumulations of pyrochlore and/or monazite in carbonatite or secondarily formed gorceixite and etc.. However, niobium and rare earths elements mineralizations, associated with precious and base metallic elements, in Kiruku Hill are estimated have been formed by a different type of genesis from those the above that the mineralizations in Kiruku Hill are inferred to have been formed in accordance with formings of silicified rocks by hydrothermal activities along NW-SE or WNW-ESE directional faultings. Niobium and rare earths elements mineralizations in Kiruku Hill were ever considered to have been formed in connection with agglomerate-associations in the previous work in the second-year programme, however, geological direct relations concerning to that to agglomerate occurrences are estimated to be unlikely reasonable.

4-2 Mineral Potentials

Mineral potentials of base metal ore veining mineralizations are likely

evaluated to be promisingly encouraged in Mkangombe Area. By the results of diamond drill works in Mkangombe North Ore Showing, it has shown a geological possibility that quality and scale of ore mineralization in deep underground could be eventually higher than that on ground surface to lead to an assumptive possibility of an occurrence of ore mineralization of economical significance in the vicinity. An occurrence of massive sphalerite ore vein, 24 cm wide, intersected by Hole MJKM-8, should support a geological consideration of a possibility of the above eventuality. Outcrops and floats of quartz veinings have been newly discovered nearby Mkangombe South Ore Showing by the current geological reconnaissance works, connectedly operated with diamond drill works. Those are evaluated to pose a geological possibility of an occurrence of ore mineralization of significance in quartz veining mineralized zones.

Occurrences of silicified and pyrite-disseminated rocks and fine veins of barite and pyrite have been encountered by diamond drill holes in Ribe and Jibana Areas. Those are unlikely evaluated to should produce an encouragement of further prospect, however, general developments of faultings and hydrothermal wall rock alterations in overall Areas are evaluated to could still pose a considerable geological potential of mineral occurrences.

Niobium and rare earths elements mineralizations in Kiruku Hill, associated with silicified rocks, likely show a smaller extent and lower quality than those in Mrima Hill, associated with carbonatite. Followings are the inferred disadvantages in connection with the Kiruku Hill mineralizations, associated with silicified rocks, in comparisons with those of other type.

1. Mineralization extension under a possible geological control by silicified rocks occurrence could be limited.
2. Mineralizations, associated with silicified rock, could be resistive to weathering effect to could cause a generally insufficient secondary enrichment effect.
3. Silicified rocks are very fine-grained, consequently, a difficulty of mineral processing technique, commonly caused by a refractory character of fine-grained ores, could as if be possibly posed in connection with the mode of occurrence of the minerals.

Mineral occurrences of niobium and rare earths elements in Kiruku Hill are likely evaluated to be discouragingly shown and less potential by the current works, however, a new discernment of the occurrence of precious and base metal mineralizations, associated with niobium and rare earths elements mineralizations, possibly genetically related to hydrothermal activity, could provide a possibility of a forming of hydrothermal mineralization of those of varied types in the vicinity to be specified by following works.

4-3 Relations between Geochemical Anomalies and Ore Mineralization

Geochemical anomalies of niobium and rare earth elements were solely revealed in Kiruku Hill area. Those anomalies are shown in two locations, namely, in Kiruku Hill Crest and in Northeastern Ridge of Kiruku Hill crest. The indicator elements, highly revealed in the anomalies are enumerated below:

In Kiruku Hill Crest anomaly : Gold, niobium, yttrium, thorium, terbium, ytterbium, lutetium, europium.

In Northeastern Ridge anomaly : Barium, strontium, uranium, lanthanum, cerium, neodymium, manganese, phosphorus, (iron).

In either anomaly of the above : Samarium, (iron).

The above two anomalies cover the areas occupied by silicified rock extensions. The Kiruku Hill Crest anomaly superimposedly covers an extension of silicified rock zone, observed in Hill crest, NW-SE directional, extended about 800 m long and about 150 m to 250 m wide. The Northeastern Ridge anomaly, NW-SE to WNW-ESE directional, is estimated to have been revealed in response to the extension of silicified rock zone, even however, the geological behaviour of the directional extension of the zone is still obscure.

The two geochemical anomalies and the silicified zone on Kiruku Hill crest commonly show a NW-SE to WNW-ESE directional extension, which coincides with that of faults in the area to lead to a geological inference that the mineralizations in the area have likely been formed under a structural control by faultings.

CHAPTER 5. CONCLUSIONS and RECOMMENDATIONS

5-1 Conclusions

The general conclusions concerning to the Project Areas evaluations by the third-year works in 1992 are stated below:

(1) Jibana Area

The underground extensions of gossanous materials and geochemical lead anomalies on ground surface, which have been targeted by diamond drill works of the current third-year programme, are estimated to be geologically represented by the occurrences of pyrite disseminations in fault fracture zones and in sandstone and siltstone beds of Mazeras Formation. Gossanous materials and geochemical lead anomalies are inferred to have been formed in the processes of residues and precipitations of iron or heavy metallic elements decomposedly formed by weatherings of such fracture zone clay and rocks, associated with pyrite disseminations, as the above, then, those are likely evaluated to could produce irresponsibilities of showing of the underground occurrence of lead-zinc-barite ore veining mineralizations.

(2) Ribe Area

Chiume Hill Mineralized Zone is evaluated by the results of the current drill works that the Zone could unlikely provide a downward underground extension of geological significance as shown on ground surface in a form of discontinuous outcrops and floats of mineralized materials of small scale.

Pyrite-disseminated silicified rock beds, which are estimated to represent downward extensions of silicified rock outcrops on ground surface, and abundant fault fracture zones with intense pyrite disseminations have been encountered by the drill holes of the current programme in Ribe Mineralized Zone. Occurrences of barite fine veins, less than 5 mm wide, are observed by unaided eye in open cracks in silicified rocks. Fault fracturing occurrences, such wall rock alterations concerning to ore mineralization as silicification and pyrite disseminations, and barite fine veins occurrences, are likely evaluated that the Ribe Mineralized Zone could pose a geological possibility to provide a field of lead-zinc-barite ore veining mineralizations, however, the current situations are with a lack of economical significance of ore forming to be associated with sphalerite, galena and etc..

(3) Mkangombe Area

It has been shown by the results of diamond drill exploration works by the current third-year programme in Mkangombe Area that the mineral occurrences in deep underground have been revealed with more encouragements of eventual

mineral potential than those on ground surface to foster future prospects of mineral occurrences of significance. The occurrence of a massive sphalerite ore vein, 24 cm wide, encountered by Hole MJKM-8, is likely evaluated to be an emboldening showing that furthers future eventual mineral potential prospects of economical significance in the vicinity.

A new occurrence of outcrops and floats of quartz ore veins in the vicinity of Mkangombe South Ore Showing, associated with copper minerals, has been revealed by a geological reconnaissance work, carried out in accordance with the progress of drill works. The new occurrence is likely evaluated to offer a mineral potential, associated with quartz veining mineralized zone.

(4) Mrima-Jombo Area

Kiruku Hill area

Geochemical anomalies of niobium and rare earths elements (REE) were revealed in the area by the current third-year works. Those anomalies are shown in two locations, namely, nearby Kiruku Hill crest and nearby northeastern ridge from Kiruku Hill crest. Silicified rock beds are observed in the geochemical anomalous coverages. The geochemical anomalous zones are likely extended in superimposed accordance with distributions of silicified rocks. Mineralization of niobium and REE in Kiruku Hill area are possibly inferred to have been formed by rock silicifications as likely supported by the chemical assay results of rocks. Extensions of geochemical anomalous zones and silicified rock zones show a coincidence with those of faults in the area to lead to a geological inference that the mineralizations in the area have likely been formed under a structural control by faultings. Thus, the mineralizations in Kiruku Hill area of niobium and REE, associated with precious and base metallic elements, are likely estimated to have been formed in accordance with progresses of the formings of silicified rocks by hydrothermal activities, which could have taken place along the faults of NW-SE to WNW-ESE directions. The mineralizations have ever been possibly assumed initially by the second-year works to have been formed in connection with agglomerate activity, however, the direct connection the above is likely reassumed currently to be poor or unfounded.

The general extent and quality of niobium-REE mineralizations in Kiruku Hill is evaluated to be smaller than those in Mrima Hill. This could possibly be caused by a difference of geological genesis of the forming of mineralizations between the above two occurrences, namely, the former is associated with silicified rocks, while, the latter is with carbonatite bodies.

Nguluku Hill area

Geochemical anomalous zone, which is evaluated to be caused by niobium-REE mineralization, has never been revealed in Nguluku area.

5-2 Recommendations

Based on the conclusions, stated above, implementations of follow works, to be deserved to warrant in future exploration programming, are recommended below:

(1) Jibana Area

Implementations of consecutive exploration works are currently evaluated to unlikely be deserved to warrant in Jibana Area.

Occurrences of pyrite-disseminated rocks in Jibana Area are unlikely estimated to be directly responsible to providing a showing of the occurrences of lead-zinc-barite ore veining mineralizations. Since, however, pyrite-disseminations, the above, are possibly inferred to have been formed by hydrothermal activities, which could have taken place nearby Karroo-Jurassic Fault, that could be related to ore mineralization, then, the Area is evaluated to could still pose a considerable geological potential of mineral occurrences. Implementations of steady further studies to specify new ore showing in the Area are considered to be required in future.

It is to be noted that geological identifiable distinction of weathered products between pyrite-disseminated materials and ore-mineralized materials would be significantly required in future works in the Area. Occurrences of silicification, mineralized fine veins, type of geochemical anomalies should be, therefore, carefully studied in the future course of detailed geological and geochemical research works prior to an establishment of diamond drill programming.

(2) Ribe Area

Implementations of consecutive exploration works in Chiume Hill Mineralized Zone and nearby are evaluated to unlikely be deserved to warrant since that the extensions of mineral occurrence of geological significance on ground surface and deep underground in the Zone have been revealed by the current works to be limited and little extended.

Implementations of consecutive exploration works in Ribe Mineralized Zone, where three diamond drill holes have been operated by the current works, are evaluated to unlikely be deserved to warrant. However, the Ribe Mineralized Zone environs are still evaluated to be one of the potentially promising targets of future mineral exploration to be required, since silicified zones, where scrutinized examinations of mineral potentials have ever insufficiently

made, are scatteredly known. In accordance with the experiences of the current works, the occurrences of ore minerals of economical significance are to be carefully studied in the progresses of detailed geological and geochemical future works, which are to be implemented prior to an establishment of future drill programmes, for an objective to necessarily exclude unpromising barren silicified zones from the future drill exploration targets.

(3) Mkangombe Area

Two drill holes, implemented by the current programme have been allocated about 30 metres apart, while, barely enough to establish an ore intesection to the depth about 60 metres below ground surface. It is to be reminded that the current diamond drill works have established a limited mineral exploration coverage in Mkangombe North Ore Showing area, then, additional future diamond drill works with reasonable scale and quantity are recommended to be consecutively implemented.

Implementations of consecutive detailed geological reconnaissance works in quartz veining mineralized zone are recommended to fulfill the coverage by those mapping in the areas, where detailed work have never been carried out. Those works are to be targeted to eventually decide further prospects of trench pitting or diamond drill and potentially lead to a new discovery of mineral occurrence of significance.

The current programme works in Mkangombe Area are to be recognized to have initially provided a springboard of the exploration activity of base metal minerals in the inland area in the district of Mombasa, otherwise such past activities have been prone to be emphasizedly implemented targeted on lead-barite ore mineralizations in coastal areas. Implementations of consecutive future works for such objectives are considered to likely be promisingly expected.

(4) Mrima-Jombo Area

Implementations of consecutive exploration works in Mrima-Jombo Area are likely evaluated to be limitedly required in future, since general extension and quality of niobium and rare earths elements mineralizations in Kiruku Hill, which are estimated to have possibly been formed by a different mode of genesis from that in Mrima Hill, are likely evaluated to be smaller than those in Mrima Hill, which are possibly estimated to have been formed by weathering of carbonatite bodies.

Implementations of research works for academic interests of the mode of occurrences of niobium and rare earths elements minerals and of secondary enrichment in silicified rocks are possibly required, since the mineralizations

in Kiruku Hill, possibly associated with silicification, could pose a particular geological interests concerning to an unique field of mineralization. Regional research works of the extensions and relations to geology and geological structure of hydrothermal activity in the Area, that could have caused silicification to rocks, are considered to be one of research themes, which could eventually lead to a possibility to specify hydrothermal ore mineralization occurrences of varied types.